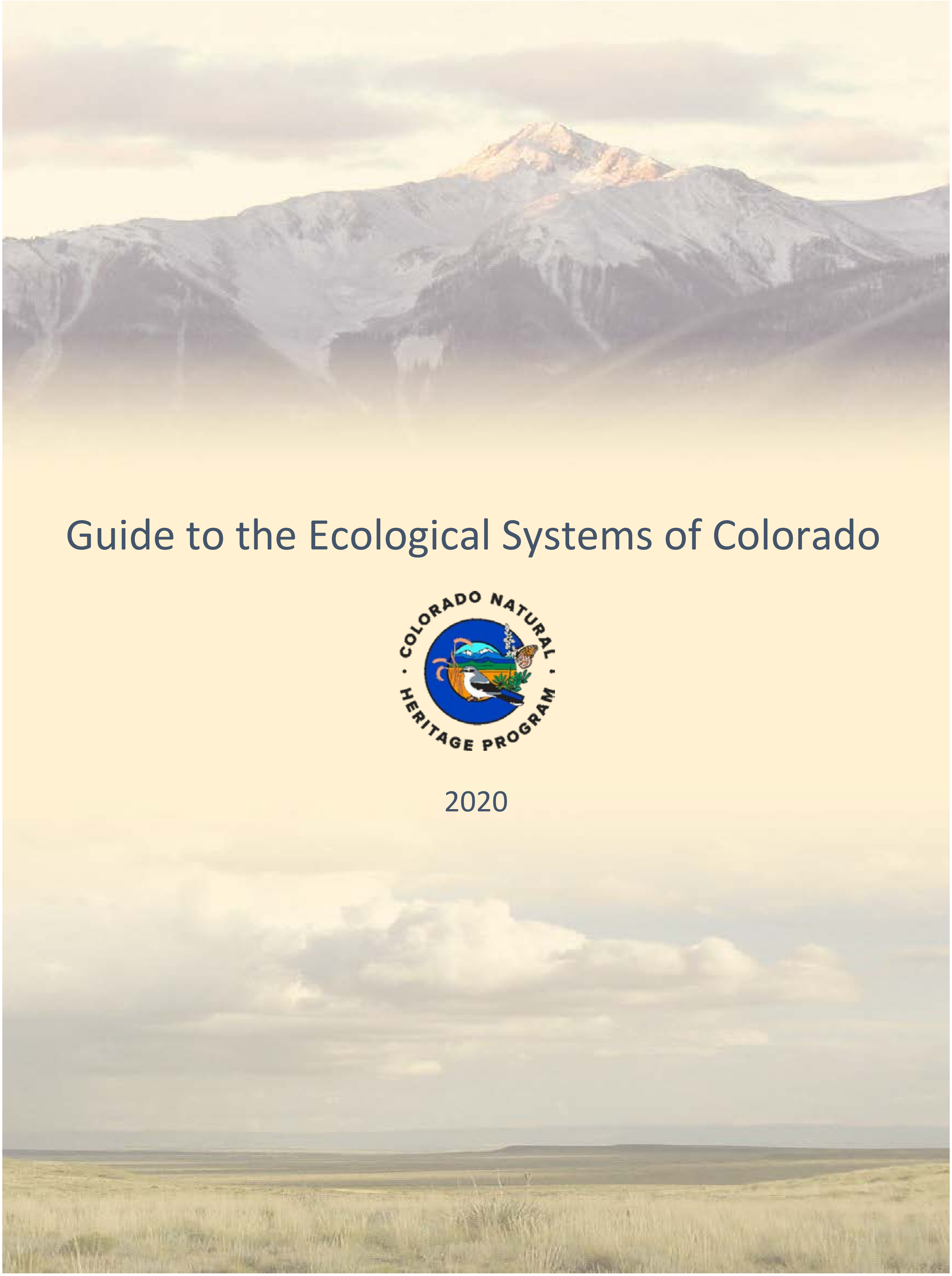

Guide to the Ecological Systems of Colorado

COLORADO NATURAL HERITAGE PROGRAM

2020

CNHP's mission is to advance the conservation of Colorado's native species and ecosystems through science, planning, and education for the benefit of current and future generations.

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This guide is a snapshot of our current understanding of Colorado's ecological systems, and summarizes decades of still ongoing discussion and investigation. We thank all who have thought about and labored to describe the natural vegetation of Colorado over the years; their work provided a solid and indispensable foundation for our effort, and we hope that this document will be built upon in turn.

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INTRODUCTION

Overview of Colorado

Colorado's boundaries encompass some 66.6 million acres, or over 104,000 square miles. Within this area, the type and extent of natural vegetation is determined by many factors, including elevation, climate, soils, disturbance patterns, and the ecological history of the landscape. Each change from lowland plain to mountain range to broad valley creates both habitat opportunities and barriers for plant species. The heterogeneity of the landscape provides the setting for a diversity of plant communities not possible in more uniform regions.

Colorado spans the continental divide amid the highest peaks of the Rocky Mountain ecological division. As a result, the state's topology is complex. To the east of the continental divide, the eastern plains rise gently at the rate of about 10 feet per mile from elevations of 3,350-3,650 feet at the state's eastern edge. The plains cover nearly 40% of eastern Colorado, and fall within the Western Great Plains ecological division. Although they appear comparatively flat, Colorado's eastern plains boast little-known dramatic river canyons, shale outcrops forming buttes and scarps, sandy stabilized dune fields, and basalt-capped mesas that are local landmarks in the eastern counties. The surface of the plains has been heavily eroded by the South Platte River in the northern portion, and the Arkansas River in the southern portion. Separating these two drainages, the remaining higher ground forms the Palmer Divide north of Colorado Springs, and the erosional remnant of the original High Plains surface reaches its westernmost extent at Cedar Point near Limon.

At elevations of 5,500 to 6,000 feet near the mountain front, the plains transition fairly abruptly to foothills and mesas that, in turn, quickly rise to montane elevations. The central portion of the state is dominated by the peaks and ranges of the Rocky Mountains. Here, a series of mountain ranges trending generally north-south include more than fifty peaks reaching elevations of 14,000 feet or more. The higher elevation portions of central Colorado fall within the Southern Rocky Mountain ecoregion. This area holds the headwaters of four major river basins. The north and south branches of the Platte, the Arkansas, and the Rio Grande rivers flow east from the divide. On the western slope of the continental divide the upper Colorado River basin includes major tributaries of the Green River (the Little Snake, Yampa, and White rivers) in the northwestern portion of the state, the Colorado and Gunnison rivers in the central western portion, and the, San Miguel, Dolores, Animas and San Juan rivers in the southwestern portion.

Between the ranges of the mountain front and more western ranges, a series of large, high mountain valleys or parks includes North, Middle and South Parks, and the San Luis Valley. The upper Arkansas Valley and the San Luis Valley, now divided by the Sangre de Cristo Range, are part of the Rio Grande Rift, which began forming 25 million years ago. The San Luis Valley is usually considered to be part of the Inter-Mountain Basins ecological division, while the other high mountain valleys belong to the Southern Rocky Mountains.

To the west, more mountains and extensive plateaus, heavily dissected by ravines and canyons, form the characteristic valley and plateau western slope landscape. Near the western border of the

state elevations decrease again, reaching a low of about 4,325 feet where the Colorado River crosses the border with Utah. The western valleys belong to the Colorado Plateau ecoregion portion of the Inter-Mountain Basins division, with the exception of portions of northwestern Colorado (primarily Moffat County), which is placed in the Wyoming Basins ecoregion. The Yampa and Little Snake rivers drain much of the Wyoming Basin.

General climate

Colorado's position at the high point of the continent means that several different weather patterns influence the climate of the state, and hence its vegetation. In general, higher elevations have cooler temperatures and receive more precipitation, although local topography has a significant effect on air movements controlling these factors. Moisture may reach the state from either the Pacific Ocean or the Gulf of Mexico, depending on current air circulation. Storms originating to the west of the state drop much of their moisture as rain or snow on the mountains and western-facing slopes; a rain-shadow effect prevents most of this precipitation from reaching the eastern plains. The western part of Colorado receives most of its yearly precipitation during winter months. Moisture from the Gulf of Mexico can produce heavy precipitation on the eastern slope of the divide, especially in spring and summer, and the plains receive the majority of their annual precipitation during the growing season. Southern portions of the state generally receive mid- to late-summer precipitation as the margin of the North American Monsoon moves north.

Geology and soils

The landscape we see today is the product of both past and ongoing geologic processes. The effects of continental drift, geologic uplifts, volcanic eruption, and erosion have resulted in a highly complex arrangement of rock and soil types that provide a substrate for Colorado's native vegetation. Colorado's eastern plains are dominated by soils derived from Tertiary (2-65 mya) and Cretaceous (65-140 mya) sedimentary formations, shaped by the action of flowing water and wind. In the central portion of the state, the Colorado Rocky Mountains are formed of igneous and metamorphic rock that is thrust up through the sedimentary layers to the east and west. Here soils are generally less well developed, except in low-lying areas, where erosion has deposited substantial soil material. The western plateaus and valleys are also primarily formed in Tertiary and Cretaceous substrates, and many soils have high concentrations of salts and minerals that inhibit plant growth. In combination with climate factors, soils are a good indicator of which type of vegetation will dominate the landscape in a particular area.

Land ownership

Ownership patterns reflect the land use history of the state, and, together with management practices are an important factor in determining the conservation status of Colorado's landscape. Arable lands, especially on the eastern plains and along river drainages, are primarily in private ownership. Colorado's mining history has left a legacy of private inholdings within extensive tracts of public land. Lower elevation lands on the west slope used primarily for grazing, mining, oil and gas extraction, and recreation are generally administered by the Bureau of Land Management (BLM). Higher elevation (mostly forested) parts of the state are largely under the administration of the U.S. Forest Service, while National Grasslands administered by the U.S. Forest Service in eastern

Colorado were formed from farmland reclaimed from the ravages of the Dust Bowl days. The distribution of state-owned land still reflects the school land grant included in the 1875 Enabling Act for the Territory of Colorado, which provided that two sections of every township (usually sections 16 and 36) be granted for the support of public schools.

About 57% of the state's surface acres are privately owned, with the remainder in federal, state, local government, or tribal ownership. Federal public lands account for a little over 36% of Colorado acreage. The BLM administers 8.4 million acres (13%) of Colorado's surface acres, as well as over 29 million acres of sub-surface mineral estate. Other federal lands in Colorado are administered U.S. Forest Service (22% of state acreage), National Park Service (1%), and other federal agencies including the U.S. Fish and Wildlife Service, Bureau of Reclamation, and Department of Defense (<1%). The State of Colorado owns nearly 5% of the acreage, and also holds about a million acres of sub-surface mineral estate on lands in other ownership. Tribal lands account for about 1% of Colorado's acreage, and the remainder is owned by governments at the county and city level.

Human influence on the landscape

In addition to natural disturbance processes such as fire, wind, and flooding, the effects of human activities have also changed patterns of disturbance in Colorado. The settlement history of Colorado has resulted in a pattern of land ownership where public lands are a significant part of the landscape.

Development

Although industrial, urban, suburban, and exurban development in Colorado are generally not occurring on public lands, these activities are a source of potential disturbance to adjacent areas. Colorado's total population of over 5.7 million people is largely concentrated in the Front Range corridor from Pueblo north to Fort Collins where 11 counties account for 83% of the state's population. Larger cities outside this area include Grand Junction, Montrose, and Durango. A network of highways, roads, and other transportation corridors, together with utility right-of-ways of various types connects populated places large and small throughout the state. In spite of the state's increasing population, and patchwork of private and public lands, more than 75% of Colorado's landscape remains covered by natural vegetation, especially in higher elevation areas.

Resource Extraction and Energy Development

Mining for coal, gold, gypsum, limestone, silver, molybdenum, soda ash, sodium bicarbonate, sand, gravel, and crushed stone, as well as the extraction of petroleum and natural gas, have had a significant role in shaping Colorado's landscape. Energy development is a significant and expanding activity in Colorado, especially in the natural gas and oil-rich areas of the northern Front Range and western slope. Beginning in the 1860s, coal and petroleum were the first energy resources to be developed in Colorado. Together with natural gas and oil shale, these fossil fuels have historically constituted the majority of energy development in the state. The BLM administers mineral leasing for all federal lands in Colorado where such rights have not been withdrawn, as well as for split-estate federal mineral rights under non-Federal lands. As part of its trust responsibility, the BLM

also oversees mineral operations on tribal lands. Colorado currently has more than 2,200 wind turbines in operation, primarily on the eastern plains. Concentrated solar energy facilities are also being developed in several areas of the state. However, with the projected future growth of these industries, Colorado can expect to see an increase in transmission line construction.

Agriculture

The original grasslands of Colorado's eastern plains were home to large numbers of grazing animals including deer, pronghorn, elk and bison. With European settlement, these native grazers were largely replaced by domestic livestock. Large-scale grazing began in the 1860s, and quickly expanded as railroads provided access to eastern markets. Both the Bureau of Land Management and the U.S. Forest Service issue grazing permits for public lands in Colorado, and state-owned lands may also be leased for grazing. Cattle and associated products form the largest portion of Colorado's agricultural economy, followed by field crops (USDA NASS 2015). Around 1900, crop farming began to expand in the state, with wheat and corn as the primary products. Although periodic droughts have repeatedly dealt hard blows to farming and ranching in Colorado, these land uses still make an important contribution to the state's economy, and have had an undeniable effect on the arrangement and condition of Colorado's natural vegetation.

Recreation and Conservation

In recent decades, recreation has become an increasingly important part of land use in Colorado. From National Parks to local open space lands, increasing numbers of residents and visitors are drawn to a variety of outdoor activities such as hiking, camping, winter sports, hunting, fishing, and off-road vehicle use. Paradoxically, recreation on Colorado's public lands can contribute to both its conservation and its degradation.

Ecological Systems

Native plant communities and ecological systems

The term plant community has been widely used to label any assemblage of plant species that can be more or less easily circumscribed by a common set of physical processes, geography, soils, and climate, within a designated area. Although such labels tend to focus on physical factors controlling the growth and survival of plants, the biogeographic and evolutionary history of individual plant species is also relevant in determining the potential possible composition of a plant community. Over the past century and more, ecologists have come to recognize that the association of plant species into communities at various scales is a dynamic process; the concept of a "stable" or "climax" community has largely been abandoned.

For the purposes of this guide, we use **ecological systems** (Comer et al. 2003) to describe the natural vegetation of Colorado. The ecological system concept and our description of Colorado's vegetation are founded on a body of previous work (see references below) that sought to describe repeating patterns of vegetation across the landscape at a variety of scales, generally with a focus on management and conservation. Phytosociological classifications focus on describing the landscape by the vegetation it supports, with an underlying assumption that similar conditions will

consistently result in similar plant associations. Natural community classifications focus on the response of component species to habitat conditions, including stochastic environmental factors, interspecific interactions, and evolutionary population dynamics, with the assumption that similar plant communities may occur in variable habitat conditions; this is the focus of the ecological system concept.

Ecological systems are dynamic assemblages or complexes of plant and/or animal communities that 1) occur together on the landscape; 2) are tied together by similar ecological processes, underlying abiotic environmental factors or gradients; and 3) form a readily identifiable unit on the ground (Comer et al. 2003). These systems provide a coarser level unit than plant associations and alliances as defined under the US National Vegetation Classification (USNVC) standard, and are more easily identified on the ground. Furthermore, although ecological systems are often approximately equivalent to the macrogroup or group level within the USNVC, they are not strictly hierarchical, so that a given plant association may occur in more than one system. Plant associations that may be found within each ecological system are listed in the descriptions herein; the user should refer to the appropriate USNVC or NatureServe Explorer association page for a detailed description of an individual plant association of interest.

Ecological system descriptions in this document are based on materials compiled by NatureServe ecologists (original concept authors) or developed by Colorado Natural Heritage Program (CNHP) staff (Colorado version authors). Ecological system names used herein are Colorado-specific (state names) but largely similar to original NatureServe (national) names. In a number of instances, we chose to combine two ecological systems under a single name, or to modify the national name. Distribution maps were produced using a variety of sources, including CNHP element occurrence records and state or national-level raster digital landcover datasets.

Plant community classifications and their uses

No doubt people have been attempting to classify non-human organisms into useful groups for nearly as long as we have been classifying ourselves into tribes, cultures, or nations. The most appropriate level of classification for conservation and management depends on the conservation target or management issue involved. Classifications have strengths and weaknesses which define their appropriate sphere of use. The USNVC plant association provides good fine-scale description of much of Colorado’s natural vegetation, and is useful for managers of relatively small parcels of land and ecological researchers who wish to understand the workings of landscapes at small scales and over short time spans. Disadvantages of the USNVC plant association and hierarchy are 1) the hierarchical format is highly artificial, leading to an overabundance of association descriptions with a focus on scientific names that is not equally accessible to all users, 2) the plant association is often described as a snapshot of conditions at a particular moment of observation; experienced ecologists will not always agree on what is present at a particular site, and 3) the fine scale promotes a reductionist view that does not well reflect the fact that plant associations are not clear, discrete units on the landscape, each possessing an inherently appropriate management method.

Introduction

Ecological systems, related to but not within the USNVC heirarchy, define larger, more manageable units on the landscape, acknowledging ecological connections among related types. The primary disadvantage of the ecological system concept is that it is a comparatively coarse-scale grouping, which can lead to unique, rare, or locally important plant communities being overlooked in the application. Areas or communities with special management needs may be at risk of going unnoticed in quick assessment using ecological systems. The best way to mitigate this risk is to provide as much description as possible of the actual occurrence of the ecological system, not just a name.

Because classifications are focused on describing relatively stable, repeating communities on the landscape, all classifications break down somewhat when dealing with ecotones or highly disturbed situations. Disturbance tends to disrupt expected patterns and introduce species which may not have previously been stable components of a community. Ecotones are a reminder that we are trying to impose order on a system that isn't paying attention to our efforts.

How to use this guide

There are a variety of ways to employ ecological systems in management, planning, and conservation efforts, even at scales that may seem too small for landscape-level concepts. At any scale, from a small parcel of several acres to a million-acre landscape, identifying a few key features will allow the use of an ecological system, together with its component plant associations:

> <u>Scale and landscape context</u>
> Think about how the vegetation is arranged on the landscape, and about the larger context of the surrounding area. Some ecological systems may be matrix-forming, while other types are embedded or mosaiced as large patches, small patches, or linear occurrences. Identify how the various types are connected, whether by similar or divergent natural vegetation, or interrupted by non-vegetated areas - natural or disturbed.
>
> <u>Natural dynamic processes</u>
> Consider the sort of disturbance cycles, such as those due to climate variation, drought, wildfire, species migrations or invasions, substrate movements both large and small, and other factors that are likely to influence the type and arrangement of vegetation.
>
> <u>Condition and variation over time</u>
> Pull together information about how dynamic processes and other impacts have shaped the vegetation over time. Can the area be described as a variation within some part of an already described natural ecological system? Adding detail to a coarse-level concept (ecological system) is usually more productive than expanding a fine-scale concept (plant association) to cover all scenarios.

<u>Outcomes</u>
Outline your goals and objectives for describing the ecological system(s) of an area. How might the above considerations affect planning needs and management results? How quickly might things change in relation to a planning timeline?

Once you have a good description of your area and requirements in mind or in hand, proceed to the ecological system key or key diagram below. When you arrive at a likely ecological system choice, read through the description to see if it fits your situation, or if it is the only fit but needs a bit more description for your use. Ecological system descriptions can be adapted to your local situation by adding additional descriptive elements as needed, and relating your local conditions to the more general information. Any of the classification levels can be made useful for management if prescriptions are written for each of the units.

Ecological system descriptions are also on the CNHP website, where periodic updates will be posted. Unless otherwise indicated, all images in this document are © CNHP.

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Introduction

Keys to Ecological Systems

Upland

Upland ecological systems generally occupy drier areas on the landscape, where the surface is wet only for short periods after precipitation events (e.g. rainfall, snowmelt, runoff). Water table levels are usually not near the surface. Dominant plant species are not those usually found in wetland areas..**UPLAND KEY**

Wetland or Riparian

Wetland ecological systems occur in areas with hydric soils, that are permanently or seasonally saturated with water. Dominant species are those typically associated with wetlands. Riparian ecological systems are directly adjacent to surface waters such as streams or lakes, and dominant species are tolerant of occasional saturated and/or flooded conditions…**WETLAND/RIPARIAN KEY**

UPLAND KEY

1a. Trees present and forming a characteristic part of the system. Trees are generally single-stemmed, woody plants more than 13 ft (4 m) tall, but may occur as dwarf-forms. May be deciduous or evergreen. ....**Key A - Forest, Woodland and Savanna Systems**

1b. Trees absent, or only a very few widely scattered individuals/clumps present. .... **(2)**

2a. Systems of high elevation areas (alpine), generally above 11,000 ft. May have snow cover present for much of the year, may be vegetated or essentially barren. .... **Key B – Alpine Systems**

2b. Systems of lower elevations, generally below 11,000 ft. .... **(3)**

3a. Vegetation extremely sparse (generally less than 10% cover), bare rock or soil dominant. Vegetation may be confined to small pockets where soil has formed in crevices, or may consist of widely scattered individuals/clumps in an otherwise unvegetated landscape. ....**Key C – Sparse or barren systems**

3b. Systems generally not dominated by bare rock or soil, generally well vegetated and dominated by shrubs or herbaceous plants, although vegetation may still appear rather sparse in some areas. .... **(4)**

4a. Systems dominated by woody shrubs (generally multi-stemmed or branched near the base, less than 13 ft tall, but may occasionally appear as tree-form) ....**Key D – Shrubland and Steppe systems**

4b. Systems dominated by grasses, forbs. ....**Key E – Grassland systems**

Upland Key A: Forest, Woodland and Savanna

1a. Trees present, with generally closed canopy, may have occasional openings, or form clumps of stunted trees below alpine areas. Dominant species include Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), white fir (*A. concolor*), aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), bristlecone pine (*P. aristata*), limber pine (*P. flexilis*), and Douglas-fir (*Pseudotsuga menziesii*). Elevations generally above 8,000 ft (montane to subalpine).. Forest -Woodland **(2)**

1b. Tree cover less than above but still forming the characteristic overstory of the system (i.e., not shrub dominated), generally open canopy, frequent openings, or scattered, park-like, etc. Dominant species include Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), ponderosa pine (*P. ponderosa*), pinyon pine (*P. edulis*), and juniper (*Juniperus* spp.). Elevations generally below 8,000 ft. ....Woodland - Savanna **(10)**

2a. Conifer dominated – elevations montane to subalpine. .... **(3)**

2b. Deciduous dominated or mixed coniferous-deciduous (if oak or curl-leaf mountain mahogany is dominant, go to 9). .... **(6)**

3a. Dominated by Engelmann spruce and/or alpine fir.. **(4)**

3b. Dominated by lodgepole pine, bristlecone pine, or limber pine. (if other conifers such as ponderosa pine, Douglas-fir, white fir, and/or quaking aspen are common, go to 7). .... **(5)**

4a. Matrix forest of subalpine areas in dry to mesic sites, or large-patch subalpine conifer forests characteristic of relatively mesic local environments (e.g., north-facing slopes, ravines, cold-air drainages, and other locations where available soil moisture is higher or lasts longer into the growing season. Canopy formed primarily by Engelmann spruce (*Picea engelmannii*) with subalpine fir (*Abies lasiocarpa*), some lodgepole pine (*Pinus contorta*) or other conifers may be present. May form scattered clumps of stunted shrub-forms (krummholz) below alpine areas..**Rocky Mountain Subalpine Spruce-Fir Forest and Woodland**

4b. Wooded areas where snow slides are frequent, characterized by a moderately dense, woody canopy of dwarfed and damaged conifers and small, deciduous trees or shrubs. .... **Northern Rocky Mountain Avalanche Chute Shrubland**

5a. Dominated by lodgepole pine (*Pinus contorta*), although other conifer species may be present, generally at elevations between 8,000 and 10,000 ft. Lodgepole pine dominated areas may intergrade with forest types of higher or lower elevations. ....**Rocky Mountain Lodgepole Pine Forest**

5b. Dominated by limber pine (*Pinus flexilis*) or bristlecone pine (*Pinus aristata*, from Clear Creek county south). Generally open (occasionally closed) canopy woodlands of dry, rocky environments at montane to subalpine elevations. May form scattered clumps of stunted shrub-forms below alpine areas. ....**Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland**

6a. Mixed forests and woodlands of various conifer species and/or aspen.................................... **(7)**

6b. Closed to open canopy forests and woodlands dominated by quaking aspen (*Populus tremuloides*) without a significant conifer component (<25%). Understory is variable from mesic to xeric herbaceous or shrubby. ....**Rocky Mountain Aspen Forest and Woodland**

7a. Mixed aspen-conifer forests and woodlands of western Colorado plateaus and central Colorado montane slopes where aspen codominates with any of a number of conifers, including Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), alpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), blue spruce (Picea pungens), lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), and ponderosa pine. (*Pinus ponderosa*). .... **Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland**

7b. Mixed conifer forests and woodlands of montane elevations where aspen may be present, but not dominant. .... **(8)**

8a. Mixed conifer forests and woodlands of dry to mesic environments. Common tree species most commonly include Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*), but these mixed-species forests may also include Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and limber pine (*Pinus flexilis*), blue spruce (*Picea pungens*). Stands may be intermixed with other forest types dominated by ponderosa pine (*Pinus ponderosa*) or quaking aspen (*Populus tremuloides*) .... **Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland**

8b. Montane or lower elevation (below 9,500 ft) woodlands, canyonlands, or savannas dominated by pines, junipers, oak, mixed montane shrubs, or curl-leaf mountain-mahogany (*Cercocarpus ledifolius*). .... **(9)**

9a. Pine dominated open to closed woodlands of foothills, mountain slopes and western plateaus/valleys. .... **(10)**

9b. Deciduous dominated large patch woodlands or tall shrublands. .... **(18)**

10a. Dominated by ponderosa pine (*Pinus ponderosa*), bristlecone pine (*P. aristata*), or limber pine (*P. flexilis*), although other conifer species or occasional stands of quaking aspen (*Populus tremuloides*) may be present. .... **(11)**

10b. Dominated by pinyon pine and/or juniper. .... **(14)**

11a. Limber pine (*Pinus flexilis*) is dominant or codominant with bristlecone pine (*P. aristata*) at higher elevations or juniper (*Juniperus* spp.) at lower elevations. .... **(12)**

11b. Ponderosa pine (*Pinus ponderosa*) dominant. .... **(13)**

12a. Dominated by limber pine (*Pinus flexilis*) or bristlecone pine (*P. aristata*, Clear Creek county and south). Generally open (occasionally closed) canopy woodlands of dry, rocky environments at montane to subalpine elevations. May form scattered clumps of stunted shrub-forms below alpine areas. .... **Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland**

12b. Bristlecone pine (*Pinus aristata*) absent. Limber pine (*P. flexilis*) dominant to co-dominant with juniper. Open woodlands of lower montane, foothills and scarps of eastern Colorado.. **Rocky Mountain Foothill Limber Pine-Juniper Woodland**

13a. Open to closed canopy ponderosa pine (*Pinus ponderosa*) forests and woodlands of montane elevations, or open, park-like savannas, often along the mountain front transition to lower elevation shrublands or grasslands, characterized by widely spaced older ponderosa pines. .... **Southern Rocky Mountain Ponderosa Pine Woodland and Savanna**

13b. Ponderosa pine dominant in places, but occurring with other tree species, including Douglas-fir (*Pseudotsuga menziesii*), Rocky Mountain juniper (*Juniperus scopulorum*), and limber pine (*Pinus flexilis*). .... **Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland**

14a. Pinyon pine (*Pinus edulis*) and/or Utah juniper (*Juniperus osteosperma*) dominated woodlands of western Colorado.. **(15)**

14b. Pinyon pine (*Pinus edulis*) and/or one-seed juniper (*Juniperus monosperma*) dominated woodlands or canyonlands of south-central or eastern Colorado. .... **(16)**

15a. Widespread, characteristic mixed pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) woodlands of warm, dry sites on mountain slopes, mesas, plateaus, and ridges throughout western Colorado. Understories are highly variable and may be sparse, grassy, or shrubby. Trees may be stunted, shrub-form, and generally confined to pockets of soil on rocky substrates (see Key C for very sparsely vegetated areas). .... **Colorado Plateau Pinyon-Juniper Woodland and Shrubland**

15b. Open savannas or occasionally more dense woodlands of Utah juniper (*Juniperus osteosperma*) in northwestern Colorado where pinyon pine (*Pinus edulis*) is not present. Generally on lower mountain slopes, hills, plateaus, basins and flats, often where juniper is adjacent to semi-desert grasslands and steppe. .... **Inter-Mountain Basins Juniper Savanna**

16a. Mixed pinyon pine (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*) woodlands of dry mountains and foothills in southern Colorado, east of the continental divide, generally not extending far from the mountain front. .... **Southern Rocky Mountain Pinyon-Juniper Woodland**

16b. Juniper dominated woodlands and savannas of eastern Colorado.. **(17)**

17a. Open grassy woodlands and savannas generally of expansive, flatter areas, but also on slopes of small bluffs and outcrops.. **Southern Rocky Mountain Juniper Woodland and Savanna**

17b. Mixed woodlands of the canyons of the Purgatoire River and nearby drainages, and on the Mesa de Maya. Occasional pinyon pine (*Pinus edulis*) or other conifers may be present in the canyons, but one-seed juniper (*Juniperus monosperma*) or Rocky Mountain juniper (*J. scopulorum*) are the characteristic overstory species. Other woody vegetation may include skunkbush sumac (*Rhus trilobata*), currant (*Ribes* spp.), common hoptree (*Ptelea trifoliata*), and littleleaf mock orange (*Philadelphus microphyllus*). ....**Southwestern Great Plains Canyon**

18a. Open to dense woodlands and shrublands of rocky ridges and scarps, dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius*). This species is typically shrub-form, but forms dense woodlands of small trees in northwestern Colorado in the vicinity of Dinosaur NM. Scattered individuals of taller tree species including Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), quaking aspen (*Populus tremuloides*), two-needle pinyon (*Pinus edulis*), or Utah juniper (*Juniperus osteosperma*) may be present...................... **Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland**

18b. Open to dense tall shrublands dominated by Gambel oak (*Quercus gambelii*) or mountain shrub species .... **Key D**

Upland Key B: Alpine (above treeline) systems

1a. Vegetated herbaceous and shrubland habitats of high elevations, generally above 11,000 ft. .... **(2)**

1b. Barren or very sparsely vegetated habitats of high elevations, generally above 11,000 ft. .... **(4)**

2a. Dominated by woody, dwarf-shrub ericaceous or willow species less than 0.5 m high. ....**Rocky Mountain Alpine Dwarf-Shrubland**

2b. Dominated by perennial grass and forb species. .... **(3)**

3a. Wind-scoured, rocky areas with little soil development, dominated by low growing cusion plants. Sparsely vegetated, with stoney pavement, often in matrix with following. .... **Rocky Mountain Alpine Fell-Field**

3b. Widespread, matrix forming herbaceous habitats of alpine environments, characterized by a dense cover of low-growing, perennial graminoids and forbs. .... **Rocky Mountain Alpine Turf**

4a. Barren or sparsely vegetated alpine bedrock, talus, or scree slope habitats. Vegetation generally limited to crevices or occurring as non-vascular (lichen) communities...................... .... **Rocky Mountain Alpine Bedrock and Scree**

4b. Alpine habitats dominated by permanent ice and snow cover or generally only exposed for a few weeks. No vascular plants are present. .... **North American Glacier and Ice Field**

Upland Key C: Sparsely vegetated systems

1a. Sparsely vegetated habitats restricted to washes, flats, or playas that are intermittently flooded. .... **Wetland/Riparian Key**

1b. Sparsely vegetated habitats of areas not generally subject to inundation. .... **(2)**

2a. Sparsely vegetated habitats characterized by shifting sandy-substrates or fine-textured shales. .... **(3)**

2b. Sparsely vegetated habitats characterized by cliffs, rock outcrops, or shaley breaks. .... **(4)**

3a. Large patch habitats characterized by the presence of actively migrating dunes. System is often a matrix including barren active dunes, sparsely vegetated dunes, and vegetated, more-or-less stabilized dunes. .... **Inter-Mountain Basins Active and Stabilized Dune**

3b. Barren or very sparsely vegetated, generally rolling to steep areas (base of cliff) where substrates are derived from marine shales. Widely scattered individuals of shrub species as well as occasional bunch grasses may be present. .... **Inter-Mountain Basins Shale Badland**

4a. Cliffs, canyons, and rock outcrops of montane areas or western plateaus and valleys. .... **(5)**

4b. Cliffs, outcrops, breaks and shale hills of the eastern plains. .... **Western Great Plains Cliff, Outcrop and Shale Barren**

5a. Barren and sparsely vegetated landscapes of western Colorado, characterized by eroded plateaus and valleys typically formed in sedimentary rock (sandstones and shales). Vegetation is generally confined to crevices and small pockets of soil, and species are those from neighboring systems, such as pinyon, juniper, and other Colorado Plateau types. .... **Colorado Plateau Mixed Bedrock Canyon and Tableland**

5b. Barren and sparsely vegetated landscapes of foothill to subalpine areas, characterized by steep cliff faces, narrow canyons, and rocky outcrops of various bedrock types. Vegetation is generally confined to crevices, and species are those from surrounding systems, sometimes including scattered trees and shrubs, that are characteristic of the Southern Rocky Mountains. .... **Rocky Mountain Cliff, Canyon and Massive Bedrock**

Upland Key D: Shrubland and Steppe systems

1a. Deciduous shrub species dominate. .... **(2)**

1b. Evergreen or partially deciduous shrubs dominate. .... **(4)**

2a. Tall shrublands of upland, generally xeric habitats on dry foothills and lower mountain slopes. Gambel oak (*Quercus gambelii*) is dominant or co-dominant with other deciduous shrubs such as serviceberry (*Amelanchier alnifolia* or *A. utahensis*), big sagebrush (*Artemisia tridentata*), mountain mahogany (*Cercocarpus* spp.), bitterbrush (*Purshia* spp.) or snowberry (*Symphoricarpos* spp). .... **Rocky Mountain Gambel Oak-Mixed Montane Shrubland**

2b. Oak (*Quercus gambelii*) not present, other deciduous shrubs dominant .... **(3)**

3a. Shrublands of foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes of the plains. Oak (*Quercus gambelii*) is generally not present. Typical dominant species are mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), chokecherry (*Prunus virginiana*), skunkbush sumac (*Rhus trilobata*), wax currant (*Ribes cereum*), mountain ninebark (*Physocarpus monogynus*), or soapweed yucca (*Yucca glauca*). Understories often grassy. Generally on drier sites than previous. .... **Rocky Mountain Lower Montane-Foothill Shrubland**

3b. Lower foothills to valley bottom shrublands restricted to temporarily or intermittently flooded drainages or flats and dominated by greasewood (*Sarcobatus vermiculatus*) .... **Inter-Mountain Basins Greasewood Flat (Wetland/Riparian Key)**

4a. Sagebrush shrubland and steppe. Sagebrush (*Artemisia* spp.) is the dominant or co-dominant shrub, may be dense or open. .... **(5)**

4b. Other shrub species dominate. .... **(10)**

5a. Sand sagebrush (*Artemisia filifolia*) shrublands primarily of the eastern plains. Generally on sandy areas associated with stabilized dune fields, river bluffs and terraces, and inactive floodplains etc. .... **Western Great Plains Sandhill Steppe**

5b. Sagebrush shrublands and steppe of the mountains and western plateaus/valleys. .... **(6)**

6a. Shrublands dominated by big sagebrush (*Artemisia tridentata*) .... **(7)**

6b. Dwarf sagebrush shrublands or shrubby grasslands. .... **(8)**

7a. Widespread characteristic shrublands of broad intermountain basins, foothills, and lower mountain slopes (generally below 7,500 ft) in the western US dominated by *Artemisia tridentata* ssp. *tridentata* or ssp. *wyomingensis*. .... **Inter-Mountain Basins Big Sagebrush Shrubland**

7b. Sagebrush shrublands of montane and subalpine elevations, dominated by *Artemisia tridentata* ssp. *vaseyana* (antelope bitterbrush may co-dominate), often with an abundant perennial herbaceous layer. .... **Inter-Mountain Basins Montane Sagebrush Steppe**

8a. Shrub-steppe dominated by perennial grasses and forbs, with big sagebrush and other shrubs forming a lesser component of the canopy.

.... **Inter-Mountain Basins Big Sagebrush Steppe**

8b. Short or dwarf sagebrush shrublands, uncommon in Colorado. .... **(9)**

9a. Windswept shrublands characterized by black sagebrush (*Artemisia nova*), little sagebrush (*Artemisia arbuscula* ssp. *longiloba*), and wind-dwarfed Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Northern Colorado, near Wyoming border. .... **Wyoming Basins Dwarf Sagebrush Shrubland and Steppe**

9b. Open shrublands and steppe dominated by black sagebrush (*Artemisia nova*) or Bigelow sage (*Artemisia bigelovii*) sometimes with Wyoming big sagebrush (*Artemisia tridentata* ssp*. wyomingensis*) codominant. Western Colorado, near Utah border only.................................. .... **Colorado Plateau Mixed Low Sagebrush Shrubland**

10a. Shrublands dominated by saltbush (*Atriplex* species). .... **(11)**

10b. Shrublands dominated by other shrub species, or by perennial bunch grasses. .... **(12)**

11a. Open-canopied to moderately dense shrublands typically of saline basins, alluvial slopes and plains, eastern or western Colorado. Shadscale saltbush (*Atriplex confertifolia*) or fourwing saltbush (*Atriplex canescens*), are typical and stands may include winterfat (*Krascheninnikovia lanata*), pale desert-thorn (*Lycium pallidum*), horsebrush (*Tetradymia canescens*), and various sagebrush (*Artemisia*) species.. ....**Inter-Mountain Basins Mixed Salt Desert Scrub**

11b. Dwarf shrublands of shallow, typically saline, alkaline, fine-textured soils developed from shale or alluvium. In Colorado, dominated by mat saltbush (*Atriplex corrugata*) or Gardner's saltbush (*Atriplex gardneri*), with very sparse herbaceous cover, and often intermingled with shale badlands. .... **Inter-Mountain Basins Mat Saltbush Shrubland**

12a. Shrubby grasslands dominated by bunch grasses including blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), saltgrass (*Distichlis spicata*), Indian rice grass (*Achnatherum hymenoides*), and alkali sacaton (*Sporobolus airoides*) with an open shrub layer. Winterfat (*Krascheninnikovia lanata*) is characteristic, but now largely been replaced by rabbitbrush (*Ericameria* and *Chrysothamnus*) species and other woody shrubs.. ....**Inter-Mountain Basins Semi-Desert Shrub-Steppe**

12b. Not as above. Shrublands of short-stature pinyon (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) trees, often occurring with deciduous shrub species such as mountain mahogany (*Cercocarpus montanus*), or Stansbury cliffrose (*Purshia stansburiana*) and other shrubs. Typically confined to xeric sites where soils are shallow. Intergrades with sparsely vegetated bedrock areas supporting similar species. .... **Colorado Plateau Pinyon-Juniper Woodland and Shrubland**

Upland Key E: Grassland systems

1a. Grasslands of montane or subalpine habitats, generally above 7,500 ft. .... **(2)**

1b. Grasslands of lower elevations. .... **(3)**

2a. Small-patch grass and forb dominated communities of mesic habitats, often characterized by tufted hairgrass (*Deschampsia caespitosa)* and associated species, but drier than sites supporting Rocky Mountain Alpine-Montane Wet Meadow system (in wetland Key C). ....
....**Rocky Mountain Subalpine-Montane Mesic Meadow**

2b. Large-patch grasslands, typically intermixed with matrix stands of spruce-fir, lodgepole pine, ponderosa pine, and aspen forests, or, in the ununual instance of South Park, forming the matrix. Characterized by bunch grasses of fescue (*Festuca* spp.), oatgrass (*Danthonia* spp.), or muhly (*Muhlenbergia* spp.). ....
.... **Southern Rocky Mountain Montane-Subalpine Grassland**

3a. Grasslands of the eastern plains, mountain front, and foothills on the eastern side of the continental divide. .... **(4)**

3b. Widespread characteristic grasslands of the western plateaus and valleys (occasionally be found in small areas on eastern plains), often intermixed with matrix stands of pinyon-juniper, sagebrush, and other shrub-dominated types. Dominant or characteristic grasses include Indian ricegrass (*Achnatherum hymenoides*)*,* threeawn (*Aristida* spp.), blue gramma (*Bouteloua gracilis*)*,* needle-and-thread (*Hesperostipa comata*), muhly (*Muhlenbergia* spp.), or James' galleta (*Pleuraphis jamesii*). ....
.... **Inter-Mountain Basins Semi-Desert Grassland**

4a. Small to large patch grasslands of mid-height grasses. .... **(5)**

4b. Widespread, matrix-forming grassland of eastern Colorado, but also occurring in smaller patches near the mountain front. Dominated by short-stature perennial grasses, especially blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). ....
.... **Western Great Plains Shortgrass Prairie**

5a. Mixed- to tallgrass grasslands of the mountain front and foothills/hogbacks, but extending further eastward on the Palmer Divide and near the Colorado-Wyoming border. Characteristic species include needle-and-thread (*Hesperostipa comata*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), green needlegrass (*Nassella viridula*), western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus cryptandrus*), or New Mexico feathergrass (*Hesperostipa neomexicana*). Small patch grasslands dominated by tallgrass species are included here. ....**Western Great Plains Foothill and Piedmont Grassland**

5b. Formerly widespread matrix-forming grasslands of extreme eastern Colorado and further east, where it was transitional between tallgrass and shortgrass prairie, may occur in small patches near the mountain front. Generally on loamier soils than previous. Species are similar, but little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), and needle-and-thread (*Hesperostipa comata*), thread are most characteristic for Colorado occurrences. ....
.... **Central Mixedgrass Prairie**

WETLAND/RIPARIAN KEY

1a. Wetlands and riparian areas of Colorado's eastern plains, including all areas below ~6,000 ft. from the Front Range east to the Kansas boarder. Within Colorado, this area is referred to as the Eastern Plains, but from a national perspective, these are part of the Western Great Plains Division *[If on the edge of the foothills, try both Key A and Key B.]* .... **Key A: Wetlands and Riparian Areas of Colorado's Eastern Plains**

1b. Wetland and riparian areas west of the Great Plains **2**

2a. Wetlands and riparian areas with alkaline or saline soils within the inter-mountain basins of the Rocky Mountains (San Luis Valley, South Park, North Park, etc.). *[If the site does not match any of the descriptions within Key B, try Key C as well. Not all wetlands and riparian areas of the inter-mountain basis will fit within this key.]* .... **Key B: Wetlands and Riparian Areas of the Inter-Mountain Basins & Valleys**

2b. Wetlands and riparian areas of the Rocky Mountains, including the foothills of the Front Range and all of the Western Slope. Localized "hanging garden" wetlands of the Colorado Plateau are also keyed here, as they are the only system specific to that region. .... **Key C: Wetlands and Riparian Areas of the Rocky Mountains & Western Valleys**

Wetlands and Riparian Key A: Colorado's Eastern Plains

1a. Low stature shrublands dominated by species such as greasewood (*Sarcobatus vermiculatus*), saltbush (*Atriplex* spp.), rabbitbrush (*Ericameria nauseosa*), silver sagebrush (*Artemisia cana*), and big sagebrush (*Artemisia tridentata*). Vegetation may be sparse and soils may be saline. Sites may be located on flats or in washes, but typically not associated with river and stream floodplains. Shrublands with >10% total vegetation cover, located on flats or in temporarily or intermittently flooded drainages, and dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of alkali sacaton (*Sporobolus airoides*), western wheatgrass (*Pascopyrum smithii*), saltgrass (*Distichlis spicata*), Nuttall's alkaligrass (*Puccinellia nuttalliana*), and common spikerush (*Eleocharis palustris*) herbaceous vegetation. .... **Inter-Mountain Basins Greasewood Flat**

1b. Wetland is not a low stature shrub-dominated saline wash or flat. **2**

2a. Herbaceous wetlands of the Western Great Plains that are isolated or partially isolated from surface water stream networks, not located on floodplains, headwaters, or in riparian zones, often depressional basins with or without an outlet.. **3**

2b. Sites located within the floodplain or immediate riparian zone of a river or stream and part of the surface water stream network. Sites may occur at the vary headwaters of a stream network and be primarily groundwater driven. Vegetation may be entirely herbaceous or may contain tall stature woody species, such as cottonwood (*Populus* spp.) or willow (*Salix*

spp.). Water levels variable. Woody vegetation that occurs along reservoir edges can also be included here. **5**

3a. Natural shallow depressional wetlands in the Western Great Plains, often called playas or playa lakes, with an impermeable soil layer, such as dense hardpan clay, that causes periodic ponding after heavy rains. Playas are variable in size and can range from less than an acre to many acres in size. Sites generally have closed contour topography and are surrounded by upland vegetation. Hydrology is typically tied to precipitation and runoff, though some sites have a strong groundwater connection. Ponding is often ephemeral or seasonal and sites may be dry throughout the entire growing season during dry years. Sites with a groundwater connection or artificial inflows can stay wet throughout the year. Species composition depends on soil salinity, may fluctuate depending on seasonal moisture availability, and many persistent species may be upland species................................. **4**

3b. Herbaceous wetlands in the Western Great Plains not associated with playas or saline basins. If depressional, the system has a connection to a downslope drainage network. .... **Western Great Plains Wet Meadow and Marsh Drainage Network**

4a. Shallow depressional wetlands with less saline soils than the next. Dominant species are typically not salt-tolerant. Sites may have obvious vegetation zonation tied to water levels, with the most hydrophytic species occurring in the wetland center where ponding lasts the longest. Common native species include western wheatgrass (*Pascopyrum smithii*), buffalograss (*Buchloe dactyloides*), spikerush (*Eleocharis* spp.), spotted evening primrose (*Oenothera canescens*), green prairie coneflower (*Ratibida tagetes*), plantain (*Plantago* spp.), knotweed (*Polygonum* spp.), and wedgeleaf (*Phyla cuneifolia*). Non-native species are very common in these sites, including Russian thistle (*Salsola tragus, =australis*), burningbush (*Bassia scoparia, =sieversiana*), and bigbract verbena (*Verbena bracteata*). Site zonation and hydrology can be impacted by agriculture and concentrated grazing. Many have been dug out or "pitted" to increase water retention and to tap shallow aquifers............ ....**Western Great Plains Closed Depression Wetland & Playa**

4b. Shallow depressional wetlands with high salinity. Salt encrustations frequently occur on the surface, and the accumulation of salt concentrations in the lowest central area of the basin can limit species cover to bare or sparse vegetation. Presence of halophytes such as pickleweed (*Salicornia* spp.), seepweed (*Suaeda* spp.), verrucose seapurslane (*Sesuvium verrucosum*), salt heliotrope (*Heliotropium curassavicum*), and media sandspurry *Spergularia maritima, =media*) can be indicator species. Other species are typically salt-tolerant, including saltgrass (*Distichlis spicata*), alkaligrass (*Puccinellia* spp.), bulrush (*Schoenoplectus* spp.), alkali sakaton (*Sporobolus airoides*), and foxtail barley (*Hordeum jubatum*). These herbaceous saline depressions can have occasional shrubs such as greasewood (*Sarcobatus vermiculatus*) and winterfat (*Krascheninnikovia lanata*), or can transition to shrub cover in the less wetland, more mesic outer zones. ....**Western Great Plains Saline Depression Wetland**

5a. Riparian to floodplain-dominated systems with enough fluvial energy and alluvial processes to support development of tree species and floodplain features such as bed and bank. Vegetation typically a complex of non-wetland and wetland zones that range from sparsely vegetated washes with occasional trees, to closed woodlands and complex patchy floodplains. Inclusion of herbaceous vegetation is possible, especially when in-channel flow is augmented with springs or other sources of groundwater discharge ………………….....**6**

5b. Lower energy groundwater-dependent or surface flow systems within the headwaters of drainage networks or on low-order streams. Processes are driven by groundwater discharge or by overland flow caught in depressions within ephemeral to intermittent channels. In-channel flow may occur during local high precipitation events, but the dominant factor in wetland creation is seasonal to continuous groundwater discharge and/or ponding in within-channel depressions. Substrate soil texture and vegetation zonation is less shaped by alluvial processes and more by longer residence times from groundwater discharge or ponding. Some examples are broad and expansive, but most are narrow and linear. Sites range from herbaceous meadows and marshes with minimal woody vegetation, but shrub zones can occur and even dominate local slopes where seasonal to continuous groundwater expression occurs. Herbaceous side channels and sloughs supported by groundwater but set within a mosaic of riparian or floodplain system supporting trees generally belong above due to dominance of alluvial processes and site capacity required for tree establishment in the plains. **8**

6a. Riparian woodlands and shrublands of the Rocky Mountain foothills on the very western margins of the Great Plains. Woodlands are dominated by cottonwood species (*Populus angustifolia, P. deltoides,* or the hybrid *P. acuminata*). Common native shrub species include willow (*Salix* spp.), thinleaf alder (*Alnus incana*), river birch (*Betula occidentalis*), redosier dogwood (*Cornus sericea*), and hawthorn (*Crataegus* spp.). Exotic shrub species include saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*). Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional Hydrogeomorphic Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. Vegetation composition can have foothill species influence and vertical strata tend to be more layered than the next due to foothill proximity. ....
..............**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6b. Riparian and floodplain woodlands and shrublands of Colorado's eastern plains. Dominant species include plains cottonwood (*Populus deltoides*), crack willow (*Salix fragilis*), peachleaf willow (*Salix amygdaloides*), narrowleaf willow (*Salix exigua*), ash (*Fraxinus* spp.), and elm (*Ulmus* spp.). Invasive woody species including saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) can invade sites. Examples of native herbaceous understory species include switchgrass (*Panicum virgatum*), western wheatgrass (*Pascopyrum smithii*), alkali cordgrass (*Spartina gracilis*), prairie cordgrass (*S. pectinata*), and needlegrasses. Non-native or native-invasive species in the genera *Agrostis, Bromus, Phalaris,* and *Phragmites* frequently invade understory with managed or impaired hydrology.. **(7)**

7a. Riparian woodlands and shrublands along small to medium streams where streamflow may dry completely for some portion of the year or water depths are generally wadeable by mid-summer. These riparian areas have less floodplain development and flashier hydrology than the next. Dominant water sources are summer rainfall and alluvial groundwater, although plains riverine systems can have various secondary water sources including irrigation runoff and groundwater. Dominant species include plains cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), narrowleaf willow (*Salix*

exigua), green ash (*Fraxinus pennsylvanica*), western wheatgrass (*Pascopyrum smithii*), switchgrass (*Panicum virgatum*), vine mesquite (*Panicum obtusum*), sand dropseed (*Sporobolus cryptandrus*), and little bluestem (*Schizachyrium scoparium*). Wetland graminoids such as sedges (*Carex* spp.) and bulrush (*Schoenoplectus* spp.) can occupy seasonally inundated channel-fringe zones, secondary channels, swales, or patches of groundwater discharge. Saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), and less desirable grasses and forbs can invade degraded examples. Groundwater depletion, lack of fire and beaver, concentrated grazing, and/or adjacent agricultural activities have resulted in species and hydroperiod changes. Like Rocky Mountain Lower Montane Riparian Woodland and Shrublands, this system can occur around artificial lakeshores where the vegetation is connected to an open water body that may experience fluctuating shoreline water levels. This can mimic the flooding and saturated conditions that occur along riverine channels and their floodplains. .... **Western Great Plains Riparian**

7b. Woodlands, shrublands, meadows, and marshes along large rivers with extensive floodplain development and with a diversity of floodplain-associated structural features. Hydroperiod and flooding is more associated with snowmelt and seasonal dynamics in the mountains than with local precipitation events. Dominant communities within this system include floodplain forests and open cottonwood galleries, mesic to wet shrublands, wet meadow and marsh communities within swales and sloughs, gravel/sand bars, and in-channel islands dominated by early successional herbs and annuals. The diverse array of patches is linked by underlying soils and the flooding regime. Dominant species include plains cottonwood (*Populus deltoides*) and willow (*Salix* spp.), western snowberry (*Symphoricarpos occidentalis*), switchgrass (*Panicum virgatum*), and saltgrass (*Distichlis spicata*). Saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), kochia, and non-native grasses and thistles have invaded degraded areas within the floodplains, which are subjected to heavy grazing and/or agriculture. Areas with more intact hydrology can support wetland graminoids such as cordgrass (*Spartina* spp.) and Emory's sedge (*Carex emoryi*). Groundwater depletion and lack of fire have created additional alterations in species composition and hydroperiod. Nearly all native wet meadow communities are heavily impacted by irrigation and water management, and the majority of the remaining mesic to wet meadow floodplain are extremely degraded examples of this system. .... **Western Great Plains Floodplain**

8a. Herbaceous wetland systems including emergent marshes, wet meadows, fens, and narrow drainages set in the headwaters of eastern Colorado prairie streams and along small tributary drainages. Primary water sources include groundwater discharge or surface flow captured in local depressions within drainage networks. Wetland species dominate and vegetation patches include wet meadows at the headwaters of drainages, which can be expansive, and small to medium sized marshes along the drainage where groundwater discharge supplements surface runoff. Shrubs can also occur, including in fen patches and on spring-fed headwater slopes. If depressional, the system has an outlet and eventual connection to a drainage. Seasonal to semi-permanent at-surface saturation or flooding throughout the growing season is common, except in drought years. ……………………….. .... **Western Great Plains Wet Meadow and Marsh Drainage Network**

8b. Expansive herbaceous wetlands with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point

during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of cattail (*Typha*), bulrush (*Schoenoplectus*), sedge (*Carex*), spikerush (*Eleocharis*), and floating genera such as pondweed (*Potamogeton*), and arrowhead (*Sagittaria*). While this system is located on the floodplain, it may be disconnected from flooding regimes and the hydrology may be entirely managed. Water may be brackish or not. Soils are highly variable. This system includes a variety of managed wetlands on floodplains (e.g., recharge ponds, moist soil units, shallow gravel pits, etc.).. **Western North American Emergent Marsh**

Wetlands and Riparian Key B: Inter-Mountain Basins and Valleys

1a. Depressional wetlands. Soils are typically alkaline to saline clay with hardpans. Salt encrustation typically visible on the soil surface or along the water edge. Water levels various. Typically herbaceous dominated, but may contain salt-tolerant shrubs on the margins. Barren and sparsely vegetated playas (generally <10% plant cover). Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies with soil moisture and greatly affects species composition. Characteristic species may include greasewood (*Sarcobatus vermiculatus*), saltgrass (*Distichlis spicata*), and/or saltbush (*Atriplex* spp.) .... **Inter-Mountain Basins Playa**

1b. Non-depressional wetlands of flats, washes, or narrow drainage networks, including inter-dunal swales .... **(2)**

2a. Non-depressional wetlands with alkaline to saline soils. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically shrub dominated. Most common species are greasewood (*Sarcobatus vermiculatus*), and saltbush (*Atriplex* spp.).. **(3)**

2b. Herbaceous or shrub-dominated non-depressional wetlands or riparian areas not as above. .... **Key C: Rocky Mountains and Western Valleys**

3a. Shrublands with >10% total vegetation cover, located on flats or in temporarily or intermittently flooded drainages. Vegetation dominated by greasewood (*Sarcobatus vermiculatus*) and saltbush (*Atriplex* spp.) with inclusions of alkali sacaton (*Sporobolus airoides*), western wheatgrass (*Pascopyrum smithii*), saltgrass (*Distichlis spicata*), Nuttall's alkaligrass (*Puccinellia nuttalliana*), and common spikerush (*Eleocharis palustris*) herbaceous vegetation. .... **Inter-Mountain Basins Greasewood Flat**

3b. Sites with < 10% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including greasewood (*Sarcobatus vermiculatus*), rabbitbrush (*Ericameria nauseosa*), silver sagebrush (*Artemisia cana*), big sagebrush (*Artemisia tridentata*), saltgrass (*Distichlis spicata*), and alkali sacaton (*Sporobolus airoides*). .... **Inter-Mountain Basins Wash**

Wetlands and Riparian Key C: Rocky Mountains and Western Valleys

1a. Herbaceous wetlands associated with seeps and springs within canyons of the Colorado Plateau region, typically along drainages of the major rivers of the region and their tributaries. Vegetation is supported by perennial water sources (seeps) that form pocketed wetlands and draping vegetation across wet cliff faces. Typical plant species include southern maidenhair fern (*Adiantum capillus-veneris*), northern maidenhair fern (*Adiantum pedatum*), Eastwood's monkeyflower (*Mimulus eastwoodiae*), common large monkeyflower (*Mimulus guttatus*), Purpus' sullivantia (*Sullivantia hapemanii* var. *purpusii*), and several species of columbine, including Mancos columbine (*Aquilegia micrantha*). .... **Colorado Plateau Hanging Garden**

1b. Wetlands not as above. Not associated with seeps and springs within canyons of the Colorado Plateau. .... **(2)**

2a. Wetland defined by groundwater inflows and organic soil (peat) accumulation of at least 40 cm in the upper 80 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. .... **Rocky Mountain Subalpine-Montane Fen**

2b. Wetland does not have at least 40 cm of organic soil (peat) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems. .... **(3)**

3a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectares and occur within a matrix of woody vegetation. [Note: Relictual woody vegetation such as standing dead trees and shrubs are included here]. .... **(4)**

3b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectares and occur within a matrix of herbaceous wetland vegetation. .... **(6)**

4a. Riparian woodlands and shrublands of the foothill and lower montane zones on both the east and west slopes of Colorado's Rocky Mountains. Woodlands are dominated by cottonwood species (*Populus angustifolia, P. deltoides,* or the hybrid *P. acuminata*). Common native shrub species include willows (*Salix* spp.), thinleaf alder (*Alnus incana*), river birch (*Betula occidentalis*), and redosier dogwood (*Cornus sericea*). Exotic shrub species include saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*). Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. .... **Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

4b. Riparian woodlands and shrublands of the montane or subalpine zone. .... **(5)**

5a. Montane or subalpine riparian woodlands (canopy dominated by trees). This system occurs as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), blue spruce (*P. pungens*), or quaking aspen (*Populus tremuloides*). .... **Rocky Mountain Subalpine-Montane Riparian Woodland**

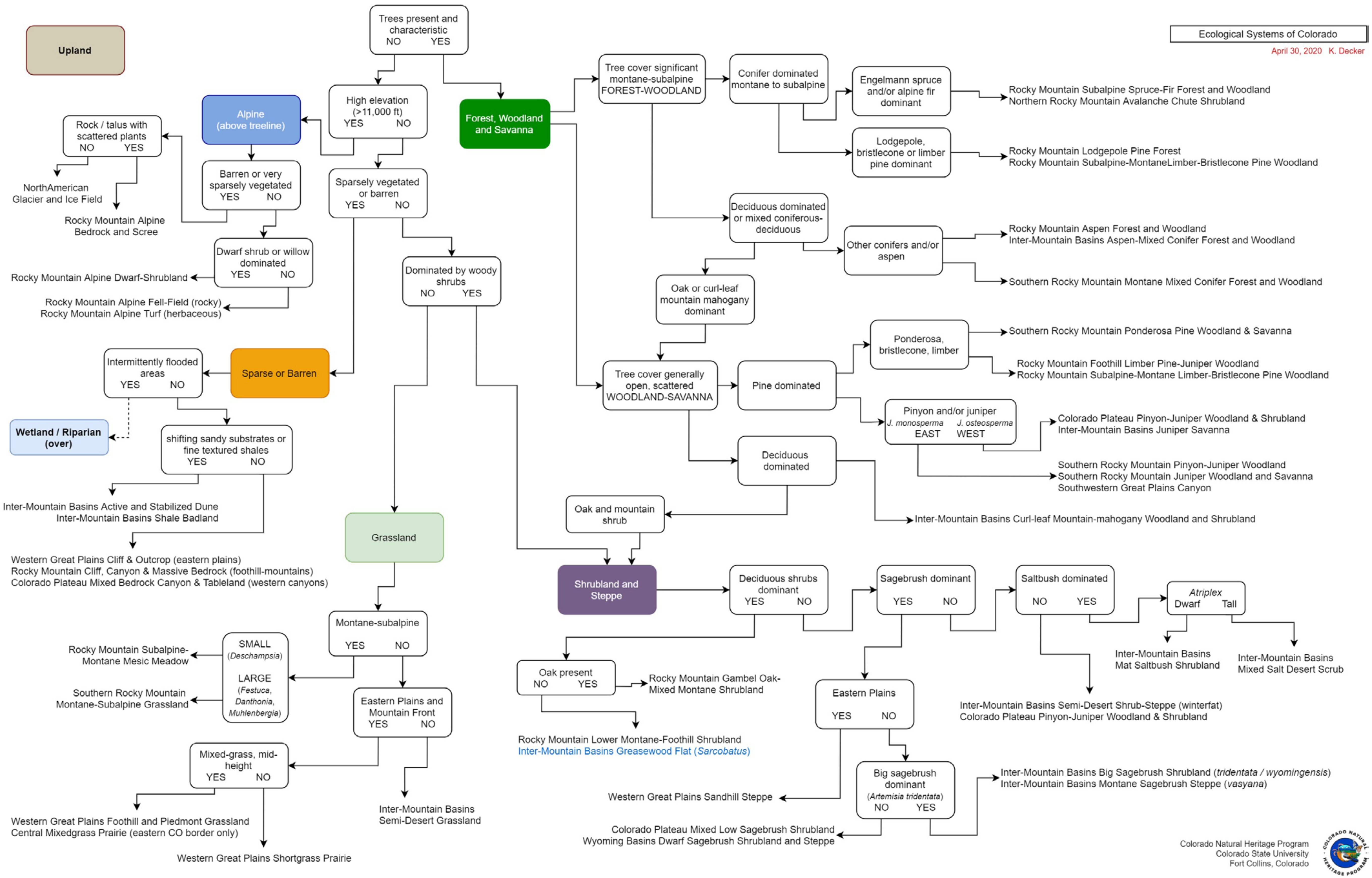
5b. Montane or subalpine shrub wetlands (canopy dominated by shrubs with sparse or no tree cover). This system is most often associated with streams (Riverine HGM Class), occurring as either a narrow band of shrubs lining streambanks of steep V-shaped canyons or as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (sometimes referred to as a shrub carr). Beaver activity is common within the wider occurrences. In addition, this system can occur around the edges of fens, lakes, seeps, and springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. In all cases, vegetation is dominated by species of willow (*Salix*), alder (*Alnus*), or birch (*Betula*). .... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

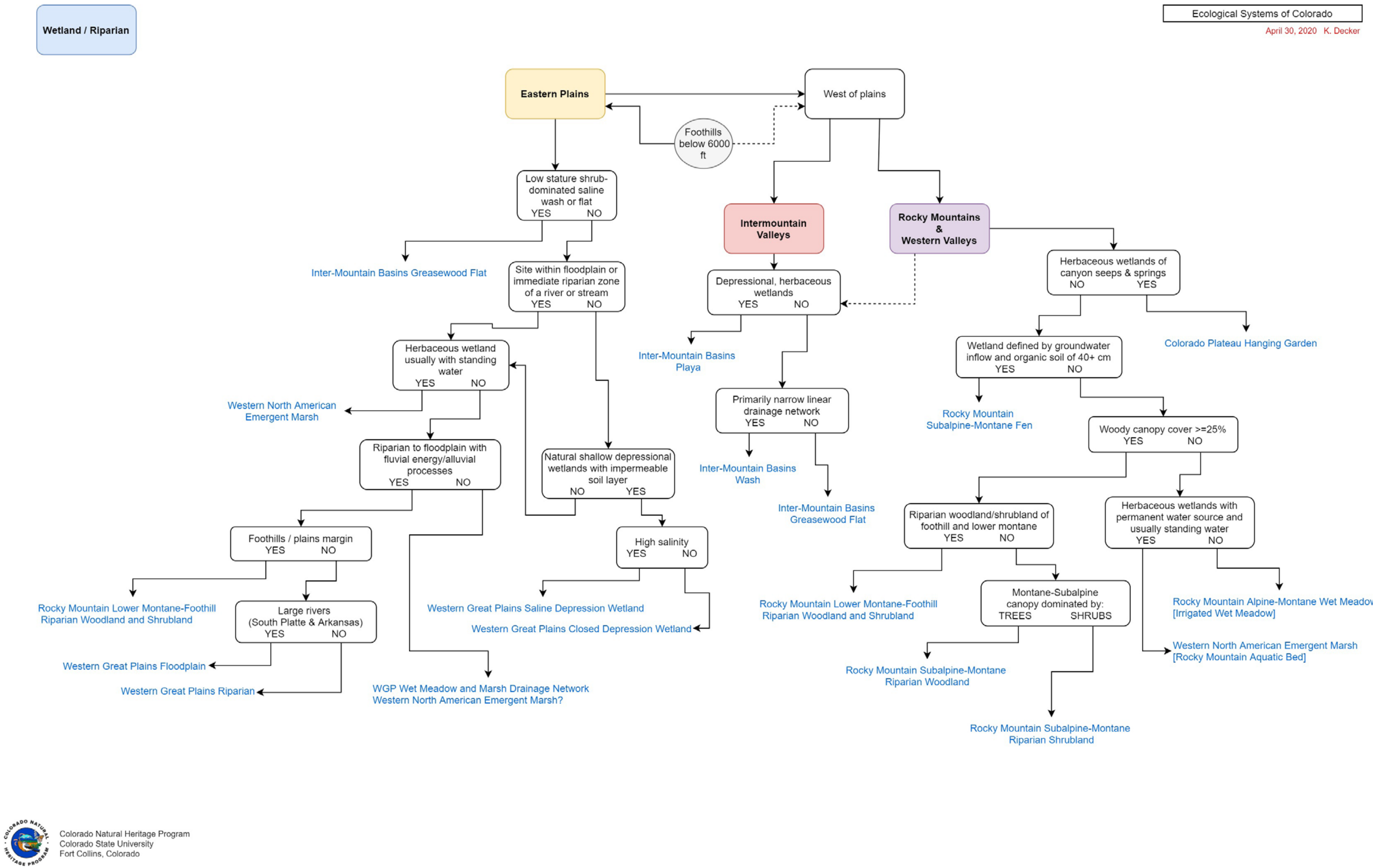
6a. Herbaceous wetlands with a permanent water source throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved species including species of threesquare or bulrush (*Schoenoplectus*), cattail (*Typha*), rush (*Juncus*), sedge (*Carex*), pondweed (*Potamogeton*), knotweed (*Polygonum*), and pond-lily (*Nuphar*). .... **Western North American Emergent Marsh**

6b. Herbaceous wetlands that typically lacks extensive standing water. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation. .... **(7)**

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

7b. Large herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water, but may have standing water early in the season if water levels are very high. Vegetation is dominated by native or non-native herbaceous species; graminoids have the highest canopy cover. Species composition may be dominated by non-native hay grasses. .... **Irrigated Wet Meadow [Not an official Ecological System.]**


Upland
Trees present and characteristic NO YES
Ecological Systems of Colorado
April 30, 2020 K. Decker
High elevation (>11,000 ft) YES NO
Alpine (above treeline)
Forest, Woodland and Savanna
Tree cover significant montane-subalpine FOREST-WOODLAND
Conifer dominated montane to subalpine
Engelmann spruce and/or alpine fir dominant
Rocky Mountain Subalpine Spruce-Fir Forest and Woodland
Northern Rocky Mountain Avalanche Chute Shrubland
Lodgepole, bristlecone or limber pine dominant
Rocky Mountain Lodgepole Pine Forest
Rocky Mountain Subalpine-MontaneLimber-Bristlecone Pine Woodland
Rock / talus with scattered plants NO YES
NorthAmerican Glacier and Ice Field
Rocky Mountain Alpine Bedrock and Scree
Barren or very sparsely vegetated YES NO
Sparsely vegetated or barren YES NO
Dwarf shrub or willow dominated YES NO
Rocky Mountain Alpine Dwarf-Shrubland
Rocky Mountain Alpine Fell-Field (rocky)
Rocky Mountain Alpine Turf (herbaceous)
Dominated by woody shrubs NO YES
Deciduous dominated or mixed coniferous-deciduous
Other conifers and/or aspen
Rocky Mountain Aspen Forest and Woodland
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland
Oak or curl-leaf mountain mahogany dominant
Ponderosa, bristlecone, limber
Southern Rocky Mountain Ponderosa Pine Woodland & Savanna
Rocky Mountain Foothill Limber Pine-Juniper Woodland
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
Intermittently flooded areas YES NO
Sparse or Barren
Tree cover generally open, scattered WOODLAND-SAVANNA
Pine dominated
Pinyon and/or juniper J. monosperma J. osteosperma EAST WEST
Colorado Plateau Pinyon-Juniper Woodland & Shrubland
Inter-Mountain Basins Juniper Savanna
Wetland / Riparian (over)
shifting sandy substrates or fine textured shales YES NO
Deciduous dominated
Southern Rocky Mountain Pinyon-Juniper Woodland
Southern Rocky Mountain Juniper Woodland and Savanna
Southwestern Great Plains Canyon
Inter-Mountain Basins Active and Stabilized Dune
Inter-Mountain Basins Shale Badland
Oak and mountain shrub
Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland
Grassland
Western Great Plains Cliff & Outcrop (eastern plains)
Rocky Mountain Cliff, Canyon & Massive Bedrock (foothill-mountains)
Colorado Plateau Mixed Bedrock Canyon & Tableland (western canyons)
Shrubland and Steppe
Deciduous shrubs dominant YES NO
Sagebrush dominant YES NO
Saltbush dominated NO YES
Atriplex Dwarf Tall
Montane-subalpine YES NO
SMALL (Deschampsia)
LARGE (Festuca, Danthonia, Muhlenbergia)
Rocky Mountain Subalpine-Montane Mesic Meadow
Southern Rocky Mountain Montane-Subalpine Grassland
Oak present NO YES
Rocky Mountain Gambel Oak-Mixed Montane Shrubland
Inter-Mountain Basins Mat Saltbush Shrubland
Inter-Mountain Basins Mixed Salt Desert Scrub
Eastern Plains and Mountain Front YES NO
Eastern Plains YES NO
Inter-Mountain Basins Semi-Desert Shrub-Steppe (winterfat)
Colorado Plateau Pinyon-Juniper Woodland & Shrubland
Rocky Mountain Lower Montane-Foothill Shrubland
Inter-Mountain Basins Greasewood Flat (Sarcobatus)
Mixed-grass, mid-height YES NO
Big sagebrush dominant (Artemisia tridentata) NO YES
Inter-Mountain Basins Big Sagebrush Shrubland (tridentata / wyomingensis)
Inter-Mountain Basins Montane Sagebrush Steppe (vasyana)
Western Great Plains Sandhill Stepppe
Inter-Mountain Basins Semi-Desert Grassland
Western Great Plains Foothill and Piedmont Grassland
Central Mixedgrass Prairie (eastern CO border only)
Colorado Plateau Mixed Low Sagebrush Shrubland
Wyoming Basins Dwarf Sagebrush Shrubland and Steppe
Western Great Plains Shortgrass Prairie
Colorado Natural Heritage Program
Colorado State University
Fort Collins, Colorado


Wetland / Riparian
Ecological Systems of Colorado
April 30, 2020 K. Decker
Eastern Plains
West of plains
Foothills below 6000 ft
Low stature shrub-dominated saline wash or flat YES NO
Inter-Mountain Basins Greasewood Flat
Site within floodplain or immediate riparian zone of a river or stream YES NO
Herbaceous wetland usually with standing water YES NO
Western North American Emergent Marsh
Riparian to floodplain with fluvial energy/alluvial processes YES NO
Natural shallow depressional wetlands with impermeable soil layer NO YES
High salinity YES NO
Western Great Plains Saline Depression Wetland
Western Great Plains Closed Depression Wetland
Foothills / plains margin YES NO
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
Large rivers (South Platte & Arkansas) YES NO
Western Great Plains Floodplain
Western Great Plains Riparian
WGP Wet Meadow and Marsh Drainage Network
Western North American Emergent Marsh?
Intermountain Valleys
Depressional, herbaceous wetlands YES NO
Inter-Mountain Basins Playa
Primarily narrow linear drainage network YES NO
Inter-Mountain Basins Wash
Inter-Mountain Basins Greasewood Flat
Rocky Mountains & Western Valleys
Herbaceous wetlands of canyon seeps & springs NO YES
Colorado Plateau Hanging Garden
Wetland defined by groundwater inflow and organic soil of 40+ cm YES NO
Rocky Mountain Subalpine-Montane Fen
Woody canopy cover >=25% YES NO
Riparian woodland/shrubland of foothill and lower montane YES NO
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
Montane-Subalpine canopy dominated by: TREES SHRUBS
Rocky Mountain Subalpine-Montane Riparian Woodland
Rocky Mountain Subalpine-Montane Riparian Shrubland
Herbaceous wetlands with permanent water source and usually standing water YES NO
Rocky Mountain Alpine-Montane Wet Meadow [Irrigated Wet Meadow]
Western North American Emergent Marsh [Rocky Mountain Aquatic Bed]
Colorado Natural Heritage Program
Colorado State University
Fort Collins, Colorado

ALPINE

North American Glacier and Ice Field

General Description

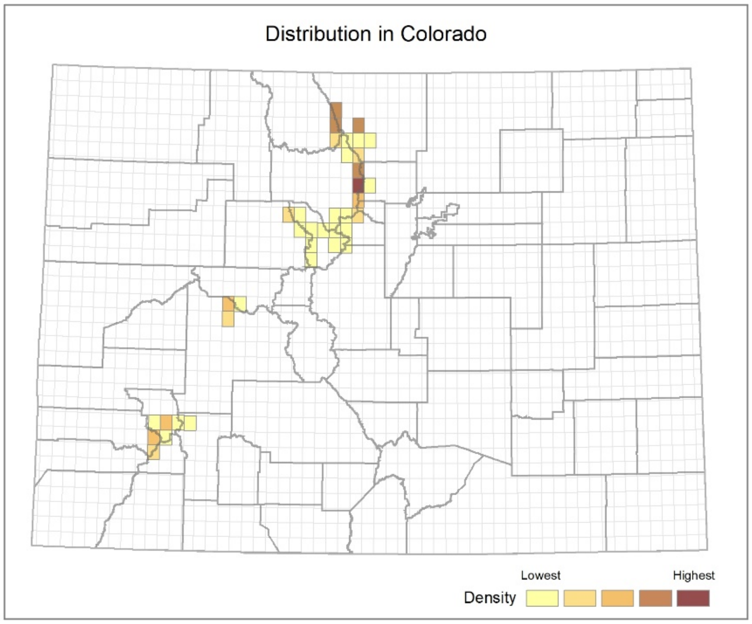
Glaciers and ice fields are widespread in the arctic latitudes of North America, and extend south into the highest elevations of the Rocky Mountains, Pacific coastal ranges, and the Sierra Madre of Mexico. Occurrences of this system are unvegetated landscapes of annual or perennial ice and snow. Permanent ice fields occur where snowfall accumulation is greater than snowmelt. Examples in Colorado are small, and restricted to alpine elevations, where they are part of the mosaic of harsh and sparsely vegetated alpine habitats. Vascular plants do not occur in this system; biotic composition may include algal blooms, insect communities, and birds or mammals foraging on the insects.

Diagnostic Characteristics

These are unvegetated areas at alpine elevations dominated by annual or perennial ice and snow fields.

Similar Systems

None



Range

Widespread in arctic latitudes of North America, and extending south into the highest elevations of the Rocky Mountains, Pacific coastal ranges, and the Sierra Madre of Mexico. Occurrences in Colorado are small, and restricted to alpine elevations.

Spatial pattern

North American glacier and Ice Field is generally a large patch system, but may include small patches in some cases.

Environment

In Colorado, this system includes scattered small glaciers, and adjacent unvegetated areas where snow cover persists for most of the year. These areas are often embedded in the overall alpine matrix of rock and scree, fell-field, and turf. The harsh conditions severely limit any biotic development.

Vegetation

None

Plant Associations

None

Associated Animal species

Casual use by birds and mammals that forage on insect species.

Dynamic processes

Persistent glacier and ice fields are driven by patterns of snow and ice retention, wind desiccation, and permafrost.

Management

These areas are little disturbed, except for recreational use (e.g., climbing or off-trail hiking). Warming climatic conditions are likely to reduce the extent of perennial snow and ice cover, possibly eliminating these occurrences from Colorado.

Original concept authors: M.S. Reid; Aug 2008
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: July 2019

References

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

Northern Rocky Mountain Avalanche Chute Shrubland

General Description

This ecological system occurs in mountains throughout the northern Rockies, from Colorado north and west into British Columbia and Alberta. In Colorado these shrublands are found at the same elevation as the subalpine coniferous forests, from 2,680 to 3,780 m (8,800-12,400 ft), and are a mix of conifers and deciduous shrubs and trees with herbaceous understory. Sites are those where vegetation on steep (15-60%) slopes is frequently disturbed by avalanche runs. Aspects vary, but are more common where unstable or heavy snowpack conditions frequently occur. Sites are often mesic to wet because avalanche paths are often in stream gullies, and snow deposition can be heavy in the run-out zones. The vegetation consists of open to moderately dense, woody canopy characterized by dwarfed and damaged conifers and small, deciduous trees/shrubs. Colorado associations in this system are poorly described, but characteristic woody species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and willows (*Salix* spp.) of higher elevations. Ground cover is dominated by mesic subalpine forbs, including arrowleaf ragwort (*Senecio triangularis*), Indian paintbrush (*Castilleja* spp.), yellow

avalanche-lily (*Erythronium grandiflorum*), Colorado false hellebore (*Veratrum tenuipetalum*), or common cow parsnip (*Heracleum maximum*).

Diagnostic Characteristics

These are typically areas in narrow, steep drainages in subalpine forests. The vegetation is often disturbed by snow-slides, which prevent the growth of taller trees. Woody vegetation is restricted in height, and may show signs of impact damage. The presence of "flag trees" with fresh scars or broken limbs on uphill side of standing trees, and brush with healthy limbs confined to the downhill side can indicate an avalanche path, although similar damage can be caused by wind action.

Similar Systems

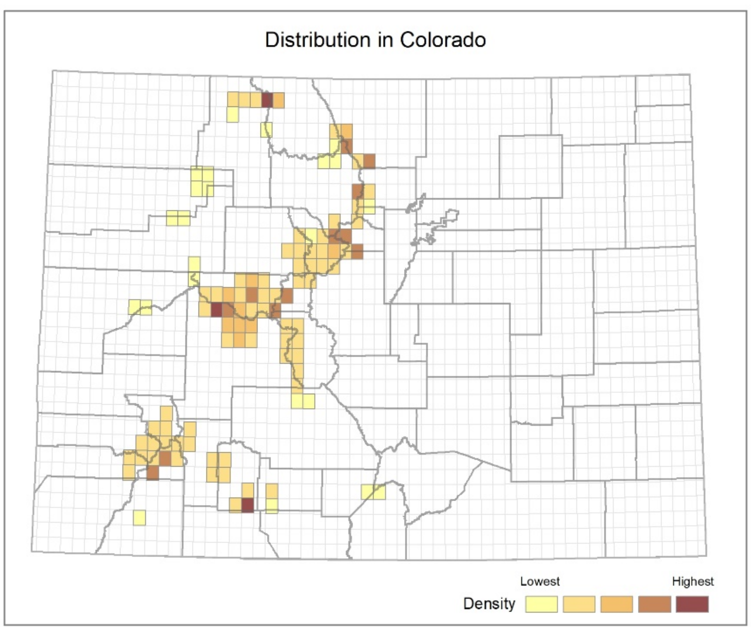
None

Range

Northern Rocky Mountain Avalanche Chute Shrubland is found in mountains throughout the northern Rockies, from Colorado north and west into British Columbia and Alberta. In Colorado these shrublands are found at the same elevation as the subalpine coniferous forests, from 2,680 to 3,780 m (8,800-12,400 ft), especially in areas with steep slopes and heavy snowfall.

Spatial pattern

Northern Rocky Mountain Avalanche Chute Shrubland is generally a small patch type, often with a generally linear form.



Environment

Sites are those where vegetation on steep (15-60%) slopes is frequently disturbed by snow avalanche runs. Aspects vary, but are more common where unstable or heavy snowpack conditions frequently occur. Sites are often mesic to wet because avalanche paths are often in stream gullies, and snow deposition can be heavy in the run-out zones, which allows the growth of dense herbaceous vegetation, together with scattered trees and shrubs.

Avalanche paths in forested areas usually appear as narrow strips straight down the mountain, that show a noticeable difference in vegetation type or age compared to the adjacent forest. The path is especially noticeable when the change is from coniferous forest to the short shrub and herbaceous vegetation, that characterizes this ecological system type.

ALPINE

Infrequently running avalanche paths through subalpine forest that appear as early seral stretches of forest are generally included in the forested system. Many avalanche paths begin above timberline and then cross through forested areas.

Vegetation

The vegetation consists of open to moderately dense, woody canopy characterized by dwarfed and damaged conifers and small, deciduous trees/shrubs. Colorado associations in this system are poorly described, but characteristic woody species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and willows (*Salix* spp.) of higher elevations. Ground cover is dominated by mesic subalpine forbs, including arrowleaf ragwort (*Senecio triangularis*), Indian paintbrush (*Castilleja* spp.), yellow avalanche-lily (*Erythronium grandiflorum*), Colorado false hellebore (*Veratrum tenuipetalum*), or common cow parsnip (*Heracleum maximum*).

Plant Associations

CEGL000582	Populus tremuloides / Cornus sericea Riparian Forest

Associated Animal species

These areas are traversed by subalpine species, and may also be used by songbirds that prefer shrubby, forest edge habitat.

Dynamic processes

Winter snow avalanches are characteristic of high mountain areas in Colorado with heavy snow accumulations on steep slopes. When the snow pack becomes unstable on these slopes, it may suddenly release large slabs of snow that slide rapidly down the slope, often in paths that have slid many times in the past, but occasionally in areas that rarely slide. Snow avalanches can reach speeds of up to 200 miles per hour, and easily demolish large trees or man-made structures in the path. Avalanche paths consist of a starting zone, a track, and a runout zone. The starting zone is often above treeline and may be unvegetated, with a gradient of 30-45 degrees, allowing sufficient snow accumulation to produce an avalanche.

An avalanche path does not necessarily run every year, and snow slides do not always run the full length of the track. This variable and intermittent disturbance pattern allows the growth of vegetation in the track, but frequent disturbance limits the growth of woody species. Variation in year-to-year snowfall and snowpack stability may allow the development of substantial tree growth in more sheltered portions of the chute for a number of years before a large slide eliminates or damages these individuals.

Management

Management concerns in these habitats are primarily driven by avalanche control measures that are intended to ensure the safety of human activity and infrastructure. Little is known about the potential effects of anthropogenically induced avalanches on the vegetation of the track itself.

Changes in snowfall amount and timing under future climate conditions could alter the frequency and/or magnitude of snow avalanches, and consequently affect the vegetation structure and composition of these areas.

Original concept authors NatureServe Western Ecology Team; Feb 2003
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: July 2019

References

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ALPINE

Rocky Mountain Alpine Bedrock and Scree

General Description

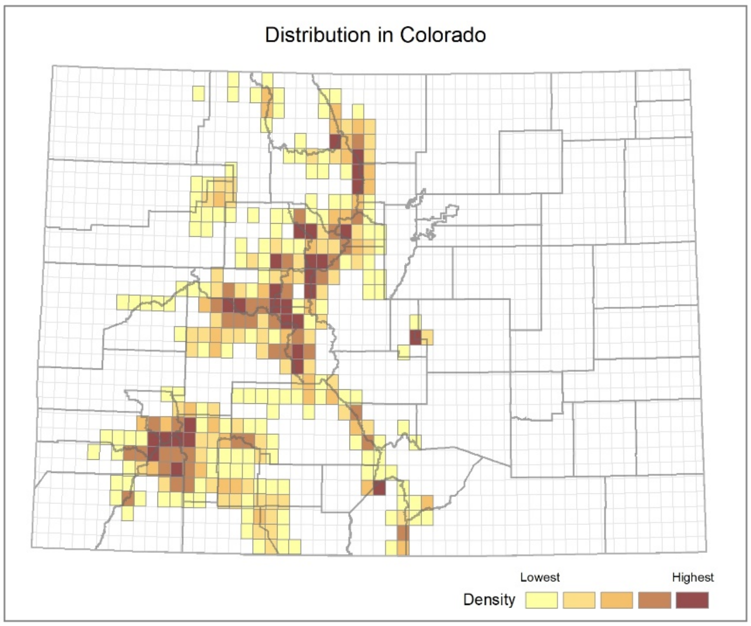
This ecological system is restricted to the higher elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. In Colorado it is generally found at or above the level of tree growth (3,350 m; 11,000 ft) where long winters, abundant snowfall, high winds, and short summers create a harsh environment. These are barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes. Slopes may be moist with snowmelt seepage, and permafrost present in some areas. Groundwater storage reservoirs in the habitat include talus slopes and debris cones, rock glaciers, blockslopes (coarse debris, larger rocks over finer material, also called blockfield), glacial till, bedrock, and wetlands. Plant growth is limited due to harsh environmental conditions, lack of stable substrates and limited soil development. Occasional pockets may support forbs, grasses, or low shrubs, but communities are primarily dominated by lichen. Clumps of Colorado blue columbine (*Aquilegia caerulea*) and mountain thistle (*Cirsium scopulorum*) are common in scree slopes.

Diagnostic Characteristics

This ecological system is characterized by the rocky substrate with little to no vegetation, and harsh environmental conditions. Sites are often talus slopes or rocky outcrops with only occasional pockets of soil that may support vegetation. Lichens are common in some areas.

Similar Systems

Rocky Mountain Alpine Fell-Field: These high elevation rocky areas are often intermingled with alpine bedrock and scree, but are distinguished by the presence of cushion plant vegetation in gravelly areas among the rocks, and are usually less steep in comparison.



Range

This ecological system is restricted to the higher elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. In Colorado it is generally found at or above the level of tree growth (3,350 m; 11,000 ft).

Spatial pattern

Rocky Mountain Alpine Bedrock and Scree is a large patch type.

Environment

Plant growth is limited due to harsh environmental conditions, lack of stable substrates and limited soil development. Habitats are rocky, and include steep talus-covered slopes, debris cones, rock glaciers, or bedrock outcrops. Plants are typically found in crevices, cracks, depressions, or small ledges in boulders and rocky outcrops where soil pockets receive moisture from snowmelt runoff or seepage. Snow cover is variable, depending on microsite conditions and interannual variation. Some areas are wind-scoured while others may accumulate deep snow pack. The growing season is short, and night-time temperatures often below freezing.

Vegetation

Vegetation is sparse (less than 10% cover), and limited to pockets of soil between rocks that may support forbs, grasses, or low shrubs; communities are primarily dominated by lichen. Clumps of Colorado blue columbine (*Aquilegia coerulea*) and mountain thistle (*Cirsium scopulorum*) are common in scree slopes. Other species often found in these rocky habitats include spike sedge (Carex nardina), alpine springbeauty (*Claytonia megarhiza*), alpine mountainsorrel (*Oxyria digyna*), sticky polemonium (*Polemonium viscosum*), and yellowdot saxifrage (*Saxifraga bronchialis*). Margins of the habitat may also support species more characteristic of adjacent alpine turf or fell-field. The Colorado endemic Weber's draba (*Draba weberi*) is occasionally found in this habitat.

ALPINE

Plant Associations

CEGL002888	Alpine Sparse (on rock and unconsolidated substrates) Nonvascular Vegetation
CEGL001938	Aquilegia coerulea - Cirsium scopulorum Scree Sparse Vegetation
CEGL001849	Athyrium americanum Alpine Sparse Vegetation
CEGL001812	Carex nardina Scree Alpine Meadow
CEGL001959	Cirsium scopulorum - Polemonium viscosum Alpine Sparse Meadow
CEGL001878	Claytonia megarhiza Rock Vegetation
CEGL001971	Heuchera bracteata - Heuchera parvifolia var. nivalis Rock Vegetation
CEGL001928	Polemonium viscosum Alpine Meadow
CEGL005902	Saxifraga bronchialis Scree Slope Alpine Sparse Vegetation
CEGL001932	Senecio taraxacoides - Oxyria digyna Alpine Sparse Meadow

Associated Animal species

American pika (*Ochotona princeps*) are characteristic of these talus slopes. Yellow-bellied marmots (*Marmota flaviventris*), mountain goat (*Oreamnos americanus*), bighorn sheep (*Ovis canadensis*), and White-tailed Ptarmigan (*Lagopus leucura*) also use these areas along with other parts of the alpine habitat matrix.

Dynamic processes

Bedrock outcrops are the primary source of the rocky debris that forms talus and scree slopes of loose, coarse, typically angular rock fragments. Weathering, freeze-thaw cycles, and the action of gravity lead to the accumulation of material at the foot of steep slopes. Mass wasting (i.e., landslide) events are rare, but can occur. Otherwise, rock movement after the initial fall is limited, and slow-growing lichens are able to develop and persist on many surfaces.

Management

These rocky, largely barren areas are generally little disturbed unless they are crossed by trails.

Original concept authors NatureServe Western Ecology Team; Feb 2003
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: Aug 2019

References

Luckman B.H. 2013. Talus Slopes. In: Elias S.A. (ed.) The Encyclopedia of Quaternary Science, vol.3, pp. 566-573. Amsterdam: Elsevier.

Rocky Mountain Alpine Dwarf-Shrubland

General Description

This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera of North America. Alpine vegetation is controlled by patterns of snow retention, desiccation by wind, permafrost, and the short growing season. In Colorado elevations are generally above 3,350 m (11,000 ft). In contrast to rocky alpine areas, these sites have relatively stable soil and are moist but well-drained, strongly acidic, and often have substantial peat accumulation. These low shrublands are found in level to concave topography where late-melting snow and subirrigation from surrounding slope supports a layer of ericaceous dwarf-shrubs or dwarf willows forming a ground cover less than 0.5 m in height. Snow willow (*Salix nivalis*) is a typical dominant shrub, often with blueberry (*Vaccinium* spp.) and alpine laurel (*Kalmia microphylla*). Dense tuffs of graminoids and scattered forbs also occur. Herbaceous species are those common at higher elevations, including fleabane (*Erigeron* spp.), lousewort (*Pedicularis* spp.), Indian paintbrush (*Castilleja* spp.), tufted hairgrass (*Deschampsia cespitosa*), white marsh marigold (*Caltha leptosepala*), yellow avalanche-lily (*Erythronium grandiflorum*), Parry's rush (*Juncus parryi*), black alpine sedge (*Carex nigricans*), and American bistort (*Polygonum bistortoides*). These alpine dwarf-shrublands are often intermingled with fell-fields.

ALPINE

Diagnostic Characteristics

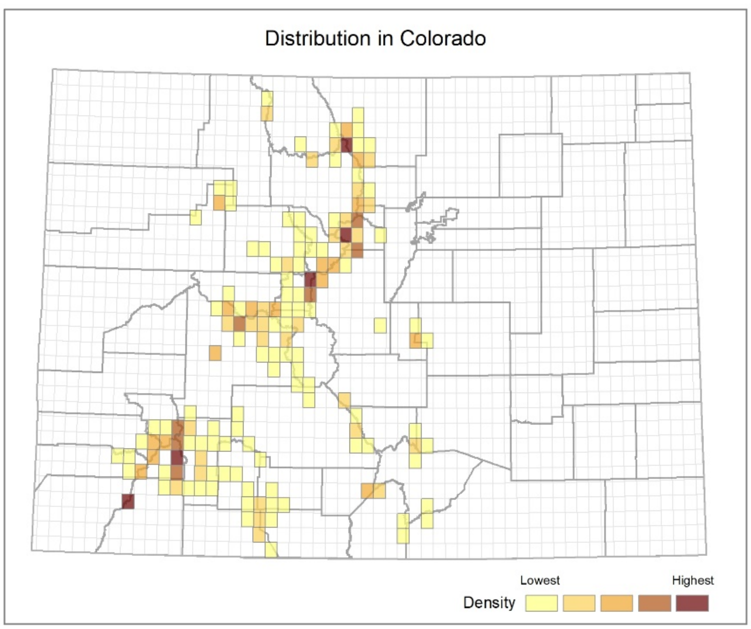
Within the alpine matrix, the dwarf-shrubland is found in mesic areas with good soil development. The dense vegetation is dominated by low-growing willow or ericaceous shrub species. The eightpetal mountain-avens (*Dryas octopetala*) communities are not included, except for one very moist association, because they occur on more windswept and drier sites than the heath communities.

Similar Systems

Rocky Mountain Subalpine-Montane Riparian Shrubland: At the highest elevations, stands of short willows are often part of riparian shrublands where they grade into alpine elevations, but these belong to what is essentially a subalpine system.

Range

This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera of North America. In Colorado, occurrences are scattered throughout the alpine matrix at elevations above 3,350 m (11,000 ft).



Spatial pattern

Rocky Mountain Alpine Dwarf-Shrubland is considered a large patch type, although small patches of these communities frequently occur embedded within the overall alpine matrix.

Environment

Sites are cold, mesic, snow bed locations formed in concave, depressional areas that retain snow until mid to late summer. Soil temperatures in these areas remain colder than in the surrounding alpine. Soils are typically moist, but well drained, strongly acidic, and may have a measurable peat component.

Vegetation

Snow willow (*Salix nivalis*) or alpine willow (*S. petrophila*) are typical dominant shrubs, often with blueberry (*Vaccinium* spp.) and alpine laurel (*Kalmia microphylla*). Shrubs form a patchy, intermittent layer less than 0.5 m in height. Dense tuffs of graminoids and scattered forbs also occur. Herbaceous species are those common at higher elevations, including fleabane (*Erigeron* spp.), lousewort (*Pedicularis* spp.), Indian paintbrush (*Castilleja* spp.), tufted hairgrass (*Deschampsia cespitosa*), white marsh marigold (*Caltha leptosepala*), yellow avalanche-lily

(*Erythronium grandiflorum*), Parry's rush (*Juncus parryi*), black alpine sedge (*Carex nigricans*), and American bistort (*Polygonum bistortoides*).

Components of these dwarf-shrub dominated communities are also likely to occur in some combination within the alpine fell-field or alpine turf systems, making this type difficult to distinguish as a separate ecological system.

Plant Associations

CEGL001894	Dryas octopetala - Polygonum viviparum Alpine Dwarf-shrub Meadow
CEGL001431	Salix arctica - (Salix petrophila, Salix nivalis) / Polygonum bistortoides Dwarf-shrubland
CEGL001432	Salix arctica - Salix nivalis Dwarf-shrubland
CEGL001430	Salix arctica / Geum rossii Dwarf-shrubland
CEGL005936	Salix nivalis / Geum rossii Dwarf-shrubland
CEGL001140	Vaccinium (cespitosum, scoparium) Dwarf-shrubland

Associated Animal species

Few animal species are found in these shrublands of limited extent, but Mountain Bluebird (*Sialia currucoides*), Townsend's Solitaire (*Myadestes townsendi*), and White-crowned Sparrow (*Zonotrichia leucophrys*) have been documented.

Dynamic processes

Soil movement is a common process in the alpine, even in vegetated sites. Soil creep (solifluction) produces small ridges (lobes) that may eventually trap snow.

Management

These dwarf-shrublands are adapted to moist areas with late lying snow. Changes in the pattern and amount of snowfall could eventually eliminate many of these habitats.

Original concept authors M.S. Reid; Sep 2005
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: August 2019

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ALPINE

Rocky Mountain Alpine Fell-Field

General Description

This ecological system is found in patches at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. In Colorado, fellfields are intermingled with alpine tundra at elevations generally above 3,350 m (11,000 ft). These are wind-scoured rocky areas that are free of snow in the winter, such as ridgetops and exposed saddles, where plants are exposed to severe environmental stress. Soils are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Plant cover is 15-50% along with exposed rocks. Most fell-field plants have a cushion or mat-like growth form, flattened close to the ground in rosettes. Leaves and stems are frequently succulent, and often densely haired, with waxy surfaces. Common species include Ross' avens (*Geum rossii*), Bellardi bog sedge (*Kobresia myosuroides*), twinflower sandwort (*Minuartia obtusiloba*), Rocky Mountain nailwort (*Paronychia pulvinata*), cushion phlox (*Phlox pulvinata*), creeping sibbaldia (*Sibbaldia procumbens*), moss campion (*Silene acaulis*), alpine clover (*Trifolium dasyphyllum*), and Parry's clover (*Trifolium parryi*).

Diagnostic Characteristics

Fellfields are rocky and wind-scoured areas that are free of snow in the winter, such as ridgetops and exposed saddles, where vegetation is exposed to severe environmental stress. Soils on these

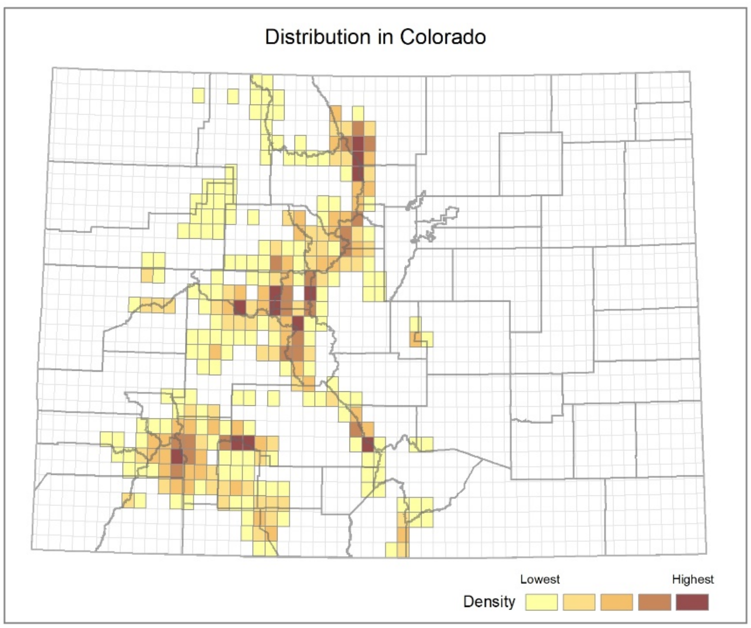
windy sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement.

Similar Systems

Rocky Mountain Alpine Turf: Alpine turf areas frequently intermingle with fell-fields, but are distinguished by a high cover of vegetation between scattered rocks, and plant community components that are taller than the mat-forming typical fell-field species.

Range

This ecological system is found in patches at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. In Colorado, fell-fields are intermingled with alpine tundra at elevations generally above 3,350 m (11,000 ft).



Spatial pattern

Rocky Mountain Alpine Fell-Fields are a large patch type, although some fairly small occurrences may be embedded within the overall alpine matrix.

Environment

The distribution of vegetation types in the alpine is controlled in part by local topography that influences snow deposition and retention, as well as soil development. Alpine fell-field is generally found in rocky, wind-scoured areas such as ridgetops and exposed saddles, where plants are exposed to severe environmental stress. Soils are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement.

Vegetation

Most fell-field plants are cushioned or matted, frequently succulent, low-growing rosettes and often densely haired, with waxy surfaces. Plant cover may be sparse to moderate between exposed rocks. Common fellfield species include arctic alpine forget-me-not (*Eritrichium nanum*), Ross' avens (*Geum rossii)*, Bellardi bog sedge (*Kobresia myosuroides*), twinflower sandwort (*Minuartia obtusiloba*), Rocky Mountain nailwort (*Paronychia pulvinata*), cushion phlox (*Phlox pulvinata*), creeping sibbaldia (*Sibbaldia procumbens*), moss campion (*Silene acaulis*), alpine clover (*Trifolium dasyphyllum*), Parry's clover (*Trifolium parryi*), and curly sedge (*Carex rupestris*). Crustose lichens are common.

ALPINE

Plant Associations

CEGL001965	Geum rossii - Minuartia obtusiloba Alpine Fell-field
CEGL001919	Minuartia obtusiloba Alpine Fell-field
CEGL001976	Paronychia pulvinata - Silene acaulis Alpine Fell-field
CEGL001134	Rubus idaeus Scree Shrubland
CEGL001933	Sibbaldia procumbens - Polygonum bistortoides Wet Meadow
CEGL001934	Silene acaulis Alpine Fell-field
CEGL001935	Trifolium dasyphyllum Alpine Fell-field
CEGL005939	Trifolium nanum Alpine Fell-field
CEGL001936	Trifolium parryi Alpine Snowbed

Associated Animal species

The deer mouse (*Peromyscus maniculatus*) is strongly associated these drier alpine fellfield sites. White-tailed Ptarmigan (*Lagopus leucura*), American pika (*Ochotona princeps*), and yellow-bellied marmot (*Marmota flaviventris*) can also be seen in this habitat.

Dynamic processes

Wind and its effects on patterns of snow cover, soil moisture, and plant growth forms is a primary factor shaping the fellfield habitat. In general, these rocky areas remain snow free throughout the year, with perhaps a thin crust of snow in some areas. Soil moisture is low, and seasonally available. The lack of snow cover and strong insolation produces a longer growing season, but also results in high rates of evapotranspiration during times of moisture availability. Fell fields are hot and dry in comparison with other parts of the alpine mosaic. Soil movement is a common process in the alpine, even in vegetated sites. Soil creep (solifluction) and freeze-thaw processes producing patterned ground are often evident. The actions of frost heaving, together with the rocky surface, produce a mosaic of different thermal microsites.

Management

Alpine landscapes in Colorado are generally in excellent condition, and well protected. Old privately-owned mining claims are scattered throughout, but there are very few active mines operating today. In the more accessible alpine areas, recreation impacts from hikers and sightseers may affect these areas. Anthropogenic nitrogen deposition is an ongoing influence on alpine phenology and species diversity which may interact with warming temperatures, although the long-term effects of this disturbance are not well known.

Warmer conditions leading to earlier snowmelt and an extended growing season in higher elevations are expected to allow the establishment of woody species above current treeline levels, although this process is likely to be slow, and limited to areas of deeper soil outside fellfields. Photoperiod cues (not influenced by climate change) for many species could negate the effects of a longer growing season. The ability of most alpine species to disperse across intervening lower elevation habitat is doubtful.

Original concept authors: R. Crawford; Sep 2005
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: August 2019

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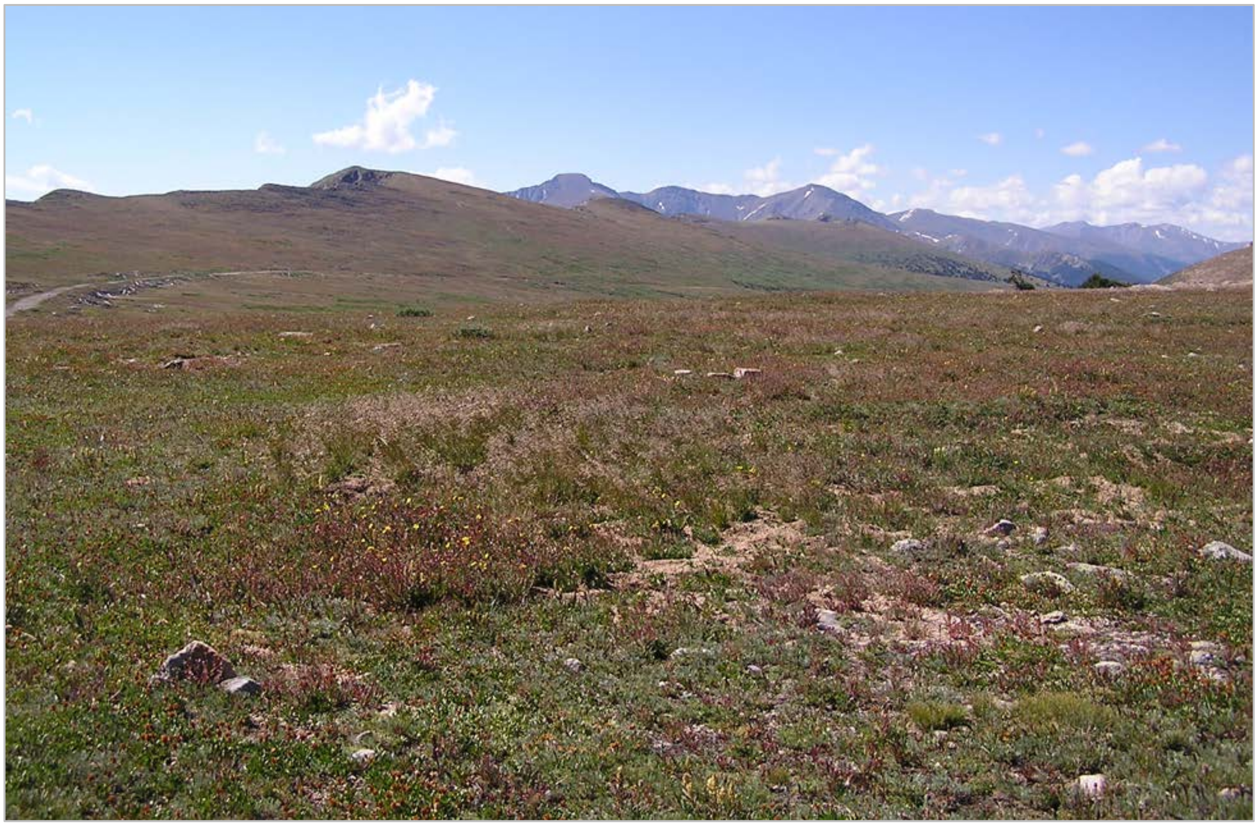
ALPINE

Rocky Mountain Alpine Turf



General Description

This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera of North America. Alpine vegetation is controlled by patterns of snow retention, desiccation by wind, permafrost, and the short growing season. In Colorado, areas of alpine turf are intermingled with fell-fields at elevations generally above 3,350 m (11,000 ft). These are drier areas on gentle to moderate slopes, flat ridges, valleys, and basins, where soils are fairly stable and the water supply is more or less constant. Vegetation is a dense turf of perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, forming a turf with prostrate and mat-forming forbs. Dominant species include boreal sagebrush (*Artemisia arctica*), blackroot sedge (*Carex elynoides*), spike sedge (*Carex nardina*), curly sedge (*Carex rupestris*), northern singlespike sedge (*Carex scirpoidea*), dryspike sedge (*Carex siccata*), alpine fescue (*Festuca brachyphylla*), Ross' avens (*Geum rossii*), Bellardi bog sedge (*Kobresia myosuroides*), cushion phlox (*Phlox pulvinata*), and alpine clover (*Trifolium dasyphyllum*). Although alpine dry tundra forms the matrix of the alpine zone, it is typically intermingled with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

Diagnostic Characteristics

The ecological systems that make up the overall alpine matrix can be difficult to distinguish in places. Broad expanses of grassy alpine meadow clearly belong to the alpine turf type, even if fairly

large rocks are abundant in the occurrence. These are areas with sufficient soil development and moisture availability to permit a dense vegetation cover to persist. Because alpine plant communities are closely tied to microsite conditions in this harsh environment, turf areas are likely to intermingle with fell-field and dwarf shrubland types in a fine-textured matrix with a number of shared species in many places.

Similar Systems

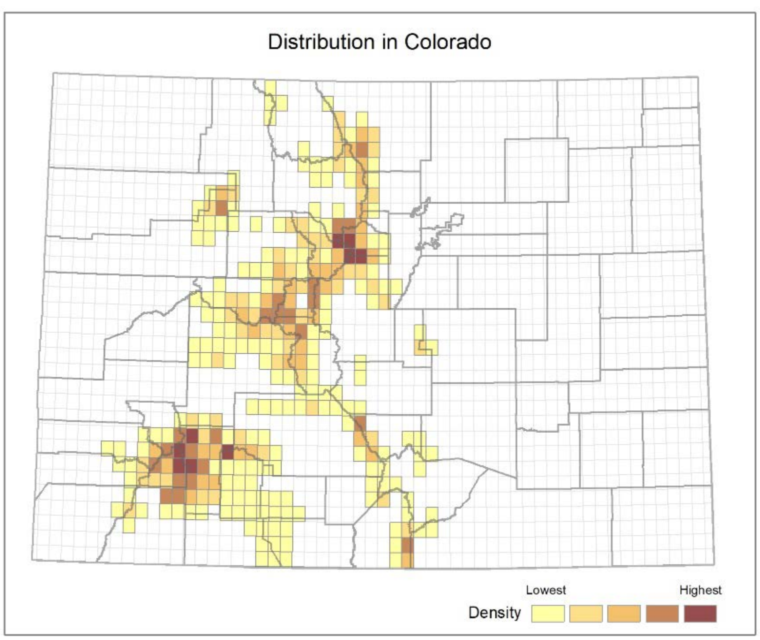
Rocky Mountain Alpine Fell-Field: These rocky, exposed areas of the alpine are characterized by cushion plants growing in a gravelly substrate, perhaps in and around larger rock-dominated areas. Similar species may also occur in intermingled alpine turf.

Rocky Mountain Alpine-Montane Wet Meadow: These herbaceous wetlands may occur at alpine elevations in small patches in the wettest areas. They are typically graminoid-dominated, but may include species that are also found in drier turf communities.

Southern Rocky Mountain Montane-Subalpine Grassland: At subalpine elevations, these grasslands may occasionally occur adjacent to alpine turf, and share some grass species. They are distinguished by being restricted to areas below treeline.

Range

Rocky Mountain Alpine Turf occurs above upper treeline throughout the Rocky Mountain cordillera of North America. Alpine habitats are restricted to high elevations, and are also near the southern extent of their continental range in Colorado. In Colorado, areas of alpine turf are intermingled with fell-fields at elevations generally above 3,350 m (11,000 ft).



Spatial pattern

Rocky Mountain Alpine Turf is generally a matrix forming type, although some areas are large patches within the overall alpine matrix.

Environment

The distribution of vegetation types in the alpine is controlled in part by local topography that influences snow deposition and retention, as well as soil development. Alpine turf is generally found on more gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant.

ALPINE

Vegetation

Alpine dry turf is formed by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant and characteristic species include boreal sagebrush (*Artemisia arctica*), blackroot sedge (*Carex elynoides*), spike sedge (*Carex nardina*), northern singlespike sedge (*Carex scirpoidea*), dryspike sedge (*Carex siccata*), curly sedge (*Carex rupestris*), tufted hairgrass (*Deschampsia caespitosa*), alpine fescue (*Festuca brachyphylla*), Idaho fescue (*Festuca idahoensis*), Ross' avens (*Geum rossii*), Bellardi bog sedge (*Kobresia myosuroides*), cushion phlox (*Phlox pulvinata*), alpine clover (*Trifolium dasyphyllum*), American bistort (*Polygonum bistortoides*), purple reedgrass (*Calamagrostis purpurascens*), eightpetal mountain-avens (*Dryas octopetala*), alpine bluegrass (*Poa alpina*), creeping sibbaldia (*Sibbaldia procumbens*), moss campion (*Silene acaulis*), and Parry's clover (*Trifolium parryi*).

Plant Associations

CEGL001848	Artemisia arctica ssp. arctica Alpine Snowbed
CEGL001851	Carex arapahoensis Alpine Fell-field
CEGL001873	Carex ebenea - Trifolium parryi Alpine Snowbed
CEGL001853	Carex elynoides - Geum rossii Alpine Turf
CEGL001855	Carex elynoides - Oreoxis spp. Alpine Turf
CEGL001852	Carex elynoides Alpine Turf
CEGL001875	Carex haydeniana Alpine Turf
CEGL001858	Carex perglobosa - Silene acaulis Alpine Sparse Meadow
CEGL001861	Carex rupestris - Geum rossii Alpine Turf
CEGL001863	Carex rupestris - Trifolium dasyphyllum Alpine Turf
CEGL001808	Carex siccata - Geum rossii Alpine Turf
CEGL001868	Carex vernacula Wet Meadow
CEGL001959	Cirsium scopulorum - Polemonium viscosum Alpine Sparse Meadow
CEGL001892	Dryas octopetala - Carex rupestris Alpine Dwarf-shrub Meadow
CEGL001893	Dryas octopetala - Carex spp. Alpine Dwarf-shrub Meadow
CEGL001895	Festuca brachyphylla - Geum rossii var. turbinatum Alpine Turf
CEGL001896	Festuca brachyphylla - Trisetum spicatum Alpine Turf
CEGL001797	Festuca brachyphylla Alpine Meadow
CEGL001631	Festuca thurberi Subalpine Grassland
CEGL001965	Geum rossii - Minuartia obtusiloba Alpine Fell-field
CEGL001970	Geum rossii - Trifolium spp. Alpine Turf
CEGL001964	Geum rossii Alpine Meadow
CEGL001907	Kobresia myosuroides - Carex rupestris var. drummondiana Alpine Turf
CEGL001908	Kobresia myosuroides - Geum rossii Alpine Turf
CEGL001909	Kobresia myosuroides - Trifolium dasyphyllum Alpine Turf
CEGL001919	Minuartia obtusiloba Alpine Fell-field
CEGL001924	Poa arctica ssp. grayana Alpine Snowbed
CEGL001927	Poa lettermanii Grassland
CEGL001656	Poa nervosa - Achnatherum lettermanii Grassland

CEGL001666	Pseudoroegneria spicata - Cushion Plants Grassland
CEGL001133	Ribes montigenum Shrubland
CEGL001929	Saxifraga chrysantha Alpine Sparse Vegetation
CEGL001933	Sibbaldia procumbens - Polygonum bistortoides Wet Meadow

Associated Animal species

Birds of the alpine include White-tailed Ptarmigan (*Lagopus leucura*), American Pipit (*Anthus rubescens*), and Brown-capped Rosy-Finch (*Leucosticte australis*). American pika (*Ochotona princeps*), yellow-bellied marmot (*Marmota flaviventris*), and elk (*Cervus elaphus*) are frequently seen in this part of the alpine matrix habitat, which is also used by bighorn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), ermine (*Mustela erminea*), and heather voles (*Phenacomys intermedius*).

Dynamic processes

Snowpack is a crucial component of alpine ecosystems, and depends on both precipitation amounts and winter-spring temperature. Vegetation in alpine areas is controlled by patterns of snow retention, wind desiccation, permafrost, and a short growing season. The length of the growing season is particularly important for the alpine zone, and for the transition zone between alpine and forest (treeline). Alpine areas have the fewest growing degree days and lowest potential evapotranspiration of any habitat in Colorado. Treeline-controlling factors operate at different scales, ranging from the microsite to the continental. On a global or continental scale, there is general agreement that cool summer temperature is a primary determinant of treeline. At this scale, the distribution of alpine ecosystems is determined by the number of days that are warm enough for alpine plant growth, but not sufficient for tree growth. Other alpine conditions that maintain treeless vegetation at high elevations include lack of soil development, persistent snowpack, steep slopes, wind, and dense turf that restricts tree seedling establishment and survival within the treeline ecotone.

Management

Alpine landscapes in Colorado are generally in excellent condition, and well protected. Ongoing threats from development in alpine habitats associated with recreation areas and activities, including associated roads and infrastructure; these are generally are limited in extent. Old privately-owned mining claims are scattered throughout, but there are very few active mines operating today. In southwestern Colorado, domestic sheep grazing and isolated mining activity are minor sources of disturbance in alpine areas. Anthropogenic nitrogen deposition is an ongoing influence on alpine phenology and species diversity which may interact with warming temperatures, although the long-term effects of this disturbance are not well known.

Warmer conditions leading to earlier snowmelt and an extended growing season in higher elevations are expected to allow the establishment of woody species above current treeline levels, although this process is likely to be slow. Photoperiod cues (not influenced by climate change) for many species could negate the effects of a longer growing season. The ability of most alpine species to disperse across intervening lower elevation habitat is doubtful.

ALPINE

Original concept authors R. Crawford and M.S. Reid; Apr 2014
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: July 2019

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FOREST & WOODLAND

Colorado Plateau Pinyon-Juniper Woodland & Shrubland

General Description

Colorado combines two Colorado Plateau pinyon-juniper ecological systems (woodland and shrubland) into a single system. The North American distribution of this ecosystem is centered in the Colorado Plateau, generally southwest of Colorado. This ecological system occurs on dry mountains and foothills of the Colorado Plateau region from the western slope of Colorado to the Wasatch Range, and south to the Mogollon Rim. Pinyon-juniper forms the characteristic woodland of Colorado's western mesas and valleys, where it is typically found at lower elevations ranging from 1,500 to 2,440 m (4,900-8,000 ft). Two-needle pinyon (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) dominate the tree canopy. Pinyon and juniper may also form sparse shrublands on rocky, shallow soils or tablelands where vegetation is largely confined to small soil pockets in exposed bedrock. These matrix-forming woodlands often occur in a mosaic with other systems, sagebrush shrublands, Gambel oak shrublands and semi-desert shrublands The understory is highly variable, and may be shrubby, grassy, sparsely vegetated, or rocky. Characteristic shrubs and dwarf-shrubs include black sagebrush (*Artemisia nova*), big sagebrush (*Artemisia tridentata*), Utah serviceberry (*Amelanchier utahensis*), littleleaf mountain mahogany (*Cercocarpus intricatus*), mountain mahogany (*Cercocarpus montanus*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), mormon-tea (*Ephedra viridis*), broom snakeweed (*Gutierrezia sarothrae*), Stansbury cliffrose (*Purshia stansburiana*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii*), and mountain snowberry (*Symphoricarpos oreophilus*). Perennial

graminoids are the most abundant species in the sparse to moderately dense herbaceous layer. Characteristic species include Indian ricegrass (*Achnatherum hymenoides*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), threeawn (*Aristida* spp.), Arizona fescue (*Festuca arizonica*), needle-and-thread (*Hesperostipa comata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), muttongrass (*Poa fendleriana*), James' galleta (*Pleuraphis jamesii*), and western wheatgrass (*Pascopyrum smithii*). The forb layer may be diverse (and may include a number of rare species), but contributes little cover.

Diagnostic Characteristics

Two-needle pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) form the canopy. In Colorado Plateau pinyon-juniper woodlands of lower elevations, Utah juniper is prevalent, but Rocky Mountain juniper (*J. scopulorum*) may codominate or replace it at higher elevations. Pinyon-juniper woodland associations are characterized by stands with 25-60% canopy cover of trees that are typically 3-10 m (10-30 ft) in height. On dry rocky mesa tops and slopes these canopy dominants may be dwarfed (< 3 m tall), forming tall shrublands. Pinyon-juniper stands may be solely dominated by pinyon pine, or may be co-dominated by juniper species. Depending on substrate, the understory can range from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all.

Similar Systems

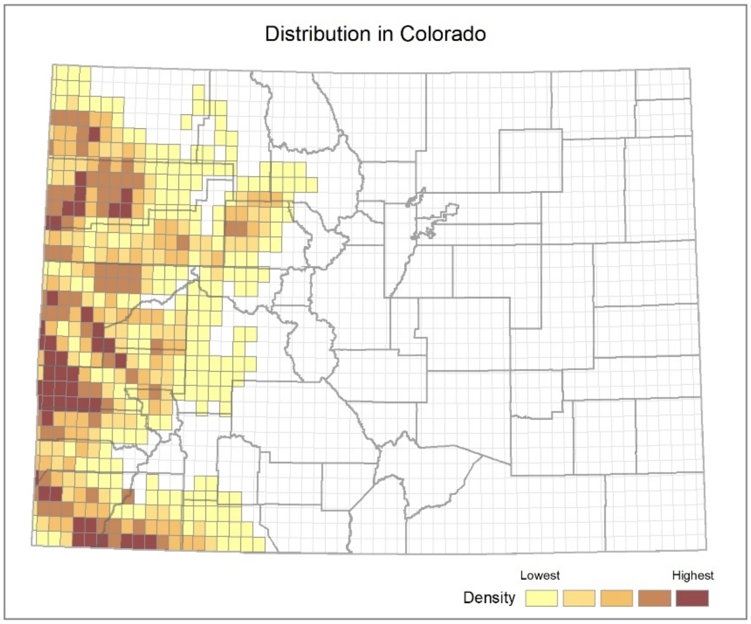
Inter-Mountain Basins Juniper Savanna: These open woodlands dominated by Utah juniper are found in northwestern Colorado, beyond the range of two-needle pinyon pine.

Southern Rocky Mountain Pinyon-Juniper Woodland: The pinyon-juniper woodlands of southeastern Colorado and north-central New Mexico are similar to the Colorado Plateau woodlands, but one-seed juniper (*Juniperus monosperma*) replaces Utah juniper.

Colorado Plateau Mixed Bedrock Canyon and Tableland: Sparse pinyon and juniper shrublands may intergrade with the extremely sparsely vegetated canyons and tablelands that support small stands of similar species.

Range

Colorado Plateau Pinyon-Juniper Woodlands and Shrublands are found throughout the Colorado Plateau, from northeastern Utah south to central Arizona, and in western New Mexico and Colorado. Colorado occurrences are widespread on the west slope, extending up the Colorado River drainage as far as the vicinity of McCoy, but are more generally found as extensive occurrences on lower elevation slopes and canyons in the westernmost tier of counties.



Spatial pattern
Colorado Plateau Pinyon-Juniper Woodlands and Shrublands are a matrix forming system.

Environment
These evergreen woodlands are adapted to cold winter minimum temperatures and low rainfall, and are often transitional between grassland or desert shrubland and montane conifer ecosystems. Annual precipitation is usually from 12-22 in (30-55 cm) in the form of rain and snow. The pinyon-juniper system has a large ecological amplitude; warmer conditions may allow expansion, as has already occurred in the past centuries, as long as there are periodic cooler, wetter years for recruitment. Increased drought may drive fires and insect outbreaks, from which these woodlands would be slow to recover. Mesic areas are generally pinyon-dominated, while junipers are able to dominate on drier sites. Stands vary considerably in appearance and composition, both altitudinally and geographically. Juniper tends to be more abundant at the lower elevations, pinyon tends to be more abundant at the higher elevations, and the two species share dominance within a broad middle-elevation zone. Stands may range from even-aged to uneven-aged stands.

Depending on substrate, pinyon-juniper stands are variable in structure and composition. Stands occur on a variety of aspects and slopes. Slope may range from nearly level to steep (up to 80%). Soils vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Parent materials likewise vary widely from granite, basalt, limestone, and sandstone to mixed alluvium. Soil depths may range from shallow to deep. Site conditions influence the stand density. Sites with fewer trees typically have relatively deep soils and support a dense herbaceous level; those with more trees have shallow, rocky soils and often occur on steeper slopes. Stands may range from even aged to un-even aged stands. Some stands may have closed canopies with little or no understory, but many stands are open with widely scattered trees with a wide variety of understory vegetation.

Vegetation
Pinyon-juniper woodland associations are characterized by stands with 25-60% canopy cover of trees that are typically 3-10 m (10-30 ft) in height. On dry rocky mesa tops and slopes these canopy dominants may be dwarfed (< 3 m tall), forming tall shrublands. On steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary sandstone, shale, and limestone, pinyon and juniper may form very sparse shrublands in cracks and pockets where soil has accumulated. Pinyon-juniper stands may be solely dominated by pinyon pine, or may be co-

dominated by juniper species. Depending on substrate, the understory can range from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all.

Characteristic shrubs and dwarf-shrubs include black sagebrush (*Artemisia nova*), big sagebrush (*Artemisia tridentata*), Utah serviceberry (*Amelanchier utahensis*), littleleaf mountain mahogany (*Cercocarpus intricatus*), mountain mahogany (*Cercocarpus montanus*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), mormon-tea (*Ephedra viridis*), cliff fendlerbush (*Fendlera rupicola*), singleleaf ash (*Fraxinus anomala*), broom snakeweed (*Gutierrezia sarothrae*), littleleaf mock orange (*Philadelphus microphyllus),* Stansbury cliffrose (*Purshia stansburiana*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii*), skunkbush sumac (*Rhus trilobata*), and mountain snowberry (*Symphoricarpos oreophilus*).

Perennial graminoids are the most abundant species in the sparse to moderately dense herbaceous layer. Characteristic species include Indian ricegrass (*Achnatherum hymenoides*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), threeawn (*Aristida* spp.), Arizona fescue (*Festuca arizonica*), needle-and-thread (*Hesperostipa comata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), muttongrass (*Poa fendleriana*), James' galleta (*Pleuraphis jamesii*), and western wheatgrass (*Pascopyrum smithii*). The forb layer may be diverse (and may include a number of rare species), but contributes little cover.

Rare plant species are typical understory components in this system, including Mesa Verde aletes (*Aletes macdougalii* ssp. *breviradiatus*), Jones blue star (*Amsonia jonesii*), Cliff Palace milkvetch (*Astragalus deterior*), Eastwood milkvetch (*Astragalus eastwoodiae*), Mancos milkvetch (*Astragalus humillimus*), violet milkvetch (*Astragalus iodopetalus*), Naturita milkvetch (*Astragalus naturitensis*), Aztec milkvetch (*Astragalus proximus*), Chapin Mesa milkvetch (*Astragalus schmolliae*), Wetherill's milkvetch (*Astragalus wetherillii*), weak-stemmed mariposa lily (*Calochortus flexuosus*), Mesa Verde stickseed (*Hackelia gracilenta*), Gypsum Valley cateye (*Oreocarya revealii*), Paradox breadroot (*Pediomelum aromaticum*), shortstem beardtongue (*Penstemon breviculus*), mesa dropseed (*Sporobolus flexuosus*), and Knowlton's cactus (*Pediocactus knowltonii*).

Plant Associations

CEGL000729	Juniperus osteosperma / Artemisia nova / Rock Woodland
CEGL000728	Juniperus osteosperma / Artemisia nova Woodland
CEGL002360	Juniperus osteosperma / Artemisia tridentata ssp. tridentata Woodland
CEGL000730	Juniperus osteosperma / Artemisia tridentata Woodland
CEGL000733	Juniperus osteosperma / Cercocarpus intricatus Woodland
CEGL000735	Juniperus osteosperma / Cercocarpus montanus Woodland
CEGL002909	Juniperus osteosperma / Coleogyne ramosissima Woodland
CCNHPXXX32	Juniperus osteosperma / Forsellesia meionandra Woodland
CEGL002815	Juniperus osteosperma / Hesperostipa comata Open Woodland
CEGL001489	Juniperus osteosperma / Hesperostipa comata Wooded Grassland
CEGL003109	Juniperus osteosperma / Leymus salinus Open Woodland

CEGL002266	Juniperus osteosperma / Mixed Shrubs Talus Woodland
CEGL002266	Juniperus osteosperma / Mixed Shrubs Talus Woodland
CEGL002362	Juniperus osteosperma / Pleuraphis jamesii Open Woodland
CEGL000738	Juniperus osteosperma / Pseudoroegneria spicata Open Woodland
CEGL000732	Juniperus osteosperma / Sparse Understory Woodland
CEGL000741	Juniperus osteosperma / Symphoricarpos oreophilus Woodland
CEGL000727	Juniperus osteosperma Woodland
CEGL002967	Juniperus scopulorum - Quercus gambelii Woodland
CEGL000743	Juniperus scopulorum / Artemisia tridentata Woodland
CEGL000778	Pinus edulis - (Juniperus osteosperma) / Bouteloua gracilis Woodland
CEGL002329	Pinus edulis - Juniperus osteosperma / Amelanchier utahensis Woodland
CEGL002118	Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland
CEGL002331	Pinus edulis - Juniperus osteosperma / Artemisia nova Woodland
CEGL002365	Pinus edulis - Juniperus osteosperma / Artemisia pygmaea Woodland
CEGL005658	Pinus edulis - Juniperus osteosperma / Artemisia tridentata (ssp. wyomingensis, ssp. vaseyana) Woodland
CEGL002366	Pinus edulis - Juniperus osteosperma / Atriplex spp. Woodland
CEGL000779	Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland
CEGL002940	Pinus edulis - Juniperus osteosperma / Cercocarpus ledifolius Woodland
CEGL005657	Pinus edulis - Juniperus osteosperma / Cercocarpus montanus - Mixed Shrubs Woodland
CEGL000781	Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland
CEGL002370	Pinus edulis - Juniperus osteosperma / Ephedra viridis - Gutierrezia sarothrae Woodland
CEGL005652	Pinus edulis - Juniperus osteosperma / Hesperostipa comata Open Woodland
CEGL002371	Pinus edulis - Juniperus osteosperma / Hesperostipa neomexicana Woodland
CEGL002328	Pinus edulis - Juniperus osteosperma / Mixed Shrubs Talus Woodland
CEGL002332	Pinus edulis - Juniperus osteosperma / Petradoria pumila Woodland
CEGL002379	Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii Woodland
CEGL002819	Pinus edulis - Juniperus osteosperma / Pseudoroegneria spicata - Cushion Plant Woodland
CEGL000782	Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland
CEGL000789	Pinus edulis - Juniperus osteosperma / Purshia tridentata Woodland
CEGL005659	Pinus edulis - Juniperus osteosperma / Quercus gambelii Woodland
CEGL002497	Pinus edulis - Juniperus osteosperma / Quercus havardii var. tuckeri Woodland
CEGL002148	Pinus edulis - Juniperus osteosperma / Sparse Understory Woodland
CEGL002802	Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland
CEGL002340	Pinus edulis - Juniperus spp. / Leymus salinus Woodland
CEGL000787	Pinus edulis - Juniperus spp. / Poa fendleriana Woodland
CEGL000788	Pinus edulis - Juniperus spp. / Pseudoroegneria spicata Woodland
CEGL000798	Pinus edulis / Achnatherum scribneri Open Woodland
CEGL000794	Pinus edulis / Rockland Woodland
CEGL000795	Pinus edulis / Sparse Understory Forest

Associated Animal species

Many animal species rely on a functioning pinyon-juniper landscape. Bird species that depend on this habitat type include Pinyon Jay (*Gymnorhinus cyanocephalus*), Gray Vireo (*Vireo vicinior*), and

Juniper Titmouse (*Baeolophus ridgwayi*). Additional typical bird species include Clark's Nutcracker (*Nucifraga columbiana*), Steller's Jay (*Cyanocitta stelleri*), Townsend's Solitaire (*Myadestes townsendi*), Cedar Waxwing (*Bombycilla cedrorum*), Bushtit (*Psaltriparus minimus*), and Blue-gray Gnatcatcher (*Polioptila caerulea*). Sensitive mammals in this habitat include Gunnison prairie dog (*Cynomys gunnisoni)*, fringed myotis (*Myotis thysanodes*), hoary bat (*Lasiurus cinereus*), and spotted bat (*Euderma maculatum*). These woodlands are also important habitat for larger game animals including mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), especially during winter. Common smaller mammals include pinyon mouse (*Peromyscus truei*) and other mice, bushy-tailed woodrat (*Neotoma cinerea*), chipmunks (*Neotamias* spp.), and porcupine (*Erethizon dorsatum*). Collared lizard (*Crotaphytus collaris*), sagebrush lizard (*Sceloporus graciosus*), bullsnake (*Pituophis catenifer*), and western rattlesnake (*Crotalus viridis*) are often found in these woodlands.

Dynamic processes

Pinyon-juniper woodlands are influenced by climate, fires, insect-pathogen outbreaks, and livestock grazing. Although it is clear that the structure and condition of many pinyon-juniper woodlands has been significantly altered since European settlement, in recent years there has been an emerging recognition that not all of these woodlands are dramatically changed by anthropogenic influence. Increasing density of pinyon juniper woodlands and expansion into adjacent grassland or shrubland are well documented in some areas, but is not a universal phenomenon in the western US. Local site conditions may result in a fine-scale mixture of type within a larger matrix of one type. The differences between these types have important implications for management actions, and efforts to maintain or restore natural processes in pinyon-juniper habitats.

Both pinyon pine and juniper are fairly slow growing, and can live for hundreds of years, a life cycle that is well adapted to xeric habitats, but is less suitable for quickly changing conditions. Although individuals of both species become reproductive after a few decades, most seed production is due to mature trees of 75 years of age or older. Both species reproduce only from seeds, and do not resprout after fire. Cone production of mature pinyon pine takes three growing seasons, and the large seeds have a fairly short life span of 1-2 years. Juniper cones (often called berries) may require 1-2 years of ripening before they can germinate. The smaller seeds of juniper are generally long-lived, surviving as long as 45 years. Birds are important dispersers of both pinyon pine and juniper seed.

The effects of fire in all types of pinyon-juniper depend in part on fuel provided by both canopy and understory, and by weather conditions during a fire. Sparse woodlands with little understory vegetation would typically have limited fire spread and little tree mortality. As tree density or understory cover (especially shrubs) increases fire spread is facilitated, and tree mortality becomes more likely. Spreading, low-intensity surface fires have historically had a limited role in this ecosystem, and instead the dominant fire effect is mortality of most trees and top-kill of most shrubs within the burned area, regardless of tree or shrub size. For many pinyon-juniper woodlands, climate fluctuation and insect or disease outbreak are more important in shaping stand structure than fire. Insect and disease mortality is a natural ongoing process, usually at a low level,

but occasionally as more severe episodic outbreaks. Weather patterns may enhance patterns of mortality or recruitment, shifting stand composition and structure on a local or regional scale.

Management

The effect of a fire on a stand is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions, and season. Large trees generally survive unless the fire gets into the crown due to heavy fuel loads in the understory. In this system fire acts to open stands, increase diversity and productivity in understory species, and create a mosaic of stands of different sizes and ages across the landscape while maintaining the boundary between woodlands and adjacent shrubs or grasslands. Altered fire regimes, overgrazing, and tree cutting can all affect stand quality and fire behavior. These factors can also disturb cryptogamic soils and lead to increased soil erosion and habitat/species loss.

Pinyon-juniper habitats in Colorado have been moderately impacted by anthropogenic disturbance. Ongoing but limited threats from urban, exurban, and commercial development are primarily in the south central and southwestern portions of Colorado, where towns, roads, and utility corridors are often in close proximity to pinyon-juniper woodlands. As with other habitats in the wildland-urban interface, areas near developed areas are most likely to be threatened by the effects of fire suppression, while more remote areas are generally in good condition. Livestock grazing has degraded the understory grasses of some stands, and invasive cheatgrass (*Bromus tectorum*) has become established in some areas. Tree removal by chaining, or cutting for firewood is a minor source of disturbance within these woodlands, but may dramatically change the habitat where it has occurred. Oil and gas development, with associated roads, pipeline corridors, and infrastructure, is an ongoing source of disturbance and fragmentation for most pinyon-juniper habitats.

Since the last major glacial period, the distribution and relative abundance of pinyon and juniper has fluctuated with changing climatic conditions. Future precipitation and temperature patterns are projected to change in a direction that is less favorable for pinyon, so that juniper may become more dominant, and these habitats are unable to persist or expand in their current form. Primary factors contributing to the vulnerability of these woodlands are the interaction of drought, fire, and insect-caused mortality, which is likely to increase under changing climate, and the extent to which the current landscape condition of the habitat has been impacted by anthropogenic disturbance.

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Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland

General Description

This widespread ecological system occurs on montane slopes and plateaus from northern Arizona and New Mexico through eastern Nevada, Utah, and Colorado, and north into western Wyoming, and southern Idaho and Montana. In Colorado, these are mixed forests and woodlands of drier areas than those supporting extensive pure aspen forests, especially east of the Continental Divide. Elevations are similar to those of aspen or mixed conifer forests, ranging from about 2,290 to 3,350 m (7,500 to 11,000 ft). The tree canopy is composed of a mix of deciduous and coniferous species, codominated by quaking aspen (*Populus tremuloides*) and various conifers that may include Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) white fir (*Abies concolor*), blue spruce (*Picea pungens*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), or Engelmann spruce (*Picea engelmannii*), depending on elevation. In places aspen may be locally dominant, but surrounded by mixed coniferous stands. As an occurrence ages, aspen is often slowly reduced until the conifer species become dominant. Understories may be shrub or herbaceous dominated. Common shrubs include Saskatoon serviceberry (*Amelanchier alnifolia*), Rocky Mountain maple (*Acer glabrum*), mountain ninebark (*Physocarpus* monogynus), mountain snowberry (*Symphoricarpos oreophilus*), common juniper (*Juniperus communis*), Oregon boxleaf (*Paxistima myrsinites*), Woods' rose (*Rosa woodsii*), or creeping barberry (*Mahonia repens*). Herbaceous species include fringed brome (*Bromus ciliatus*), bluejoint (*Calamagrostis canadensis*),

Geyer's sedge (*Carex geyeri*), oatgrass (*Danthonia* spp.), blue wildrye (*Elymus glaucus*), Thurber fescue (*Festuca thurberi*) needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), western yarrow (*Achillea millefolium* var. *occidentalis*), heartleaf arnica (*Arnica cordifolia*), Indian paintbrush (*Castilleja* spp.), fleabane (*Erigeron* spp.), northern bedstraw (*Galium boreale*), silvery lupine (*Lupinus argenteus*), and many other forbs.

Diagnostic Characteristics

These mixed forests are characterized by a canopy where aspen is dominant or co-dominant, but with a variety of conifer species also present. These are successional forests; in the absence of stand-replacing disturbance, conifers will eventually replace aspen as dominant in the canopy.

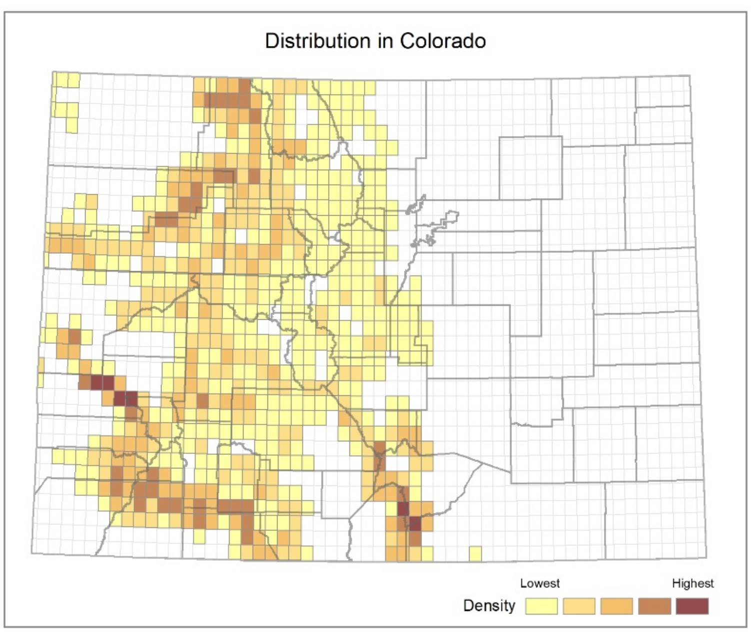
Similar Systems

Rocky Mountain Aspen Forest and Woodland: Aspen forests and woodlands are characterized by large stands of pure aspen without conifers present. These forests are primarily found on Colorado’s west slope, and appear to be relatively persistent.

Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland: these mixed forests and woodlands can be difficult to distinguish from the aspen-mixed conifer type. In general, if aspen is present in small patches rather than co-dominant, occurrences should be considered as belonging to the mixed conifer type. Both this and the pure aspen forest are likely to intergrade in many areas with the aspen-mixed conifer system.

Range

The Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland system occurs on montane slopes and plateaus from northern Arizona and New Mexico through eastern Nevada, Utah, and Colorado, and north into western Wyoming, and southern Idaho and Montana. Colorado occurrences are found throughout the mountainous portion of the state at elevations of 2,290 to 3,350 m (7,500 to 11,000 ft), but are most common on the east slope.



Spatial pattern

In Colorado, Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland is probably generally found as a large patch, but may also occur in a matrix with aspen forests and mixed conifer forests.

Environment

Occurrences occupy similar environments, and are often

intermixed with mixed-conifer or aspen forests. Local conditions, biogeographic history, and competitive interactions over many decades are prime determinants of stand composition. Sites may be dry or mesic, but are generally at montane to subalpine elevations where annual precipitation exceeds evapotranspiration. The lower elevational limit of aspen growth coincides with a mean annual temperature of about 7°C. Occurrences are found on a variety of slopes and aspects, and soils are variable but with sufficient moisture availability to support forest growth. Well-drained, shallow soils will support more open stands.

Vegetation

The tree canopy is composed of a mix of deciduous and coniferous species, codominated by quaking aspen (*Populus tremuloides*) and various conifers that may include Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) white fir (*Abies concolor*), blue spruce (*Picea pungens*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), or Engelmann spruce (*Picea engelmannii*), depending on elevation. Understories may be shrub or herbaceous dominated. Common shrubs include Saskatoon serviceberry (*Amelanchier alnifolia*), Rocky Mountain maple (*Acer glabrum*), mountain ninebark (*Physocarpus* monogynus), mountain snowberry (*Symphoricarpos oreophilus*), common juniper (*Juniperus communis*), Oregon boxleaf (*Paxistima myrsinites*), Woods' rose (*Rosa woodsii*), or creeping barberry (*Mahonia repens*). Herbaceous species include fringed brome (*Bromus ciliatus*), bluejoint (*Calamagrostis canadensis*), Geyer's sedge (*Carex geyeri*), oatgrass (*Danthonia* spp.), blue wildrye (*Elymus glaucus*), Thurber fescue (*Festuca thurberi*) needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), western yarrow (*Achillea millefolium* var. *occidentalis*), heartleaf arnica (*Arnica cordifolia*), Indian paintbrush (*Castilleja* spp.), fleabane (*Erigeron* spp.), northern bedstraw (*Galium boreale*), silvery lupine (*Lupinus argenteus*), and many other forbs.

Plant Associations

CEGL000527	Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest
CEGL000529	Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest
CEGL000535	Populus tremuloides - Picea pungens Forest
CEGL000537	Populus tremuloides - Pinus contorta / Juniperus communis Forest
CEGL000540	Populus tremuloides - Pinus flexilis Forest
CEGL000541	Populus tremuloides - Pinus ponderosa Rocky Mountain Forest
CEGL000543	Populus tremuloides - Pseudotsuga menziesii / Amelanchier alnifolia Forest
CEGL000545	Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest

Associated Animal species

These mixed forests provide habitat for many mammal species, including mountain lion (*Felis concolor)*, bobcat (*Felis rufus*), black bear (*Ursus americanus)*, weasel (*Mustela* spp.), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), golden-mantled ground squirrel (*Callospermophilus lateralis*), chipmunks (*Neotamias* spp.). A variety of forest birds in these habitats include Northern Goshawk (*Accipiter gentilis*), Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), Hairy Woodpecker (Dryobates villosus), Steller's Jay (*Cyanocitta stelleri*), Dusky Grouse (*Dendragapus obscurus*), Black-capped Chickadee (*Poecile atricapillus*), Mountain Chickadee

(*Poecile gambeli*), Cassin's Sparrow (*Peucaea cassinii*), Dark-eyed Junco (*Junco hyemalis*), Hermit Thrush (*Catharus guttatus*), Pine Siskin (*Spinus pinus*), and House Wren (*Troglodytes aedon*).

Dynamic processes

Although aspen is not fire tolerant, it is highly competitive in burned areas if other conditions are suitable. Aspen clones can survive in the understory of cool, moist mixed conifer and low elevation spruce-fir, and can respond quickly to disturbances. Even when stands are severely burned, aspen often resprouts. Because aspen is considered an early-seral species characteristic of disturbance, most occurrences of this forest type are thought to represent instances of conifers succeeding to aspen. An occurrence may originate after a large, stand-replacing disturbance such as crown fire, disease outbreak, windthrow, or clearcutting. Aspen is extremely shade intolerant, and will eventually be replaced by conifer species that sprout in the understory. Fire suppression in particular, as well as livestock grazing and the elimination of predators on large ungulates have apparently increased the reproductive success of shade-tolerant conifers in aspen stands, resulting in these mixed forest and woodland stands. The fact that processes operating prior to European settlement have not returned to historic patterns has made it difficult to predict the future trajectory of this and the associated forest types.

Management

Aspen-mixed conifer forests in Colorado are generally in good condition, especially in areas where they are more remote from the wildland-urban interface. In areas of exurban development fire suppression will continue to be a factor in the changing composition of these forests and woodlands. In some areas extensive removal of beetle-killed conifers may allow expansion of this system, especially the aspen component. Livestock grazing, and grazing by large ungulates can suppress the aspen component of these forests, but is likely to be less of a factor than in the past. Changing climate conditions are likely to alter the relative dominance of overstory species, overall species composition and relative cover, primarily through the action of fire, insect outbreak, and drought. Drought and disturbance tolerant species will be favored over drought vulnerable species. The higher biodiversity in overstory species may allow these forests and woodlands to adapt to changing climate, even in the face of potential increases in area burned.

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Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland

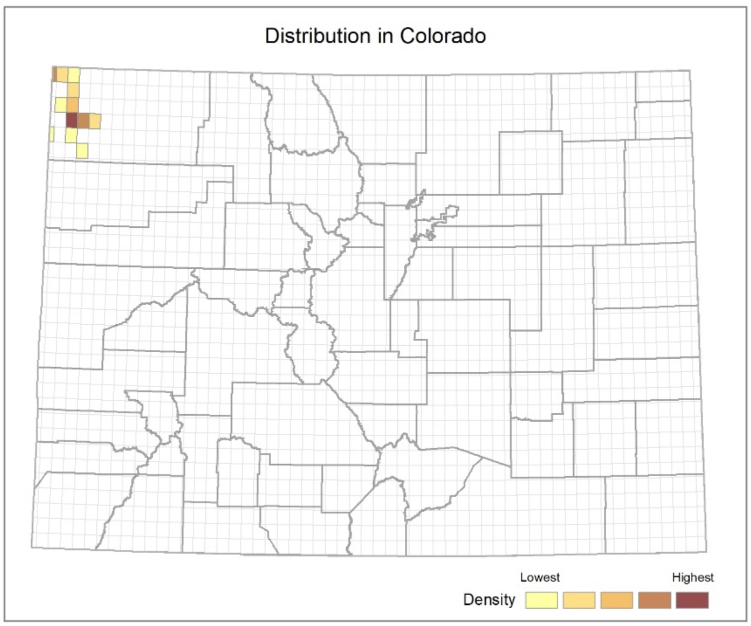
General Description

This ecological system occurs on outcrops and escarpments in the hills and mountain ranges of the Intermountain West from the eastern foothills of the Sierra Nevada in California, northeast to the foothills of the Bighorn Mountains of north-central Wyoming. In Colorado this system is found only in the northwestern portion of the state, in the vicinity of Douglas Mountain and Cold Spring Mountain in Moffat County. Sites are mountain slopes and ridgelines between 1,980 and 2,620 m (6,500 to 8,600 ft). These tall shrublands are characterized by a canopy of 2-5 m (6-15 ft) tall curl-leaf mountain mahogany (*Cercocarpus ledifolius*), often treelike in form. Scattered individuals of taller tree species including Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), quaking aspen (*Populus tremuloides*), two-needle pinyon (*Pinus edulis*), or Utah juniper (*Juniperus osteosperma*) may emerge from the canopy. A shrub understory that may include chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier* spp.), big sagebrush (*Artemisia tridentata*), mountain snowberry (*Symphoricarpos oreophilus*), Woods' rose (*Rosa woodsii*), and Oregon boxleaf (*Paxistima myrsinites*) is present in some stands. Shrubs are largely absent in other areas, where the herbaceous understory is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*).

Diagnostic Characteristics
This system is characterized by stands dominated by tall-shrub or tree-like curl-leaf mountain mahogany (*Cercocarpus ledifolius*).

Similar Systems
None

Range
Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland occurs on outcrops and escarpments in the hills and mountain ranges of the Intermountain West from the eastern foothills of the Sierra Nevada in California, northeast to the foothills of the Bighorn Mountains of north-central Wyoming. In Colorado this system is found only in the northwestern portion of the state, in the vicinity of Douglas Mountain and Cold Spring Mountain in Moffat County.



Spatial pattern
Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland is a large patch ecological system.

Environment
The ridges and mountain slopes where these woodlands occur are semi-arid, with annual precipitation of about 14.5 inches. Most precipitation is received in spring and fall. Winters are cold and relatively dry. Occurrences are found on rocky or deep, well drained, often calcareous soils derived mainly from limestone or basal conglomerate. Slopes range from 0 to 75 percent.

Vegetation

Curl-leaf mountain mahogany (*Cercocarpus ledifolius*) is a slow-growing, drought-tolerant species that can form dense shrublands or short woodlands. In Colorado these tall shrublands are characterized by a canopy of 2-5m tall curl-leaf mountain mahogany (*Cercocarpus ledifolius*), often treelike in form. Scattered individuals of taller tree species including Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), quaking aspen (*Populus tremuloides*), two-needle pinyon (*Pinus edulis*), or Utah juniper (*Juniperus osteosperma*) may emerge from the canopy. Mesic stands are characterized by an understory of chokecherry (*Prunus virginiana*). Higher elevation stands on rocky soils have understory dominated by mountain big sagebrush (*Artemisia tridentata*

ssp. *vaseyana*) or Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*). Other shrubs that may be present include serviceberry (*Amelanchier* spp.), mountain snowberry (*Symphoricarpos oreophilus*), waxcurrent (*Ribes cereum*), Woods' rose (*Rosa woodsii*), and Oregon boxleaf (*Paxistima myrsinites*).

Drier stands have an understory of bluebunch wheatgrass (*Pseudoroegneria spicata*). Other graminoid species that may be present include Indian ricegrass (*Achnatherum* hymenoides), Columbia needlegrass (*Achnatherum nelsonii*), onespike danthonia (*Danthonia unispicata*), needle-and-thread (*Hesperostipa comata*), prairie Junegrass (*Koeleria macrantha*), and Sandberg bluegrass (*Poa secunda*). The herbaceous layer is variable; common forbs include tapertip onion (*Allium acuminatum*), prairie sagewort (*Artemisia frigida*), arrowleaf balsamroot (*Balsamorhiza sagittata*), spotted stickseed (*Hackelia patens*), oblongleaf bluebells *Mertensia oblongifolia,* spiny phlox (*Phlox hoodii*, and rock goldenrod (*Petradoria pumila*).

Plant Associations

CEGL001022	Cercocarpus ledifolius / Artemisia tridentata ssp. vaseyana Woodland
CEGL000966	Cercocarpus ledifolius / Prunus virginiana Scrub
CEGL000967	Cercocarpus ledifolius / Pseudoroegneria spicata Scrub

Associated Animal species

There are no known obligate species of these shrublands, but a variety of birds, small mammals, and herpetofauna are likely to use the habitat for both nesting and foraging. Larger mammals (deer, elk, pronghorn, mountain lion, bear) frequenting the surrounding areas will occasionally be seen as well, as these shrublands can provide good cover.

Dynamic processes

Curlleaf mountain mahogany individuals are drought tolerant and slow growing, but can be extremely long lived. The relatively thick bark of curl-leaf mountain mahogany may allow it to survive light fire, but it generally does not resprout after burning. Stands that have burned within the past few decades are tall shrublands rather than tree-like forms.

Management

Occurrences are fairly small and fragmented. Well-developed stands are typically confined to rocky areas that offer protection from stand-replacing fire, but this type may have expanded under fire suppression. Browsing or grazing by wildlife or domestic livestock can suppress growth and reproduction, but is currently not a primary disturbance in this system in Colorado.

Original concept authors: M.S. Reid, G. Kittel and K.A. Schulz, May 2018
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: June 2019

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Rocky Mountain Aspen Forest and Woodland

General Description

Quaking aspen (*Populus tremuloides*) has the largest distribution of any tree native to North America. This widespread ecological system occurs throughout much of the western U.S. and north into Canada, although it is more common in the montane and subalpine zones of the southern and central Rocky Mountains. In Colorado this system is most common on the west slope at elevations of 2,290 to 3,350 m (7,500-11,000 ft), with smaller stands represented on the east slope. These are upland forests and woodlands dominated by quaking aspen without a significant conifer component (<25% relative tree cover). The open growth form of this tree allows light to penetrate to the understory. Aspen forest and woodlands usually occur as a mosaic of many plant associations and may be surrounded by a diverse array of other systems, including grasslands, wetlands, or coniferous forests. Understory composition is vairable and may be lush, with multiple shrub and herbaceous layers, or less complex.

Diagnostic Characteristics

These forests and woodlands are characterized by extensive quaking aspen stands and very few conifers. The typically lush understory appears lighter and more open than in aspen-mixed conifer forests, due to the dominance of deciduous trees. Understories are variable, and may be shrub or

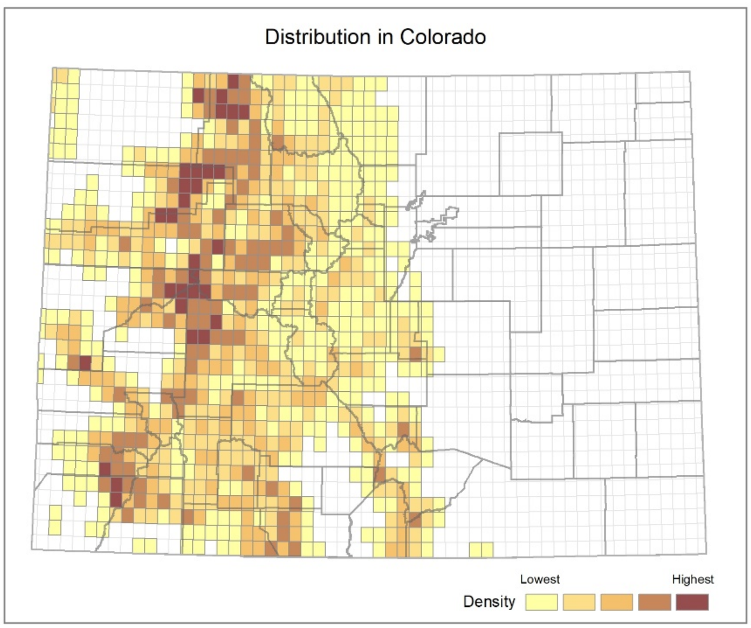
herbaceous dominated. In general, these forests are more mesic in comparison to the aspen-mixed conifer types.

Similar Systems

Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland: These mixed forests are characterized by a canopy where aspen is dominant or co-dominant, but with a variety of conifer species also present. These are considered successional forests; in the absence of stand-replacing disturbance, conifers will eventually replace aspen as dominant in the canopy.

Range

This widespread ecological system occurs throughout much of the western U.S. and north into Canada, although it is more common in the montane and subalpine zones of the southern and central Rocky Mountains. In Colorado this system is most common on the west slope, with smaller stands represented on the east slope.



Spatial pattern

Rocky Mountain Aspen Forest and Woodland is a large patch type.

Environment

Quaking aspen is able to grow on a wide variety of sites, both dry and mesic, but is limited to areas where annual precipitation exceeds evapotranspiration and annual mean temperature does not exceed 8°C (45°F). In the central Rocky Mountains, quaking aspen distribution is highly correlated with elevation, due to its influence on temperature and precipitation patterns. Occurrences at high elevations are limited by cold temperatures and are found on warmer southern aspects. At lower elevations occurrences are restricted by lack of moisture to cooler northern aspects and mesic microsites. Topography is variable, sites range from level to steep slopes. The soils are typically deep and well developed with rock often absent, and texture ranges from sandy loam to clay loams. Parent materials are variable and may include sedimentary, metamorphic or igneous rocks.

Vegetation

The aspen canopy allows sufficient light penetration for the development of a lush understory that may be dominated by shrubs, graminoids, or forbs. The typically diverse species composition in these woodlands makes it difficult to delineate plant associations with certainty from place to place.

In effect, there are groups of associations characterized by understory structure, variable levels of moisture, and disturbance history.

Common shrubs include Rocky Mountain maple (*Acer glabrum*), Saskatoon serviceberry (*Amelanchier alnifolia*), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*),common juniper (*Juniperus communis*), chokecherry (*Prunus virginiana*), Wood's rose (*Rosa woodsii*), russet buffaloberry (*Shepherdia canadensis*),mountain snowberry (*Symphoricarpos oreophilus*), and the dwarf-shrubs creeping barberry (*Mahonia repens*) and whortleberry (*Vaccinium* spp.). Common graminoids include mountain brome (*Bromus marginatus*), wooly brome (*Bromus lanatipes*), pinegrass (*Calamagrostis rubescens*), dryspike sedge (*Carex siccata*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*Carex rossii*), blue wildrye (*Elymus glaucus*), slender wheatgrass (*Elymus trachycaulus*), and Thurber fescue (*Festuca thurberi*). Exotic grasses such as the perennials Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and timothy (*Phleum pratense*) are often common in occurrences disturbed by grazing. Associated forbs may include common yarrow (*Achillea millefolium*), monkshood (*Aconitum columbianum*), heartleaf arnica (*Arnica cordifolia*), paintbrush (*Castilleja* spp.), Engelmann's aster (*Eucephalus engelmannii*), larkspur (*Delphinium* spp.), Richardson's geranium (*Geranium richardsonii*), common cowparsnip (*Heracleum maximum*), Porter's licorice-root (*Ligusticum porteri*), silvery lupine (*Lupinus argenteus*), sweetcicely (*Osmorhiza berteroi*), western brackenfern (*Pteridium aquilinum*), Fendler's meadow-rue (*Thalictrum fendleri*), western valerian (*Valeriana occidentalis*), American vetch (*Vicia americana*), mule-ears (*Wyethia amplexicaulis*), and many others.

Plant Associations

CEGL000563	Populus tremuloides / Acer glabrum Forest
CEGL000567	Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Calamagrostis rubescens Forest
CEGL002816	Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Mixed Graminoid Forest
CEGL000568	Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Tall Forbs Forest
CEGL000569	Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Thalictrum fendleri Forest
CEGL000564	Populus tremuloides / Amelanchier alnifolia Forest
CEGL000579	Populus tremuloides / Carex geyeri Forest
CEGL000578	Populus tremuloides / Carex siccata Forest
CEGL000581	Populus tremuloides / Ceanothus velutinus Forest
CEGL000583	Populus tremuloides / Corylus cornuta Forest
CEGL000585	Populus tremuloides / Festuca thurberi Forest
CEGL000586	Populus tremuloides / Heracleum sphondylium Forest
CEGL000608	Populus tremuloides / Hesperostipa comata Forest
CEGL000588	Populus tremuloides / Juniperus communis / Carex geyeri Forest
CEGL000589	Populus tremuloides / Juniperus communis / Lupinus argenteus Forest
CEGL000587	Populus tremuloides / Juniperus communis Forest
CEGL000592	Populus tremuloides / Lonicera involucrata Forest
CEGL000594	Populus tremuloides / Mahonia repens Forest

CEGL005932	Populus tremuloides / Physocarpus monogynus Forest
CEGL000596	Populus tremuloides / Prunus virginiana Forest
CEGL000597	Populus tremuloides / Pteridium aquilinum Forest
CEGL000598	Populus tremuloides / Quercus gambelii / Symphoricarpos oreophilus Forest
CEGL000600	Populus tremuloides / Ribes montigenum Riparian Forest
CEGL003149	Populus tremuloides / Rosa woodsii Riparian Forest
CEGL000604	Populus tremuloides / Salix scouleriana Forest
CEGL000605	Populus tremuloides / Sambucus racemosa Forest
CEGL000606	Populus tremuloides / Shepherdia canadensis Forest
CEGL000613	Populus tremuloides / Symphoricarpos oreophilus / Carex rossii Forest
CEGL000614	Populus tremuloides / Symphoricarpos oreophilus / Festuca thurberi Forest
CEGL000616	Populus tremuloides / Symphoricarpos oreophilus / Thalictrum fendleri Forest
CEGL000610	Populus tremuloides / Symphoricarpos oreophilus Forest
CEGL000618	Populus tremuloides / Tall Forbs Forest
CEGL000619	Populus tremuloides / Thalictrum fendleri Forest
CEGL000620	Populus tremuloides / Vaccinium myrtillus Forest
CEGL000622	Populus tremuloides / Wyethia amplexicaulis Forest

Associated Animal species

Aspen forests provide essential wildlife habitat; mesic areas are most diverse. Where aspen is near riparian areas, beaver (*Castor canadensis*) make extensive use of these trees. Mammals both large and small can be found in these forests, including elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus)*, coyote (*Canis latrans)*, bats (*Myotis* spp.), shrews (Family *Soricidae)*, squirrels (Family *Sciuridae*), pocket gopher (*Family Geomyidae)*, white-footed mice (*Peromyscus spp.)*, and voles (*Microtus* spp.). Aspen forests are important for cavity-nesting birds but also provide habitat for many songbirds. Species found in these forests include Warbling Vireo (*Vireo gilvus*), House Wren (*Troglodytes aedon*), Red-naped Sapsucker (*Sphyrapicus nuchalis*), Williamson's Sapsucker (*Sphyrapicus thyroideus*), Hairy Woodpecker (*Dryobates villosus*), Northern Flicker (*Colaptes auratus*), Tree Swallow (*Tachycineta bicolor*), Violet-green Swallow (*Tachycineta thalassina*), American Robin (*Turdus migratorius*), Mountain Bluebird (*Sialia currucoides*), Yellow-rumped Warbler (*Setophaga coronata*), Western Wood-Pewee (*Contopus sordidulus*), Dark-eyed Junco (*Junco hyemalis*), and Purple martin (*Progne subis*).

Dynamic processes

Aspen is extremely shade intolerant, but is able to establish quickly in disturbed open areas due to its ability to reproduce by vegetative sprouting. The tufted seed capsules produced by mature aspen trees can be wind dispersed over considerable distances. Although quaking aspen establishment from seed is common in Alaska, northern Canada and eastern North America, this is less true in the western US, probably because germinated seedlings do not receive sufficient moisture for survival.

Colorado's western slope appears to occupy the margins between the seral aspen type found in boreal and montane areas, and the stable type that is characteristic of Colorado Plateau highlands. Seral aspen types (i.e., aspen-mixed conifer) are common and may be intermingled with persistent

aspen stands, and are thought to originate with stand-replacing disturbance, especially fire. Rocky Mountain Aspen Forest and Woodland occurrences are generally persistent aspen stands that have remained stable over periods of 80 years or more with little to no conifer development.

Disturbance type, frequency, and extent is important in determining the appearance of these woodlands. Stands that have escaped catastrophic fire may exhibit multi-layered structure with regeneration and/or recruitment as well as mature canopy. Small- to moderate-scale disturbance can create gaps that are filled in by younger stems that are already present in the under or mid-story. Single-layer stands where regeneration patterns have been altered by grazing may also belong to this system.

Management

In the absence of historic predators, elk grazing appears to have increased in many stands, with consequent impacts on aspen regeneration. Grazing management may be needed to reduce impacts on drought-stressed areas. Overall exposure to warmer and effectively drier conditions is low for this system in Colorado; stands at lower elevations are most at risk. These forests are moderately resilient, and in generally good condition. Aspen dynamics are variable across the west, depending on both spatial and temporal scales; as a result there is much uncertainty about the future distribution of this species. Low elevation stands impacted by drought are likely to experience dieback, but in other areas the interaction of changing climate and disturbance regimes may favor aspen. Drier and warmer conditions in the future are likely to increase disease and insect outbreaks, and may reduce the frequency of occasions suitable for aspen seed production and successful recruitment.

Original concept authors M.S. Reid, G. Kittel and K.A. Schulz; May 2018
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: August 2019

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Rocky Mountain Foothill Limber Pine-Juniper Woodland

General Description

This ecological system occurs in foothill and lower montane zones in the Rocky Mountains from northern Montana south to north-central Colorado and on escarpments across Wyoming extending out into the western Great Plains. In Colorado, this system is limited to foothill and montane areas near the Wyoming border, and to the High Plains escarpment in the Ogallala formation further east, where stands are believed to be either relictual from larger coniferous woodlands of the Pleistocene, or of more recent origin, perhaps due to seed caching by indigenous peoples. Elevations range from 1,600 to about 2,590 m (5,250 to 8,500 ft). Soils are generally shallow and rocky. These woodlands are characterized by an open tree canopy or patchy woodland that is dominated by either limber pine (*Pinus flexilis*) or Rocky Mountain juniper (*Juniperus scopulorum*), with occasional inclusions of ponderosa pine (*Pinus ponderosa*). A sparse shrub layer may be present, with skunkbush sumac (*Rhus trilobata*), mountain mahogany (*Cercocarpus montanus*), and wax current (*Ribes cereum*) being the most common species at foothill elevations. Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) may be present at higher elevations. Herbaceous layers are generally sparse, but range to moderately dense and are typically dominated by perennial graminoids or forbs of the adjacent shrublands or grasslands, such as blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), and little bluestem (*Schizachyrium*

scoparium) at lower elevations, and fescue (*Festuca* spp.), timber oatgrass (*Danthonia intermedia*), spike fescue (*Leucopoa kingii*), needle-and-thread (*Hesperostipa comata*), littleseed ricegrass (*Piptatheropsis micrantha*), Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*) at higher elevations.

Diagnostic Characteristics

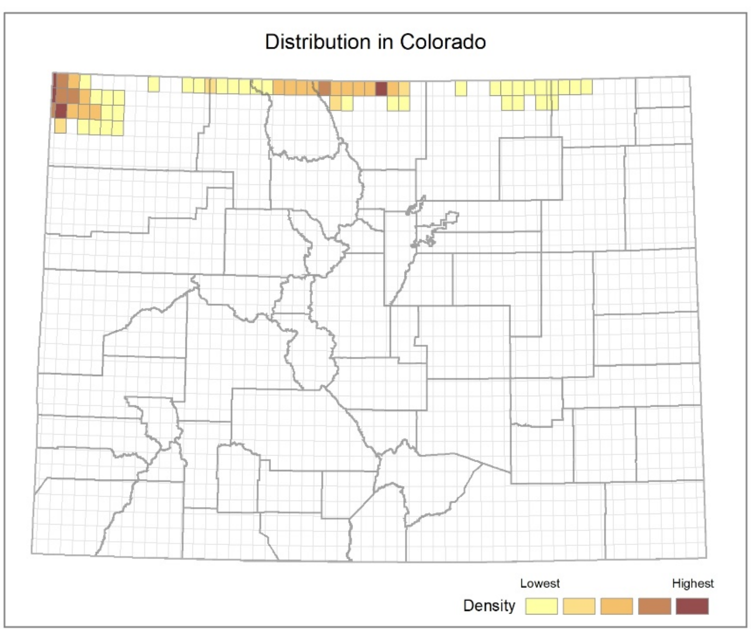
These open woodlands are characterized by the presence of limber pine at lower montane or foothill elevations, generally below ponderosa pine woodlands or mixed conifer forest, or on foothill ridges, rocky breaks, and escarpments on the plains. Bristlecone pine (*Pinus aristata*) is absent from these sparse woodlands, but Rocky Mountain juniper is commonly present or dominant.

Similar Systems

<u>Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland</u>: These are coniferous woodlands of dry, high elevation sites where tree growth is difficult. Stands are characterized by the dominance of either bristlecone or limber pine, although they do not necessarily occur together. Limber pine is more widely distributed, ranging further north, and also occurs in mixed conifer systems.

Range

This ecological system occurs in foothill and lower montane zones of the Rocky Mountains from Canada and northern Montana south to north-central Colorado and on escarpments across extending out into the western Great Plains. In Colorado, this system is not widespread, and is limited to foothill and montane areas near the Wyoming border, and to the High Plains escarpment in the Ogallala formation further east.



Spatial pattern

Rocky Mountain Foothill Limber Pine-Juniper Woodland is a large patch type, although some occurrences in Colorado can be fairly small.

Environment

These are woodlands of dry, often rocky habitats at lower elevations, usually occurring below more forested areas. Substrates are shallow soils formed in weathered granitic rock (foothill/lower montane sites), or calcareous sandstone and shale (plains escarpments). Annual precipitation

ranges from about 14-18 in, depending on location. Soils are coarse- to fine-textured, often gravelly with a high percentage of rock.

Vegetation

These woodlands are characterized by an open tree canopy or patchy woodland that is dominated by either limber pine (*Pinus flexilis*) or Rocky Mountain juniper (*Juniperus scopulorum*), with occasional inclusions of ponderosa pine (*Pinus ponderosa*). A sparse shrub layer may be present, with skunkbush sumac (*Rhus trilobata*), mountain mahogany (*Cercocarpus montanus*), and wax current (*Ribes cereum*) being the most common species at foothill elevations. Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) may be present at higher elevations. Herbaceous layers are generally sparse, but range to moderately dense and are typically dominated by perennial graminoids or forbs of the adjacent shrublands or grasslands, such as blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), and little bluestem (*Schizachyrium scoparium*) at lower elevations, and fescue (*Festuca* spp.), timber oatgrass (*Danthonia intermedia*), spike fescue (*Leucopoa kingii*), needle-and-thread (*Hesperostipa comata*), littleseed ricegrass (*Piptatheropsis micrantha*), Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*) at higher elevations.

Plant Associations

CEGL000745	Juniperus scopulorum / Cercocarpus montanus Woodland
CEGL000747	Juniperus scopulorum / Piptatheropsis micrantha Woodland
CEGL000748	Juniperus scopulorum / Pseudoroegneria spicata Woodland
CEGL000749	Juniperus scopulorum / Purshia tridentata Woodland
CEGL000750	Juniperus scopulorum / Schizachyrium scoparium Woodland
CEGL000807	Pinus flexilis / Juniperus communis Woodland
CEGL000809	Pinus flexilis / Juniperus scopulorum Woodland
CEGL000810	Pinus flexilis / Leucopoa kingii Woodland

Associated Animal species

Clark's Nutcrackers (*Nucifraga columbiana*) are key dispersers of limber pine seeds in foothill and montane areas, but are not typically seen further east. Nocturnal rodents such as deer mice (*Peromyscus maniculatus*) and Ord's kangaroo rats (*Dipodomys ordii*), are thought to be primary dispersers in plains escarpment stands. Other wildlife use of these woodlands is poorly understood.

Dynamic processes

Disturbances in these woodlands include fire, drought, tree removal, livestock grazing, and disease (white pine blister rust) or insect attack (pine beetle). Fire regimes are highly variable, depending on elevation and stand structure. These lower-treeline woodlands are thought to have more frequent fires than limber pine in montane-subalpine elevations.

No individuals older than 200 years in these lower limber pine stands have been documented, in contrast to trees in higher elevation areas that may reach 1500 years of age. Changes in disturbance frequency may be responsible for this difference, and require additional study.

Management

The ecotonal nature of these woodlands, in combination with a lack of knowledge about the true range of historical variation, can lead to assumptions that limber pine trees are invading sagebrush and grassland ranges. Management efforts that focus on tree removal in an attempt to return to a particular 20th century snapshot condition are not well supported by research.

Original concept authors G. Jones, K.A. Schulz, G. Kittel; Nov 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: October 2019

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Rocky Mountain Gambel Oak-Mixed Montane Shrubland

General Description

This ecological system occurs in the mountains, plateaus, and foothills in the southern Rocky Mountains and Colorado Plateau ecoregions. In Colorado these shrublands are most commonly found along dry foothills and lower mountain slopes of western Colorado, and at the mountain front edge of the western Great Plains from approximately 1,830 to 2,750 m (6,000-9,000 ft) in elevation, and are often located above pinyon-juniper woodlands. Vegetation may be dominated by Gambel oak (*Quercus gambelii*) either alone, or with serviceberry (*Amelanchier alnifolia* or *A. utahensis*), big sagebrush (*Artemisia tridentata*), mountain mahogany (*Cercocarpus* spp.), bitterbrush (*Purshia* spp.) or snowberry (*Symphoricarpos* spp). In some places stands of montane shrublands dominated by these and other species are intermingled and Gambel oak is absent or a minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics. Although this is a shrub-dominated system, some trees may be present. In well-developed sites, some of the shrubs may grow to tree-like sizes. Adjacent communities often include mixed conifer forests, aspen forests at higher elevations, and pinyon-juniper woodlands at lower elevations. Sagebrush shrubland or steppe, and montane to foothills grasslands may also be part of the adjacent landscape.

Diagnostic Characteristics

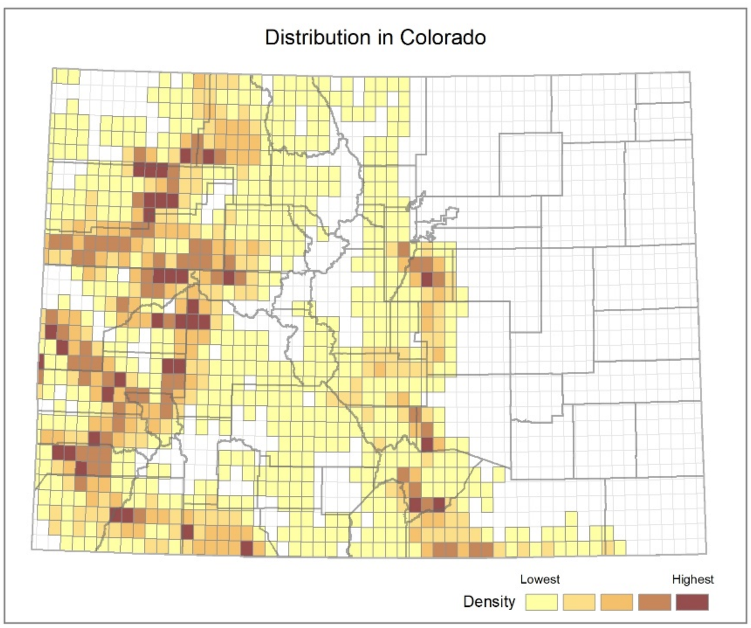
These are mixed-species shrublands characterized by taller shrubs. Gambel oak is usually dominant, but some areas may be dominated by other shrubs including serviceberry, big sagebrush, mountain mahogany, or other mesic montane species.

Similar Systems

Rocky Mountain Lower Montane-Foothill Shrubland: In general, these are mixed shrublands in drier areas where Gambel oak (*Quercus gambelii*) is absent, although they may intergrade in places with oak/mixed mountain shrublands.

Range

Rocky Mountain Gambel oak-Mixed Montane shrublands occur in the mountains, plateaus, and foothills in the southern Rocky Mountains and Colorado Plateau ecoregions, including the Uinta and Wasatch ranges and the Mogollon Rim. It also extends into the high mountains of the Trans-Pecos of Texas. Oak and mixed mountain shrublands are widespread in the western half of Colorado, and along the southern stretch of the eastern mountain front.



Spatial pattern

Rocky Mountain Gambel Oak-Mixed Montane Shrubland is a large patch type.

Environment

This ecological system typically occupies the lower slope positions of the foothill and lower montane zones where it may occur on level to steep slopes, cliffs, escarpments, rimrock slopes, rocky outcrops, and scree slopes. Climate is semi-arid and characterized by mostly hot-dry summers with mild to cold winters and annual precipitation of 25-70 cm in (10-27). Precipitation mostly occurs as winter snows but may also consist of some late summer rains. Substrates are variable and include soil types ranging from calcareous, heavy, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. Soils are typically poorly developed, rocky to very rocky, and well-drained. Parent materials include alluvium, colluvium, and residuum derived from igneous, metamorphic, or sedimentary rocks such as granite, gneiss, limestone, quartz, monzonite, rhyolite, sandstone, schist, and shale.

In general, the upper and lower elevational limits of Gambel oak shrublands are believed to be controlled by temperature and moisture stress. At more northern latitudes, the zone of tolerable

cold stress is found at lower elevations, but, at the same time, the areas where summer moisture stress is tolerable are at higher elevations. The northern distributional limit of Gambel oak corresponds to the point where these two opposing factors converge.

Vegetation

Stands dominated by Gambel oak are common in the southern part of Colorado, but are completely interspersed with stands dominated by other shrub species, especially serviceberry (*Amelanchier* spp.) and mahogany (*Cercocarpus* spp.) at higher elevations. The vegetation is typically dominated by Gambel oak alone or codominant with Saskatoon serviceberry (*Amelanchier alnifolia*), Utah serviceberry (*Amelanchier utahensis*), big sagegrush (*Artemisia tridentata*), mountain mahogany (*Cercocarpus montanus*), chokecherry (*Prunus virginiana*), Stansbury cliffrose (*Purshia stansburiana*), antelope bitterbrush (*Purshia tridentata*), mountain snowberry (*Symphoricarpos oreophilus*), or roundleaf snowberry (*Symphoricarpos rotundifolius*). Vegetation types in this system may occur as sparse to dense shrublands composed of mid to tall shrubs. Occurrences may be multi-layered, with some short shrubby species occurring in the understory of the dominant overstory species. Occurrences can range from dense thickets with little understory to relatively mesic mixed-shrublands with a rich understory of shrubs, grasses and forbs. These shrubs often have a patchy distribution with grass growing in between. Scattered trees are occasionally present in stands and typically include species of pine or juniper. Annual grasses and forbs are seasonally present, and weedy annuals are often present, at least seasonally.

Non-oak dominated montane shrublands are of variable species composition, depending on site conditions such as elevation, slope, aspect, soil type, moisture availability, and past history. Species present may include mountain mahogany (*Cercocarpus montanus*), skunkbush sumac (*Rhus trilobata*), cliff fendlerbush (*Fendlera rupicola*), antelope bitterbrush (*Purshia tridentata*), wild crab apple (*Peraphyllum ramosissimum*), snowberry (*Symphoricarpos* spp.), and serviceberry (*Amelanchier* spp.).

Plant Associations

CEGL002569	Amelanchier alnifolia / Symphoricarpos oreophilus Shrubland
CEGL003817	Amelanchier utahensis - Fendlera rupicola Shrubland
CEGL001068	Amelanchier utahensis - Mixed Shrub / Carex geyeri Shrubland
CEGL001069	Amelanchier utahensis / Pseudoroegneria spicata Shrubland
CEGL001067	Amelanchier utahensis Shrubland
CEGL002696	Arctostaphylos patula Shrubland
CEGL002783	Jamesia americana - (Physocarpus monogynus, Holodiscus dumosus) Rock Outcrop Shrubland
CEGL002967	Juniperus scopulorum - Quercus gambelii Woodland
CEGL001113	Quercus gambelii - Cercocarpus montanus / (Carex geyeri) Shrubland
CEGL002341	Quercus gambelii - Holodiscus dumosus Shrubland
CEGL001109	Quercus gambelii / Amelanchier alnifolia Shrubland
CEGL001110	Quercus gambelii / Amelanchier utahensis Shrubland
CEGL001111	Quercus gambelii / Artemisia tridentata Shrubland
CEGL005995	Quercus gambelii / Carex geyeri Shrubland

CEGL001112	Quercus gambelii / Carex inops ssp. heliophila Shrubland
CEGL002805	Quercus gambelii / Festuca thurberi Shrubland
CEGL002915	Quercus gambelii / Hesperostipa comata Shrubland
CEGL001114	Quercus gambelii / Paxistima myrsinites Shrubland
CEGL002949	Quercus gambelii / Poa fendleriana Shrubland
CEGL005994	Quercus gambelii / Prunus virginiana Shrubland
CEGL002338	Quercus gambelii / Rhus trilobata Shrubland
CEGL002337	Quercus gambelii / Sparse Understory Shrubland
CEGL001117	Quercus gambelii / Symphoricarpos oreophilus Shrubland
CEGL002477	Quercus gambelii Shrubland

Associated Animal species

Oak and mixed mountain shrublands are important habitat for mule deer (*Odocoileus hemionus*) and black bear (*Ursus americanus)*. Other mammals found in this habitat include elk (*Cervus elaphus*), mountain lion (*Felis concolor*)*,* bobcat (*Felis rufus)*, coyote (*Canis latrans)*, skunk (Family *Mephitidae)*, poucupine (*Erethizon dorsatum*)*,* Abert's squirrel (*Sciurus aberti*), rock squirrel (*Otospermophilus variegatus*), chipmunks (*Neotamias* spp.), and Mexican woodrat (*Neotoma mexicana*). Bird species include Wild Turkey (*Meleagris gallopavo*), Virginia's Warbler (*Oreothlypis virginiae*), Green-tailed Towhee (*Pipilo chlorurus*), Spotted Towhee (*Pipilo maculatus*), Dusky Flycatcher (*Empidonax oberholseri*), Woodhouse's Scrub-Jay (*Aphelocoma woodhouseii)*, Blue-gray Gnatcatcher (*Polioptila caerulea*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Orange-crowned Warbler (*Oreothlypis celata*), and Broad-tailed Hummingbird (*Selasphorus platycercus*).

Dynamic processes

The shrub growth form of the dominant species, and ability to quickly colonize new areas make this system highly resilient to disturbance, and tolerant of fire. Fire causes die-back of the dominant shrub species in some areas, promotes stump sprouting of the dominant shrubs in other areas, and controls the invasion of trees into the shrubland system. Density and cover of Gambel oak and serviceberry often increase after fire. Gambel oak reproduces primarily by sprouting of new stems, especially after disturbances such as brush control, fire, and grazing, although recruitment from seedlings does occur. The extensive clonal root system of Gambel oak is a primary contributor to its ability to survive during periods when seedling establishment is impossible. Most of the other shrub species reproduce both vegetatively and by seedling recruitment, as well as resprouting easily after fire. Natural fires typically result in a system with a mosaic of dense shrub clusters and openings dominated by herbaceous species. Variable disturbance patterns may account for the local dominance of a particular species.

Management

Because oak is generally unpalatable to cattle, livestock grazing can facilitate the increase of oak cover at the expense of understory grasses. Livestock grazing has degraded the understory grass community of some oak stands, and cheatgrass and knapweed have become established in some areas. Mixed mountain shrublands are generally less impacted by invasives.

Oak shrublands are most vulnerable to drought and variability of late frosts. The vulnerability of other mountain shrub species is not well known. The ability to resprout after disturbance increases shrub resilience. Oak and mixed mountain shrublands have comparatively low vulnerability to the effects of climate change by mid-century. Primary vulnerability-reducing factors are the wide ecological amplitude of these shrublands in Colorado, and their ability to withstand or recover from disturbance relatively quickly, which offsets the lower landscape condition score due to past anthropogenic disturbance levels.

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Rocky Mountain Lodgepole Pine Forest

General Description

This ecological system is widespread in upper montane to subalpine elevations of the Rocky Mountains, Intermountain region, and north into the Canadian Rockies. In Colorado, lodgepole does not naturally occur south of northern Saguache County. Occurrences are extensive stands of almost exclusively lodgepole pine (*Pinus contorta*), with a sparse shrub or herbaceous understory, at elevations of about 2,440 to 3,350 m (8,000 to 11,000 ft). Common understory species include the low-growing ericaceous shrubs bearberry (*Arctostaphylos uva-ursi*), and blueberry (*Vaccinium* spp.). Sparse patches of grasses and forbs are found where a canopy opening permits light to penetrate. The structure of lodgepole pine forests is driven by fire history in combination with local soil and topography. Most forests in this ecological system are early to mid-successional forests which developed following fires. Following stand-replacing fires, lodgepole pine will rapidly colonize and develop into dense, even-aged stands. Under fire suppression, older, dense stands have experienced significant mortality from mountain pine beetle outbreaks.

Diagnostic Characteristics

This system is characterized by extensive stands of almost exclusively lodgepole pine (*Pinus contorta*). Some stands are intermingled with adjacent stands of mixed conifer (at lower

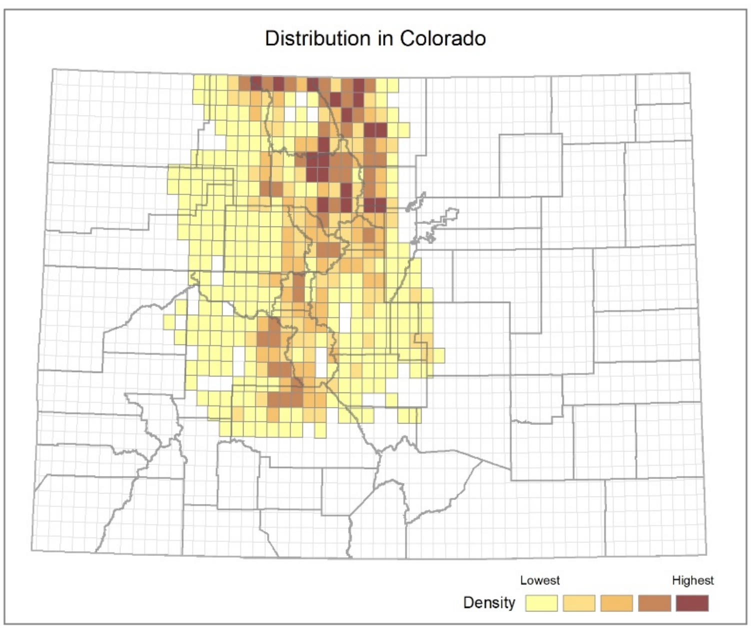
elevations), or spruce-fir and quaking aspen forest (at higher elevations). Mature stands are often easy to pass through due to the quite sparse shrub or herbaceous understory. In Colorado, many occurrences are currently dominated by standing dead trees due to a severe outbreak of mountain pine beetle. Cleared or burned areas may support dense stands of young lodgepole pine.

Similar Systems

Rocky Mountain Subalpine Spruce-Fir Forest and Woodland: These forests and woodlands are extensive at and above elevations supporting lodgepole pine forests, and may intermingle with them. Although lodgepole pine may be present, Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) dominate the canopy, either together or alone. Understory vegetation cover is typically much greater and more diverse in spruce-fir forests.

Range

Rocky Mountain Lodgepole Pine Forests are widespread in upper montane to subalpine elevations of the Rocky Mountains, Intermountain region, and north into the Canadian Rockies. In Colorado, lodgepole does not naturally occur south of northern Saguache County.



Spatial pattern

Rocky Mountain Lodgepole Pine Forests are a matrix-forming type.

Environment

Soils supporting these forests are typically well-drained, gravelly, have coarse textures, are acidic, and rarely formed from calcareous parent materials. In Colorado, lodgepole pine forests generally occur between 2,440 to 3,350 m (8,000 to 11,000 ft) on gentle to steep slopes on all aspects. In southern Colorado, white fir (*Abies concolor*) appears to take the place of lodgepole pine in coniferous forests of similar elevations.

Lodgepole pine is a northern species that can tolerate a wide range of annual precipitation patterns, from fairly dry to fairly wet, but generally grows only where annual precipitation is at least 18-20 inches. These forests are found on drier sites than spruce-fir forest, although snowfall is typically heavy. Summers are often quite dry, and lodgepole pine is dependent on snowmelt moisture for most of the growing season. Lodgepole pine is tolerant of very low winter temperatures, and in many lodgepole forests summer temperatures can fall below freezing, so there is no true frost-free season.

Vegetation

These forests are dominated by Rocky Mountain lodgepole pine (*Pinus contorta* var. *latifolia*) with shrub, grass, or barren understories. Many stands consist of only lodgepole pine, but others are intermingled with mixed conifer or quaking aspen stands (the latter occurring with inclusions of deeper, typically fine-textured soils). Shrub and herbaceous layers are often poorly developed in lodgepole pine forests, and plant species diversity is low. Some common understory shrubs include kinnikinnick (*Arctostaphylos uva-ursi*), snowbrush ceanothus (*Ceanothus velutinus*), twinflower (*Linnaea borealis*), creeping barberry (*Mahonia repens*), antelope bitterbrush (*Purshia tridentata*), dwarf bilberry (*Vaccinium caespitosum*), whortleberry (*Vaccinium myrtillus*), grouse whortleberry (*Vaccinium scoparium*), and currant (*Ribes* spp.).

Plant Associations

CEGL002167	Ceanothus velutinus Shrubland
CEGL000141	Pinus contorta / Carex geyeri Forest
CEGL000144	Pinus contorta / Carex rossii Forest
CEGL005933	Pinus contorta / Jamesia americana Forest
CEGL000764	Pinus contorta / Juniperus communis Woodland
CEGL005934	Pinus contorta / Rock Woodland
CEGL000163	Pinus contorta / Shepherdia canadensis Forest
CEGL000168	Pinus contorta / Vaccinium cespitosum Forest
CEGL005935	Pinus contorta / Vaccinium myrtillus Forest
CEGL000172	Pinus contorta / Vaccinium scoparium Forest

Associated Animal species

Few species make extensive use of these forests, but they provide cover for cover for mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), black bear (*Ursus americanus*) and a variety of birds and small mammals. The pine squirrel (also called chickaree, *Tamiasciurus hudsonicus*) is often encountered. Bird species include Ruby-crowned Kinglet (*Regulus calendula*), Yellow-rumped Warbler (*Setophaga coronata*), Red Crossbill (*Loxia curvirostra*), Pine Siskin (*Spinus pinus*), Hermit Thrush (*Catharus guttatus*), and Mountain Chickadee (*Poecile gambeli*). Small ponds and associated mesic habitat within these forests may support wood frog (*Lithobates sylvatica*), boreal toad (*Anaxyrus boreas boreas)*, and barred tiger salamander (*Ambystoma mavortium*).

Dynamic processes

Lodgepole pine is a rapidly colonizing, shade-intolerant conifer which usually occurs in lower subalpine forests in the major ranges of the western United States. Establishment is episodic and linked to stand-replacing disturbances, primarily fire. The frequency of natural fires in Rocky Mountain lodgepole pine stands ranges from a few years to 200 or more years. Low to moderate serverity surface fires are likely to have a return interval on the order of a few decades, while stand-replacing fires are generally less frequent.

The incidence of serotinous cones varies within and between varieties of lodgepole pine, and is most prevalent in Rocky Mountain populations. Closed, serotinous cones appear to be strongly

favored by fire, and allow rapid colonization of fire-cleared substrates. In stands having a multi-aged population structure, with regeneration occurring, there is typically a higher proportion of trees bearing nonserotinous cones.

Management

Lodgepole forests in Colorado have experienced significant mortality due to the mountain pine beetle, and the interaction of this factor with increased fire and drought frequency and intensity could lead to conspicuous changes in the future extent and form of these forests. Warming temperatures and effectively drier conditions are expected to have an effect on fire frequency and severity. Fire suppression effects in lodgepole pine forests are evident at a landscape level in an overall lack of variety in successional stages. Thinning and salvage logging are a source of disturbance.

Lodgepole pine forest is moderately vulnerable to the effects of climate change by mid-century. Primary contributing factors are its vulnerability to forest disturbances that may increase in the future, and the fact that it is at the southern edge of its distribution in Colorado. Lodgepole forests in Colorado have experienced significant mortality due to the mountain pine beetle, and the interaction of this factor with increased fire and drought frequency and intensity could lead to conspicuous changes in the future extent and form of these forests. Lodgepole stands near the southern end of the range may be lost.

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Rocky Mountain Subalpine Spruce-Fir Forest and Woodland

General Description

Colorado combines Rocky Mountain spruce-fir types into a single ecological system. Spruce-fir dry-mesic forest and spruce-fir moist-mesic forest together form the primary matrix system of the subalpine zones of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico and the Intermountain region. In Colorado these forests are found throughout the mountainous portion of the state at elevations of 2,680 to 3,780 m (8,800-12,400 ft), generally up to the alpine zone, where stunted individual trees form a krummholz dwarf forest. Spruce-fir forest typically dominates the wettest and coolest habitats below treeline. These areas are characterized by long, cold winters, heavy snowpack that may persist until late summer, and short, cool summers where frost is common. Moist-mesic occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, and often grade into subalpine riparian forests. Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire. Stand replacing fires are estimated to occur at intervals of about 300 years for dry-mesic areas, and longer (350-400 years) for more mesic sites. Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) dominate the canopy, either together or alone. Lodgepole pine (*Pinus contorta*) or quaking aspen (*Populus tremuloides*) stands are common in many occurrences. Common understory species may include heartleaf arnica (*Arnica cordifolia*),

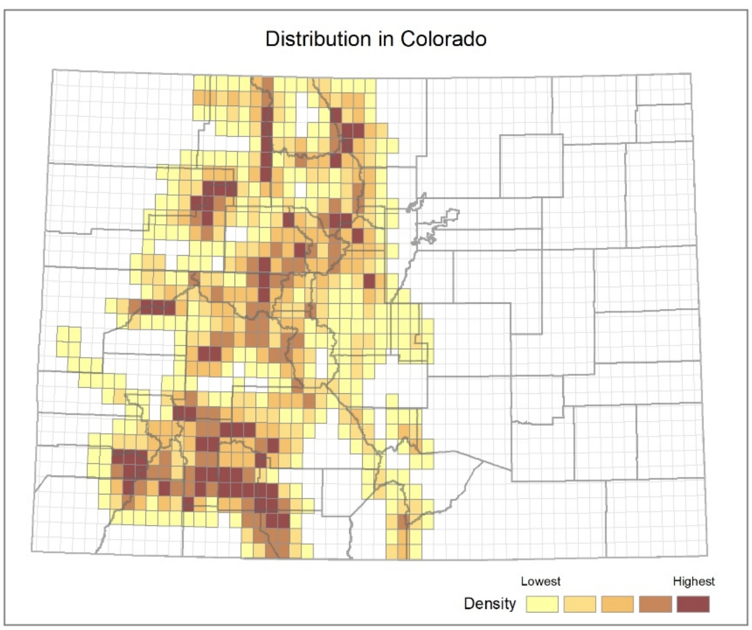
Geyer's sedge (*Carex geyeri*), fleabane (*Erigeron* spp.), strawberry (*Fragaria virginiana*), common juniper (*Juniperus communis*), silvery lupine (*Lupinus argenteus*), lousewort (*Pedicularis* spp.), smallflowered woodrush (*Luzula parviflora*), little false Solomon's-seal (*Maianthemum stellatum*), tall fringed bluebells (*Mertensia ciliata*), Jacob's-ladder (*Polemonium pulcherrimum*), gooseberry currant (*Ribes montigenum*), and whortleberry (*Vaccinium* spp.). Many other forbs may be present, typically with very low cover, and varying according to microsite conditions. Litter and duff typically form a thick layer under mature stands.

Diagnostic Characteristics

Spruce-fir dominated stands occur on all but the most xeric sites above 3,050 m (10,000 ft), and in cool, sheltered valleys at elevations as low as 2,680 m (8,800 ft). The relative dominance of the two canopy tree species and the understory composition vary substantially over a gradient from excessively moist to xeric sites. Spruce-fir forest treeline elevation, species composition, and dominance change with latitude. Subalpine fir (*Abies lasiocarpa*) increases in importance with increasing latitude, and shares dominance with Engelmann spruce (*Picea engelmannii*) at tree line over the northern half of the Southern Rocky Mountains ecoregion. In north-central Colorado, "ribbon forest" stands of spruce-fir forest occur as islands or long narrow stands of trees in open meadow areas.

Similar Systems

Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland: These matrix-forming conifer-dominated forests are often adjacent to, and may intermingle with spruce-fir forest at elevations of up to 3,050 m (10,000 ft). Although they may include some Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*), they are characterized by Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*), often with other species including limber pine (*Pinus flexilis*) and quaking aspen (*Populus tremuloides*).



Range

Spruce-fir dry-mesic forest and spruce-fir moist-mesic forest together form the primary matrix system of the subalpine zones of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico and the Intermountain region. In Colorado these forests are found throughout the mountainous portion of the state at elevations of 2,680 to 3,780 m (8,800-12,400 ft).

Spatial pattern

Spruce-fir dry-mesic forest and spruce-fir moist-mesic forest together are matrix-forming; moist-mesic areas may occur as large patches within the dry-mesic matrix.

Environment

These high elevation forests form the matrix of the subalpine zone. Sites are cold, and precipitation is primarily in the form of snow. These forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, high plateaus, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Moist-mesic occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines.

The length of the growing season is particularly important for both alpine and subalpine zones, and for the transition zone between alpine vegetation and closed forest (treeline). Treeline-controlling factors operate at different scales, ranging from the microsite to the continental. On a global or continental scale, there is general agreement that temperature is a primary determinant of treeline. At more local scales, soil properties, slope, aspect, topography, and their effect on moisture availability, in combination with disturbances such as avalanche, grazing, fire, pests, disease, and human impacts all contribute to the formation of treeline. Patterns of snow depth and duration, wind, insolation, vegetation cover, and the autecological tolerances of each tree species influence the establishment and survival of individuals within the treeline ecotone.

Vegetation

Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) dominate the canopy, either together or alone. Lodgepole pine (*Pinus contorta*) or quaking aspen (*Populus tremuloides*) stands are common in many occurrences. Common understory species may include heartleaf arnica (*Arnica cordifolia*), Geyer's sedge (*Carex geyeri*), fleabane (*Erigeron* spp.), strawberry (*Fragaria virginiana*), common juniper (*Juniperus communis*), silvery lupine (*Lupinus argenteus*), lousewort (*Pedicularis* spp.), smallflowered woodrush (*Luzula parviflora*), little false Solomon's-seal (*Maianthemum stellatum*), tall fringed bluebells (*Mertensia ciliata*), Jacob's-ladder (*Polemonium pulcherrimum*), gooseberry currant (*Ribes montigenum*), and whortleberry (*Vaccinium* spp.). Many other forbs may be present, typically with very low cover, and varying according to microsite conditions. Litter and duff typically form a thick layer under mature stands.

Plant Associations

CEGL000304	Abies lasiocarpa - Picea engelmannii / Carex geyeri Forest
CEGL000919	Abies lasiocarpa - Picea engelmannii / Juniperus communis Woodland
CEGL000321	Abies lasiocarpa - Picea engelmannii / Moss Forest
CEGL000373	Abies lasiocarpa - Picea engelmannii / Polemonium pulcherrimum Forest
CEGL000340	Abies lasiocarpa - Picea engelmannii / Vaccinium cespitosum Forest
CEGL000343	Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus Forest
CEGL000344	Abies lasiocarpa - Picea engelmannii / Vaccinium scoparium Forest
CEGL000985	Abies lasiocarpa - Picea engelmannii Krummholz

CEGL000305	Abies lasiocarpa / Carex rossii Forest
CEGL000325	Abies lasiocarpa / Pedicularis racemosa Forest
CEGL000364	Picea engelmannii / Erigeron eximius Forest
CEGL000366	Picea engelmannii / Geum rossii Forest
CEGL000368	Picea engelmannii / Hypnum revolutum Forest
CEGL000377	Picea engelmannii / Trifolium dasyphyllum Forest
CEGL000379	Picea engelmannii / Vaccinium myrtillus Forest
CEGL000381	Picea engelmannii / Vaccinium scoparium Forest
CEGL000294	Abies lasiocarpa - Picea engelmannii / Acer glabrum Forest
CEGL000300	Abies lasiocarpa - Picea engelmannii / Calamagrostis canadensis Swamp Forest
CEGL000331	Abies lasiocarpa - Picea engelmannii / Ribes (montigenum, lacustre, inerme) Forest
CEGL000986	Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca) Krummholz
CEGL000328	Abies lasiocarpa - Picea engelmannii Ribbon Forest
CEGL000310	Abies lasiocarpa / Erigeron eximius Forest
CEGL000332	Abies lasiocarpa / Rubus parviflorus Forest
CEGL000364	Picea engelmannii / Erigeron eximius Forest
CEGL000371	Picea engelmannii / Moss Forest
CEGL000374	Picea engelmannii / Ribes montigenum Forest
CEGL000527	Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest
CEGL002899	Betula glandulosa / Sphagnum spp. Shrub Fen

Associated Animal species

Mammals of these high elevation forests include elk (*Cervus elaphus*), lynx (*Lynx canadensis*), pine marten (*Martes americana*), ermine (*Mustela erminea*), snowshoe hare *(Lepus americanus*), American pika (*Ochotona princeps*), Yellow-bellied marmot (*Marmota flaviventris*), pine squirrel (also called chickaree *Tamiasciurus hudsonicus*) and various small rodents. Boreal toad (*Anaxyrus boreas boreas*) and western terrestrial garter snake (*Thamnophis elegans*) may be found in this habitat. Bird species include Boreal Owl (*Aegolius funereus*), Ruby-crowned Kinglet (*Regulus calendula*), Hermit Thrush (*Catharus guttatus*), Mountain Chickadee (*Poecile gambeli*), Yellow-rumped Warbler (*Setophaga coronata*), Pine Siskin (*Spinus pinus*), Dark-eyed Junco (*Junco hyemalis*), Pine Grosbeak (*Pinicola enucleator*), Canada Jay (often called Gray Jay in Colorado, *Perisoreus canadensis*), Red-Breasted Nuthatch (*Sitta canadensis*), Dusky grouse (*Dendragapus obscurus*), and American Three-toed Woodpecker (*Picoides dorsalis*). In treeline krummholz stands White-crowned Sparrow (*Zonotrichia leucophrys*), Mountain Bluebird (*Sialia currucoides*), Clark's Nutcracker (*Nucifraga columbiana*) are often observed.

Dynamic processes

Engelmann spruce trees can be very long-lived, reaching 500 years of age. This species can rapidly recolonize and dominate burned or cleared sites, or can succeed other species such as lodgepole pine (*Pinus contorta*) or quaking aspen (*Populus tremuloides*). Seedling establishment and survival are greatly affected by the balance of snow accumulation and snowmelt. Soil moisture, largely provided by snowmelt, is crucial for seed germination and survival. Although snowpack insulates seedlings and shields small trees from wind desiccation, its persistence shortens the growing season and can reduce recruitment.

Fire, spruce-beetle outbreaks, avalanches, and windthrow all play an important role in shaping the dynamics of spruce-fir forests. Old-growth in spruce-fir forests is characterized by treefall and windthrow gaps in the canopy, with large downed logs, rotting woody material, tree seedling establishment on logs or on mineral soils unearthed in root balls, and snags. Fires in the subalpine forest are typically stand replacing, resulting in the extensive exposure of mineral soil and initiating the development of new forests. Stand replacing fires are estimated to occur at intervals of about 300 years for dry-mesic areas, and longer (350-400 years) for more mesic sites. Fire return intervals, intensity, and extent depend on a variety of local environmental factors. Fire is much less important in krummholz communities. Spruce beetle (*Dendroctonus rufipennis*) outbreaks may be as significant as fire in the development of spruce-fir forests. Blowdowns involving multiple treefalls add to the mosaic of spruce-fir stands. Under a natural disturbance regime, subalpine forests were probably characterized by a mosaic of stands in various stages of recovery from disturbance, with old-growth just one part of the larger forest mosaic. This mosaic was constantly changing and highly variable from place to place, so the extent of presettlement old-growth forest is uncertain.

Management

Spruce-fir forest landscapes in Colorado are generally in very good condition, well protected, and minimally impacted by anthropogenic disturbance. Areas of severe beetle-kill may experience increased disturbance from salvage logging or hazard tree cutting. Because natural fire return intervals in these habitats are long, fire suppression has not had widespread effects on the condition of spruce-fir habitat. At a landscape scale, however, age structures of spruce-fir forest are probably somewhat altered from pre-settlement conditions. Spruce-fir forests are subject to disturbance by recreational use, hunting, livestock grazing, mining, and logging, but in general, threats from housing, roads, and recreational development and similar anthropogenic disturbance are minor for spruce-fir habitats.

Climate change projections indicate an increase in droughts and faster snowmelt, which could increase forest fire frequency and extent, as well as insect outbreaks within this ecosystem. It is not known if spruce-fir forests will be able to regenerate under such conditions, especially in lower elevation stands, and there is a potential for a reduction or conversion to other forest types, depending on local site conditions. The vulnerability of these forests to warmer temperatures, drought, and increased mortality from insect outbreaks are primary factors contributing to vulnerability. The restriction of this habitat to higher elevations and its relatively narrow biophysical envelope, slow-growth, and position near the southern end of its distribution in Colorado are additional factors. However, there may be a lag time before the effects of changing climate are evident.

Original concept authors R. Crawford, M.S. Reid, C. Chappell and G. Kittel; Jan 2007 & Mar 2010
Colorado version authors Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: July 2019

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Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland

General Description

This large patch ecological system occurs throughout the Rocky Mountains on dry, rocky ridges and slopes. In Colorado, The elevational range of 2,740 to 3,660 m (9,000 to 12,000 ft), is similar to that of spruce-fir forest, however bristlecone pine (*Pinus aristata*) is found on generally drier sites. These are typically open-canopy woodlands of xeric, high elevation sites where desiccating winds, rocky substrates and a short growing season limit plant growth. Limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus aristata*) do not necessarily occur together, but the two species occupy a similar ecological niche, often near the edge of tolerable conditions for tree growth. This species of bristlecone pine is more-or-less endemic to the Southern Rocky Mountain ecoregion south of the 40th parallel. Limber pine is more widely distributed, ranging further north, and also occurs in mixed conifer systems. Where the two species co-occur, there may be a tendency for limber pine to be restricted to the most xeric part of the site. Other trees, including juniper (*Juniperus* spp.) ponderosa pine (*Pinus ponderosa*), or Douglas-fir (*Pseudotsuga menziesii*) may also occur. An open shrub layer or sparse herbaceous layer of xeric species may be present.

Diagnostic Characteristics

These are coniferous woodlands of dry, high elevation sites where tree growth is difficult. Stands are characterized by the dominance of either bristlecone or limber pine. These trees can be exceptionally long-lived. Limber pine has a wide elevational niche, and can occur at both upper and lower treeline.

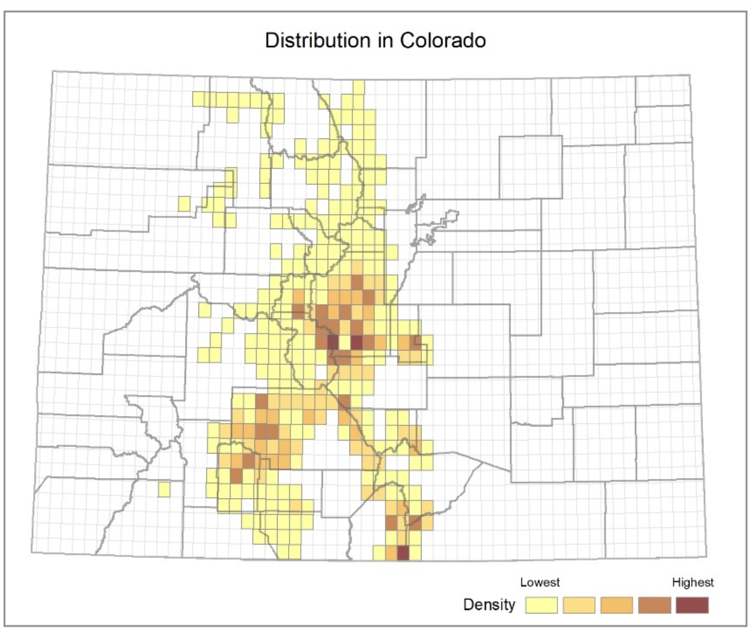
Similar Systems

Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland: Both limber pine and bristlecone pine may occur as part of the mixed conifer canopy, but these mixed forests and woodlands are generally found on more mesic areas allowing greater plant growth and species diversity. The limber-bristlecone woodland may intergrade with mixed conifer forest on very dry sites.

Rocky Mountain Foothill Limber Pine-Juniper Woodland: These are lower-treeline woodlands, generally below ponderosa pine woodlands or mixed conifer forest, and may extend out onto eastern foothills, rocky breaks, and escarpments on the plains in areas protected from fire. Bristlecone pine is absent from these sparse woodlands.

Range

Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland occurs throughout the Rocky Mountains south of Montana, into northern New Mexico. In Colorado, northern occurrences are dominated by limber pine. Bristlecone pine becomes dominant in South Park and the Cochetopa Hills.



Spatial pattern

Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland is a large patch ecological system.

Environment

These woodlands are found on harsh, dry sites exposed to desiccating winds. The growing season is short, precipitation is low, and substrates are rocky and generally scoured free of snow by wind. Plant growth under such conditions is limited. Limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus aristata*) do not necessarily occur together, but the two species occupy a similar ecological niche, often near the edge of tolerable conditions for tree growth. In

more mesic areas, these species are replaced by more rapidly growing species such as Engelmann spruce (*Picea engelmannii*).

Vegetation

The open tree canopy is often patchy and is strongly dominated by limber pine (*Pinus flexilis*) or bristlecone pine (*Pinus aristata*), depending on latitude and elevation. In northern Colorado, limber pine is more abundant and occupies a very wide elevational range. South of I-70, limber pine is gradually replaced by bristlecone pine at the highest elevations, then at progressively lower elevations, south into New Mexico. Other trees that are occasionally present include juniper (*Juniperus* spp.), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), or Douglas-fir (*Pseudotsuga menziesii*). The typically sparse understory may be shrubby or grassy. Shrub species include kinnikinnick (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), creeping barberry (*Mahonia repens*), antelope bitterbrush (*Purshia tridentata*), gooseberry currant (*Ribes montigenum*), or whortleberry (*Vaccinium* spp). These woodlands are often adjacent to dry subalpine grasslands or alpine turf, and the herbaceous layer often includes species from these systems. Grasses present may include purple reedgrass (*Calamagrostis purpurascens*), Arizona fescue (*Festuca arizonica*), Thurber fescue (*Festuc*a thurberi), spike fescue (*Leucopoa kingii*) or bluebunch wheatgrass (*Pseudoroegneria spicata*).

Plant Associations

CEGL000759	Pinus aristata / Festuca arizonica Woodland
CEGL000760	Pinus aristata / Festuca thurberi Woodland
CEGL002894	Pinus aristata / Juniperus communis Woodland
CEGL000761	Pinus aristata / Ribes montigenum Woodland
CEGL000762	Pinus aristata / Trifolium dasyphyllum Woodland
CEGL002895	Pinus aristata / Vaccinium myrtillus Woodland
CEGL005415	Pinus aristata Krummholz
CEGL000802	Pinus flexilis / Arctostaphylos uva-ursi Woodland
CEGL000803	Pinus flexilis / Calamagrostis purpurascens Woodland
CEGL005416	Pinus flexilis / Festuca arizonica - Muhlenbergia montana Woodland
CEGL000807	Pinus flexilis / Juniperus communis Woodland
CEGL000810	Pinus flexilis / Leucopoa kingii Woodland

Associated Animal species

These dry and exposed high-elevation woodlands provide less suitable animal habitat than most other forested habitats. Seeds of the dominant conifers are used by Clark's nutcrackers (*Nucifraga columbiana*), Steller's jays (*Cyanocitta stelleri*), chipmunks (*Neotamias* spp.), and golden-mantled ground squirrels (*Callospermophilus lateralis*). Additional species occasionally observed in this habitat include the Canada Jay (often called Gray Jay in Colorado, *Perisoreus canadensis*), Red Crossbill (*Loxia curvirostra*), Pine Grosbeak (*Pinicola enucleator*), and Cassin's Finch (*Haemorhous cassinii*). Mammals may also include porcupine (*Erethizon dorsatum)*, bushy-tailed woodrat (*Neotoma cinerea*), and deer mice (*Peromyscus maniculatus*).

Dynamic processes

Fire intervals are highly variable in this system, with some stands experiencing low-intensity, fairly frequent fires that do not kill many trees, and leave fire-scarred individuals in open, grassy stands. Stand-replacing fire may be more typical in other settings. Although these five-needle pines are not completely dependent on fire for regeneration, they are both colonizing pioneer species on disturbed areas, and are better able to colonize harsher sites compared to other tree species. Both bristlecone pine and limber pine, however are also slow-growing, long-lived trees in which individuals may live for 1000 or more years, and so are not necessarily only early-seral species. The oldest trees are found on extremely arid sites, such as bedrock, talus slopes, and south-facing slopes where sparse fuels prevent the spread of fire.

Limber pine seeds are comparatively large, and typically dispersed by Clark's nutcrackers, which can carry the seeds some distance before caching them. Bristlecone pine has smaller, winged seeds that are often wind dispersed, but that may also be collected and cached by nutcrackers, Steller's jays, chipmunks, and golden-mantled ground squirrels. Seedlings are generally hardy and drought-tolerant.

Management

Five-needle pines, including bristlecone and limber pine are highly susceptible to declines caused by a combination of attack by mountain pine beetles, and infection by white pine blister rust. It is important to protect stands where trees have proven to be resistant to the rust infection. Research is ongoing regarding the interaction of these two mortality-causing agents, and the potential for changing climate conditions to exacerbate the declines.

Original concept authors K.A. Schulz; Jan 2014
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: July 2019

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Southern Rocky Mountain Juniper Woodland and Savanna

General Description

This ecological system occupies lower and warmer elevations, primarily along the eastern and southern edge of the southern Rockies and Arizona-New Mexico mountains. In the canyons and tablelands of the southern Great Plains this system forms extensive cover at some distance from the mountain front. In Colorado, this system is largely confined to the southeastern plains where it forms an extensive matrix with the Southwestern Great Plains Canyon ecological system. Elevations in this area range from 1,430 to 1,800 m (4,700 to 5,900 ft). This system varies from a savanna with widely spaced mature juniper trees in a grassland understory to more densely wooded juniper stands with sparser understory growth. One-seed juniper (*Juniperus monosperma*) is most typical of Colorado occurences, and occasional two-needle pinyon (*Pinus edulis*) may be present. These woodlands intergrade with surrounding shrubland and grassland communities, and have many shrub and graminoid species in common. Grasses are similar to those found in adjacent Western Great Plains Shortgrass Prairie, with blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), and James' galleta (*Pleuraphis jamesii*) being most common. Shrubby succulents including soapweed (*Yucca* spp.) and pricklypear or cholla (*Opuntia* or *Cylindropuntia* spp.) are typically present.

FOREST & WOODLAND

Diagnostic Characteristics

These are open to moderately dense savannas and woodlands of breaks, mesa slopes, and canyon or arroyo rims on Colorado's eastern plains. The canopy is dominated primarily by one-seed juniper, with only occasional pinyon pine in places. Some areas can be characterized as scarp woodlands, with trees occurring in a fairly narrow band on rocky, seldom burned areas below the scarp rim, and above the adjacent plain.

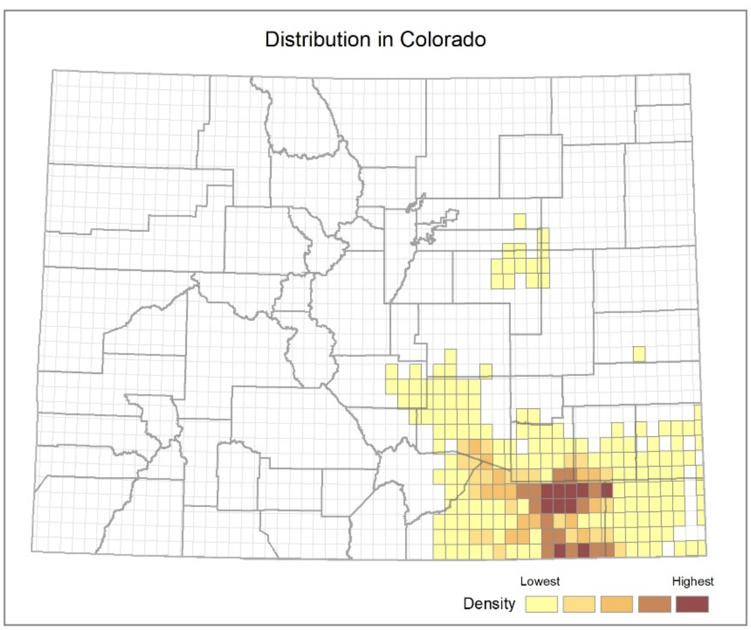
Similar Systems

<u>Southern Rocky Mountain Pinyon-Juniper Woodland</u>: These mixed woodlands where two-needle pinyon pine co-dominates with one-seed juniper are generally found at higher elevations in the foothill to lower montane areas of southeastern Colorado. Associated species are more typical of southern Rocky Mountains than the Great Plains.

<u>Southwestern Great Plains Canyon</u>: The edges of these canyons intergrade with the juniper woodland and savanna. In some instances, stands of juniper woodland and savanna can be considered part of the canyon matrix but extensive stands of juniper woodland are not included in the canyon system.

Range

Southern Rocky Mountain Juniper Woodland and Savanna is found at lower and warmer elevations, primarily along the eastern and southern edge of the southern Rockies and Arizona-New Mexico mountains. In the canyons and tablelands of the southern Great Plains this system forms extensive cover at some distance from the mountain front. In Colorado, this system is largely confined to the southeastern plains.



Spatial pattern

Southern Rocky Mountain Juniper Woodland and Savanna is a large patch type.

Environment

These woodlands occur in a semi-arid region, with a moderate deficit of precipitation in relation to potential evapotranspiration. Drought is a characteristic climatic extreme in the region. Annual precipitation is generally less than 20 inches, and soils are periodically moist only in a shallow top layer typically less than 1-2 feet deep. A large proportion (70-80%) of annual precipitation falls during the growing season, and most of this is received during a limited

number of large rainfall events. Daily precipitation amounts are usually small (5mm or less), and do not contribute much to soil water recharge, which instead is primarily dependent on large but infrequent rainfall events.

Until fairly recently, juniper communities of the western Great Plains were largely confined to rocky or shale outcrops in areas where local topography acted as a fire break within the grassland matrix, or along the mountain front. Over the past century, many of these communities have extended their distribution as more individual trees become established and persist further out into the grassland.

In addition to the action of fire, the local density of trees is controlled by soil depth and moisture availability. Soils are variable across the distribution of these woodlands and savannas in warm dry sites of the Western Great Plains. In general, woodlands are more often on shallow or very shallow, rocky soils (i.e., rarely burned sites), while savannas occupy areas of deeper, fine-textured soils.

Vegetation

These juniper communities occur as savannas within the shortgrass prairie matrix or as more thickly wooded areas. In the driest areas, a few scattered juniper are embedded in a grassland matrix; in more mesic areas grassland is found as small patches in juniper woodland matrix. One-seed juniper (*Juniperus monosperma*) is most typical of Colorado occurences, and occasional two-needle pinyon (*Pinus edulis*) may be present. These woodlands intergrade with surrounding shrubland and grassland communities, and have many shrub and graminoid species in common. Grasses are similar to those found in adjacent Western Great Plains Shortgrass Prairie, with blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), and James' galleta (*Pleuraphis jamesii*) being most common. Shrubby succulents including soapweed (*Yucca* spp.) and pricklypear or cholla (*Opuntia* or *Cylindropuntia* spp.) are typically present.

Plant Associations

CEGL000708	Juniperus monosperma / Bouteloua curtipendula Open Woodland
CEGL000709	Juniperus monosperma / Bouteloua eriopoda Open Woodland
CEGL000710	Juniperus monosperma / Bouteloua gracilis Open Woodland
CEGL000714	Juniperus monosperma / Cercocarpus montanus - Ribes cereum Woodland
CEGL000713	Juniperus monosperma / Cercocarpus montanus Woodland
CEGL000722	Juniperus monosperma / Hesperostipa neomexicana Open Woodland

Associated Animal species

Bird species associated with these woodlands and savannas include Gray Vireo (*Vireo vicinior*), Juniper Titmouse (*Baeolophus ridgwayi*), Ash-throated Flycatcher (*Myiarchus cinerascens*), Lark Sparrow (*Chondestes grammacus*), Mourning Dove (*Zenaida macroura*, in edge areas), and a variety of raptors and cavity nesting species. Species of adjacent shortgrass prairie may also occasionally be seen. Large mammals include mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*). Small mammals include the desert cottontail (*Sylvilagus audubonii*), pinyon mouse (*Peromyscus truei*), white-throated woodrat (*Neotoma albigula*), and other rodents. These woodlands and savannas also provide habitat for a variety of reptiles, including Colorado checkered

whiptail lizard (*Aspidoscelis neotesselatus*), six-lined racerunner lizard (*Aspidoscelis sexlineata*), Hernandez's short-horned lizard (*Phrynosoma hernandesi*), bullsnake (*Pituophis catenifer*), North American racer (*Coluber constrictor*) coachwhip (*Coluber flagellum*), and prairie rattlesnake (*Crotalus viridis*).

Dynamic processes

Processes that influence the formation and persistence of juniper savannas and woodlands include climate, fires, grazing, tree harvest, and insect-pathogen outbreaks.

In the western Great Plains region drought can occur during any season, generally having its greatest impact during the growing season, when most annual precipitation occurs. Drought can result in widespread tree die-off, although native juniper species are generally drought tolerant and more likely to persist under drought conditions in comparison with other tree species.

Junipers reproduce only from seeds, and do not resprout after fire. The role of fire in maintaining herbaceous cover and suppressing woody vegetation is well demonstrated in most grassland types. Large scale climatic conditions act to determine seasonality and frequency of wildfire in the region, while extent and local fire effects are dependent on topographic and edaphic conditions. The generally open, rolling plains and often windy conditions in the shortgrass prairie facilitate the spread of fire when fuel loads are sufficient. Conversely, breaks and rocky areas that are protected from fire are able to support woody vegetation, even under the dry conditions typical of the region. In burned areas, graminoids are better adapted than trees or shrubs to withstand the effects of fire.

Although woody species encroachment into grasslands has been observed worldwide, it is by no means universal, and opinions regarding the mechanisms and causes of the trend are still evolving. Change in fire regime, in particular the widespread fire suppression of post-settlement years, is believed to contribute to the persistence and expansion of woody species into grasslands of North America. In addition, the practice of extensive grazing of domestic livestock beginning in the mid-1800s in the western U.S. has been identified as contributing to the reduction in grassland cover and consequent expansion of woody species. Juniper are also susceptible to several species of woodboring beetles and fungal diseases, which may cause localized mortality or reduced vigor of affected trees.

Management

Grazing by domestic livestock is the most likely agricultural use of these woodlands and savannas, and has probably been heavy in some areas during early open range conditions. Management for increased livestock production tends to produce a more homogeneous understory dominated by key forage species. Tree clearing for “range improvement” is a minor source of disturbance within these woodlands, but dramatically changes the habitat where it has occurred. Tree harvest for fuelwood or fencing is the primary consumptive use of biological resources in these woodlands, and can have noticeable local impacts.

In some areas, understory vegetation has been altered by the presence of invasive annual grasses such as cheatgrass (*Bromus tectorum*), which can have an impact on the frequency and intensity of fire. The extent of this issue in southwestern Great Plains stands is unknown. Projected warmer and drier conditions may favor the persistence of drought-tolerant juniper.

Original concept authors K.A. Schulz; Nov 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: September 2019

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Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland

General Description

Colorado combines the dry-mesic and moist-mesic Southern Rocky Mountain mixed conifer types into a single ecological system. These mixed montane conifer forests of the Rocky Mountains are found throughout the southern Rockies, extending north and west into Utah, Nevada, Wyoming and Idaho. In Colorado dry-mesic and mesic mixed-conifer forests form a matrix together that can occur on all aspects at elevations generally from 1,830 to around 3,050 m (6,000 to 10,000 ft), where they are often adjacent to ponderosa, aspen or spruce-fir forest. Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the most common dominant trees, but many different conifer species may be present, and stands may be intermixed with other forest types dominated by ponderosa pine (*Pinus ponderosa*) or quaking aspen (*Populus tremuloides*). Douglas-fir stands are characteristic of drier sites, often with ponderosa pine and Gambel oak (*Quercus gambelii*). More mesic stands are found in cool ravines and on north-facing slopes, and are likely to be dominated by white fir with blue spruce (*Picea pungens*) or quaking aspen stands. Natural fire processes in this system are highly variable in both return interval and severity. Fire in cool, moist stands is infrequent, and the understory may be quite diverse. In addition to the dominant trees, these mixed-species forests may also include Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and limber pine (*Pinus flexilis*), which reaches the southern limit of its distribution in the San Juan mountains. Typical understory shrub species include Rocky Mountain maple (*Acer*

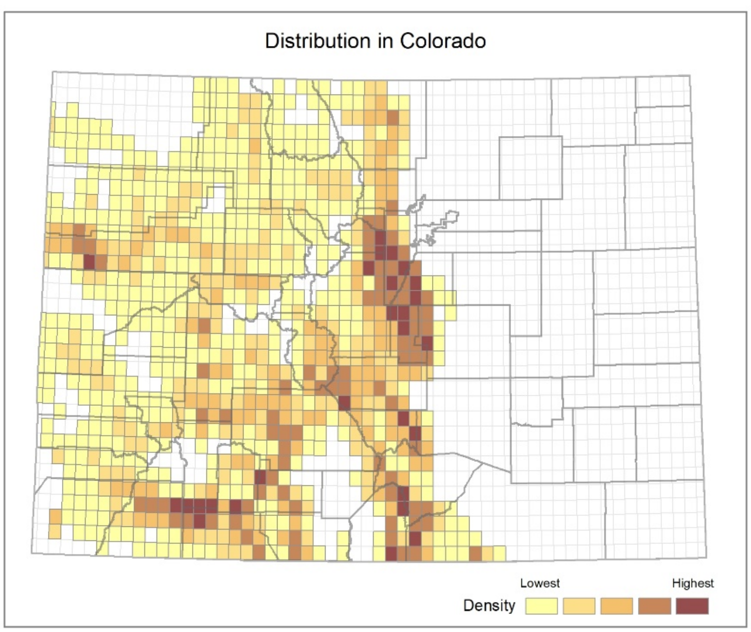
glabrum), Saskatoon serviceberry (*Amelanchier alnifolia*), kinnikinnick (*Arctostaphylos uva-ursi*), rockspirea (*Holodiscus dumosus*), fivepetal cliffbush (*Jamesia americana*), common juniper (*Juniperus communis*), creeping barberry (*Mahonia repens*), Oregon boxleaf (*Paxistima myrsinites*), mountain ninebark (*Physocarpus monogynus*), mountain snowberry (*Symphoricarpos oreophilus*), thimbleberry (*Rubus parviflorus*), and whortleberry (*Vaccinium myrtillus*). Where soil moisture is favorable, the herbaceous layer may be quite diverse.

Diagnostic Characteristics

The dry-mesic and mesic mixed conifer types are highly variable in composition, depending on the local conditions. Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the most common dominant trees, but many different conifer species may be present, and stands may be intermixed with other forest types dominated by ponderosa pine (*Pinus ponderosa*) or quaking aspen (*Populus tremuloides*). White fir dominates forests at cooler sites. Douglas-fir stands are characteristic of drier sites, often with ponderosa pine and Gambel oak (*Quercus gambelii*). More mesic stands are found in cool ravines and on north-facing slopes, and are likely to be dominated by white fir with blue spruce (*Picea pungens*) or quaking aspen stands.

Similar Systems

Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland: The aspen-mixed conifer type can be difficult to distinguish from these mixed conifer forests and woodlands In general, if aspen is present in small patches rather than co-dominant, occurrences should be considered as belonging to the mixed conifer type. Both aspen-mixed conifer and the pure aspen forest are likely to intergrade in many areas with the mixed conifer system.



Range

These forests and woodlands occur throughout the southern Rockies of Colorado and New Mexico and on the margins of the Colorado Plateau, extending north to Wyoming and west into Utah, Arizona, Nevada, and Idaho. In Colorado dry-mesic and mesic mixed-conifer forests form a matrix together that can occur on all aspects at elevations generally from 1,830 to around 3,050 m (6,000 to 10,000 ft), where they are often adjacent to ponderosa, aspen or spruce-fir forest.

Spatial pattern

These mixed conifer forests and woodlands are generally large patch types, but may occasionally be matrix forming.

Environment

The similar environmental tolerances of mixed-conifer and aspen forest means that the two habitat types are somewhat intermixed in many areas. These forests appear to represent a biophysical space where a number of different overstory species can become established and grow together. Local conditions, biogeographic history, and competitive interactions over many decades are prime determinants of stand composition.

Although cool moist mixed-conifer forests are generally warmer and drier than spruce-fir forests, these stands are often in relatively cool-moist environments where fires were historically infrequent with mixed severity. When stands are severely burned, aspen often resprouts. Warm-dry mixed conifer forests had a historic fire-regime that was more frequent, with mixed severity. In areas with high severity burns, aspen or Gambel oak resprouts and dominates the site for a relatively long period of time.

Vegetation

Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the most common dominant trees, but many different conifer species may be present, and stands may be intermixed with other forest types dominated by ponderosa pine (*Pinus ponderosa*) or quaking aspen (*Populus tremuloides*).

Typical understory shrub species include Rocky Mountain maple (*Acer glabrum*), Saskatoon serviceberry (*Amelanchier alnifolia*), kinnikinnick (*Arctostaphylos uva-ursi*), rockspirea (*Holodiscus dumosus*), fivepetal cliffbush (*Jamesia americana*), common juniper (*Juniperus communis*), creeping barberry (*Mahonia repens*), Oregon boxleaf (*Paxistima myrsinites*), mountain ninebark (*Physocarpus monogynus*), mountain snowberry (*Symphoricarpos oreophilus*), thimbleberry (*Rubus parviflorus*), and whortleberry (*Vaccinium myrtillus*). With higher soil moisture, herbaceous layer diversity increases. Typical graminoids include fringed brome (*Bromus ciliatus*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*C. rossii*), dryspike sedge (*C. siccata*), Parry's oatgrass (*Danthonia parryi*), squirreltail (*Elymus elymoides*), blue wildrye (*Elymus glaucus*), slender wheatgrass (*Elymus trachycaulus*), fescue (*Festuca* spp.), prairie Junegrass (*Koeleria macrantha*), smallflowered woodrush (*Luzula parviflora*), mountain muhly (*Muhlenbergia montana*), muttongrass (*Poa fendleriana*), and Sandberg bluegrass (*Poa secunda*). Understory forbs include yarrow (*Achillea millefolium*), heartleaf arnica (*Arnica cordifolia*), Fendler's meadow-rue (*Thalictrum fendleri*), mountain goldenbanner (*Thermopsis montana*), hookedspur violet (*Viola adunca*), and species of many other genera, including beardtongue (*Penstemon*), lupine (*Lupinus*), vetch (*Vicia*), sandwort (*Arenaria*), and bedstraw (*Galium*).

Plant Associations

CEGL000240 Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest

CEGL000243	Abies concolor / Arctostaphylos uva-ursi Forest
CEGL000247	Abies concolor - Pseudotsuga menziesii / Erigeron eximius Forest
CEGL000251	Abies concolor / Mahonia repens Forest
CEGL000255	Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest
CEGL000261	Abies concolor / Quercus gambelii Forest
CEGL000263	Abies concolor / Symphoricarpos oreophilus Forest
CEGL000265	Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus Forest
CEGL000385	Picea pungens / Arctostaphylos uva-ursi Forest
CEGL000386	Picea pungens / Arnica cordifolia Forest
CEGL000387	Picea pungens / Carex siccata Forest
CEGL000388	Picea pungens / Cornus sericea Riparian Woodland
CEGL000389	Picea pungens / Equisetum arvense Riparian Woodland
CEGL000390	Picea pungens / Erigeron eximius Forest
CEGL000392	Picea pungens / Juniperus communis Forest
CEGL000393	Picea pungens / Linnaea borealis Forest
CEGL000394	Picea pungens / Lonicera involucrata Forest
CEGL000395	Picea pungens / Mahonia repens Forest
CEGL000418	Pseudotsuga menziesii / Acer glabrum Forest
CEGL000420	Pseudotsuga menziesii / Amelanchier alnifolia Forest
CEGL000424	Pseudotsuga menziesii / Arctostaphylos uva-ursi Forest
CEGL000428	Pseudotsuga menziesii / Bromus ciliatus Forest
CEGL000430	Pseudotsuga menziesii / Carex geyeri Forest
CEGL000431	Abies concolor - Pseudotsuga menziesii / Carex rossii Forest
CEGL000433	Pseudotsuga menziesii / Festuca arizonica Forest
CEGL000438	Pseudotsuga menziesii / Jamesia americana Forest
CEGL000439	Pseudotsuga menziesii / Juniperus communis Forest
CEGL000442	Pseudotsuga menziesii / Mahonia repens Forest
CEGL000443	Pseudotsuga menziesii / Muhlenbergia montana Forest
CEGL000446	Pseudotsuga menziesii / Paxistima myrsinites Forest
CEGL000449	Pseudotsuga menziesii / Physocarpus monogynus Forest
CEGL000452	Pseudotsuga menziesii / Quercus gambelii Forest
CEGL000462	Pseudotsuga menziesii / Symphoricarpos oreophilus Forest
CEGL000887	Abies concolor / Festuca arizonica Woodland
CEGL000890	Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus Scree Woodland
CEGL000894	Picea pungens / Alnus incana Riparian Woodland
CEGL000895	Picea pungens / Festuca arizonica Woodland
CEGL000898	Pseudotsuga menziesii / Cercocarpus montanus Woodland
CEGL000899	Pseudotsuga menziesii / Cornus sericea Riparian Woodland
CEGL000902	Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland
CEGL000904	Pseudotsuga menziesii / Leucopoa kingii Woodland
CEGL000908	Pseudotsuga menziesii / Pseudoroegneria spicata Woodland
CEGL000911	Pseudotsuga menziesii Scree Woodland
CEGL002167	Ceanothus velutinus Shrubland

CEGL002637	Picea pungens / Betula occidentalis Riparian Woodland
CEGL002639	Pseudotsuga menziesii / Betula occidentalis Riparian Woodland
CEGL002754	Pseudotsuga menziesii / Acer negundo Riparian Woodland
CEGL002808	Pseudotsuga menziesii / Artemisia tridentata (ssp. vaseyana, ssp. wyomingensis) Woodland
CEGL002809	Pseudotsuga menziesii / Poa fendleriana Woodland

Associated Animal species

Characteristic bird species in mixed conifer forest include Steller's Jay (*Cyanocitta stelleri*), Red-breasted Nuthatch (*Sitta canadensis*), Mountain Chickadee (*Poecile gambeli*), Hermit Thrush (*Catharus guttatus*), Western Tanager (*Piranga ludoviciana*), Pine Siskin (*Spinus pinus*), Townsend's Solitaire (*Myadestes townsendi*), Northern Flicker (*Colaptes auratus*), Olive-sided Flycatcher (*Contopus cooperi*), Dark-eyed Junco (*Junco hyemalis*), Clark's Nutcracker (*Nucifraga columbiana*), and Northern goshawk (*Accipiter gentilis*). These forests also provide seasonal habitat for elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), bobcat (*Felis rufus*), and mountain lion (*Felis concolor*), and are home to a variety of smaller mammals including porcupine (*Erethizon dorsatum*), chipmunks (Neotamias spp.), Abert's squirrel (*Sciurus aberti*), golden-mantled ground squirrel (*Callospermophilus lateralis*), pine squirrel (also called chickaree *Tamiasciurus hudsonicus*), deer mice (*Peromyscus maniculatus*), and bushy-tailed woodrat (*Neotoma cinerea*).

Dynamic processes

Long-term ecological dynamics of mixed conifer forests are relatively understudied. There has been considerable recent debate about historic range of variation for stand density and high-severity fire incidence in mixed conifer forests. Natural fire processes in this system are probably highly variable in both return interval and severity, depending on stand composition, site conditions, biogeographic history, and short- and long-term climate patterns. For instance, drought and high temperatures prior to fire initiation are associated with larger burned area as fine fuels become dry. Additional disturbances in mixed conifer forests may be due to wind storms or insect-pathogen outbreaks. Spruce budworm infestations are a major source of tree mortality and can affect landscape-scale dynamics in mixed conifer forest.

Although cool moist mixed-conifer forests are generally warmer and drier than spruce-fir forests, these stands are often in relatively cool-moist environments where fires were historically infrequent with mixed severity. When stands are severely burned, aspen often resprouts. Warm-dry mixed conifer forests had a historic fire-regime that was more frequent, with mixed severity. In areas with high severity burns, aspen or Gambel oak often resprouts and dominates the site for a relatively long period of time. In some locations, much of these forests have been logged or burned during European settlement, and present-day occurrences are second-growth forests dating from fire, logging, or other occurrence-replacing disturbances.

The ecotonal nature of mixed conifer stands increases the difficulty of interpreting their vulnerability to climate change, and their capacity to move into new areas. Changing climate conditions are likely to alter the relative dominance of overstory species, overall species composition and relative cover, especially through the action of fire, insect outbreak, and drought.

The diversity of species within this type, however, is expected to increase its flexibility in the face of climate change. Outcomes for particular stands are likely to depend on current composition and location. Drought and disturbance tolerant species will be favored over drought vulnerable species. Species such as blue spruce that are infrequent and have a narrow bioclimatic envelope are likely to decline or move up in elevation. Abundant species that have a wide bioclimatic envelope such as Gambel oak and aspen are likely to increase. Current stands of warm, dry mixed conifer below 2,590 m (8,500 ft) may be at higher risk or may convert to pure ponderosa pine stands as future precipitation scenarios favor rain rather than snow. Upward migration into new areas may be possible.

Management

Mixed conifer forest landscapes in Colorado are generally in very good condition and not severely impacted by fire suppression. In areas adjacent to development, mixed conifer stands may be part of the wildland-urban interface, where they are most likely to be threatened by the effects of fire suppression. Exurban development and recreational area development are a threat to these forests along the Front Range and I-70 corridor in mountain areas. Roads and utility corridors are a source of disturbance and fragmentation in mixed conifer forest statewide, but these stands naturally occur in smaller patches than some other forest types, so threats are minor. A number of tree species in mixed conifer are suitable for timber harvest, so logging is an ongoing source of disturbance in these forests. Threats from livestock grazing and hunting or recreational activities are minimal for mixed conifer forests. Mining and mine tailings are a small source of disturbance.

Stands in the southern part of Colorado have been impacted by the western spruce budworm and drought. Budworm outbreaks are part of a natural cycle in mixed conifer forest, but may be intensified by increasing drought frequency and the generally higher temperatures projected in coming decades. The ecotonal nature of mixed conifer stands increases the difficulty of interpreting their vulnerability to climate change, and their capacity to move into new areas. The diversity of species within mixed conifer forest may increase its flexibility in the face of climate change. Changing climate conditions are likely to alter the relative dominance of overstory species, overall species composition and relative cover, primarily through the action of fire, insect outbreak, and drought. Drought and disturbance tolerant species will be favored over drought vulnerable species. Warmer and drier conditions can be expected to change the relative tree species abundance in mixed conifer forests. Although some stands may convert to other types, the diverse species composition of these forests increases the likelihood that some species will benefit under future conditions. Novel mixed conifer types may appear.

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Southern Rocky Mountain Pinyon-Juniper Woodland

General Description

This southern Rocky Mountain ecological system occurs on dry mountain slopes, ridges, and foothills in southern Colorado, in mountains and plateaus of northern New Mexico and Arizona, and extends out onto breaks in the southern Great Plains. In Colorado, the southern Rocky Mountain pinyon-juniper woodlands are found in the south central part of the state, around the San Luis Valley, southern mountain front east to Mesa de Maya, and north into the Arkansas River Valley and Palmer Divide. Elevations range from to about 1,670 m (5,500 ft) east of the mountain front, to 2,650 m (8,700 ft) in the vicinity of Browns Canyon in the upper Arkansas drainage. Two-needle pinyon (*Pinus edulis*) and/or one-seed juniper (*Juniperus monosperma*) dominate the tree canopy. Rocky Mountain juniper (*Juniperus scopulorum*) may codominate or replace one-seed juniper at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau. Shrubs include Bigelow sage (*Artemisia bigelovii*), mountain mahogany (*Cercocarpus montanus*), and Gambel oak (*Quercus gambelii*), while common grasses are Scribner needlegrass (*Achnatherum scribneri*), blue grama (*Bouteloua gracilis*), Arizona fescue (*Festuca arizonica*), or James' galleta (*Pleuraphis jamesii*). In the canyons and tablelands to the east, two-needle pinyon is uncommon or absent, and this system is replaced by the Southern Rocky Mountain Juniper Woodland and Savanna system.

Diagnostic Characteristics

These are coniferous woodlands of the dry mountains and foothills in south-central and south-eastern Colorado. They are distinguished by the presence of both two-needle pinyon (*Pinus edulis*) and either one-seed juniper (*Juniperus monosperma*) or Rocky Mountain juniper (*Juniperus scopulorum*) in the canopy. Stands may be moderately open to densly wooded, and intermingled with adjacent ecological system communities of foothills or plains grassland, foothill shrublands, Gambel-oak / mixed mountain shrubland, or ponderosa pine woodland. Depending on substrate, the understory can range from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs).

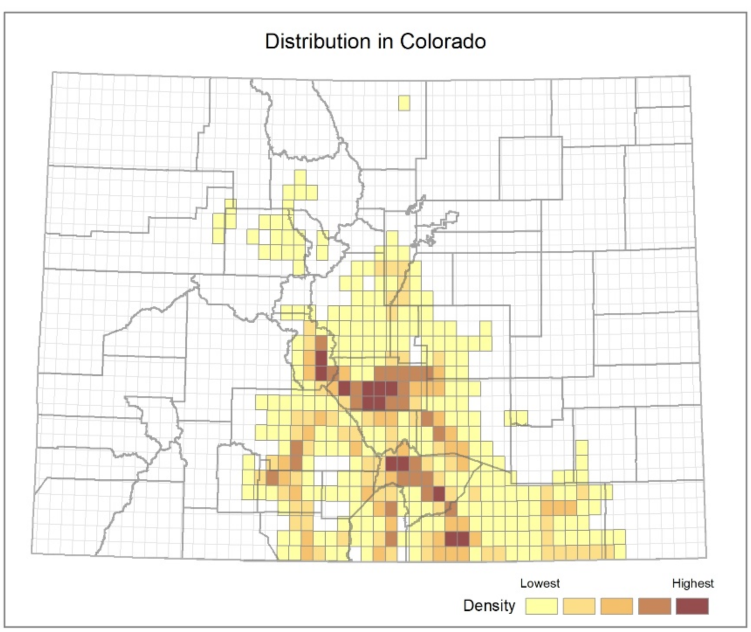
Similar Systems

Colorado Plateau Pinyon-Juniper Woodland: The pinyon-juniper woodlands of western Colorado and the Colorado Plateau are similar to the Southern Rocky Mountain Pinyon-Juniper Woodlands, but Utah juniper (*Juniperus osteosperma*) replaces one-seed juniper (*Juniperus monosperma*).

Southern Rocky Mountain Juniper Woodland and Savanna: These are open to moderately dense savannas and woodlands of breaks, mesa slopes, and canyon or arroyo rims on Colorado's eastern plains. The canopy is dominated primarily by one-seed juniper, with only occasional pinyon pine in places.

Range

This southern Rocky Mountain ecological system occurs on dry mountain slopes, ridges, and foothills in southern Colorado, in mountains and plateaus of northern New Mexico and Arizona, and extends out onto breaks in the southern Great Plains. In Colorado, these woodlands are found in the south central part of the state, around the San Luis Valley, southern mountain front east to Mesa de Maya, and north into the Arkansas River Valley and Palmer Divide.



Spatial pattern

Southern Rocky Mountain Pinyon-Juniper Woodland is a matrix-forming ecological system.

Environment

Southern Rocky Mountain Pinyon-Juniper Woodlands occur throughout the western portions of the southern Great Plains, on almost any site where local topography permits the establishment and persistence of woody species. These pinyon-juniper woodlands occur on

mountain foothill slopes, mesas, cuestas, broad basins, and valley floors, and occupy a broad zone of intermediate moisture and temperature conditions between the warmer, drier grasslands of lower elevations and the cool mesic forests of higher elevations.

These evergreen woodlands are adapted to cold winter minimum temperatures and low rainfall, and are often transitional between grassland and montane conifer ecosystems. In general, the pinyon-juniper woodlands of the region are confined to relatively higher sites in foothills and mesa margins adjacent to the plains, primarily at elevations between 1,830 and 2,290 m (6,000-7,500) feet, while juniper-dominated woodlands and savannas are characteristic at lower elevations to the east and south. Mesic areas are generally pinyon-dominated, while junipers are able to dominate on drier sites. Stands vary considerably in appearance and composition, both altitudinally and geographically. Juniper tends to be more abundant at the lower elevations, pinyon tends to be more abundant at the higher elevations, and the two species share dominance within a broad middle-elevation zone.

Soils are variable across the distribution of these woodlands in warm dry sites of the Southern Rocky Mountain foothills. Stands occur on a variety of aspects and slopes. Slope may range from nearly level to steep (up to 80%). Soils vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Most soils supporting pinyon and juniper in the region are formed in material weathered from sedimentary substrates, especially shale and sandstone, or from the basalt mesas, plateaus and lava flow outcroppings that characterize the Raton-Clayton volcanic field in northeastern New Mexico and adjoining areas in Colorado and Oklahoma. Soil depths may range from shallow to deep.

Vegetation

Woodlands are dominated by two-needle pinyon pine (*Pinus edulis*) and/or one-seed juniper (*Juniperus monosperma*). At higher elevations Rocky Mountain juniper (*Juniperus scopulorum*) may be present with or instead of one-seed juniper. Understory layers are variable and generally similar in species composition to adjacent forest, shrubland, or grassland communities. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau. Shrubs include Bigelow sage (*Artemisia bigelovii*), mountain mahogany (*Cercocarpus montanus*), and Gambel oak (*Quercus gambelii*), while common grasses are Scribner needlegrass (*Achnatherum scribneri*), blue grama (*Bouteloua gracilis*), Arizona fescue (*Festuca arizonica*), or James' galleta (*Pleuraphis jamesii*).

Plant Associations

CEGL000705	Juniperus monosperma / Artemisia bigelovii Woodland
CEGL000708	Juniperus monosperma / Bouteloua curtipendula Open Woodland
CEGL000709	Juniperus monosperma / Bouteloua eriopoda Open Woodland
CEGL000710	Juniperus monosperma / Bouteloua gracilis Open Woodland
CEGL000711	Juniperus monosperma / Bouteloua hirsuta Open Woodland
CEGL000714	Juniperus monosperma / Cercocarpus montanus - Ribes cereum Woodland
CEGL000713	Juniperus monosperma / Cercocarpus montanus Woodland
CEGL000722	Juniperus monosperma / Hesperostipa neomexicana Open Woodland

CEGL000721	Juniperus monosperma / Quercus x pauciloba Woodland
CEGL002151	Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Open Woodland
CEGL005649	Pinus edulis - Juniperus (monosperma, deppeana) / Cercocarpus montanus - Mixed Shrubs Woodland
CEGL005651	Pinus edulis - Juniperus (monosperma, deppeana) / Quercus gambelii Woodland
CEGL005650	Pinus edulis - Juniperus monosperma / Artemisia tridentata (ssp. wyomingensis, ssp. vaseyana) Woodland
CEGL005660	Pinus edulis - Juniperus monosperma / Hesperostipa comata Open Woodland
CEGL000793	Pinus edulis - Juniperus monosperma / Quercus x pauciloba Woodland
CEGL002907	Pinus edulis - Juniperus scopulorum Woodland
CEGL000787	Pinus edulis - Juniperus spp. / Poa fendleriana Woodland
CEGL000788	Pinus edulis - Juniperus spp. / Pseudoroegneria spicata Woodland
CEGL000798	Pinus edulis / Achnatherum scribneri Open Woodland
CEGL002908	Pinus edulis / Leymus ambiguus Open Woodland
CEGL000794	Pinus edulis / Rockland Woodland
CEGL000795	Pinus edulis / Sparse Understory Forest

Associated Animal species

Pinyon-juniper woodlands provide both food and shelter for a variety of wildlife species. Pinyon seeds are an important food source for birds such as Pinyon Jay (*Gymnorhinus cyanocephalus*), Clark's Nutcracker (*Nucifraga columbiana*), Woodhouse's Scrub-Jay (*Aphelocoma woodhouseii*), and Juniper Titmouse (*Baeolophus ridgwayi*), as well as mammals including deermice (*Peromyscus maniculatus*), pinyon mice (*Peromyscus truei*), woodrats (*Neotoma* spp.), chipmunks (*Neotamias* spp.), tree squirrels (*Sciurus* spp.), and black bear (*Ursus americanus*). Bats and cavity-nesting birds make use of trees in these woodlands, and large mammals including mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) may also find cover and browse.

Dynamic processes

There is a tendency for pinyon to be more dominant at higher (often more mesic) sites, and juniper relatively more dominant at lower sites. Both pinyon pine and juniper reproduce only from seeds, and do not resprout after fire. These species are fairly slow growing, and can live for hundreds of years, a life cycle that is well adapted to xeric habitats, but is less suitable for quickly changing conditions. Although individuals of both species become reproductive after a few decades, most seed production is due to mature trees of 75 years of age or older. Old growth stands are critical for species like the Pinyon jay. Pinyon-juniper woodlands are influenced by climate, fires, insect-pathogen outbreaks, and livestock grazing.

In the southern Rocky Mountains where these woodland are found, drought can occur during any season, generally having its greatest impact during the growing season, when most annual precipitation occurs. Drought can result in widespread tree die-off, and warmer temperatures are likely to increase drought-induced mortality in pinyon pine. The native juniper species are generally drought tolerant and more likely to persist under drought conditions in comparison with pinyon pine, so that juniper may become more dominant in these woodlands.

Large scale climatic conditions also act to determine seasonality and frequency of wildfire in the region, while extent and local fire effects are dependent on topographic and edaphic conditions. The effects of fire in all types of pinyon-juniper depend in part on fuel provided by both canopy and understory, and by weather conditions during a fire. Change in fire regime, in particular the widespread fire suppression of post-settlement years, is believed to contribute to the persistence and expansion of woody species into grasslands of North America. In addition, the practice of extensive grazing of domestic livestock beginning in the mid-1800s in the western U.S. has been identified as contributing to the reduction in grassland cover and consequent expansion of woody species. Although it is clear that the structure and condition of many pinyon-juniper woodlands has been significantly altered since European settlement, in recent years there has been an emerging recognition that not all of these woodlands are dramatically changed by anthropogenic influence. Increasing density of pinyon juniper woodlands and expansion into adjacent grassland or shrubland are well documented in some areas, but it is not a universal phenomenon in the western U.S., and opinions regarding the mechanisms and causes of the trend are still evolving.

Pinyon are susceptible to a fungal pathogen which causes black stain root disease (primarily on more mesic sites), and to infestations of the pinyon ips bark beetle (*Ips confusus*) which has caused extensive mortality in pinyon-juniper habitats in southern Colorado. Extended drought can increase the frequency and intensity of insect outbreaks. Juniper are also susceptible to several species of woodboring beetles and fungal diseases, which may cause localized mortality or reduced vigor of affected trees.

Management

Ongoing but limited threats from residential and commercial development are primarily in the foothill and mountain-front region, where towns, roads, and utility corridors may occur within pinyon-juniper woodlands and savannas. Clearing or thinning for fire suppression interrupts the natural seral progression of the impacted stands and may degrade the usefulness of the remaining woodland for wildlife. These woodlands often provide good habitat for large game animals, so hunting is a regular, although small, source of human disturbance in these areas. In some areas, understory vegetation has been altered by the presence of invasive annual grasses such as cheatgrass (*Bromus tectorum*), which can have an impact on the frequency and intensity of fire. The extent of this issue in southwestern Great Plains stands is unknown.

Since the last major glacial period, the distribution and relative abundance of pinyon and juniper has fluctuated with changing climatic conditions. Future precipitation and temperature patterns are projected to change in a direction that is less favorable for pinyon, so that juniper may become more dominant, and these habitats are unable to persist or expand in their current form. Primary factors contributing to the vulnerability of these woodlands are the interaction of drought, fire, and insect-caused mortality, which is likely to increase under changing climate, and the extent to which the current landscape condition of the habitat has been impacted by anthropogenic disturbance.

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Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
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Southern Rocky Mountain Ponderosa Pine Woodland and Savanna

General Description

Colorado combines Southern Rocky Mountain ponderosa pine woodlands and ponderosa savannas into a single ecological system. This widespread ecological system is most common throughout the Southern Rocky Mountains from New Mexico to Wyoming, but is also found in the Colorado Plateau region and further west in scattered locations of the Great Basin. In Colorado, these woodlands are the matrix-forming forests of montane elevations in the Front Range and on the southern flank of the San Juan Mountains. Ponderosa pine woodlands are typical of warm and dry sites generally between 1,740 and 2,900 m (5,700-9,500 ft). These matrix-forming woodlands occur at the lower treeline ecotone above foothill grasslands and shrublands, or intermingled with more mesic coniferous forests. Ponderosa pine (*Pinus ponderosa* var. *scopulorum*) is the dominant conifer, although Douglas-fir (*Pseudotsuga menziesii*), juniper (*Juniperus* spp.), quaking aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) may also be present in the canopy. The understory may be shrubby or grassy. Common shrub species are sagebrush (*Artemisia tridentata*), kinnikinnick (*Arctostaphylos uva-ursi*), greenleaf manzanita (*Arctostaphylos patula*), mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii),* chokecherry (*Prunus virginiana*), and wax currant (*Ribes cereum*). Common grasses include bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum*

smithii), and species of grama (*Bouteloua*), needle-and-thread (*Hesperostipa*), needlegrass (*Achnatherum*), fescue (*Festuca*), and muhly (*Muhlenbergia*). In some areas of the Colorado Front Range, these woodlands form more open savannas, with widespread, mature trees in a grassland understory. Mixed fire regimes and surface fires of variable return intervals maintain these woodlands and savannas, depending on climate, degree of soil development, and understory density.

Diagnostic Characteristics

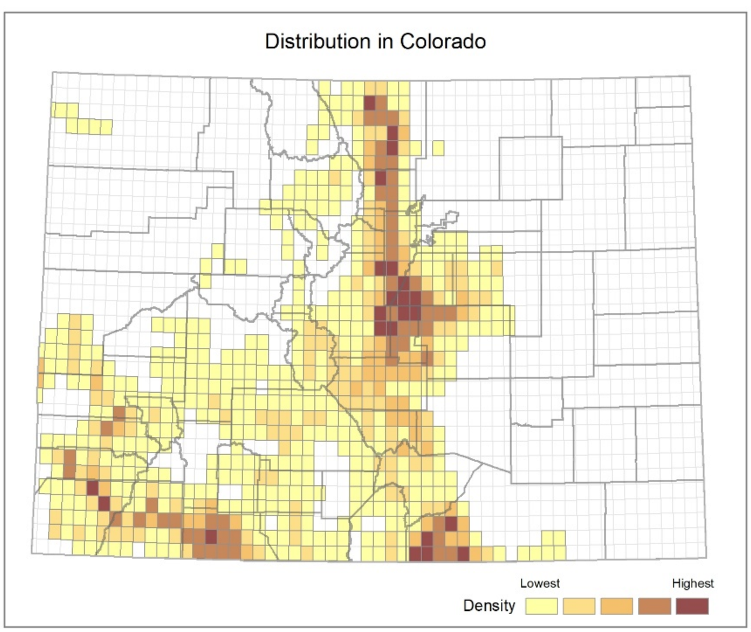
Ponderosa pine dominates the canopy although Douglas-fir (*Pseudotsuga menziesii*), juniper (*Juniperus* spp.), quaking aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) may also be present in the canopy. Stands may be open savannas with grassy understory or more dense woodlands.

Similar Systems

Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland: Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the most common dominant trees. The dry-mesic and mesic mixed conifer types are highly variable in composition, depending on the local conditions, but typically include a number of conifer species, including ponderosa pine. Stands of mixed conifer may be intermixed with forest types dominated by ponderosa pine.

Range

Southern Rocky Mountain Ponderosa Pine Woodland and Savanna occurs throughout the Southern Rocky Mountains from New Mexico to Wyoming, but is also found in the Colorado Plateau region and further west in scattered locations of the Great Basin. In Colorado, these woodlands are the matrix-forming forests of montane elevations in the Front Range and on the southern flank of the San Juan Mountains.



Spatial pattern

Southern Rocky Mountain Ponderosa Pine Woodland and Savanna is a matrix forming type in Colorado.

Environment

Ponderosa pine is able to tolerate fairly warm temperatures as long as there is enough moisture, especially in the growing season. Although periodic seasonal drought is characteristic across the range of ponderosa pine, this species is generally found where annual

precipitation is at least 13 inches, with most precipitation occurring as winter snow or summer monsoon.

Ponderosa woodlands are not found at high elevations, but instead form a broad zone of coniferous forest along the southern flank of the San Juan Mountains, as well as along the eastern mountain front, generally at elevations between 1,740 and 2,900 m (5,700-9,500 ft). These woodlands are in within the central portion of their North American distribution in Colorado. Ponderosa pine occupies relatively dry, nutrient-poor sites compared to other montane conifers, but shows wide ecological amplitude throughout its distribution. Substrates are generally igneous, metamorphic, and sedimentary material derived soils, including basalt, basaltic, andesitic flows, intrusive granitoids and porphyrites, and tuffs. Exposed rock and bare soil consistently occur to some degree in all the associations.

Vegetation

Ponderosa pine (*Pinus ponderosa* var. *scopulorum*) is the dominant conifer, although Douglas-fir (*Pseudotsuga menziesii*), juniper (*Juniperus* spp.), quaking aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) may also be present in the canopy. The understory may be shrubby or grassy. Common shrub species are sagebrush (*Artemisia tridentata*), kinnikinnick (*Arctostaphylos uva-ursi*), greenleaf manzanita (*Arctostaphylos patula*), mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii),* chokecherry (*Prunus virginiana*), and wax currant (*Ribes cereum*). Common grasses include bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum smithii*), and species of grama (*Bouteloua*), needle-and-thread (*Hesperostipa*), needlegrass (*Achnatherum*), fescue (*Festuca*), and muhly (*Muhlenbergia*).

Plant Associations

CEGL000848	Pinus ponderosa / Bouteloua gracilis Woodland
CEGL000852	Pinus ponderosa / Cercocarpus montanus / Andropogon gerardii Open Woodland
CEGL000856	Pinus ponderosa / Festuca arizonica Woodland
CEGL000857	Pinus ponderosa / Festuca idahoensis Woodland
CEGL000854	Pinus ponderosa / Purshia stansburiana Woodland
CEGL000842	Pinus ponderosa / Arctostaphylos patula Woodland
CEGL000844	Pinus ponderosa / Arctostaphylos uva-ursi Woodland
CEGL000845	Pinus ponderosa / Artemisia arbuscula Woodland
CEGL002794	Pinus ponderosa / Artemisia tridentata ssp. vaseyana Woodland
CEGL000848	Pinus ponderosa / Bouteloua gracilis Woodland
CEGL000182	Pinus ponderosa / Carex geyeri Woodland
CEGL000849	Pinus ponderosa / Carex inops ssp. heliophila Woodland
CEGL000183	Pinus ponderosa / Carex rossii Forest
CEGL000851	Pinus ponderosa / Cercocarpus montanus Woodland
CEGL000856	Pinus ponderosa / Festuca arizonica Woodland
CEGL000859	Pinus ponderosa / Juniperus communis Woodland
CEGL000861	Pinus ponderosa / Juniperus scopulorum Woodland

CEGL000186	Pinus ponderosa / Leucopoa kingii Woodland
CEGL000862	Pinus ponderosa / Muhlenbergia montana Woodland
CEGL000190	Pinus ponderosa / Physocarpus monogynus Forest
CEGL000854	Pinus ponderosa / Purshia stansburiana Woodland
CEGL000870	Pinus ponderosa / Quercus gambelii Woodland
CEGL000874	Pinus ponderosa / Quercus x pauciloba Woodland
CEGL000199	Pinus ponderosa / Ribes cereum Forest
CEGL000877	Pinus ponderosa / Rockland Woodland
CEGL000201	Pinus ponderosa / Schizachyrium scoparium Open Woodland
CEGL005645	Pinus ponderosa var. scopulorum / Cercocarpus ledifolius Southern Rocky Mountain Woodland
CEGL005647	Pinus ponderosa var. scopulorum / Purshia tridentata Southern Rocky Mountain Woodland

Associated Animal species

Ponderosa woodlands provide habitat for a number of mammal species, including mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), mountain lion (*Felis concolor*), porcupine (*Erethizon dorsatum*), Abert's squirrel (*Sciurus aberti*), chipmunks (*Neotamias* spp.), golden-mantled ground squirrel (*Callospermophilus lateralis*), bat species including Allen's big-eared bat (*Idionycteris phyllotis*), little brown myotis (*Myotis lucifugus*), Townsend's big-eared bat (*Corynorhinus townsendii pallescens*), and others. The federally listed as threatened Pawnee montane skipper (*Hesperia leonardus montana*) is found in open ponderosa woodlands with suitable understory habitat. Bird species using these woodlands include Grace's Warbler (*Setophaga graciae*), Pygmy Nuthatch (*Sitta pygmaea*), White-breasted Nuthatch (*Sitta carolinensis*), Cassin's Finch (*Haemorhous cassinii*), Steller's Jay (*Cyanocitta stelleri*), Mountain Chickadee (*Poecile gambeli*), Chipping Sparrow (*Spizella passerina*), Western Wood-Pewee (*Contopus sordidulus*) , Northern Flicker (*Colaptes auratus*), Western Bluebird (*Sialia mexicana*), Northern Pygmy-Owl (*Glaucidium gnoma*), and Flammulated Owl (*Psiloscops flammeolus*).

Dynamic processes

Ponderosa pine is a drought-resistant and shade-intolerant conifer which often forms the lower treeline in the major mountain ranges of the western United States. Older trees develop thick bark and drop lower limbs, which gives them resistance to ground fires. Historically, ground fires and drought were influential in maintaining open-canopy conditions in these woodlands. With settlement and subsequent fire suppression, occurrences have become denser. Presently, many occurrences contain understories of more shade-tolerant species, such as Douglas-fir and/or white fir (*Abies concolor*) as well as younger cohorts of ponderosa pine. These structural changes have affected fuel loads and altered fire regimes. Presettlement fire regimes were primarily frequent (5-15 year return intervals), low-intensity ground fires triggered by lightning strikes or fires deliberately set by indigenous peoples. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature ponderosa pine.

Ponderosa forest and woodland historically experienced relatively frequent low intensity fires that controlled the density, age, and structure of stands. With fire suppression, ponderosa has increased into foothills grassland, stands have greatly increased in density, and open ponderosa savanna habitat has decreased. Increased tree density and fuel accumulation has resulted in more severe

fires in this habitat, as well as increased occurrence of mountain pine beetle and dwarf mistletoe infestation. The alteration of natural fire regimes through fire suppression is an ongoing threat for ponderosa habitat where it is near developed areas.

These forests are susceptible to outbreaks of the mountain pine beetle (*Dendroctonus ponderosae*) and mistletoe infestations, both of which may be exacerbated by increased drought. Mountain pine beetle has caused extensive mortality in ponderosa pine habitats throughout Colorado, although the current outbreak appears to be subsiding. Impacts of native grazers or domestic livestock, and the spread of invasive grasses could also alter understory structure and composition, with the potential to negatively impact soil stability.

Management

Ponderosa pine landscapes in Colorado have been moderately impacted by anthropogenic activities. Urban and exurban development are a primary threat to ponderosa pine habitat, especially along the Front Range, but also in other parts of the state. Increasing development has led to an extensive wildland-urban interface in ponderosa habitat, as well as fragmentation of stands in exurban areas due to housing, roads, and utility corridors; this trend is likely to continue.

Drought in combination with future projected higher temperatures is likely to reduce ponderosa pine regeneration, especially in drier, lower elevation areas. Increased drought may drive fires and insect outbreaks. This ecosystem is well adapted to warm, dry conditions if precipitation is not too much reduced, and may be able to expand into higher elevations under future climate conditions.

Original concept authors M.S. Reid and K.A. Schulz May 2018
Colorado version authors: Colorado Natural Heritage Program Staff: Renée Rondeau, Karin Decker
Version date: October 2019

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Southwestern Great Plains Canyon

General Description

This system occurs in both perennial- and intermittent-stream canyons of the southwestern Great Plains in southeastern Colorado, southwestern Kansas, and northwestern Oklahoma. In Colorado, the canyon of the Purgatoire above the Arkansas River is the primary example of this type. Soils can range from deep loams to alluvial to sandy. The mosaic of soil types which have developed from sandstone, limestone, basalt, and shale parent materials create a complex mosaic of grasslands, shrublands, and woodlands within the canyon system. Although the system combines many elements from Southern Rocky Mountains Juniper Woodland and Savanna, Southern Rocky Mountains Lower Montane-Foothills Shrubland, Western Great Plains Shortgrass Prairie, and other shrublands, the varied geology, diverse soil types, and topographic dynamics together form a distinct ecological system complex characteristic of the canyons and dissected mesas of the southwestern Great Plains. Vegetation varies both regionally and locally depending on latitude, aspect, slope position and substrate and can range from riparian vegetation to xeric or mesic woodlands and shrublands. Rock outcrops with sparse vegetation are also common. Open to moderately dense juniper (*Juniperus monosperma*) woodlands occupy most of the canyonland slopes. Scattered pinyon pine (*Pinus edulis*) may occur within these community types but are never

dominant. Juniper is the most common tree species, and forms extensive woodlands with an understory of grama (*Bouteloua* spp.), and James' galleta (*Pleuraphis jamesii*), or sometimes with an open shrub layer dominated by mountain mahogany (*Cercocarpus montanus*). A mosaic of shrub species is characteristic of canyon walls and slopes, and varies with substrate and moisture availability. Common species include Bigelow sage (*Artemisia bigelovii*), skunkbush sumac (*Rhus trilobata*), currant (*Ribes* spp.), common hoptree (*Ptelea trifoliata*), littleleaf mock orange (*Philadelphus microphyllus*), and soapweed yucca (*Yucca glauca*). James' seaheath (*Frankenia jamesii*) and spiny greasebush (*Glossopetalon spinescens* var. *meionandrum =Forsellesia meionandra*) form a community restricted to gypsiferous and calciferous soils. Canyon floors, gravelly river benches and the bases of mesa slopes often support a degraded shrubby grassland of rabbitbrush (*Ericameria nauseosus*) and cholla (*Cylindropuntia imbricata)* with a grassy understory. Occasional seeps and springs of the canyon walls provide habitat for rare ferns.

Diagnostic Characteristics

This system is primarily distinguished by its topography, and by the combination of several ecosystem elements within the canyon complex. These are intermittent or perennial drainages eroded below the surrounding comparatively flat plains, or canyons incised in mesa slopes. Exposed rocky rims and shelves are common within the canyon. Sides of the drainage typically support woodland or shrubland communities.

Similar Systems

Western Great Plains Cliff, Outcrop and Shale Barren: These scattered hogbacks, ridges, rocky outcrops, shallow canyons, mesa slopes, shale breaks, and barrens may be adjacent to or intermixed with the canyon complex, but are typically smaller, more isolated habitats.

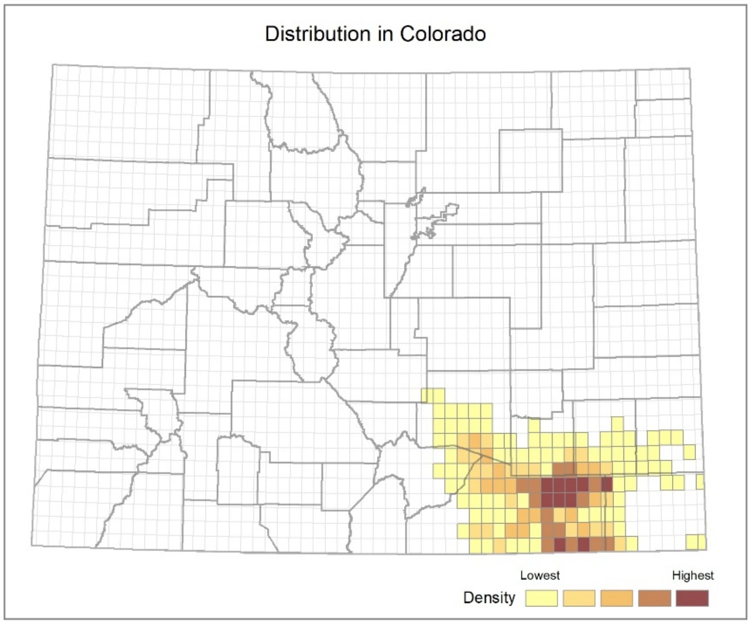
Southern Rocky Mountain Juniper Woodland and Savanna: These woodlands are co-occuring and often form an extensive matrix with the Southwestern Great Plains Canyon ecological system. Stands of this system are typically mapped as juniper woodland and savanna even if occurring on canyon sides.

Range

This system occurs in both perennial- and intermittent-stream canyons of the southwestern Great Plains in southeastern Colorado, southwestern Kansas, and northwestern Oklahoma. In Colorado, the canyon of the Purgatoire above the Arkansas River is the primary example of this type.

Spatial pattern

Southwestern Great Plains Canyon is a large patch type.



Environment

The climate of the region, classified as a semi-arid, is characterized by large seasonal contrasts, as well as interannual and longer term variability. Annual precipitation is generally less than 20 inches. Soils can range from deep loams to alluvial to sandy. The mosaic of soil types which have developed from sandstone, limestone, basalt, and shale parent materials create a complex mosaic of vegetation types within the canyon system.

Vegetation

Open to moderately dense juniper (*Juniperus monosperma*) woodlands occupy most of the canyonland slopes. Scattered pinyon pine (*Pinus edulis*) may occur within these community types but are never dominant. One-seed juniper (*Juniperus monosperma*) is the most common tree species, and forms extensive woodlands with an understory of warm season perennial grasses, that may include black grama (*Bouteloua eriopoda*), blue grama (*B. gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*) or James' galleta (*Pleuraphis jamesii*), or sometimes with an open shrub layer dominated by mountain mahogany (*Cercocarpus montanus*). A mosaic of shrub species is characteristic of canyon walls and slopes, and varies with substrate and moisture availability. Common species include Bigelow sage (*Artemisia bigelovii*), skunkbush sumac (*Rhus trilobata*), currant (*Ribes* spp.), common hoptree (*Ptelea trifoliata*), littleleaf mock orange (*Philadelphus microphyllus*), and soapweed yucca (*Yucca glauca*). James' seaheath (*Frankenia jamesii*) and spiny greasebush (*Glossopetalon spinescens* var. *meionandrum =Forsellesia meionandra*) form a community restricted to gypsiferous and calciferous soils. Canyon floors, gravelly river benches and the bases of mesa slopes often support a degraded shrubby grassland of rabbitbrush (*Ericameria nauseosus*) and cholla (*Cylindropuntia imbricata)* with a grassy understory. Sparsely vegetated rock outcrops are common. Occasional seeps and springs of the canyon walls provide habitat for rare ferns.

Plant Associations

CEGL000990	Artemisia bigelovii / Achnatherum hymenoides Shrubland
CEGL002912	Cercocarpus montanus - Rhus trilobata / Andropogon gerardii Shrubland
CEGL002913	Cercocarpus montanus / Achnatherum scribneri Shrubland
CEGL001092	Cercocarpus montanus / Hesperostipa comata Shrubland
CEGL002911	Cercocarpus montanus / Hesperostipa neomexicana Shrubland
CEGL000708	Juniperus monosperma / Bouteloua curtipendula Open Woodland

Forest & Woodland

CEGL000709	Juniperus monosperma / Bouteloua eriopoda Open Woodland
CEGL000710	Juniperus monosperma / Bouteloua gracilis Open Woodland
CEGL000714	Juniperus monosperma / Cercocarpus montanus - Ribes cereum Woodland
CEGL000713	Juniperus monosperma / Cercocarpus montanus Woodland
CEGL000722	Juniperus monosperma / Hesperostipa neomexicana Open Woodland
CEGL001117	Quercus gambelii / Symphoricarpos oreophilus Shrubland
CWSFRHTR0B	Rhus trilobata - Philadelphus microphyllus Shrubland
CEGL002910	Rhus trilobata Rocky Mountain Shrubland

Associated Animal species

Mammals associated with the canyonlands include pinyon mouse (*Peromyscus truei*), several woodrat species (*Neotoma* spp.), bighorn sheep (*Ovis canadensis*), and bats. Canyons also provide corridors for species more generally found in foothill to montane habitats, including the occasional mountain lion (*Felis* concolor) and black bear (*Ursus americanus*). Cliffs and outcrops in the canyon complex provide nesting areas for Peregrine Falcon (*Falco peregrinus*) and Peregrine Falcon (*Falco peregrinus*), and roosting sites for Wild Turkey (*Meleagris gallopavo*), or bats such as the Townsend's big eared bat (*Corynorhinus townsendii pallescens*). Because of the varied topography, relatively permanent water along stream beds, and southern location, these canyonlands have a rich herpetofauna. This system provides good habitat for a number of species including plains leopard frog (*Lithobates blairi*), red-spotted toad (*Anaxyrus punctatus*), Mexican spadefoot toad (*Spea multiplicata*), Texas horned lizard (*Phrynosoma cornutum*), Colorado checkered whiptail (*Aspidoscelis neotesselata*), collared lizard (*Crotaphytus collaris*), blackneck garter snake (*Thamnophis cyrtopsis*), groundsnake (*Sonora semiannulata*), longnose snake (*Rhinocheilus lecontei*), and speckled kingsnake (*Lampropeltis holbrooki*). Streams in the canyons also support populations of native fish.

Dynamic processes

Communities in the canyons are subject to the same ecological processes found in the surrounding uplands of the southwestern plains, including fire, drought, and grazing. However, little is known about how the comparatively sheltered and dissected nature of the canyon interior is likely to modify or ameliorate the effects of most processes.

Management

The integrity of these canyonlands is linked both to land management practices in the adjacent uplands, and to the management of both groundwater and surface flows. Grazing by domestic livestock is the most likely agricultural use of these canyonlands, and has probably been heavy in some areas during early open range conditions. Tree harvest for fuelwood or fencing is the primary consumptive use of biological resources in the woodlands, and can have noticeable local impacts. Alteration of natural hydrology regimes by dams, diversions, ditches, roads, and groundwater usage have considerably changed channel morphology, riparian vegetation, and natural processes from pre-settlement conditions. Projected warmer and drier conditions may favor the persistence of drought-tolerant juniper.

Original concept authors S. Menard and K. Kindscher May 2004
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
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SHRUBLAND, STEPPE & SAVANNA

Colorado Plateau Mixed Low Sagebrush Shrubland

General Description

These open shrublands and steppe occur in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats, and also extend across northern New Mexico into the southern Great Plains on limestone hills. In Colorado these shrublands are poorly documented, especially in northwestern Colorado, at the boundary between the Colorado Plateau and Wyoming Basins ecoregions. In this area it is not clear which stands belong to this system, and which to the Wyoming Basins Dwarf Sagebrush Shrubland and Steppe. Associations mapped at Dinosaur and Colorado National Monuments were assigned to this system, but could be considered as belonging to the Wyoming Basins type. Occurrences in southeastern Colorado have been documented at elevations of 1,400 to 1,675 m (4,600 to 5,500 ft), and are characterized by Bigelow sage (*Artemisia bigelovii*). West slope stands are dominated by black sage (*A. nova*) or occasional Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*), at elevations of 2,130 to 2,470 m (7,000 to 8,100 ft). Typical grass species that may form 25% or more cover are Indian ricegrass (*Achnatherum hymenoides*), purple threeawn (*Aristida purpurea*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), or muttongrass (*Poa fendleriana*).

Diagnostic Characteristics

This system shares diagnostic shrub species (*Artemisia nova* and *Artemisia arbuscula*) with the Wyoming Basins Dwarf Sagebrush Shrubland and Steppe. It is unclear if the stands dominated by

black sagebrush can be correctly separated between the two types in northwestern Colorado, since the primary other diagnostic species, Wyoming threetip sagebrush (*Artemisia tripartita* ssp. *rupicola*) does not occur in our state. Pending further research, stands within the Wyoming Basins ecoregion can be assigned to the Wyoming Basins type if they belong to an association documented for that type.

Similar Systems

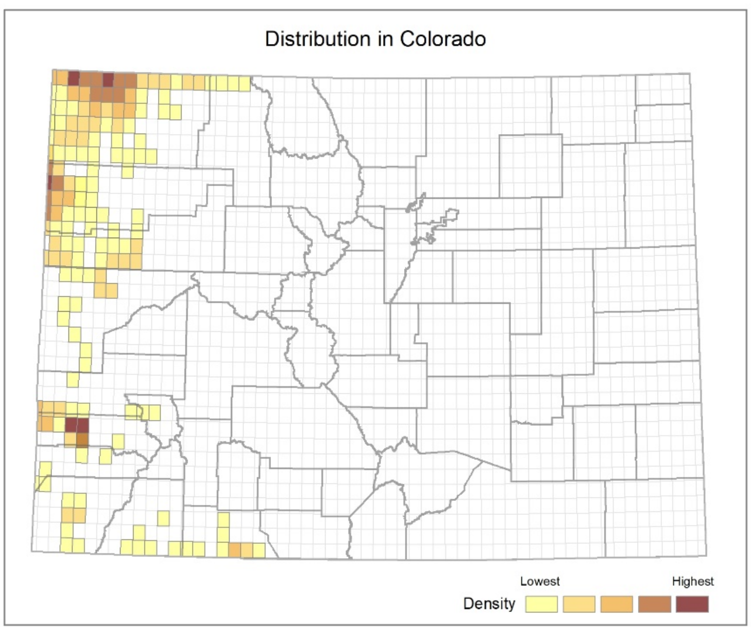
Wyoming Basins Dwarf Sagebrush Shrubland and Steppe: these low-stature open shrublands are dominated by dwarf sagebrush species *(Artemisia arbuscula* and *A. no*va). Low-growing, wind-dwarfed Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*) is also a common component in this system. Black sage is restricted to shallow-soiled, rocky, wind-exposed ridges in this Wyoming Basins system.

Range

These open shrublands and steppe occur in the Colorado Plateau, Tavaputs Plateau and Uinta Basin, and also extend across northern New Mexico into the southern Great Plains.

Spatial pattern

Colorado Plateau Mixed Low Sagebrush Shrubland is a large patch type in Colorado.



Environment

Stands of Colorado Plateau Mixed Low Sagebrush Shrubland are generally found on shallow, dry, rocky soils, on calcareous, alkaline substrates. These sites typically experience extreme drought in summer.

Vegetation

Occurrences in southeastern Colorado are characterized by Bigelow sage (*Artemisia bigelovii*). West slope stands are dominated by black sage (*Artemisia nova*) or Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*).Typical grass species that may form 25% or more cover are Indian ricegrass (*Achnatherum hymenoides*), purple threeawn (*Aristida purpurea*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), muttongrass (*Poa fendleriana*), or bluebunch wheatgrass (*Pseudoroegneria spicata*).

Plant Associations

CEGL000990	Artemisia bigelovii / Achnatherum hymenoides Shrubland
CEGL001742	Artemisia bigelovii / Bouteloua gracilis Dwarf-shrub Grassland
CEGL002344	Artemisia frigida - (Bouteloua gracilis, Achnatherum hymenoides, Poa secunda) - Lichens Rocky Mesa Dwarf-shrubland
CEGL001425	Artemisia nova / Hesperostipa comata Shrubland
CEGL002698	Artemisia nova / Poa fendleriana Shrubland
CEGL001423	Artemisia nova / Poa secunda Shrubland
CEGL001424	Artemisia nova / Pseudoroegneria spicata Shrubland
CEGL001417	Artemisia nova Shrubland
CEGL001041	Artemisia tridentata ssp. wyomingensis / Bouteloua gracilis Shrubland

Associated Animal species

These dwarf shrublands may provide habitat for birds such as Sagebrush Sparrow (*Artemisiospiza nevadensis*), Sage Thrasher (*Oreoscoptes montanus*), Brewer's Sparrow (*Spizella breweri*), and Loggerhead Shrike (*Lanius ludovicianus*), as well as mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and a variety of small mammals and reptiles common to arid environments in the region.

Dynamic processes

Sagebrush species in these shrublands do not resprout after fire, and depend on establishment from seed. Due to the arid environment and poor soils, recovery from fire is likely to be slow.

Management

Black sagebrush shrubland may provide important winter forage for both wildlife and domestic livestock, but does not tolerate sustained heavy browsing. Seasonal timing of precipitation is important for sagebrush habitats; summer moisture stress may be limiting if winter precipitation is low. Winter snowpack is critical for sagebrush growth; lower elevations are probably more at risk from temperature impacts under projected warming conditions in comparison to upper elevations, due to less snow, and consequently greater water stress. Increased drought intensity and/or frequency is likely to increase the impacts of fire in sagebrush shrublands, as well as play a role in the spread of invasive species.

Original concept authors: K.A. Schulz; May 2018
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: Oct 2019

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Inter-Mountain Basins Big Sagebrush Shrubland

General Description

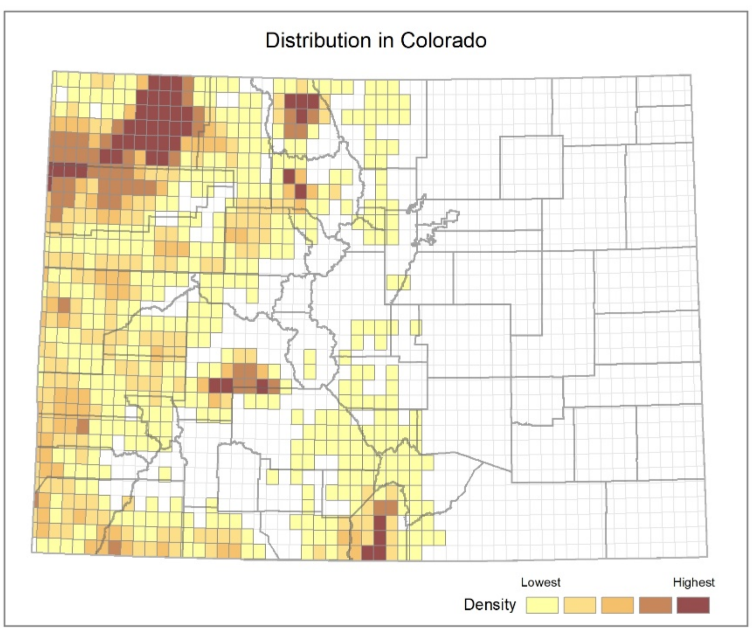
This matrix-forming ecological system occurs throughout the much of western U.S., on deep, well-drained and non-saline soils of broad basins between mountain ranges, or on plains and foothills. In Colorado, the largest occurrences are in the western half of the state, but this system can also be found in smaller stands in eastern Colorado. Sites are typically flat to rolling hills with deep, well-drained sandy or loam soils between 1,525 to 2,590 m (5,000 to 8,500 ft) in elevation. Northwestern Colorado, North Park, Middle Park, and the upper Gunnison Basin have large and continuous stands of sagebrush shrublands. These shrublands are dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and/or Wyoming big sagebrush (ssp. *wyomingensis*), often with scattered juniper trees (*Juniperus* spp.). Other shrubs including rabbitbrush (*Chrysothamnus* or *Ericameria* spp.), winterfat (*Krascheninnikovia lanata*), and antelope bitterbrush (*Purshia tridentata*) may be present in some stands. Perennial grasses typically contribute less than 25% vegetative cover. Common species can include Indian rice grass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis),* thickspike wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*), Idaho fescue (*Festuca idahoensis*), needle-and-thread (*Hesperostipa comata*), basin wildrye (*Leymus cinereus),* James' galleta (*Pleuraphis jamesii),* western wheatgrass (*Pascopyrum smithii*), Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*).

Diagnostic Characteristics
Inter-Mountain Basins Big Sagebrush Shrublands are characterized by stands of taller sagebrush species with a significant herbaceous understory, often forming extensive open-canopy shrublands on deep and fine-textured soils, at elevations generally below 2,290 m (7,500 ft).

Similar Systems
Inter-Mountain Basins Montane Sagebrush Steppe: Montane sagebrush steppe is dominated by montane big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), and is found at higher elevations, where it may be adjacent to or intergrade with big sagebrush shrublands.

Wyoming Basins Dwarf Sagebrush Shrubland and Steppe: These low-stature open shrublands are dominated by dwarf sagebrush *(Artemisia arbuscula* and *A. nova)*. These dwarf shrublands are often found on poorly drained soils with low aeration, in contrast to the big sagebrush shrublands that are usually on well drained and aerated soils.

Range
The distribution of Inter-Mountain Basins Big Sagebrush Shrublands is centered west and north of Colorado in the Wyoming Basins, Great Basin and southern Columbia Plateau. These shrublands are found in more limited extent elsewhere throughout the western US, from northern Arizona/New Mexico north to the Canadian border in eastern Washington. In Colorado these shrublands are at the southeastern edge of the current ecosystem distribution, where they occupy valleys and foothills up to about 2,590 m (8,500 ft) in the western half of the state, especially in the wide basins of Moffat County, Middle Park, and Gunnison County. The largest east slope occurrences are in North Park and the San Luis Valley, with scattered smaller stands elsewhere.



Spatial pattern
These sagebrush shrublands are matrix forming a few areas of northwestern Colorado, and in areas west of Colorado, but are primarily in large patches elsewhere in the state.

Environment
Big sagebrush shrublands are typically found in broad basins between mountain ranges, on plains and foothills. This system is usually found on flat to rolling hills with well-drained clay soils between 1,525 to 2,590 m (5,000 to 8,500 ft) in elevation. Soils are typically deep, well-drained and non-saline.

In many places the climate envelope of big sagebrush shrublands is broadly similar to that of pinyon-juniper woodlands, and the two types may be interspersed. Seasonal timing of precipitation is important for sagebrush habitats; summer moisture stress may be limiting if winter precipitation is low. Winter snowpack (and runoff) is critical for sagebrush growth; lower elevations are probably more at risk from temperature impacts in comparison to upper elevations due to less snow, and consequently greater water stress.

Vegetation

These are sagebrush shrublands of lower, drier elevations, dominated by basin big sagebrush (*Artemisia tridentata* ssp*. tridentata*) and/or Wyoming big sagebrush (ssp. *wyomingensis*).), often with scattered juniper trees (*Juniperus* spp.). Other shrubs including rabbitbrush (*Chrysothamnus* or *Ericameria* spp.), winterfat (*Krascheninnikovia lanata*), and antelope bitterbrush (*Purshia tridentata*) may be present in some stands. Understories are typically grassy, and common graminoid species include Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), Geyer's sedge (*Carex geyeri*), thickspike wheatgrass (*Elymus lanceolatus*), Idaho fescue (*Festuca idahoensis*), Thurber fescue (*F. thurberi*), needle-and-thread (*Hesperostipa comata*), basin wildrye (*Leymus cinereus*), western wheatgrass (*Pascopyrum smithii*), James' galleta (*Pleuraphis jamesii*), Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*). Perennial forb species typically contribute less than 25% vegetative cover.

Plant Associations

CEGL001073	Artemisia cana ssp. viscidula / Purshia tridentata Shrubland
CEGL001018	Artemisia tridentata (ssp. tridentata, ssp. xericensis) / Pseudoroegneria spicata Shrub Grassland
CEGL001006	Artemisia tridentata / Achnatherum hymenoides Shrubland
CEGL001005	Artemisia tridentata / Pleuraphis jamesii Shrubland
CEGL002966	Artemisia tridentata ssp. tridentata / Hesperostipa comata Shrubland
CEGL001016	Artemisia tridentata ssp. tridentata / Leymus cinereus Shrubland
CEGL001017	Artemisia tridentata ssp. tridentata / Pascopyrum smithii - (Elymus lanceolatus) Shrubland
CEGL001015	Artemisia tridentata ssp. tridentata / Pleuraphis jamesii Shrubland
CEGL002200	Artemisia tridentata ssp. tridentata / Sporobolus airoides Shrubland
CEGL001028	Artemisia tridentata ssp. vaseyana / Pascopyrum smithii Shrubland
CEGL001050	Artemisia tridentata ssp. wyomingensis - Purshia tridentata / Pseudoroegneria spicata Shrubland
CEGL001046	Artemisia tridentata ssp. wyomingensis / Achnatherum hymenoides Shrubland
CEGL002810	Artemisia tridentata ssp. wyomingensis / Achnatherum pinetorum Shrubland
CEGL000994	Artemisia tridentata ssp. wyomingensis / Balsamorhiza sagittata Shrubland
CEGL001041	Artemisia tridentata ssp. wyomingensis / Bouteloua gracilis Shrubland
CEGL001044	Artemisia tridentata ssp. wyomingensis / Elymus albicans Shrubland
CEGL001043	Artemisia tridentata ssp. wyomingensis / Elymus elymoides Shrubland
CEGL005478	Artemisia tridentata ssp. wyomingensis / Festuca idahoensis Shrubland
CEGL002761	Artemisia tridentata ssp. wyomingensis / Hesperostipa comata Colorado Plateau Shrubland
CEGL001045	Artemisia tridentata ssp. wyomingensis / Leymus ambiguus Shrubland
CEGL002813	Artemisia tridentata ssp. wyomingensis / Leymus salinus Shrubland
CEGL001047	Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Grassland

CEGL002084	Artemisia tridentata ssp. wyomingensis / Pleuraphis jamesii Shrubland
CEGL002775	Artemisia tridentata ssp. wyomingensis / Poa fendleriana Shrubland
CEGL001049	Artemisia tridentata ssp. wyomingensis / Poa secunda Shrubland
CEGL001535	Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Grassland
CEGL001009	Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrubland
CEGL002768	Artemisia tridentata ssp. wyomingensis / Sparse Understory Shrubland
CEGL001536	Artemisia tripartita ssp. tripartita / Festuca idahoensis Shrub Grassland
CEGL002713	Ericameria nauseosa Shrubland
CEGL001350	Grayia spinosa / Achnatherum hymenoides Shrubland
CEGL001327	Krascheninnikovia lanata / Hesperostipa comata Dwarf-shrubland

Associated Animal species

These tall sagebrush shrublands provide habitat for a number of sagebrush specialist birds, including Brewer's Sparrow (*Spizella breweri*), Sage Sparrow (*Artemisiospiza nevadensis*), Sage Thrasher (*Oreoscoptes montanus*), Gunnison Sage-Grouse (*Centrocercus minimus*), and Greater Sage-Grouse (*Centrocercus urophasianus). Sagebrush lizards (Sceloporus graciosus) are common. Mammals using sagebrush shrublands include elk* (*Cervus elaphus*)*, mule deer* (*Odocoileus hemionus*)*,* pronghorn (*Antilocapra americana),* badger (*Taxidea taxus*), *white-tailed jackrabbit* (*Lepus townsendii*), pocket gopher (*Thomomys* spp.), *sagebrush vole* (*Lemmiscus curtatus*), Gunnison's and white-tailed prairie dogs dogs (*Cynomys gunnisoni* and *C. leucurus*).

Dynamic processes

Although big sagebrush tolerates dry conditions and fairly cool temperatures it is not fire adapted, and none of the subspecies resprout after fire. Intense fires that enhance wind erosion and eliminate the seed bank can have a severe impact. Increased drought may increase fire frequency and severity, eliminating sagebrush in some areas, especially at drier sites of lower elevations. Increased fire frequency and severity in these shrublands may result in their conversion to grasslands dominated by exotic species.

Grazing by large ungulates (both wildlife and domestic livestock) can change the structure and nutrient cycling of sagebrush shrublands, but the interaction of grazing with other disturbances such as fire and invasive species under changing climatic conditions appears complex and not well studied in Colorado.

Management

Increased fire frequency and severity in these shrublands could result increasing area dominated by exotic grasses, especially cheatgrass (*Bromus tectorum*). Warmer, drier sites (typically found at lower elevations) are more invasible by cheatgrass. Sagebrush shrubland landscapes in Colorado have been moderately impacted by anthropogenic disturbance. Threats from exurban or recreational area development are limited, but ongoing at a very low level. Chaining or other shrub removal for mown hay, and to a lesser extent conversion to cropland is a substantial threat in northwestern Colorado. Large coal mining operations that completely remove this habitat prior to reclamation activity are an ongoing threat to the connectivity and quality of these shrublands. Oil and gas development, with associated roads, pipeline corridors, and infrastructure is another

ongoing source of anthropogenic disturbance, fragmentation, and loss in this habitat in northwestern Colorado.

Sagebrush shrublands have comparatively low vulnerability to the effects of climate change by mid-century. The primary factor contributing to this ranking is the comparatively low projected exposure to warmer and drier future conditions in the part of Colorado where the greater portion of this habitat is found. Under a longer time frame, these shrublands may have higher vulnerability. In particular, the degraded condition of some areas, and the vulnerability of this ecosystem to potential increases in fire frequency and severity, could increase the vulnerability to climate change.

Original concept authors: K.A. Schulz, Aug 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: June 2019

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Inter-Mountain Basins Juniper Savanna

General Description

This widespread ecological system occupies dry foothills and sandsheets of northwestern Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho. In Colorado these juniper savannas are largely restricted to the northwestern corner of the state, beyond the range of pinyon pine, but may also occur at lower, drier elevations of the west slope, adjacent to pinyon-juniper woodlands. Elevations range from 1,500-2,300 m (4,900-7,550 ft). This system is characterized by open tree canopies of Utah juniper (*Juniperus osteosperma*) with high cover of perennial bunch grasses and forbs, with blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), and James' galleta (*Pleuraphis jamesii*) being most common. Denser tree patches may also occur. Sagebrush (*Artemesia*) species are often present.

Diagnostic Characteristics

Occurrences are open woodlands of Utah juniper (*Juniperus osteosperma*), lacking pinyon pine. Perennial bunch grasses are dominant between the trees.

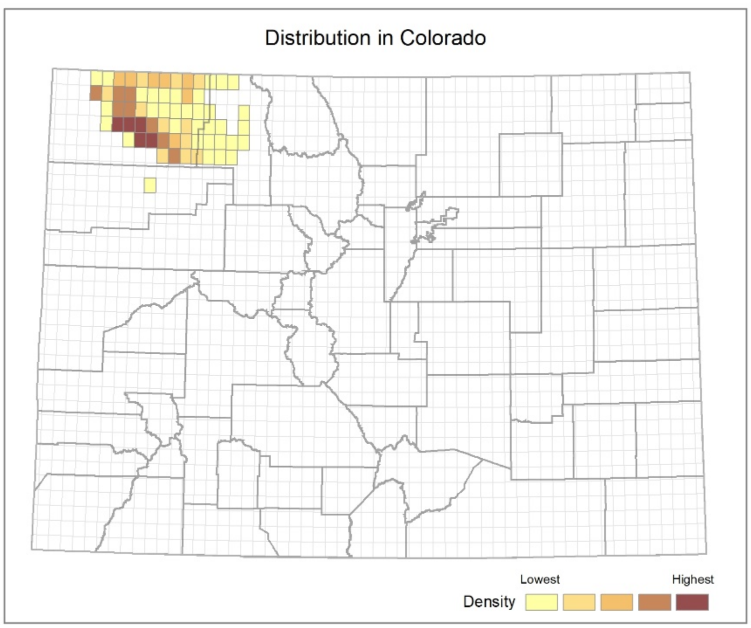
Similar Systems

Colorado Plateau Pinyon-Juniper Woodland: These are mixed-canopy woodlands including two-needle pinyon pine (*Pinus edulis*), and occurring at somewhat higher elevations. This type is widespread on Colorado's west slope, except in the northwestern part of the state.

Southern Rocky Mountain Juniper Woodland and Savanna: These juniper woodlands and savanna are characterized by one-seed juniper (*Juniperus monosperma*), and are found in southeastern Colorado.

Range

This widespread ecological system occupies dry foothills and sandsheets in northwestern Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho. In Colorado these juniper savannas are primarily restricted to the vicinity of Sandwash Basin and Vermillion Bluffs in the northwestern corner of the state, beyond the range of pinyon pine. Juniper woodlands lacking pinyon pine may also occur adjacent to pinyon-juniper woodlands at lower, drier elevations elsewhere on the west slope.



Spatial pattern

Inter-Mountain Basins Juniper Savanna is a large patch type in Colorado.

Environment

These open juniper woodlands are adapted to drought, hot, dry summers and cold, wet winters. In general these woodlands occupy areas that are somewhat drier than adjacent pinyon-juniper woodlands Annual precipitation is usually from 25-35 cm (10-14 in), but the seasonal distribution varies across the range of this ecological system. Generally, winter precipitation in the form of westerly storms is maximal along the northwest edge of the range and summer moisture increases to the east and south.

Stands occur on a variety of aspects and slopes. The aspect does not appear to be important except in cases of elevational extremes. The slope may vary but typically is fairly steep and rocky. Soils are typically poorly developed, thin and rocky. Soil textures vary, but often range from gravelly loams to gravelly clay loams. Parent materials are limestone or sandstone.

Vegetation

Vegetation is characterized by open tree canopies of Utah juniper (*Juniperus osteosperma*) with high cover of perennial bunch grasses and forbs, with blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), and James' galleta (*Pleuraphis jamesii*) being most common. Denser tree patches may also occur. Sagebrush (*Artemesia*) species are often present.

Plant Associations

CEGL002815	Juniperus osteosperma / Hesperostipa comata Open Woodland
CEGL001489	Juniperus osteosperma / Hesperostipa comata Wooded Grassland
CEGL000738	Juniperus osteosperma / Pseudoroegneria spicata Open Woodland
CEGL000741	Juniperus osteosperma / Symphoricarpos oreophilus Woodland
CEGL000748	Juniperus scopulorum / Pseudoroegneria spicata Woodland
CEGL000750	Juniperus scopulorum / Schizachyrium scoparium Woodland

Associated Animal species

Animal species in this ecological system are often similar to those found in pinyon-juniper landscape. Great basin spadefoot toads (*Spea intermontana*) use ponds in these areas. Reptiles include Hernandez's short-horned lizard (*Phrynosoma hernandesi*), sagebrush lizard (*Sceloporus graciosus*), striped whipsnake (*Masticophis taeniatus*), and midget faded rattlesnake (*Crotalus oreganus concolor*). These woodlands are also important habitat for larger game animals including mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), especially during winter.

Dynamic processes

Processes that influence the formation and persistence of juniper savannas and woodlands include climate, fires, grazing, tree harvest, and insect-pathogen outbreaks. Due to alteration of fire intensity and frequency, grazing, and changes in climate trees may increase in frequency on sites that were once shrublands or grasslands. Conversely, extended or extreme drought, tree removal, fire, and increased disturbance can decrease or eliminate trees in some areas.

Within a given region, the density of trees, both historically and currently, is also strongly related to topoedaphic gradients. Less steep sites, especially those with finer textured soils are where savannas, grasslands, and shrub steppes have occurred in the past. Juniper stands on these gentler slopes may have been large, but more savanna-like with very open upper canopy and high grass production.

Management

The ecotonal nature of these woodlands, in combination with a lack of knowledge about the true range of historical variation, can lead to assumptions that juniper trees are invading sagebrush and grassland ranges. Management efforts that focus on tree removal in an attempt to return to a particular 20th century snapshot condition are not well supported by research. Projected warmer and drier conditions may favor the persistence of drought-tolerant juniper. Livestock grazing has degraded the understory grasses of some stands, and invasive cheatgrass (*Bromus tectorum*) has become established in some areas.

Original concept authors K.A. Schulz, Nov 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Renée Rondeau, Karin Decker
Version date: Oct 2019

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Inter-Mountain Basins Mat Saltbush Shrubland

General Description

This ecological system occurs on gentle slopes and rolling plains in the northern Colorado Plateau and Uinta Basin, especially on Mancos Shale and arid, wind-swept basins and plains across parts of Wyoming. In western Colorado these communities are common on sites with shale-derived clay soils. These shrublands generally restricted to elevations below 2,130 m (7,000 ft), and are most extensive in the southwestern corner of Colorado on Ute Mountain Ute tribal lands, on valley floors of the salt anticlines (Disappointment Valley, Paradox Valley, and Dry Creek Basin), in the Grand Valley and Montrose vicinity, and in north-central Moffat County. Examples in extreme southwestern Colorado are more sparsely vegetated than those in northwestern Colorado. These landscapes typically support dwarf-shrublands composed of relatively pure stands of the low-growing mat saltbush (*Atriplex corrugata*) or Gardner's saltbush (*Atriplex gardneri*), typically with a sparse herbaceous layer. Occurrences may be adjacent to or intermingled with shale badlands or mixed salt desert shrublands.

Diagnostic Characteristics

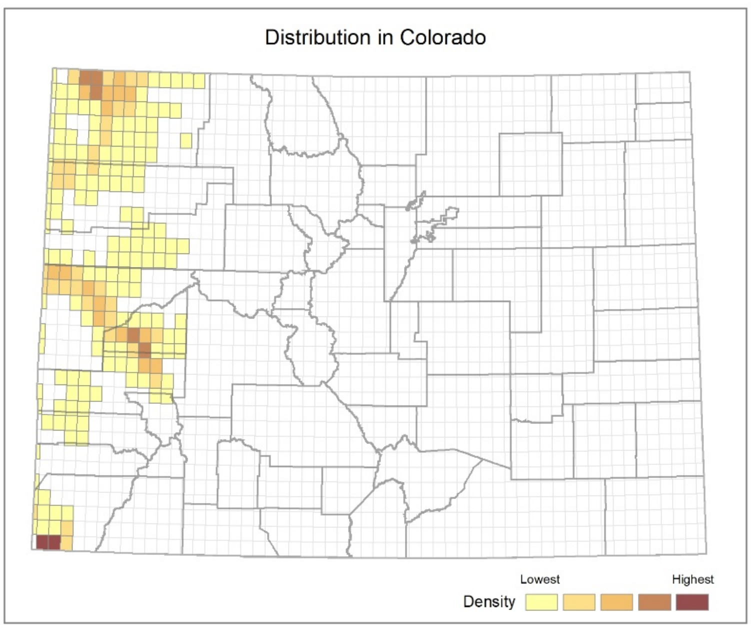
These shrublands are characterized by sparse vegetation dominated by dwarf *Atriplex* species, primarily on fine shale-derived soils.

Similar Systems

Inter-Mountain Basins Shale Badland: These very sparsely vegetated to barren shale communities are also characterized by dwarf saltbush (*Atriplex*) species, but are on steep and eroded areas. They may be adjacent to mat saltbush shrublands.

Range

The Inter-Mountain Basins Mat Saltbush Shrublands occur on fine shale-derived soils in the northern Colorado Plateau and Uinta Basin, and into southwestern Wyoming. In western Colorado these shrublands are found at elevations below 2,130 m (7,000 ft), and are most extensive in the southwestern corner of Colorado on Ute Mountain Ute tribal lands, on valley floors of the salt anticlines (Disappointment Valley, Paradox Valley, and Dry Creek Basin), in the Grand Valley and Montrose vicinity, and in north-central Moffat County.



Spatial pattern

In Colorado, Inter-Mountain Basins Mat Saltbush Shrubland is generally found as a large patch type, although it may be matrix-forming in parts of the Colorado Plateau.

Environment

This ecological system occurs on gentle slopes, rolling plains and arid, wind-swept plains and basins. Substrates are shallow, typically saline, alkaline, fine-textured soils developed from shale or alluvium, typically with poor infiltration. Such soils have a tendency to swell when wet, then shrink as they dry out, causing significant movement in the upper part of the soil column. The southern part of the Colorado distribution of these dwarf shrublands is within the zone of late summer monsoon moisture; otherwise summers are hot and dry, while winters are cold and also dry.

Vegetation

Mat saltbush shrubland typically supports relatively pure stands of low-growing mat saltbush (*Atriplex corrugata*) or Gardner's saltbush (*Atriplex gardneri*). Other dwarf-shrub species that may be present include bud sagebrush (*Picrothamnus desertorum*) and shortspine horsebrush (*Tetradymia spinosa*). Shadscale saltbush (*Atriplex confertifolia*) or fourwing saltbush (*Atriplex canescens*) may be present but do not codominate. Scattered perennial forbs occur, such as desert princesplume (*Stanleya pinnata*), evening primrose (*Oenothera* spp.), mariposa lily (*Calochortus* spp.) and phacelia (*Phacelia* spp.), and can produce a colorful display of spring flowers in years with

sufficient precipitation. Indian rice grass (*Achnatherum hymenoides*) and alkali sacaton (*Sporobolus airoides)* may be present in swales*.* Annuals may include desert trumpet (*Eriogonum inflatum*)*,* and introduced species such as African mustard (*Malcolmia africana*) and cheatgrass (*Bromus tectorum*). Some areas are essentially barren, or very sparsely vegetated.

Plant Associations

CEGL001437	Atriplex corrugata Dwarf-shrubland
CEGL001316	Atriplex cuneata - Frankenia jamesii / Sporobolus airoides Shrubland
CEGL001444	Atriplex gardneri / Achnatherum hymenoides Dwarf-shrubland
CEGL001442	Atriplex gardneri / Leymus salinus Dwarf-shrubland
CEGL001441	Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland
CEGL001446	Atriplex gardneri / Xylorhiza venusta Dwarf-shrubland
CEGL001438	Atriplex gardneri Dwarf-shrubland

Associated animal species

These sparsely vegetated shrublands provide limited habitat for animals. Mammals such as white-footed mice (*Peromyscus* spp.), white-tailed antelope squirrel (*Ammospermophilus leucurus*), desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), coyote (*Canis latrans*), and mule deer (*Odocoileus hemionus*) may occasionally be seen. Common reptiles include the collared lizard (*Crotaphytus collaris*), desert spiny lizard (*Sceloporous magister*), striped whipsnake (*Masticophis taeniatus*), and prairie rattlesnake (*Crotalus viridis*). Ravens (*Corvus corax*) and hawks (*Buteo* spp.) may prey on small mammals of these areas.

Dynamic processes

Vegetation of these shrublands is well adapted to periodic drought conditions, however, the naturally sparse plant cover along with fine-grained salt soils make these shrublands especially vulnerable to water and wind erosion, especially where vegetation has been depleted by grazing or other disturbances. Because these desert shrublands are sparsely vegetated, with low fuel availability, fire impacts are limited.

Management

Domestic livestock presence during wet periods can result in significant soil disturbance and potential damage to soil structure. These habitats have been fragmented by energy development activities in some areas. The interaction of soil types and precipitation patterns largely determines the composition and extent of these shrublands, which may undergo conversion to other types under future climate conditions. The altered condition of many stands is a confounding factor.

Original concept authors: K.A. Schulz, Jan 2016
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: June 2019

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Inter-Mountain Basins Mixed Salt Desert Scrub

General Description

This ecological system includes open-canopied shrublands of typically saline desert basins, alluvial slopes and plains across the intermountain western U.S. Although this is a matrix forming system in the Great Basin, it is a large patch system where it occurs in western Colorado and in areas on the plains near the mountain front. Elevations are generally below 2,130 m (7,000 ft). Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. Mixed salt desert scrub is characterized by the taller saltbush species shadscale saltbush (*Atriplex confertifolia*) or fourwing saltbush (*Atriplex canescens*), and may include winterfat (*Krascheninnikovia lanata*), pale desert-thorn (*Lycium pallidum*), horsebrush (*Tetradymia canescens*), and various sagebrush (*Artemisia*) species. Grasses and forbs are sparse to moderately dense, and dominated by species tolerant of the harsh soils. Typical perennial grasses include Indian rice grass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis),* thickspike wheatgrass (*Elymus lanceolatus* ssp*. lanceolatus*), western wheatgrass (*Pascopyrum smithii*), James' galleta (*Pleuraphis jamesii),* Sandberg bluegrass (*Poa secunda*), or alkali sacaton (*Sporobolus airoides*).

Diagnostic Characteristics

In Colorado occurrences are nearly always characterized by the presence of shadscale saltbush (*Atriplex confertifolia*, primarily on the west slope), and/or fourwing saltbush (*A. canescens*, more usual on the eastern plains). These taller saltbush species are usually accompanied by other salt-tolerant shrubs, and the grassy understory is sparse.

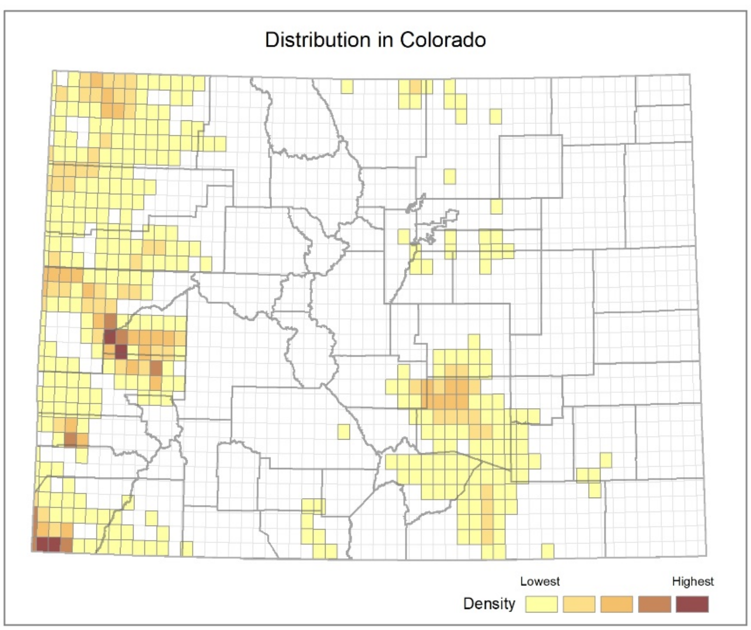
Similar Systems

Inter-Mountain Basins Mat Saltbush Shrubland: The mat saltbush shrublands are characterized by dwarf *Atriplex* species although scattered individuals of taller saltbush species may be present. Understory vegetation is typically much sparser than in mixed saltbush shrublands.

Inter-Mountain Basins Shale Badland: These very sparsely vegetated to barren shale communities are characterized by dwarf *Atriplex* species on steep and eroded areas. They may be adjacent to mixed salt desert shrublands.

Range

The distribution of Inter-Mountain Basins Mixed Salt Shrublands is centered in the Great Basin, to the west of Colorado, but the system is also common in the Colorado Plateau and Wyoming Basins. Colorado occurrences are found in dry, lower-elevation valleys of the west slope, and in saline soils of the eastern plains, primarily near the mountain front, but extending further east in southeastern Colorado, where calcareous soils are common.



Spatial pattern

Although this is a matrix forming system in the Great Basin, Inter-Mountain Basins Mixed Salt Shrubland is a large patch system in Colorado.

Environment

Inter-Mountain Basins Mixed Salt Shrublands are found on arid to semi-arid sites at elevations generally below 2,130 m (7,000 ft), on any aspect. Sites are variable and can include valley bottoms and floodplains, alluvial flats, and gentle to moderate slopes. Distribution of these shrublands is closely tied to warm, dry soils. These are stressful environments for plants due to low precipitation and/or soil salinity. Substrates may be shallow, coarse-textured (rocky or sandy) non-saline soils derived from sandstone, or deep, fine-textured saline, typically alkaline soils derived from shales. Salinity in these substrates can be due to either poor drainage (e.g., areas with temporary ponds that accumulate

salts), or derived from soil components. These shrublands are generally sparsely vegetated, with low to moderate levels of litter or bare soil between plants. Biological soil crusts are present in some stands.

This is typically a system of extreme climatic conditions, with warm to hot summers and freezing winters. In Colorado, the period of greatest moisture is often fall and winter, although precipitation patterns can be highly variable between even nearby local areas, as well as from year to year. The amount of winter soil moisture accumulation and storage will affect spring plant growth in these shrublands. Variable precipitation patterns give these shrublands a changing character over time.

Vegetation

Mixed salt desert scrub is characterized by the taller saltbush species shadscale saltbush (*Atriplex confertifolia*) or fourwing saltbush (*Atriplex canescens*), and may include black greasewood (*Sarcobatus vermiculatus*), winterfat (*Krascheninnikovia lanata*), pale desert-thorn (*Lycium pallidum*), horsebrush (*Tetradymia canescens*), broom snakeweed (*Gutierrezia sarothrae*) and various sagebrush (*Artemisia*) species. Grasses and forbs are sparse to moderately dense, and dominated by species tolerant of the harsh soils. Typical perennial grasses include Indian rice grass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis),* thickspike wheatgrass (*Elymus lanceolatus* ssp*. lanceolatus*), western wheatgrass (*Pascopyrum smithii*), James' galleta (*Pleuraphis jamesii),* Sandberg bluegrass (*Poa secunda*), or alkali sacaton (*Sporobolus airoides*).

Plant Associations

CEGL001040	Artemisia tridentata ssp. wyomingensis - Atriplex confertifolia Shrubland
CEGL001282	Atriplex canescens - Artemisia tridentata Shrubland
CEGL001287	Atriplex canescens - Ephedra viridis Talus Shrubland
CEGL001285	Atriplex canescens - Krascheninnikovia lanata Shrubland
CEGL001289	Atriplex canescens / Achnatherum hymenoides Shrubland
CEGL001283	Atriplex canescens / Bouteloua gracilis Shrubland
CEGL001288	Atriplex canescens / Pleuraphis jamesii Shrubland
CEGL001291	Atriplex canescens / Sporobolus airoides Shrubland
CEGL001281	Atriplex canescens Shrubland
CEGL001301	Atriplex confertifolia - Krascheninnikovia lanata Shrubland
CEGL001313	Atriplex confertifolia - Sarcobatus vermiculatus Shrubland
CEGL001311	Atriplex confertifolia / Achnatherum hymenoides Shrubland
CEGL001314	Atriplex confertifolia / Hesperostipa comata Shrubland
CEGL001307	Atriplex confertifolia / Leymus salinus Shrubland
CEGL001304	Atriplex confertifolia / Pleuraphis jamesii Shrubland
CEGL001312	Atriplex confertifolia / Pseudoroegneria spicata Shrubland
CEGL001294	Atriplex confertifolia Great Basin Shrubland
CEGL001293	Atriplex confertifolia Wyoming Basins Shrubland
CEGL001323	Krascheninnikovia lanata / Achnatherum hymenoides Dwarf-shrubland
CEGL001327	Krascheninnikovia lanata / Hesperostipa comata Dwarf-shrubland
CEGL001320	Krascheninnikovia lanata Dwarf-shrubland

Associated Animal species

These grassy shrublands provide food and shelter for a number of small mammals, including harvest mice (*Reithrodontomys* spp.), voles (*Microtus* spp.), chipmunks (*Neotamias* spp.), woodrats (*Neotoma* spp.) cottontail (*Sylvilagus* spp.), and black-tailed jackrabbits (*Lepus californicus*). Snakes and lizards are also common. The vegetation is used occasionally by mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*). Scaled and Gambel's Quail (*Callipepla squamata* and *C. gambelii*) may use these shrublands in Colorado. Saltbush shrublands of eastern Colorado are occasionally used by Horned Lark (*Eremophila alpestris*), Lark Bunting (*Calamospiza melanocorys*), Brewer's Blackbird (*Euphagus cyanocephalus*), Brewer's Sparrow (*Spizella breweri*), and other species of adjacent grasslands.

Dynamic processes

Fire has not been historically important as a process in mixed salt shrublands, although its incidence may be increasing. Fire tolerance of *Atriplex* species is varied; individuals that survive a fire are usually able to resprout. Soil disturbance due to flash flooding is important in some areas.

Management

Many of the dominant shrubs are palatable to both wildlife and domestic livestock. Fourwing saltbush can increase under moderate disturbance, including grazing. However the tendency of cattle to browse on the inflorescences of saltbush can alter reproductive dynamics of these shrub species and change stand composition. The dominant shrubs are able to grow whenever temperatures are favorable, but only if there is sufficient soil moisture. Soil moisture accumulation is primarily in winter, and influences the amount of spring plant growth. Since these are communities of arid landscapes, they could be less vulnerable to climate change where stands are in good condition. However, changing soil moisture patterns may eventually favor semi-desert grassland in areas currently occupied by this system.

Original concept authors: R. Crawford, M.S. Reid and K.A. Schulz, Jan 2016
Colorado version authors: Colorado Natural Heritage Program Staff: Renée Rondeau, Karin Decker
Version date June 2019

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Inter-Mountain Basins Montane Sagebrush Steppe

General Description

This matrix-forming ecological system includes sagebrush communities occurring at montane and subalpine elevations across the western U.S. Colorado occurrences are found primarily on the west slope, often in proximity to, but at higher elevations than big sagebrush shrublands. Elevations range from 2,290 to over 3,050 m (7,500 to 10,000 ft). This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general, this system is found on fine-textured soils, some source of subsurface moisture or more mesic sites, zones of higher precipitation, and areas of snow accumulation. These open shrublands are characterized by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), often intermingled with Wyoming big sagebrush (ssp. *wyomingensis*) or silver sagebrush (*Artemisia cana*) at lower elevations. A variety of other shrubs including Saskatoon serviceberry (*Amelanchier alnifolia*), rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), mountain snowberry (*Symphoricarpos oreophilus*), antelope bitterbrush (*Purshia tridentata*), and wax currant (*Ribes cereum*) may be present. Both forbs and grasses are typically well represented in the understory. Common graminoids include Idaho fescue (*Festuca idahoensis*), Thurber fescue (*Festuca thurberi*), timber oatgrass (*Danthonia intermedia*), Parry's oatgrass (*Danthonia parryi*), squirreltail (*Elymus elymoides*), slender wheatgrass (*Elymus trachycaulus*), spike fescue (*Leucopoa kingii*), western

wheatgrass, bluebunch wheatgrass, muttongrass (*Poa fendleriana*), Sandberg bluegrass and upland sedges (*Carex* spp.). Forb species may include common yarrow (*Achillea millefolium*), rosy pussytoes (*Antennaria rosea*), white sagebrush (*Artemisia ludoviciana*), milkvetch (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), Indian paintbrush (*Castilleja* spp.), fleabane (*Erigeron* spp.), buckwheat (*Eriogonum* spp.), strawberry (*Fragaria virginiana*), avens (*Geum* spp.), owl's-claws (*Hymenoxys hoopesii*), lupine (*Lupinus*, spp.), phlox (*Phlox* spp.), and cinquefoil (*Potentilla* spp.).

Diagnostic Characteristics

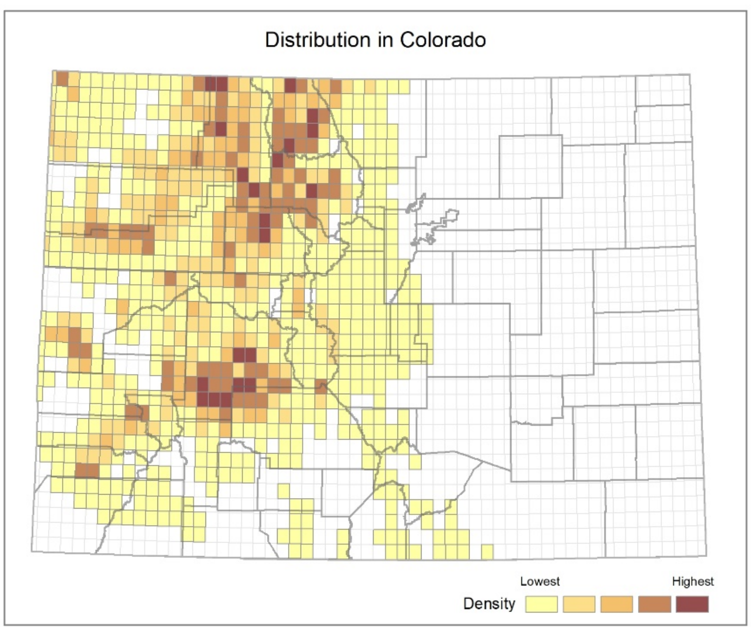
These are open sagebrush shrublands of montane elevations, characterized by the dominance of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), which may intermix with Wyoming big sagebrush (ssp. *wyomingensis*). The understory is also more characteristic of higher, more mesic elevations in comparison with basin big sagebrush (ssp. *tridentata*) shrublands, and will typically have good cover and diversity of grasses and forbs.

Similar Systems

<u>Inter-Mountain Basins Big Sagebrush Shrubland</u>: These big sagebrush shrublands are dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), sometimes in combination with Wyoming big sagebrush (ssp. *wyomingensis*), and are generally found at lower, drier sites than montane sagebrush steppe. The two shrubland types may be adjacent and intergrade.

Range

Inter-Mountain Basins Montane Sagebrush Steppe is found at montane to subalpine elevations across the western U.S., ranging from New Mexico into Canada. Occurrences are found in the Rocky Mountains as well as mountain ranges further west. In Colorado occurrences are found primarily on the west slope, especially in the larger intermountain valleys of North Park, Middle Park, and the Gunnison Basin.



Spatial pattern

Inter-Mountain Basins Montane Sagebrush Steppe is generally a matrix-forming type, although some stands in Colorado are large patches.

Environment

Montane sagebrush steppe is typically found in broad basins between mountain ranges, on plains and foothills. Sites are typically flat to rolling hills with deep, well-drained sandy or loam soils above 2,290 m (7,500 ft) in elevation. Most

annual precipitation falls as snow in winter. Temperatures exhibit large annual and diurnal variation. The climatic niche of these open shrublands is similar to that of oak-mixed montane shrublands.

Vegetation

These open shrublands are characterized by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), often intermingled with Wyoming big sagebrush (ssp. *wyomingensis*) or silver sagebrush (*Artemisia cana*) at lower elevations. A variety of other shrubs including Saskatoon serviceberry (*Amelanchier alnifolia*), rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), mountain snowberry (*Symphoricarpos oreophilus*), antelope bitterbrush (*Purshia tridentata*), and wax currant (*Ribes cereum*) may be present. Both forbs and grasses are typically well represented in the understory. Common graminoids include (*Festuca idahoensis*), Thurber fescue (*Festuca thurberi*), timber oatgrass (*Danthonia intermedia*), Parry's oatgrass (*Danthonia parryi*), squirreltail (*Elymus elymoides*), slender wheatgrass (*Elymus trachycaulus*), spike fescue (*Leucopoa kingii*), western wheatgrass, bluebunch wheatgrass, muttongrass (*Poa fendleriana*), Sandberg bluegrass and upland sedges (*Carex* spp.). Forb species may include common yarrow (*Achillea millefolium*), rosy pussytoes (*Antennaria rosea*), white sagebrush (*Artemisia ludoviciana*), milkvetch (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), Indian paintbrush (*Castilleja* spp.), fleabane (*Erigeron* spp.), buckwheat (*Eriogonum* spp.), strawberry (*Fragaria virginiana*), avens (*Geum* spp.), owl's-claws (*Hymenoxys hoopesii*), lupine (*Lupinus*, spp.), phlox (*Phlox* spp.), and cinquefoil (*Potentilla* spp.).

Plant Associations

CEGL002820	Amelanchier utahensis - Artemisia tridentata (ssp. vaseyana, ssp. wyomingensis) Shrubland
CEGL002694	Arctostaphylos patula - Artemisia tridentata (ssp. vaseyana, ssp. wyomingensis) Shrubland
CEGL001409	Artemisia arbuscula ssp. arbuscula / Festuca idahoensis Shrub Grassland
CEGL001552	Artemisia cana ssp. viscidula / Festuca idahoensis Shrub Wet Meadow
CEGL001071	Artemisia cana ssp. viscidula / Festuca thurberi Shrubland
CEGL002698	Artemisia nova / Poa fendleriana Shrubland
CEGL001423	Artemisia nova / Poa secunda Shrubland
CEGL001424	Artemisia nova / Pseudoroegneria spicata Shrubland
CEGL005827	Artemisia tridentata ssp. vaseyana - (Purshia tridentata) / Muhlenbergia montana - (Hesperostipa comata ssp. comata) Shrubland
CEGL002807	Artemisia tridentata ssp. vaseyana - Holodiscus dumosus Shrubland
CEGL001034	Artemisia tridentata ssp. vaseyana - Symphoricarpos oreophilus / Elymus trachycaulus ssp. trachycaulus Shrubland
CEGL002811	Artemisia tridentata ssp. vaseyana / Achnatherum lettermanii Shrubland
CEGL002806	Artemisia tridentata ssp. vaseyana / Achnatherum pinetorum Shrubland
CEGL001020	Artemisia tridentata ssp. vaseyana / Balsamorhiza sagittata Shrubland
CEGL001532	Artemisia tridentata ssp. vaseyana / Carex geyeri Shrub Grassland
CEGL001533	Artemisia tridentata ssp. vaseyana / Festuca idahoensis Shrub Grassland
CEGL001024	Artemisia tridentata ssp. vaseyana / Festuca thurberi Shrubland
CEGL002931	Artemisia tridentata ssp. vaseyana / Hesperostipa comata Shrubland
CEGL001025	Artemisia tridentata ssp. vaseyana / Leucopoa kingii Shrubland

CEGL001027	Artemisia tridentata ssp. vaseyana / Leymus cinereus Shrubland
CEGL001028	Artemisia tridentata ssp. vaseyana / Pascopyrum smithii Shrubland
CEGL002812	Artemisia tridentata ssp. vaseyana / Poa fendleriana Shrubland
CEGL001029	Artemisia tridentata ssp. vaseyana / Poa secunda Shrubland
CEGL001030	Artemisia tridentata ssp. vaseyana / Pseudoroegneria spicata Shrubland
CEGL001047	Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Grassland

Associated Animal species

These montane sagebrush shrublands provide habitat for a number of sagebrush specialist birds. Characteristic species include Brewer's Sparrow (*Spizella breweri*), Sage Sparrow (*Artemisiospiza nevadensis*), Sage Thrasher (*Oreoscoptes montanus*), Green-tailed Towhee (*Pipilo chlorurus*), and Gunnison Sage-Grouse (*Centrocercus minimus*). Mammals using sagebrush shrublands include elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), badger (*Taxidea taxus*), white-tailed jackrabbit (*Lepus townsendii*), pocket gopher (*Thomomys* spp.), sagebrush vole (*Lemmiscus curtatus*), Gunnison's and white-tailed prairie dogs dogs (*Cynomys gunnisoni* and *C. leucurus*).

Dynamic processes

Although sagebrush tolerates dry conditions and fairly cool temperatures it is not fire adapted, and is likely to be severely impacted by intense fires that enhance wind erosion and eliminate the seed bank. These higher elevation shrub steppe areas are less susceptible to invasion by cheatgrass and other exotic species.

Management

Grazing by domestic livestock is common; prolonged livestock use can cause a decrease in the abundance of native bunch grasses and increase in the cover of shrubs and non-native grass species, such as Kentucky bluegrass (*Poa pratensis*). Threats to sagebrush shrublands from exurban or recreational area development are limited, but ongoing at a very low level. Hunting and recreation are minor sources of disturbance in this habitat.

Under experimental warming conditions in a high-elevation population, mountain big sagebrush had increased growth, suggesting that longer growing season length could facilitate the expansion of sagebrush habitat into areas that were formerly too cold for the shrub. However, high summer temperatures resulted in lower growth rate, due to increased water stress. Sagebrush shrublands have comparatively low vulnerability to the effects of climate change by mid-century. The primary factor contributing to this ranking is the comparatively low projected exposure to warmer and drier future conditions in the part of Colorado where the greater portion of this habitat is found. Under a longer time frame, these shrublands may have higher vulnerability. In particular, the degraded condition of some areas, and the vulnerability of this ecosystem to potential increases in fire frequency and severity, could increase the vulnerability to climate change.

Original concept authors R. Crawford, M.S. Reid and K.A. Schulz, Aug 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: Sept 2019

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Inter-Mountain Basins Semi-Desert Shrub-Steppe

General Description

This ecological system occurs throughout the intermountain western U.S., typically at lower elevations on alluvial fans and flats with moderate to deep soils. In Colorado, this system is generally a large-patch type, except in the San Luis Valley, where it is matrix forming. Colorado's shrub-steppes are grass-dominated areas with an open shrub layer at elevations from 2,280-2,900 m (7,500-9,500 ft). Typical grass species include blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), saltgrass (*Distichlis spicata*), Indian rice grass (*Achnatherum hymenoides*), and alkali sacaton (*Sporobolus airoides*). Historically, the shrub layer was dominated by winterfat (*Krascheninnikovia lanata*) in most areas, but this species has decreased under grazing pressure in many areas. Winterfat has largely been replaced by rabbitbrush (*Ericameria* and *Chrysothamnus*) species and other woody shrubs. Pinyon-juniper woodlands and sagebrush shrublands are commonly adjacent to this system at the upper elevations.

Diagnostic Characteristics

These are open, grassy shrublands characterized by short shrub species, not dominated by sagebrush, and occurring generally on lower, drier elevations of Colorado's west slope and in the

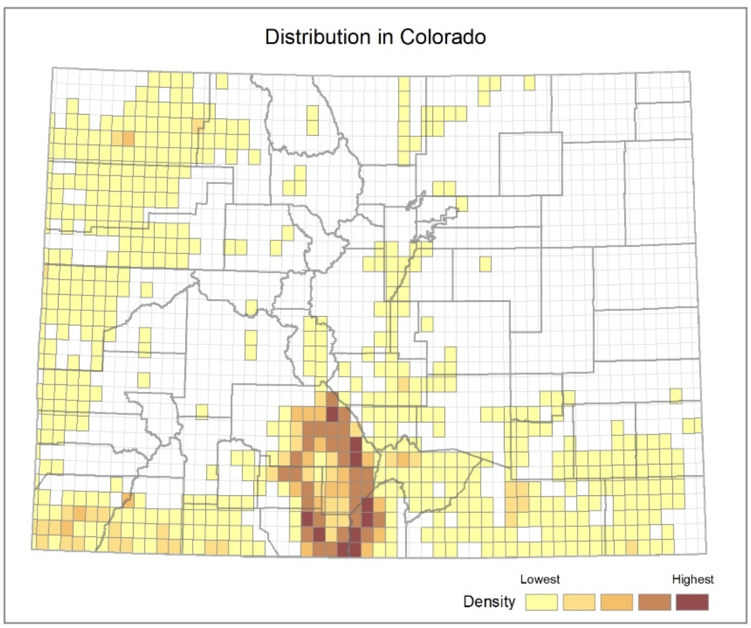
San Luis Valley. Although some areas of winterfat (*Krascheninnikovia lanata*) remain, this species has largely been replaced by rabbitbrush (*Ericameria* and *Chrysothamnus*) species and other woody shrubs in this shrub-steppe system. In Colorado, semi-desert shrub steppe is generally found at elevations between the lower elevation big sagebrush shrubland and the higher montane sagebrush steppe.

Similar Systems

Inter-Mountain Basins Mixed Salt Desert Shrubland: These open shrublands are nearly always characterized by the presence of shadscale saltbush (*Atriplex confertifolia*, primarily on the west slope), and/or fourwing saltbush (*A. canescens*, more usual on the eastern plains). These taller saltbush species are usually accompanied by other salt-tolerant shrubs, and the grassy understory is sparse.

Range

Inter-Mountain Basins Semi-Desert Shrub-Steppe occurs throughout the intermountain west, but is most common in the Colorado Plateau and areas adjacent to that ecoregion.



Spatial pattern

In Colorado, this system is generally a large-patch type, except in the San Luis Valley, where it is matrix forming.

Environment

Semi-desert shrub steppe in Colorado generally occurs between 2,280-2,900 m (7,500-9,500 ft) in elevation, on windswept mesas, valley floors, gentle slopes, or shoulders of ridges. Sites are alluvial fans and flats with moderate to deep soils. Some sites can be flat, poorly drained and intermittently flooded with a shallow or perched water table often within 1 m (3 ft) depth. Temperatures are continental with large annual and diurnal variation. Summers are hot and winters cold, with low annual precipitation, ranging from 18-40 cm (7-16 in) and high inter-annual variation. Much of the precipitation falls as snow, and growing-season drought is characteristic.

Vegetation

These semi-arid open shrublands are usually dominated by grasses with short or dwarf shrubs. Typical grass species include blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), saltgrass (*Distichlis spicata*), Indian rice grass

(*Achnatherum hymenoides*), and alkali sacaton (*Sporobolus airoides*). Historically, the shrub layer was dominated by winterfat (*Krascheninnikovia lanata*) in most areas. Currently, most occurrences are dominated by rabbitbrush species (*Ericameria nauseosa, E. parryi, Chrysothamnus greenei* and/or *C. viscidiflorus*) and other shrubs or dwarf shrubs, including fourwing saltbush (*Atriplex canescens*), broom snakeweed (*Gutierrezia sarothrae*), spineless horsebrush (*Tetradymia canescens*), fringed sagebrush (*Artemisia frigida*), plains pricklypear (*Opuntia polyacantha*), and occasional big sagebrush (*Artemisia tridentata*). Forbs are generally not a conspicuous component of the vegetation except in disturbed sites and are highly variable across the range. Sanddune cryptantha (*Cryptantha fendleri*), nodding buckwheat (*Eriogonum cernuum*), sanddune wallflower (*Erysimum capitatum*), flatspine stickseed (*Lappula occidentalis*), and tanseyleaf tansyaster (*Machaeranthera tanacetifolia*, hairy golden aster (*Heterotheca villosa*), and goosefoot (*Chenopodium* spp.) have been reported in this system from the San Luis Valley. Weedy annual grasses and forbs may include the exotics cheatgrass (*Bromus tectorum*), tansymustard (*Descurainia* spp.), burningbush (*Bassia scoparia*), and Russian thistle (*Salsola* spp.).

Plant Associations

CEGL001742	Artemisia bigelovii / Bouteloua gracilis Dwarf-shrub Grassland
CEGL002813	Artemisia tridentata ssp. wyomingensis / Leymus salinus Shrubland
CEGL001288	Atriplex canescens / Pleuraphis jamesii Shrubland
CEGL002781	Chrysothamnus viscidiflorus - Ericameria parryi Shrub Grassland
CEGL002799	Chrysothamnus viscidiflorus / Hesperostipa comata Shrubland
CEGL002530	Chrysothamnus viscidiflorus Shrub Grassland
CEGL003495	Ericameria nauseosa / Bouteloua gracilis Shrub Grassland
CEGL002921	Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Grassland
CEGL003751	Ericameria parryi / Achnatherum hymenoides Shrubland
CEGL001321	Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Grassland
CEGL001324	Krascheninnikovia lanata / Pascopyrum smithii - Bouteloua gracilis Dwarf-shrub Grassland
CEGL001322	Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland
CEGL001326	Krascheninnikovia lanata / Poa secunda Dwarf-shrubland
CEGL001320	Krascheninnikovia lanata Dwarf-shrubland
CEGL002299	Opuntia polyacantha / Pleuraphis jamesii Shrubland

Associated Animal species

Pronghorn (*Antilocapra americana*) often favor these open shrublands due to the good visibility provided by low-growing vegetation. Other large grazers and browsers such as mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) may also be seen. Pallid bat (*Antrozous pallida*) will use these shrublands in areas near rocky outcrops. Although not restricted to this habitat, a number of small mammal species of concern, including the silky pocket mouse (*Perognathus flavus sanluisi*), plains pocket mouse (*Perognathus flavescens relictus*), northern nocket gopher (*Thomomys talpoides agrestis*), and Gunnison's prairie dog (*Cynomys gunnisoni*), will occasionally be found in shrub-steppe in the San Luis Valley. Reptiles include the plateau fence lizard (*Sceloporus tristichus*), Hernandez's short-horned lizard (*Phrynosoma hernandesi*), and western rattlesnake (*Crotalus viridis*).

Dynamic processes

These open shrub-steppe areas were historically influenced by large-scale natural ecological processes such as drought, fire, and grazing by large mammals. Disturbance may be important in maintaining the woody shrub component of the vegetation.

Plant growth and reproduction depends on sufficient soil moisture during the growing season (generally April through September). The growth and flowering rate of winterfat during spring and early summer is linked to winter precipitation levels, which replenish soil moisture. Winterfat is generally able to use deeper soil moisture than more shallow-rooted grasses and forbs, but low levels of winter precipitation may result in reduced infiltration depth of this moisture when plant growth during the previous growth year has depleted shallow soil moisture. Winterfat seed production relies on sufficient summer moisture for a typical seed crop. Depletion of soil moisture during very dry growing seasons also reduces the infiltration depth of winter precipitation, decreasing the soil moisture available in both shallow and deeper soil layers. Shallow-rooted shrubs, grasses, or forbs will be the first species affected by extreme drought, which can reduce the growth and survival of these species.

Management

Anthropogenic changes including fire suppression and historic heavy livestock grazing have altered most occurrences of this shrub-steppe type. Historically, winterfat (Krascheninnikovia lanata) was typically dominant in this dwarf-shrub system. This shrub, together with the perennial grasses needle-and-thread (*Hesperostipa comata*) and Indian ricegrass (*Achnatherum hymenoides*) are considered decreasers under grazing. As a consequence of changes in grazing patterns due to domestic livestock, Greene's rabbitbrush (*Chrysothamnus greenei*) is now the dominant shrub in the San Luis Valley, although the wetter areas still have significant amounts of winterfat. Other shrubs that have increased from historic heavy livestock grazing include Parry's rabbitbrush (*Ericameria* parryi), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), and broom snakeweed (*Gutierrezia sarothrae*). Changes in either fall precipitation or winter/spring precipitation could affect germination and establishment of cheatgrass (*Bromus tectorum*). This annual grass can germinate in either spring or fall if precipitation is adequate, and is able to establish and spread if not constrained by frequent drought. Increasing frequency of severe drought events can eventually lead to critical changes in community composition. Although these shrublands are predicted to experience adequate or increased winter moisture, summer growing season conditions may act to overcome any potential benefit. If conditions are not exacerbated by increased disturbance and invasion by exotic species, these shrublands are likely to be able to persist in their current condition.

Original concept authors G. Kittel, M.S. Reid, K.A. Schulz; Apr 2014
Colorado version authors Colorado Natural Heritage Program Staff: Renée Rondeau, Karin Decker
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Rocky Mountain Lower Montane-Foothill Shrubland

General Description

This ecological system is found in the foothills, canyon slopes and lower montane of the Rocky Mountains and ranges from southern New Mexico extending north into Wyoming, and west into the Intermountain region. In Colorado these shrublands are most common in the northern portion of the state especially on dry foothills, ridges, and basins of the northern Colorado Front Range. Elevations range from 1,490 to 2,590 m (4,900 to 8,500 ft). The component associations typically form a patchy mosaic of shrub communities that can change noticeably across short geographic distances and are, as well, often transitional between plains systems and montane systems. In general, these are mixed shrublands of areas where Gambel oak (*Quercus gambelii*) is absent, although they may intergrade in places with oak/mixed mountain shrublands. Occurrences of this system are dominated by low to moderate height shrubs averaging 1-2 m in height. The herbaceous stratum rarely exceeds 1m in height. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), chokecherry (*Prunus virginiana*), skunkbush sumac (*Rhus trilobata*), wax currant (*Ribes cereum*), mountain ninebark (*Physocarpus monogynus*), or soapweed yucca (*Yucca glauca*). Understory grass species vary with site conditions; common species include mountain muhly (*Muhlenbergia montana*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), Arizona fescue (*Festuca arizonica*),

needle-and-thread (*Hesperostipa comata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Scattered individuals of Rocky Mountain juniper (*Juniperus scopulorum*), ponderosa pine (*Pinus ponderosa*), or other conifers may be present.

Diagnostic Characteristics

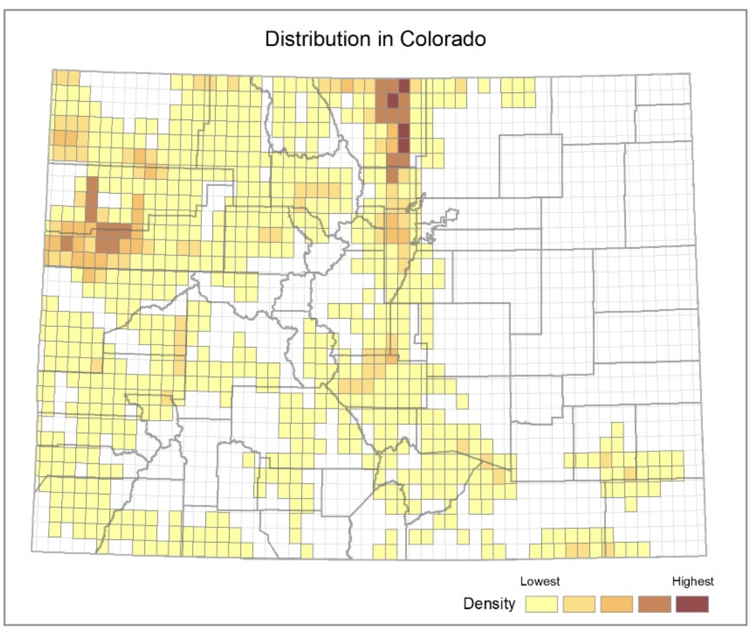
These foothill and lower montane shrublands are often transitional between grassland or shrubland types and savanna or forest ecosystems.

Similar Systems

<u>Rocky Mountain Gambel Oak-Mixed Montane Shrubland</u>: These are shrublands of generally more mesic areas, usually dominated by Gambel oak and/or serviceberry. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics.

Range

Rocky Mountain Lower Montane-Foothill Shrublands occur in the foothills, canyon slopes and dry lower montane of the Rocky Mountains and ranges from southern New Mexico extending north into Wyoming, and west into the Intermountain region. In Colorado these shrublands are most common in the northern portion of the state especially on dry foothills, ridges, and basins of the northern Colorado Front Range.



Spatial pattern

Rocky Mountain Lower Montane-Foothill Shrublands are generally a large patch type in Colorado, although some very large occurrences are found in the northern Front Range.

Environment

These shrublands occur in the foothills, ridges, canyon slopes and lower mountains of the Rocky Mountains and on outcrops, mesas, and canyon slopes in the western Great Plains, at elevations between 1,490 and 2,590 m (4,900 to 8,500 ft). In general, these are mixed shrublands of areas where oak is absent, although they may intergrade in places with oak/mixed mountain shrublands, such as at the northern extent of Gambel oak along the mountain front in Colorado, or with other *Quercus* species on the Mesa de Maya. Although this system is often associated with exposed sites, rocky substrates, and dry conditions which limit tree growth, the principle species characterizing these shrublands form associations that range from xeric to mesic.

The component associations typically form a patchy mosaic of shrub communities that can change noticeably across short geographic distances and are, as well, often transitional between plains systems and montane systems. In general, temperature decreases and precipitation increases with altitude, resulting in a foothill and lower montane habitat that is appreciably more mesic than that of the adjacent plains These shrublands appear to be environmentally intermediate between grasslands and savanna/forest associations, being drier than the latter, and moister than the former.

Vegetation

Communities of this system are diverse, and species composition varies with elevation, aspect, soils, and disturbance history. Only a few of the component associations have a widespread distribution; many are restricted to a relatively small portion of the range. Communities range from xeric to mesic, and may be transitional to riparian woodland and shrublands. The dominant shrub species are generally well adapted to poor soils, dry sites, and disturbance by fire. Association of this system are dominated by low to moderate height shrubs averaging 1-2 m in height. The herbaceous stratum rarely exceeds 1m in height. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), skunkbush sumac (*Rhus trilobata*), wax currant (*Ribes cereum*), mountain ninebark (*Physocarpus monogynus*), serviceberry (*Amelanchier* spp.) or soapweed yucca (*Yucca glauca*). Many of the dominant shrub species are also members of the shrub layer in ponderosa or mixed conifer woodlands.

Understory grass species vary with site conditions, and include species of both plains and montane. Common species include mountain muhly (*Muhlenbergia montana*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), Arizona fescue (Festuca arizonica), needle-and-thread (*Hesperostipa comata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Other graminoids that may be present include Indian ricegrass (*Achnatherum hymenoides*), threeawn (*Aristida* spp.), sedge (*Carex* spp.), squirreltail (*Elymus elymoides*), slender wheatgrass (*Elymus trachycaulus*), prairie Junegrass (*Koeleria macrantha*), spike fescue (*Leucopoa kingii*), slimstem muhly (*Muhlenbergia filiculmis*), and little bluestem (*Schizachyrium* scoparium). The introduced grasses cheatgrass (*Bromus tectorum*), smooth brome (*B. inermis*), and Kentucky bluegrass (*Poa pratensis*) are often present. Forbs and dwarf-shrubs generally have low cover. Typical forbs include common yarrow (*Achillea millefolium*), pussytoes (*Antennaria* spp.), textile onion (*Allium textile*), white sagebrush (*Artemisia ludoviciana*), milkvetech (*Astragalus* spp.), sulphur-flower buckwheat (*Eriogonum umbellatum*), shaggy fleabane (*Erigeron pumilus*), little sunflower (*Helianthus pumilus*), hairy false goldenaster (*Heterotheca villosa*), mountain bladderpod (*Lesquerella montana*), prairie bluebells (*Mertensia lanceolata*), plains pricklypear (*Opuntia polyacantha*), and cinquefoil (*Potentilla* spp.), among others. Scattered individuals of Rocky Mountain juniper (*Juniperus scopulorum*), ponderosa pine (*Pinus ponderosa*), or other conifers may be present.

Plant Associations

CEGL001070	Amelanchier (utahensis, alnifolia) - Cercocarpus montanus Shrubland

CEGL001069	Amelanchier utahensis / Pseudoroegneria spicata Shrubland
CEGL001067	Amelanchier utahensis Shrubland
CEGL002782	Artemisia frigida / Bouteloua gracilis Dwarf-shrubland
CEGL001421	Artemisia nova / Leymus salinus Shrub Grassland
CEGL005805	Cercocarpus montanus - Artemisia tridentata Shrubland
CEGL003820	Cercocarpus montanus - Fendlera rupicola Shrubland
CEGL002912	Cercocarpus montanus - Rhus trilobata / Andropogon gerardii Shrubland
CEGL002913	Cercocarpus montanus / Achnatherum scribneri Shrubland
CEGL001086	Cercocarpus montanus / Bouteloua curtipendula Shrubland
CEGL001087	Cercocarpus montanus / Elymus lanceolatus ssp. lanceolatus Shrubland
CEGL001092	Cercocarpus montanus / Hesperostipa comata Shrubland
CEGL002911	Cercocarpus montanus / Hesperostipa neomexicana Shrubland
CEGL002914	Cercocarpus montanus / Muhlenbergia montana Shrubland
CEGL001090	Cercocarpus montanus / Pseudoroegneria spicata Shrubland
CEGL001091	Cercocarpus montanus / Rhus trilobata var. trilobata Shrubland
CEGL001108	Prunus virginiana - (Prunus americana) Wet Shrubland
CEGL005606	Prunus virginiana / Leymus cinereus Shrubland
CEGL005453	Prunus virginiana Great Plains Shrubland
CEGL001055	Purshia tridentata / Artemisia frigida / Hesperostipa comata Shrubland
CEGL001057	Purshia tridentata / Muhlenbergia montana Shrubland
CEGL002910	Rhus trilobata Rocky Mountain Shrubland
CEGL001124	Ribes cereum / Leymus ambiguus Shrubland
CEGL001131	Symphoricarpos occidentalis Shrubland
CEGL002951	Symphoricarpos oreophilus Shrubland

Associated Animal species

Shrub communities of this system can provide important seasonal food and cover for wildlife at critical times of the year. Mammals using these shrublands include pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*), black bear (*Ursus americanus)*, mountain lion (*Felis concolor)*, bobcat (*Felis rufus*), and numerous smaller species. Typical bird species include Virginia's Warbler (*Oreothlypis virginiae*), Spotted Towhee (*Pipilo maculatus*), Green-tailed Towhee (*Pipilo chlorurus*), Broad-tailed Hummingbird (*Selasphorus platycercus*), MacGillivray's Warbler (*Geothlypis tolmiei*), Dusky Flycatcher (*Empidonax oberholseri*), and Blue-gray Gnatcatcher (*Polioptila caerulea*). Fence lizards (*Sceloporus* spp.) and Prairie rattlesnake (*Crotalus viridis*) are also found in these shrublands.

Dynamic processes

Fire is a naturally occurring process in lower montane and foothill shrublands, but the system is not always fire-driven. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too dry to allow much tree growth, even in the absence of fire. With the exception of antelope bitterbrush (*Purshia tridentata*), the dominant shrubs are generally able to survive fire and resprout vigorously after being top-killed. Variation in response to fire within and between species may gradually change the composition of a shrubland. Repeated fires may greatly decrease shrub abundance. Fire regimes in this type are probably naturally

variable, depending on local site factors. Fire can greatly increase available soil nutrients in this system, although erosion potential also increases in burned areas.

Lower montane and foothill shrublands evolved with a variety of native browsers and grazers, and dominant shrubs in these shrublands are generally palatable to browsing animals, and are tolerant of herbiverory at moderate levels. Herbivory affects energy and material flow in the system, but may also have differential impacts on life history stages of species. Some species are able to compensate for annual growth lost to herbivory, at least under conditions of high resource availibility. However, unbrowsed shrubs produced many more flowers and seeds than browsed shrubs.

Management

Land use within the lower montane and foothills shrublands as well as in adjacent areas can fragment the landscape and reduce connectivity between patches and between occurrences and the surrounding landscape. In the Colorado Front Range, many of these habitats are in areas that are highly desirable for suburban or exurban development, roads, or recreational infrastructure. Other occurrences of this system along the mountain front are found on public (open space) lands where recreational use can be a major source of disturbance, with a concomitant increase in weedy exotic species.

Original concept authors M.S. Reid and K.A. Schulz; May 2018
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: July 2019

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Western Great Plains Sandhill Steppe

General Description

This shrub-steppe system is found primarily in the south-central areas of the western Great Plains. Occurrences range from southeastern Wyoming and adjacent southwestern Nebraska south of the Nebraska Sandhills south through eastern Colorado and New Mexico to north-central Texas. The greater part of the system occurs in the Central Shortgrass Prairie Ecoregion in eastern Colorado, western Kansas and southwestern Nebraska. In eastern Colorado, this system is found in extensive tracts on sandy soils of Quaternary eolian deposits along the South Platte, Arikaree and Republican Rivers, between Big Sandy and Rush Creeks, and along the Arkansas and Cimarron Rivers, where it is contiguous with areas in Kansas. Elevations are generally below 1,680 m (5,500 ft). These open shrublands are characterized by a sparse to moderately dense woody layer dominated by sand sagebrush (*Artemisia filifolia*), and are sometimes called sandsage prairie. Soapweed yucca (*Yucca glauca*), broom snakeweed (*Gutierrezia sarothrae*), or pricklypear (*Opuntia* spp.) are common subshrubs in many areas. Gramminoids are generally dominant, and include sand bluestem (*Andropogon hallii*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), prairie sandreed (*Calamovilfa longifolia*), needle-and-thread (*Hesperostipa comata*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), and threeawn (*Aristida* spp.).

Diagnostic Characteristics

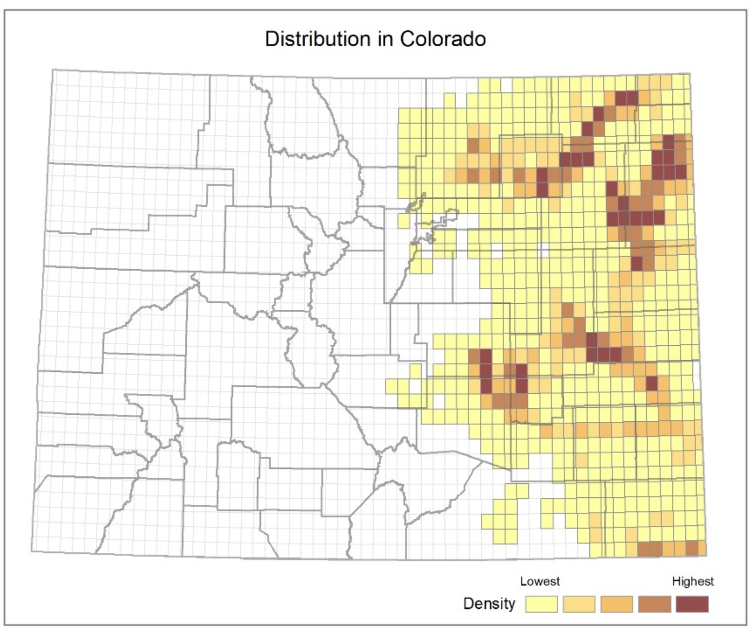
Western Great Plains Sandhill Steppe is characterized by sandy soils supporting open shrublands dominated by sand sagebrush.

Similar Systems

No other systems in Colorado are similar to sandhill steppe, although stands may be embedded within a variable shortgrass prairie matrix that shares some species. The sandhill prairie of Nebraska is also found on sandy soils, but does not reach into Colorado.

Range

Occurrences range from southeastern Wyoming and adjacent southwestern Nebraska south of the Nebraska Sandhills south through eastern Colorado and New Mexico to north-central Texas. The greater part of the system occurs in the Central Shortgrass Prairie Ecoregion in eastern Colorado, western Kansas and southwestern Nebraska. In eastern Colorado, this system is found in extensive tracts on sandy soils of Quaternary eolian deposits along the South Platte, Arikaree and Republican Rivers, between Big Sandy and Rush Creeks, and along the Arkansas and Cimarron Rivers, where it is contiguous with areas in Kansas.



Spatial pattern

Western Great Plains Sandhill Steppe is a large patch forming ecological system.

Environment

Throughout its range Western Great Plains Sandhill Steppe is closely tied to sandy soils. This system, however, is likely to intergrade closely with shortgrass prairie, perhaps forming a locally patchy sandsage/shortgrass matrix, and therefore it may be difficult to delimit as a distinct ecological system in places. Little is known about the tolerance of sandsage for soils other than well-drained sand with a low silt and clay component. Such soils are often "droughty", with reduced water-holding ability, and consequently, the potential for increased water stress to resident plants

Sandsage shares the dry and warm climate of shortgrass. Annual average precipitation is on the order of 25-47 cm (10-18 in), with a mean of 40 cm (16 in). The growing season is generally long, with frequent high temperatures. Colorado's eastern plains exhibit climatic differences from north to south which may be reflected in the local expression of sandsage prairie. Occurrences in

southern Colorado experience a longer growing season, lower annual precipitation, and differences in precipitation patterns, and may be dominated by different species than northern stands.

Vegetation

This system is characterized by a sparse to moderately dense woody layer dominated by individual sandsage (*Artemisia filifolia*) shrubs. The intervening ground is most often dominated by a sparse to moderately dense layer of tall, mid- or short grasses. Graminoid species such as sand bluestem (*Andropogon hallii*), threeawn (*Aristida spp.*), grama (*Bouteloua* spp.), prairie sandreed (*Calamovilfa longifolia*), needle-and-thread (*Hesperostipa comata*), and sand dropseed (*Sporobolus cryptandrus*) are typical. Other shrub species may also be present including tree cholla (*Cylindropuntia imbricata*), broom snakeweed (*Gutierrezia sarothrae*), pricklypear (*Opuntia* spp.), western sandcherry (*Prunus pumila* var. *besseyi*), and soapweed yucca (*Yucca glauca*).

Plant Associations

CEGL001467	Andropogon hallii - Calamovilfa longifolia Grassland
CEGL001466	Andropogon hallii - Carex inops ssp. heliophila Grassland
CEGL001459	Artemisia filifolia / Andropogon hallii Shrubland
CEGL002176	Artemisia filifolia / Bouteloua (curtipendula, gracilis) Shrubland
CEGL001473	Calamovilfa longifolia - Hesperostipa comata Grassland

Associated Animal species

Greater and Lesser Prairie-Chicken (*Tympanuchus cupido* and *T. pallidicinctus*), Cassin's sparrows (*Peucaea cassinii*), and ornate box turtles (*Terrapene ornata ornata*) are indicators of a healthy sandsage system. Bullsnake (*Pituophis catenifer*), racer (*Coluber constrictor*), prairie rattlesnake (*Crotalus viridis*) are common; longnosed snake (*Rhinocheilus lecontei*), and Texas horned lizard (*Phrynosoma cornutum,*) are inhabitants of some sandsage areas of south of Arkansas River in southeastern Colorado. Yellow mud turtle (*Kinosternon flavescens*), plains leopard frog (*Lithobates blairi*), and northern cricket frog (*Acris crepitans*) can be found in moist areas within the sandhill steppe. Ord's kangaroo rat (*Dipodomys ordii*) is a typical burrower in sandy areas.

Dynamic processes

The incidence of drought accompanied by higher temperatures is a key determinant of the extent of sand dune activation in the Great Plains. The extensive eolian sand deposits of the Great Plains, although at present largely stabilized by vegetation, are a sensitive indicator of climate trends. During the past 10,000 years, these areas are likely to have fluctuated between active dune fields and stabilized, vegetated dunes, depending on climate and disturbance patterns. Extended periods of severe drought or other disturbance that results in loss of stabilizing vegetation can quickly lead to soil movement and blowouts that inhibit vegetation re-establishment, and may eventually lead to dramatically different species composition.

Drought is the most important extreme event that is likely to alter the character of these shrublands. Warmer and drier conditions, and resulting reduced vegetation cover could allow reactivation of currently stabilized sandy soils throughout eastern Colorado. Although sandsage

does not reproduce vegetatively, it is able to resprout after fire. Fire extent and intensity are correlated with climate and grazing effects on fuel loads. Fire and grazing are both important disturbance processes for sandsage habitat, and may interact with drought, as well as permitting invasive exotic plant species to establish and spread.

Management

Occurrences in Colorado are significantly impacted by anthropogenic activities. In some cases this has increased the extent of sandsage shrubland if midgrass prairie is converted to shortgrass-sandsage community, due in large part to long-term continuous grazing by domestic livestock. Many areas are now lacking the diversity and interspersion of patch types that provides ideal habitat for species such as the Lesser Prairie Chicken. Sandsage shrublands have limited but ongoing threat of conversion to tilled agriculture or urban/exurban and commercial development. Oil and gas development, and wind turbine farms, with associated roads, utility corridors, and infrastructure is a primary ongoing source of anthropogenic disturbance, fragmentation, and loss in this habitat.

Extended periods of drought that decrease levels of vegetation cover would increase the likelihood that sandy substrates will be mobilized. The loss of native plant biodiversity in many stands decreases the available assemblage of drought-adapted species that can boost resilience to this vulnerability. Sandsage shrublands are moderately vulnerable to the effects of climate change by mid-century, primarily due to the concentration of greatest exposure for all temperature variables on the eastern plains of Colorado, where this ecosystem is found. In addition, anthropogenic disturbance in these shrublands has reduced the overall landscape condition of the habitat. These shrublands are well adapted to sandy soils, and may be able to expand into adjacent areas under warmer, drier conditions, depending on disturbance interactions. Overall condition and composition of these shrublands may change with changing climate.

Original concept authors: S. Menard, K. Kindscher, K.A. Schulz and L. Elliott; Oct 2014
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: July 2019

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GRASSLAND

Central Mixedgrass Prairie

General Description

The mixedgrass or midgrass prairie system ranges from South Dakota to northern Texas and is bordered by the shortgrass prairie on the western edge and the tallgrass prairie to the east. Although the greater part of the mixedgrass prairie lies to the east of Colorado, the western extent of this system has probably moved in and out of what is now eastern Colorado during much of the Holocene, as climatic conditions alternated between wetter and drier. In the sandhills of eastern Colorado, midgrass prairie dominated large areas in the early years of the 1900s. By the late 1940s, most of these communities had been replaced by shortgrass or sandsage communities, due to the effects of grazing and drought. Due to its position on the periphery of the range of the midgrass prairie ecological system, Colorado has probably never supported extensive tracts of this type. Occurrences are typically dominated by warm-season grasses of medium height, including little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), with additional midgrass or shortgrass species often present, and a diverse forb component.

Diagnostic Characteristics

Good examples of this ecological system are rare in Colorado. Conservation Reserve Program (CRP) lands often have a superficial appearance of mixedgrass prairie because they are seeded with little bluestem. In addition to the dominance of mid-height grass species, especially little bluestem, the

mixedgrass prairie should include a diverse forb component, occasional shrub species, and limited areas of bare ground.

Similar Systems

Western Great Plains Foothill and Piedmont Grassland: Mid-height grasses are also characteristic of the foothill grasslands, and include species also found in mixedgrass prairie. These grasslands are at higher elevations, and in areas discontiguous with the historic distribution of mixedgrass prairie.

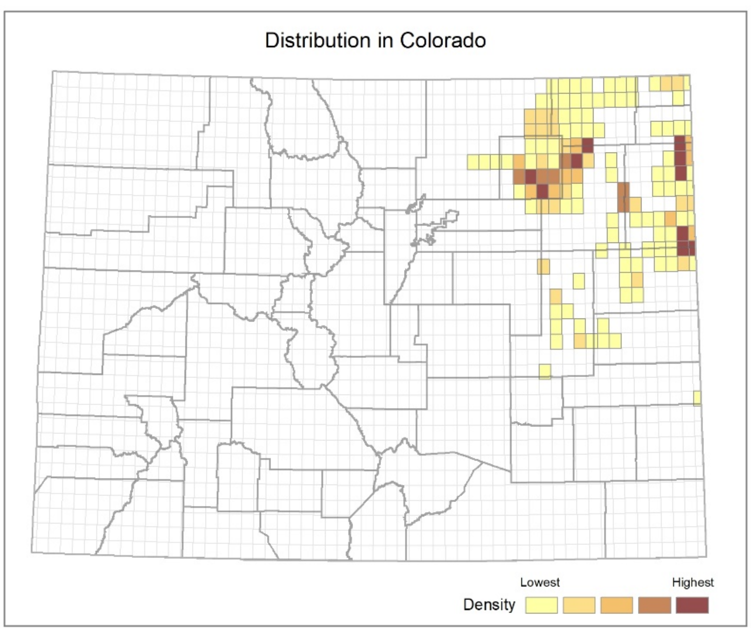
Western Great Plains Sandhill Steppe: Remnant stands of mixedgrass prairie are intermingled with areas of sandy soil and stabilized dune-fields that are dominated by sand sagebrush. These areas may once have been mixedgrass prairie under wetter climatic conditions.

Western Great Plains Shortgrass Prairie: Shortgrass prairie may include stands of mid-height grasses, but, in general is drier, dominated by blue grama, and typically with more areas of sparser vegetation cover. Some areas that are now shortgrass prairie may have supported mixedgrass prairie under wetter climatic conditions.

Northwestern Great Plains Mixedgrass Prairie: Mid-height grasses are also characteristic of these grasslands to the north. A few stands of this type may occur along the Colorado-Wyoming border, but in general these would not be representative of the system.

Range

Regions characterized by loess soils in west-central Kansas and central Nebraska, the Red Hills region of south-central Kansas and northern Oklahoma are all included in this system. Colorado occurrences are currently restricted to small areas in the northeastern part of the state, near the border with Nebraska or Kansas.



Spatial pattern

Although this system forms the matrix vegetation in parts of the Central Mixedgrass Prairie ecoregion, it is a large patch system in Colorado.

Environment

The Central Mixedgrass Prairie occurs in a semi-arid climate that is intermediate between the drier shortgrass region to the west, and the wetter tallgrass region to the east. Differences in topography and soil characteristics occur across the range of this system. It is often

characterized by rolling to extremely hilly landscapes with soils developed from loess, shale, limestone or sandstone parent material. In Colorado, Mollisol or Entisol soils are most prevalent and range from silt loams to sand, with sandy loams most common. Loess-derived soils are typical of these prairies. Loess is the fine rock powder that resulted from the grinding of rock beneath the ice sheet that covered much of North America 18,000 years ago. As the ice melted, wind-blown loess was deposited throughout the midwest. Loess deposits are common, but because these soils are fertile and easily tilled, there are now few deep deposits with undisturbed native vegetation.

Vegetation

Because of its position between two other prairie systems, this system contains elements from both shortgrass and tallgrass prairies, which combine to form the midgrass prairie ecological system throughout its range. The majority of mixedgrass associations in this system are dominated by little bluestem (*Schizachyrium scoparium*) or western wheatgrass (*Pascopyrum smithii*), although other grass species such as sideoats grama (*Bouteloua curtipendula*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Hesperostipa comata*), blue grama (*Bouteloua gracilis*), prairie Junegrass (Koeleria macrantha), and threeawn (*Aristida* spp.) are often present. Numerous forb and sedge (*Carex* spp.) species can also occur within the mixedgrass system in the Western Great Plains. Although forbs do not always significantly contribute to the canopy, they should be an important part of the community. Some dominant forb species include sunflower (*Helianthus* spp.), blacksamson echinacea (*Echinacea angustifolia*), upright prairie coneflower (*Ratibida columnifera*), dotted blazing star (*Liatris punctata*), slimflower scurfpea (*Psoralidium tenuiflorum*), rush skeletonplant (*Lygodesmia juncea),* and ragweed (*Ambrosia psilostachya*). Prairie moonwort (*Botrychium campestre*) is found in some areas. Shrubs can occur in areas protected from fire due to topographic conditions. Non-native species are common in many occurrences.

Plant Associations

CEGL001756	Bouteloua gracilis - Bouteloua dactyloides Grassland
CEGL002037	Hesperostipa comata - Bouteloua gracilis - Carex filifolia Grassland
CEGL001321	Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Grassland
CEGL001573	Panicum obtusum - Bouteloua dactyloides Wet Meadow
CEGL001578	Pascopyrum smithii - Bouteloua gracilis Grassland
CEGL001368	Sarcobatus vermiculatus / Sporobolus airoides Wet Shrubland
CEGL002036	Schizachyrium scoparium - Bouteloua curtipendula Loess Mixedgrass Grassland
CEGL001594	Schizachyrium scoparium - Bouteloua curtipendula Western Great Plains Grassland

Associated Animal species

Although there are no animal species which are strictly endemic to midgrass prairie, grassland birds such as Chestnut-collared Longspur (*Calcarius ornatus*), Lark Bunting (*Calamospiza melanocorys*), Cassin's Sparrow (*Peucaea cassinii*), and Grasshopper Sparrow (*Ammodramus savannarum*) do use these mid-height grasslands for major portions of their life cycle. Greater Prairie Chicken (*Tympanuchus cupido*) was likely historically common in this habitat. Both mule deer (*Odocoileus hemionus*) and whitetail deer (*Odocoileus virginianus*), as well as black-tailed jackrabbit (*Lepus californicus*), cottontails (*Sylvilagus* spp.), olive-backed pocket mouse

(*Perognathus fasciatus*), and pocket gophers (*Thomomys* spp.) are typical mammals of these grasslands. Plains leopard frog (*Lithobates blairi*) and ornate box turtle (*Terrapene ornata ornata*) can also be found in this system.

Dynamic processes

The distribution, species richness and productivity of plant species within the midgrass ecological system is controlled primarily by environmental conditions, especially soil moisture and topography. The relative dominance of the various grass and forb species within different associations in the system can strongly depend on the history and degree of natural or human disturbance. Although the greater part of the mixedgrass prairie lies to the east of Colorado, the western extent of this system has probably moved in and out of what is now eastern Colorado during much of the Holocene, as climatic conditions alternated between wetter and drier. Periodic drought, fire, and grazing were historically the primary processes occurring within the system. In larger occurrences (now outside Colorado) fire and grazing can occur at spatial and temporal scales approaching those at which they naturally occurred, but Colorado occurrences are not currently of adequate size to support these processes. The diversity in this mixedgrass system likely reflects both the short- and long-term responses of the vegetation to these often concurrent disturbance regimes.

Management

As much as 70% of the original extent of these mixedgrass prairies has been lost by conversion to agriculture and other disturbance. Non-native species are common to dominant in some occurrences. Grazing tends to favor the shortgrass species such as blue grama, and may change the balance of dominant species. Fire suppression and overgrazing can lead to the invasion of this system by woody species such as eastern redcedar (*Juniperus virginiana*). The extent of this type in Colorado has historically been closely tied to climatic conditions, expanding during wetter times and contracting under drier conditions. Warmer summer nighttime low temperatures and/or extended periods of drought are likely to eliminate this type from Colorado, and, if fire frequency remains low, allow the establishment of woody species, with the potential for conversion to a more arid grassland type or savanna.

Original concept authors: S. Menard, K. Kindscher, L. Elliott and J. Drake, May 2016.
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: May 2019

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GRASSLAND

Inter-Mountain Basins Semi-Desert Grassland

General Description

These widespread dry grasslands occur throughout the intermountain western U.S. as large patches in mosaics with shrubland systems dominated by sagebrush, saltbush, blackbrush, mormon-tea, and other shrub species. Colorado's semi-desert grasslands are found primarily on dry plains and mesas of the west slope at elevations of 1,450 to 2,320 m (4,750-7,600 ft). These grasslands occur in both lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are typically well-drained sandstone- or shale-derived soils. Some sandy soil occurrences have a high cover of biological soil crusts. Soil salinity depends on the amount and timing of precipitation and flooding. These grasslands are typically dominated by drought-resistant perennial bunch grasses such as Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), ring muhly (*Muhlenbergia torreyi*), James' galleta (*Pleuraphis jamesii*), or bluebunch wheatgrass (*Pseudoroegneria spicata*). Scattered shrubs and sub-shrubs may be present, including sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), jointfir (*Ephedra* spp.), snakeweed (*Gutierrezia sarothrae*), or winterfat (*Krascheninnikovia lanata*).

Diagnostic Characteristics

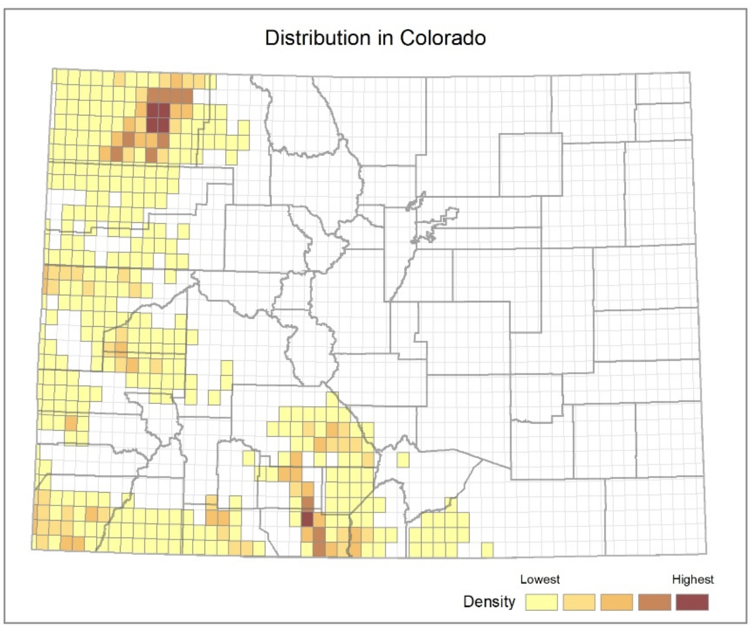
These grasslands are characterized by drought-resistant perennial bunch grasses forming open-canopied grasslands with widely scattered shrubs. Total cover is sparse to moderate, and areas of bare soil are likely to be common.

Similar Systems

Western Great Plains Foothill and Piedmont Grassland: A number of bunch grass species are also characteristic of the foothill grasslands. Foothill and Piedmont Grasslands are typical of the western edge of the plains, and are likely to be more mesic than the semi-desert grasslands with generally higher vegetative cover.

Range

These widespread semi-desert grasslands occur throughout the intermountain western U.S. They are most common in the Colorado Plateau ecoregion. In Colorado semi-desert grasslands are found primarily on dry plains and mesas of the west slope, with some occurrences in the San Luis Valley or near the southern mountain front.



Spatial pattern

Inter-Mountain Basins Semi-Desert Grassland is a large patch type.

Environment

West Slope low-elevation grasslands occur in semi-arid to arid climates with cold temperate conditions. Hot summers and cold winters with freezing temperatures and snow are common. Grasslands of the western valleys receive a significant portion of annual precipitation in July through October during the summer monsoon storms, with the rest falling as snow during the winter and early spring months. Annual precipitation is usually from 20-40 cm (8-16 in). Semi-desert grassland species are generally drought tolerant, and are adapted to low precipitation levels and a long growing season.

These grasslands occur in xeric lowland and upland areas and may occupy swales, playas, mesa tops, plateau parks, alluvial flats, and plains. Substrates are typically well-drained sandstone- or shale-derived soils. Soils are typically aridisols, which are dry for most of the year, even during the growing season, and there is little infiltration of water into the soil Some sandy soil occurrences

have a high cover of cryptogams on the soil. Soil salinity depends on the amount and timing of precipitation and flooding.

Vegetation

These grasslands are typically dominated by drought-resistant perennial bunch grasses such as Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), ring muhly (*Muhlenbergia torreyi*), James' galleta (*Pleuraphis jamesii*), or bluebunch wheatgrass (*Pseudoroegneria spicata*). Scattered shrubs and sub-shrubs may be present, including sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), jointfir (*Ephedra* spp.), snakeweed (*Gutierrezia sarothrae*), or winterfat (*Krascheninnikovia lanata*). Blackbrush (*Coleogyne ramosissima*) is uncommon in Colorado occurrences, but typical further west.

Plant Associations

CEGL001652	Achnatherum hymenoides - Sporobolus contractus Grassland
CEGL002343	Achnatherum hymenoides Colorado Plateau Grassland
CEGL005800	Aristida purpurea Grassland
CEGL001751	Bouteloua eriopoda - Pleuraphis jamesii Grassland
CEGL001754	Bouteloua gracilis - Bouteloua curtipendula Grassland
CEGL001755	Bouteloua gracilis - Bouteloua hirsuta Grassland
CEGL005389	Bouteloua gracilis - Muhlenbergia torreyi - Aristida purpurea Grassland
CEGL001759	Bouteloua gracilis - Pleuraphis jamesii Grassland
CEGL001760	Bouteloua gracilis Grassland
CEGL002588	Elymus lanceolatus Grassland
CEGL003495	Ericameria nauseosa / Bouteloua gracilis Shrub Grassland
CEGL001703	Hesperostipa comata - Achnatherum hymenoides Grassland
CEGL001705	Hesperostipa comata Great Basin Grassland
CEGL001708	Hesperostipa neomexicana Grassland
CEGL001779	Muhlenbergia asperifolia Wet Meadow
CEGL002363	Muhlenbergia pungens Grassland
CEGL001778	Pleuraphis jamesii - Sporobolus airoides Grassland
CEGL001777	Pleuraphis jamesii Grassland
CEGL001657	Poa secunda Moist Meadow
CEGL001674	Pseudoroegneria spicata - Achnatherum hymenoides Grassland
CEGL001666	Pseudoroegneria spicata - Cushion Plants Grassland
CEGL001677	Pseudoroegneria spicata - Poa secunda Grassland
CEGL001660	Pseudoroegneria spicata Grassland
CEGL001661	Pseudoroegneria spicata ssp. inermis Grassland
CEGL001688	Sporobolus airoides Monotype Wet Meadow
CEGL001685	Sporobolus airoides Southern Plains Wet Meadow
CEGL005609	Pseudoroegneria spicata - Crepis acuminata Grassland

Associated Animal species

In contrast to the shortgrass prairie, these grasslands do not provide extensive animal habitat in Colorado. In areas near rocky outcrops, pallid bat (*Antrozous pallida*) is a typical resident.

Gunnison's and white-tailed prairie dogs (*Cynomys gunnisoni* and *C. leucurus*), as well as other small burrowing or ground-dwelling animals provide prey for hawks (*Buteo* spp.). Burrowing Owl (*Athene cunicularia*), Vesper sparrow (*Pooecetes gramineus*), and other species of semi-arid areas may be seen. Sagebrush lizard (*Sceloporus graciosus*) and bullsnake (*Pituophis catenifer*) are likely to be common, and Great Basin spadefoot toad (*Spea intermontana*) may use small ponds within this habitat.

Dynamic processes

This system is maintained by frequent fires that eliminate woody plants. A combination of precipitation, temperature, and soils limits this system to the lower elevations within the region. The dominant perennial bunch grasses and shrubs within this system are all highly drought-resistant. Grasses that dominate semi-arid grasslands develop a dense network of roots concentrated in the upper parts of the soil where rainfall penetrates most frequently.

The semi-desert grassland system is vulnerable to invasion by exotic species, particularly cheatgrass (*Bromus tectorum*). Although frequent fires in grasslands may have been common historically, the introduction of cheatgrass has altered the dynamics of the system, increasing both fire frequency and post-fire cheatgrass dominance. Cheatgrass is easily ignited, and also provides an abundance of fine fuels that carry fire.

Floristic composition in grasslands is influenced by both environmental factors and grazing history. Many grassland occurrences are already highly altered from pre-settlement condition. Grazing is generally believed to lead to the replacement of palatable species with less palatable ones more able to withstand grazing pressure. Grazing by domestic livestock may act to override or mask whatever natural climatic or edaphic mechanism is responsible for maintaining an occurrence. This habitat is also adapted to grazing and browsing by native herbivores including deer, elk, bison, and pronghorn, as well as burrowing and grazing by small mammals such as gophers, prairie dogs, rabbits, and ground squirrels. Activities of these animals can influence both vegetation structure and soil disturbance, potentially suppressing tree establishment. Periodic drought is common in the range of semi-desert grasslands, but may not be as great a factor in the vegetation dynamics of this system as in grasslands of the plains.

Management

Many areas that previously supported desert grasslands have been converted to agricultural use. Remnant stands of desert grasslands have been highly altered by livestock grazing, and it is likely that grasslands formerly occupied some sites that are now covered by pinyon-juniper or shrubland. Grazing by domestic livestock can also influence the relative proportion of cool- vs. warm-season grasses, or favor the increase of woody shrub species. Semi-desert grassland species are generally drought tolerant, and are adapted to low precipitation levels and a long growing season. Climate related vulnerability for these grasslands is minimal, but the impacted condition of many stands may inhibit their potential for expansion. Changes in the timing and amount of precipitation may affect the future composition and persistence of these grasslands.

GRASSLAND

Original concept authors: G.P. Jones and K.A. Schulz; Nov 2015
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Renée Rondeau
Version date: July 2019

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Rocky Mountain Subalpine-Montane Mesic Meadow

General Description

This ecological system is widespread in the Rocky Mountain cordillera from New Mexico into Candada. In Colorado, these meadows are generally restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. Elevations are typically above 2,740 m (9,000 ft). Small patches of these mesic, forb-rich meadows are likely to be found intermingled with forest stands, subalpine grassland, riparian shrublands and wet meadows, or alpine ecotone communities. Soils are typically moist or saturated during spring snowmelt, but drier later in the season. Moderate- to low-gradient slopes of glacial till or alluvial deposits lying above wetter areas are typical substrates. Vegetation is characterized by diverse forb cover, although graminoids may be dense in some places. Forb taxa include species of fleabane (*Erigeron* spp.), goldenrod (*Solidago* spp.) balsamroot (*Balsamorhiza* spp.), mule-ears (*Wyethia* spp.), lupine (*Lupinus* spp.), and other members of the Aster family (Asteraceae), penstemons (*Penstemon* spp.), bluebells (*Mertensia* spp.) paintbrush (*Castilleja* spp.), as well as many other, less showy species. Important graminoids include tufted hairgrass (*Deschampsia cespitosa*), bluejoint (*Calamagrostis canadensis*), spike trisetum (*Trisetum spicatum*), native perennial brome (*Bromus* spp.) and sedge (*Carex* spp.) or rush (*Juncus* spp.) species.

GRASSLAND

Diagnostic Characteristics

These are herbaceous-dominated, higher elevation types that are intermediate between drier montane-subalpine grassland and alpine-montane wet meadows. Soils are seasonally moist or saturated in the spring, but dry out during the growing season. Occurrences may be adjacent to spruce-fir forests.

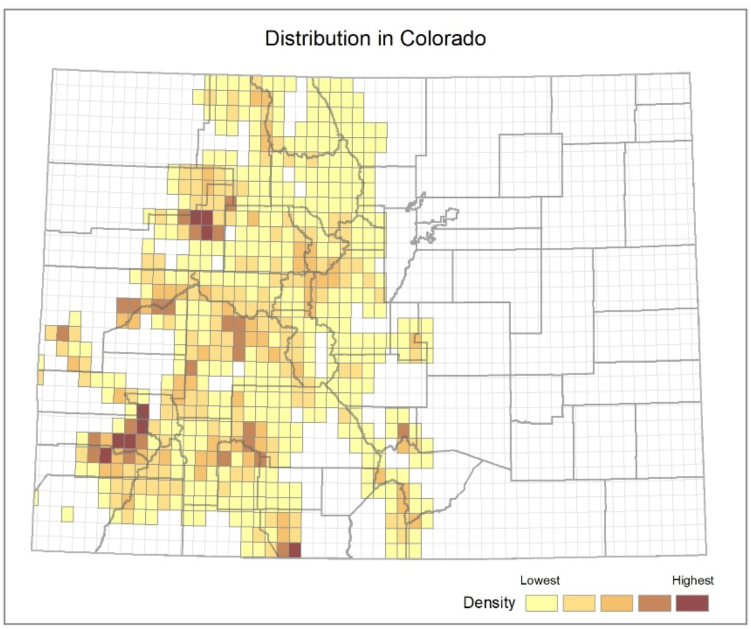
Similar Systems

Rocky Mountain Alpine-Montane Wet Meadow: These are generally wetter than the mesic meadow areas, often with hummocky organic soils. Wet meadows are seasonally saturated or flooded, remaining wet longer in the season than mesic meadows, but eventually drying by season's end.

Southern Rocky Mountain Montane-Subalpine Grassland: These are graminoid-dominated, generally drier and more rocky areas with fewer forb species. In most sites, taller bunch grasses are characteristic.

Range

This ecological system is widespread in the Rocky Mountain cordillera from New Mexico into Candada. In Colorado, it is found throughout the mountainous part of the state, generally at elevations of 2,740 m (9,000 ft) or above.



Spatial pattern

Rocky Mountain Subalpine-Montane Mesic Meadow is a large patch type, although some fairly small occurrences may be embedded within the mosaic of subalpine vegetation.

Environment

These are areas where tree development is restricted by various factors, including snow cover amount and duration, soil moisture patterns, temperature, wind, and edaphic conditions. These communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but dry out later in the growing season, usually by mid-summer. More exposed sites are typically xeric, while sites receiving snowmelt from late-lying snowbanks are more mesic. Soil moisture variation can be fairly fine-grained, depending on slope exposure and soil composition.

Vegetation

Vegetation is characterized by diverse forb cover, although graminoids may be dense in some places. Forb taxa include species of fleabane (*Erigeron* spp.), goldenrod (*Solidago* spp.) balsamroot (*Balsamorhiza* spp.), mule-ears (*Wyethia* spp.), and other members of the Aster family (Asteraceae), lupine (*Lupinus* spp.), larkspur (*Delphinium* spp.) penstemon (*Penstemon* spp.), bluebells (*Mertensia* spp.) paintbrush (*Castilleja* spp.), as well as many other, less showy species. Important graminoids include tufted hairgrass (*Deschampsia cespitosa*), bluejoint (*Calamagrostis canadensis*), spike trisetum (*Trisetum spicatum*), native perennial brome (*Bromus* spp.) and sedge (*Carex* spp.) or rush (*Juncus* spp.) species.

Plant Associations

CEGL001880	Deschampsia cespitosa - Achillea millefolium var. occidentalis Wet Meadow
CEGL001884	Deschampsia cespitosa - Geum rossii Wet Meadow
CEGL001885	Deschampsia cespitosa - Ligusticum tenuifolium Wet Meadow
CEGL001887	Deschampsia cespitosa - Mertensia ciliata Wet Meadow
CEGL001889	Deschampsia cespitosa - Potentilla diversifolia Wet Meadow
CEGL001970	Geum rossii - Trifolium spp. Alpine Turf
CEGL001915	Ligusticum porteri - Lupinus parviflorus ssp. myrianthus Meadow
CEGL001916	Ligusticum porteri - Vicia americana Meadow
CEGL001917	Ligusticum tenuifolium - Trollius laxus ssp. albiflorus Meadow
CEGL001935	Trifolium dasyphyllum Alpine Fell-field
CEGL001936	Trifolium parryi Alpine Snowbed

Associated Animal species

Yellow-bellied marmot (*Marmota flaviventris*), deer mice (*Peromyscus maniculatus*), voles (*Microtis* spp.), chipmunks (*Neotamias* spp.), and northern pocket gopher (*Thomomys talpoides*) may be resident in these mesic meadows. Occasional use by porcupine (*Erethizon dorsatum*), snowshoe hare (*Lepus americanus*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and other subalpine species is likely. Bird species include Vesper Sparrow (*Pooecetes gramineus*), Mountain Bluebird (*Sialia currucoides*), Horned Lark (*Eremophila alpestris*), and Brewer's Blackbird (*Euphagus cyanocephalus*).

Dynamic processes

The composition and productivity of these meadow communities is variable according to the influence of late-lying snowbanks. Soils in proximity to snowbanks are likely to be flooded or saturated during early snowmelt, while other nearby areas are drier. Patterns of snowmelt runoff help determine the vegetation components, according to the varied ability of species to withstand wet or dry conditions during the growing season. Seasonal and daily temperature variation on the various slope exposures also influences species composition, and cold temperatures may act to exclude trees from these meadows. Some common alpine species are present in these subalpine areas as well, perhaps due to cold air drainage effects. Frequent disturbance by burrowing mammals, especially pocket gophers, can create areas of loose soil that facilitate water infiltration, as well as generating a variety of microenvironments.

Management

Mesic meadows that have been grazed by domestic livestock often have non-native species present. Typical non-natives include Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*) and common timothy (*Phleum pratense*), dandelion (*Taraxacum officinale*), and Canada thistle (*Cirsium arvense*). If future climate conditions are warmer and drier, changes in timing and amount of snowpack and runoff may have an adverse effect on these plant communities.

Original concept authors NatureServe Western Ecology Team; Jan 2006
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: August 2019

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Southern Rocky Mountain Montane-Subalpine Grassland

General Description

This ecological system includes grasslands of montane to subalpine elevations in the Southern Rocky Mountains from New Mexico to Wyoming. Montane and subalpine grasslands in Colorado are generally interspersed in forest communities as park-like openings that vary in size from a few to several thousand acres. The montane grassland of South Park in Central Colorado is an exception, covering more than one million acres. This ecological system typically occurs between 2,200 and 3,350 m (7,200 and 11,000 feet) on gentle to steep slopes or more level park-like basins. A variety of factors, including fire, wind, cold-air drainage, climatic variation, soil properties, competition, and grazing have been proposed as mechanisms that maintain open grasslands and parks in forest surroundings; influential factors may vary by site. These large patch grasslands are intermixed with forests of spruce-fir, lodgepole, ponderosa pine, mixed conifers, and aspen. Within the subalpine zone, forbs tend to be more prominent at higher elevations, and shrubs at lower elevations. Associations are variable depending on site factors such as slope, aspect, precipitation, soils, and disturbance history, but generally lower elevation montane grasslands are more xeric and dominated by muhly (*Muhlenbergia* spp.), bluebunch wheatgrass (*Pseudoroegneria spicata*), Arizona fescue (*Festuca arizonica*), and Idaho fescue (*Festuca idahoensis*), while upper montane or subalpine grasslands are more mesic and may be dominated by Thurber fescue (*Festuca thurberi*) or timber oatgrass (*Danthonia intermedia*).

GRASSLAND

Diagnostic Characteristics

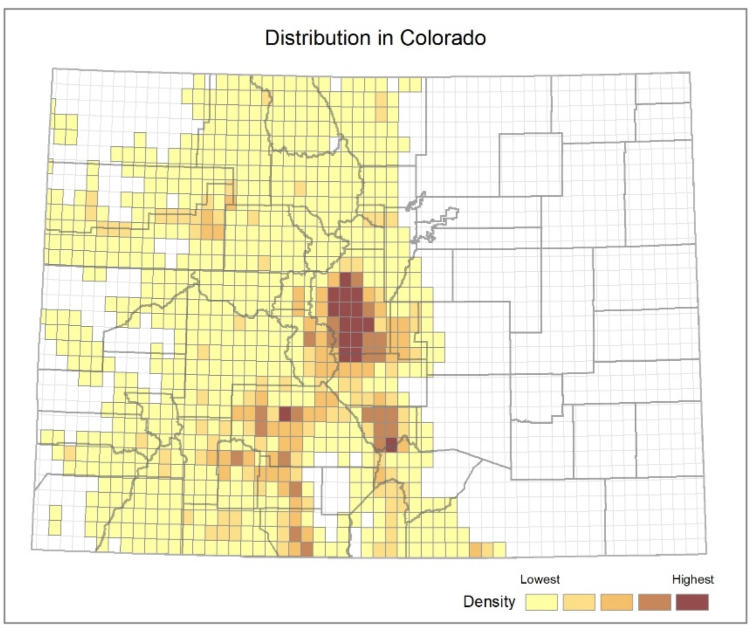
Montane to subalpine grasslands are graminoid-dominated open areas generally within the matrix of forest and shrubland types. Occurrences are variable throughout the range of the system. Although forbs are present in most of these grasslands, they are not as prevalent as in alpine turf.

Similar Systems

Western Great Plains Foothill and Piedmont Grassland: These grasslands of the mountain front may occasionally intergrade with montane-subalpine grasslands at elevations up to 2,280 m (7,500 ft), but are generally lower and characterized by plains to foothills species such as blue grama (*Bouteloua gracilis*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), or needle-and-thread (*Hesperostipa comata*).

Range

These grasslands of montane to subalpine elevations are found throughout the Southern Rocky Mountains from New Mexico to Wyoming.



Spatial pattern

Southern Rocky Mountain Montane-Subalpine Grassland is generally a large patch type, except for the extensive occurrence in South Park, Colorado.

Environment

The general climate in the range of this ecological system is characterized by cold winters and relatively cool summers, although temperatures are more moderate at lower elevations. Precipitation patterns differ between the east and west sides of the Continental Divide. In general, these grasslands experience long winters, deep snow, and short growing seasons. Average annual precipitation ranges between 20 to 40 inches, and the majority of this falls as snow. Snow cover in some areas can last from October to May, and serves to insulate the plants beneath from periodic subzero temperatures. Other areas are kept free from snow by wind. Rapid spring snowmelt usually saturates the soil, and, when temperatures rise plant growth is rapid. Precipitation during the growing season is highly variable, but provides less moisture than snowmelt. Growing seasons are short, typically from June through August at intermediate locations, although frost can occur at almost any time.

The geology of the Southern Rocky Mountains is extremely complex. Not surprisingly, soils are also highly variable, depending on the parent materials from which they were derived and the conditions under which they developed. Podzolic soils have developed on most high mountain areas as a result of cool to cold temperatures, relatively abundant moisture, and the dominant coniferous forest vegetation. In the intermingled parks and open treeless slopes or ridges, grassland soils have developed. Soil texture is important in explaining the existence of montane-subalpine grasslands. These grasslands often occupy the fine-textured alluvial of colluvial soils of valley bottoms, in contrast to the coarse, rocky material of adjacent forested slopes. Soils are often similar to prairie soils, with a dark brown A-horizon that is rich in organic matter, well drained, and slightly acidic. Other factors that may explain the absence of trees in this system are soil moisture (too much or too little), competition from established herbaceous species, cold air drainage and frost pockets, high snow accumulation, beaver activity, slow recovery from fire, and snow slides. Where grasslands occur intermixed with forested areas, the less pronounced environmental differences mean that trees are more likely to invade.

Vegetation

These large patch grasslands are intermixed with forests of spruce-fir, lodgepole, ponderosa pine, mixed conifers, and aspen. Within the subalpine zone, forbs tend to be more prominent at higher elevations, and shrubs at lower elevations. Associations are variable depending on site factors such as slope, aspect, precipitation, and latitude, but generally, lower elevation montane grasslands are more xeric and dominated by muhly (*Muhlenbergia* spp.), bluebunch wheatgrass (*Pseudoroegneria spicata*), Arizona fescue (*Festuca arizonica*), and Idaho fescue (*Festuca idahoensis*), while upper montane or subalpine grasslands are more mesic and may be dominated by Thurber fescue (*Festuca thurberi*) or timber oatgrass (*Danthonia intermedia*). Parry's oatgrass (*Danthonia parryi*) is found across most of the elevational range of this system. Montane grasslands in the Colorado Front Range are often dominated by spike fescue (*Leucopoa kingii*) or mountain muhly (*Muhlenbergia montana*). In the San Juan Mountains of southwestern Colorado, these grasslands are dominated by *Festuca thurberi* and other large bunch grasses. Grasses of the foothills and piedmont, such as blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), needle-and-thread (*Hesperostipa comata*), prairie Junegrass (*Koeleria macrantha*), Sandberg bluegrass (Poa secunda), western wheatgrass (*Pascopyrum smithii*), or little bluestem (*Schizachyrium scoparium*) may be included in lower elevation occurrences. Higher, more mesic locations may support additional graminoid species including sedge (*Carex* spp.), alpine fescue (*Festuca brachyphylla*), Drummond's rush (*Juncus drummondii*), alpine timothy (*Phleum alpinum*), or spike trisetum (*Trisetum spicatum*). Woody species are generally sparse or absent, but occasional individuals from the surrounding forest communities may occur. Scattered dwarf-shrubs may be found in some occurrences; species vary with elevation and location. Forbs are more common at higher elevations.

Plant Associations

CEGL001874	Carex duriuscula Grassland
CEGL001879	Danthonia intermedia - Solidago multiradiata Grassland
CEGL001794	Danthonia intermedia Grassland
CEGL001795	Danthonia parryi Grassland

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CEGL001599	Deschampsia cespitosa Wet Meadow
CEGL002588	Elymus lanceolatus Grassland
CEGL001605	Festuca arizonica - Muhlenbergia filiculmis Grassland
CEGL001606	Festuca arizonica - Muhlenbergia montana Grassland
CEGL001614	Festuca idahoensis - Elymus trachycaulus Grassland
CEGL001617	Festuca idahoensis - Festuca thurberi Grassland
CEGL001618	Festuca idahoensis - Geranium viscosissimum Grassland
CEGL001897	Festuca idahoensis Grassland
CEGL001630	Festuca thurberi - (Lathyrus lanszwertii var. leucanthus, Potentilla spp.) Grassland
CEGL001631	Festuca thurberi Subalpine Grassland
CEGL001479	Leymus cinereus Alkaline Wet Meadow
CEGL001780	Muhlenbergia filiculmis Grassland
CEGL001647	Muhlenbergia montana - Hesperostipa comata Grassland
CEGL001646	Muhlenbergia montana Grassland
CEGL002363	Muhlenbergia pungens Grassland
CEGL001578	Pascopyrum smithii - Bouteloua gracilis Grassland
CEGL005654	Pascopyrum smithii Southern Rocky Mountain Grassland
CEGL001925	Poa fendleriana Grassland
CEGL001657	Poa secunda Moist Meadow
CEGL001676	Pseudoroegneria spicata - Poa fendleriana Grassland
CEGL001660	Pseudoroegneria spicata Grassland

Associated Animal species

Pocket gophers (*Thomomys* spp.) and other small mammals are common in these grasslands, which also provide forage areas for elk (*Cervus elaphus*). Typical bird species are Vesper sparrow, Mountain Bluebird (*Sialia currucoides*), Horned Lark (*Eremophila alpestris*), and Brewer's Blackbird (*Euphagus cyanocephalus*).

Dynamic processes

A variety of factors, including fire, wind, cold-air drainage, climatic variation, soil properties, competition, and grazing have been proposed as mechanisms that maintain open grasslands and parks in forest surroundings. Observations and repeat photography studies in sites throughout the southern Rocky Mountains indicate that trees do invade open areas, but that the mechanisms responsible for this trend may differ from site to site. Climatic variation, fire exclusion, and grazing appear to interact with edaphic factors to facilitate or hinder tree invasion in these grasslands.

Pocket gophers (*Thomomys* spp.) are a widespread source of disturbance in montane-subalpine grasslands. The activities of these burrowing mammals result in increased aeration, mixing of soil, and infiltration of water, and are an important component of normal soil formation and erosion. In addition, below-ground herbivory of pocket gophers can restrict tree establishment. The interaction of multiple factors indicates that management for the maintenance of these montane and subalpine grasslands may be complex.

Floristic composition in these grasslands is influenced by both environmental factors and grazing history. Grazing is generally believed to lead to the replacement of palatable species with less palatable ones more able to withstand grazing pressure. In general, palatable grasses are replaced by nonpalatable forbs or shrubs under cattle grazing, while palatable forbs are characteristically absent from grasslands with a long history of sheep use. Annual species are uncommon except on heavily disturbed areas.

Management

Grazing by domestic livestock may act to override or mask whatever natural mechanism is responsible for maintaining an occurrence. Montane-subalpine grasslands were first grazed by domestic livestock beginning in the late 1800's. After lower-elevation, more accessible rangelands were overstocked in the 1870's and 1880's, use of montane and subalpine grasslands increased dramatically. By the turn of the century nearly all grazable land was being utilized, and much was already overgrazed. As National Forests were established following the Organic Administration Act of 1897, regulation of grazing on these high elevation grasslands was instituted. Use levels peaked near the end of the first World War, and current use levels are substantially lower than the highest previous level.

Warmer and drier conditions are likely to facilitate the spread of invasive species, and may allow woody species to establish in grasslands. An increase in forest fire activity under future conditions may allow grassland to expand into adjacent burned areas. Montane grasslands are moderately vulnerable to the effects of climate change by mid-century. Primary contributing factors are vulnerability of these area to invasive species, and the generally highly disturbed condition of occurrences, both of which are likely to interact with the significant increases in temperature across much of the distribution of the habitat in Colorado to reduce resilience of these habitats. Research in New Mexico suggests that both changing disturbance regimes and climatic factors are linked to tree establishment in some montane grasslands. Increased tree invasion into montane grasslands was apparently linked to higher summer nighttime temperatures, and less frost damage to tree seedlings; this trend could continue under projected future temperature increases. Increased disturbance may also facilitate the continued spread of introduced exotic species as climate conditions change. The interaction of multiple factors indicates that management for the maintenance of these montane and subalpine grasslands may be complex.

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Western Great Plains Foothill and Piedmont Grassland

General Description

These grasslands are found at the extreme western edge of the Great Plains, where increasing elevation and precipitation facilitate the development of mixed to tallgrass associations on certain soils. The Colorado piedmont is the area between the foothills and the remnant surface of the High Plains to the east, a broad basin eroded by the drainages of the South Platte and Arkansas rivers. This large patch system typically occurs between 1,600 and 2,200 m (5,250-7,200 feet) in elevation. Most occurrences can be characterized as a mixed- to tall-grass dominated system on typically found on moderate to gentle slopes and in swales, primarily occuring as a relatively narrow elevational band between montane woodlands and shrublands and the shortgrass steppe. The system also extends east on the Front Range piedmont alongside the Chalk Bluffs at the Colorado-Wyoming border, out into the Great Plains on the Palmer Divide, and on slopes below mesas and foothills in southeastern Colorado and northeastern New Mexico. Colorado occurrences of this system may be dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), green needlegrass (*Nassella viridula*), western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus cryptandrus*), needle-and-thread (*Hesperostipa comata*), or New Mexico feathergrass (*Hesperostipa neomexicana*). Remnant stands of "tallgrass prairie" in mesic areas near the mountain front can be considered a special

component of this system, since tallgrass communities of the foothills and piedmont are disjunct from the Great Plains tallgrass prairie with large expanses of mid-grass and shortgrass prairies in between.

Diagnostic Characteristics

These are mixedgrass communities of areas on the western margin of the shortgrass prairie region; disjunct from mixedgrass prairie types east of Colorado. Prior to European settlement, grassland communities were probably common in Rocky Mountain foothills, mesas, hogbacks, small drainages, and swales that are now largely under or surrounded by urban and suburban development. Remnants of these grasslands can still be found in undeveloped areas, and, although often highly altered, are characterized by the presence of mid- to tallgrass species.

Typical adjacent ecological systems include foothill shrublands, ponderosa pine savannas and woodlands, and pinyon-juniper savannas and woodlands as well as shortgrass prairie and periodic foothills riparian corridors. Together, these systems may form a complex mosaic of vegetation in the ecotonal foothill region.

Similar Systems

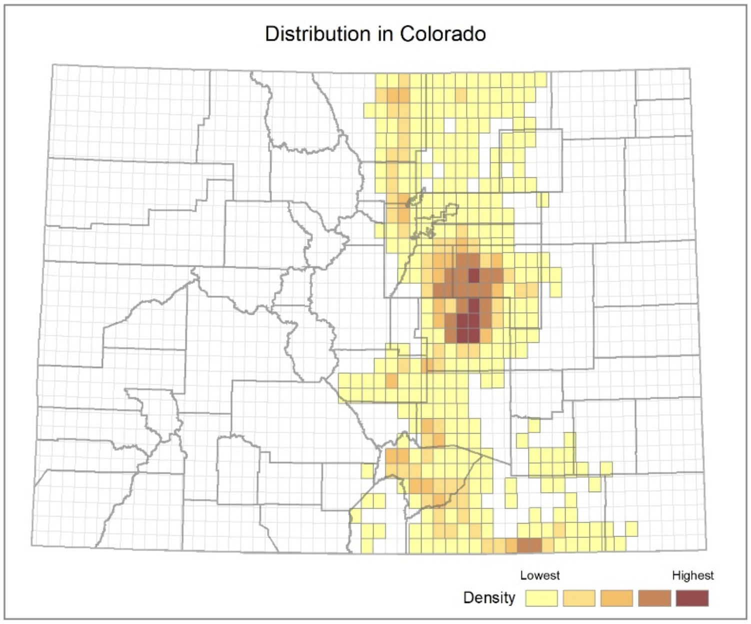
Central Mixedgrass Prairie: A number of mid-height grasses are characteristic of the mixedgrass prairie, and include species also found in foothill and piedmont grassland. Central Mixedgrass Prairie occurs only in limited areas near the eastern border of Colorado, at lower elevations, and is not contiguous with foothill and piedmont grasslands.

Southern Rocky Mountain Montane-Subalpine Grassland: These grasslands of higher elevations occasionally intergrade with montane-subalpine grasslands at elevations below 7,500 ft, but are characterized by montane to subalpine species including muhly (*Muhlenbergia* spp.), bluebunch wheatgrass (*Pseudoroegneria spicata*), Arizona fescue (*Festuca arizonica*), and Idaho fescue (*Festuca idahoensis*).

Northwestern Great Plains Mixedgrass Prairie: Mid-height grasses are also characteristic of these grasslands to the north. A few stands of this type may occur along the Colorado-Wyoming border, but in Colorado these would be assigned to the foothill and piedmont system.

Range

This grassland type is found in the transitional zone between the Rocky Mountains and the western Great Plains. It occurs along the mountain front from New Mexico to Wyoming, and is also found along the margins of mesas and uplifts in the panhandles of Texas and Oklahoma, and the edges of the Black Hills in South Dakota.



Spatial pattern

Western Great Plains Foothill and Piedmont Grassland is a large patch type.

Environment

The western Great Plains has a continental climate with both east-west and north-south gradients. Over the central plains, precipitation decreases from east to west, while temperatures and day-lengths increase from north to south. Near the mountain front, precipitation increases again with increasing elevation, permitting the growth of taller grass species than are characteristic of the shortgrass prairie that once dominated most of Colorado's eastern plains. The Colorado piedmont is the area between the foothills and the remnant surface of the High Plains to the east, a broad basin eroded by the drainages of the South Platte and Arkansas rivers. Grasslands of the foothills and piedmont are typically found between 1,600 and 2,200 m (5,250-7,200 feet) in elevation on the comparatively narrow band of hill and mesa landforms dissected by small streams at the mountain front, but may extend or occur disjunctly to the east where topography, soils, and precipitation patterns are similar. Soils are typically well-drained alluvial material, often cobbly. In areas where mesa landforms occur, seeps on slopes below the caprock may support more mesic associations.

Vegetation

Colorado occurrences of this system may be dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), green needlegrass (*Nassella viridula*), western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus cryptandrus*), needle-and-thread (*Hesperostipa comata*), or New Mexico feathergrass (*Hesperostipa neomexicana*). Other graminoids that are often present include mountain muhly (*Muhlenbergia montana*), threeawn (*Aristida* spp.), prairie Junegrass (*Koeleria macrantha*), and sun sedge (*Carex inops* ssp. *heliophila*).

Forbs are usually present with 10-40% cover and diversity can be high, although non-native species are usually present. Common native species include nodding onion (*Allium cernuum*), prairie sagewort (*Artemisia frigida*), milkvetch (*Astragalus* spp.), curlycup gumweed (*Grindelia squarrosa*), little sunflower (*Helianthus pumilus*), hairy false goldenaster (*Heterotheca villosa*), dotted blazing star (*Liatris punctata*), sidebells penstemon (*Penstemon secundiflorus*), slimflower scurfpea (*Psoralidium tenuiflorum*), and upright prairie coneflower (*Ratibida columnifera*). Scattered shrubs

include nylon hedgehog cactus (*Echinocereus viridiflorus*), pricklypear (*Opuntia* spp.), broom snakeweed (*Gutierrezia sarothrae*), and soapweed yucca (*Yucca glauca*).

Plant Associations

CEGL001463	Andropogon gerardii - Schizachyrium scoparium Western Great Plains Grassland
CEGL001464	Andropogon gerardii - Sorghastrum nutans Western Great Plains Grassland
CEGL001465	Andropogon gerardii - Sporobolus heterolepis Western Foothills Grassland
CEGL001754	Bouteloua gracilis - Bouteloua curtipendula Grassland
CEGL001756	Bouteloua gracilis - Bouteloua dactyloides Grassland
CEGL001755	Bouteloua gracilis - Bouteloua hirsuta Grassland
CEGL001760	Bouteloua gracilis Grassland
CEGL001703	Hesperostipa comata - Achnatherum hymenoides Grassland
CEGL001702	Hesperostipa comata Colorado Front Range Grassland
CEGL001708	Hesperostipa neomexicana Grassland
CEGL001713	Nassella viridula Grassland
CEGL001583	Pascopyrum smithii - Nassella viridula Grassland
CEGL001677	Pseudoroegneria spicata - Poa secunda Grassland
CEGL001660	Pseudoroegneria spicata Grassland
CEGL001594	Schizachyrium scoparium - Bouteloua curtipendula Western Great Plains Grassland

Associated Animal species

Grazing and browsing herbivores that have been historically associated with these grasslands include mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*). Small grazing and burrowing mammals such as pocket gophers (*Thomomys* spp.), black-tailed prairie dog (*Cynomys ludovicianus*), rabbits (*Sylvilagus* spp.), and ground squirrels are typically present, and preyed upon by raptors. The ecotonal nature of these grasslands is believed to contribute to the presence of numerous butterfly species, including several rare species.

Dynamic processes

Although grasslands are generally believed to be influenced by fire, little is known about fire dynamics in this system as compared to the larger grassland systems of the Great Plains. The tendency of foothill and piedmont grasslands to intermix with adjacent systems is likely to effect the fire dynamics within the system. Fuel loads in these mid- to tallgrass communities are typically higher than in adjacent shortgrass, which may historically have resulted in more frequent fires.

This system was naturally subject to grazing and browsing by native herbivores including deer, elk, bison, and pronghorn, as well as burrowing and grazing by small mammals. Activities of these animals can influence both vegetation structure and soil disturbance. Periodic drought is common in the Western Great Plains, but may not be as great a factor in the vegetation dynamics of this system as in grasslands of the plains.

In the absence of disturbance such as grazing and fire, dead plant material accumulates on the surface. In comparison with wetter regions, decomposition is slow in these semi-arid grasslands and nutrients may accumulate in litter. Wind and water erosion can remove nutrients. Fire quickly

returns nutrients to the soil. Herbivory has a much greater influence on energy and nutrient pathways in grasslands than in forests, and a greater proportion of biomass is moving through the grazing pathway in comparison to other ecosystems.

Management

Western Great Plains Foothill and Piedmont Grassland is one of the most severely altered systems in the ecoregion. Along the Front Range, the zone historically occupied by these grasslands has proved to be highly favored for housing and water development, as well as agricultural activities including hay meadows and domestic livestock grazing. As a result, virtually all occurrences of this system have been severely fragmented and invaded by non-native species, or lost entirely through land use conversion. The best remaining areas are generally within local or regional open space lands. The generally fair to poor condition of many occurrences in Colorado may tend to inhibit the potential of this ecosystem to persist or move into new areas under future climate conditions.

Original concept authors K.A. Schulz; Jan2014
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Western Great Plains Shortgrass Prairie

General Description

Shortgrass prairie is characteristic of the warm, dry southwestern portion of the Great Plains, lying to the east of the Rocky Mountains, and ranging from the Nebraska Panhandle south into Texas and New Mexico. The northern extent of this type represents the transition to cooler, more mesic mixed-grass types, generally occuring in southeastern Wyoming and southwestern Nebraska, although occasional shortgrass stands may be found further north. In Colorado, the shortgrass prairie system is found at elevations from about 1,110 m (3,650 ft) at the eastern border, to around 1,830 m (6,000 ft) near the mountain front, where it may intergrade with foothill and piedmont grasslands. The larger intact tracts are in southeastern Colorado. Prior to settlement, the shortgrass prairie was a generally treeless landscape characterized by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). In much of its range, shortgrass prairie forms the matrix vegetation with blue grama dominant. Other grasses include three-awn (*Aristida purpurea*), side-oats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*),needle-and-thread (*Hesperostipa comata*), June grass (*Koeleria macrantha*), western wheatgrass (*Pascopyrum smithii*), James' galleta (*Pleuraphis jamesii*), alkali sacaton (*Sporobolus airoides*), and sand dropseed (*Sporobolus cryptandrus*). Local inclusions of mesic or sandy soils may support taller grass species

including sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and prairie sandreed (*Calamovilfa longifolia*), as well as scattered shrub species including sandsage (*Artemisia filifolia*), prairie sagewort (*Artemisia frigida*), fourwing saltbush (*Atriplex canescens*), tree cholla (*Cylindropuntia imbricata*), spreading buckwheat (*Eriogonum effusum*), snakeweed (*Gutierrezia sarothrae*), pale wolfberry (*Lycium pallidum*), and soapweed yucca (*Yucca glauca*) may also be present. One-seed juniper (*Juniperus monosperma*) and occasional pinyon pine (*Pinus edulis*) trees are often present on shale breaks within the shortgrass prairie matrix.

Diagnostic Characteristics

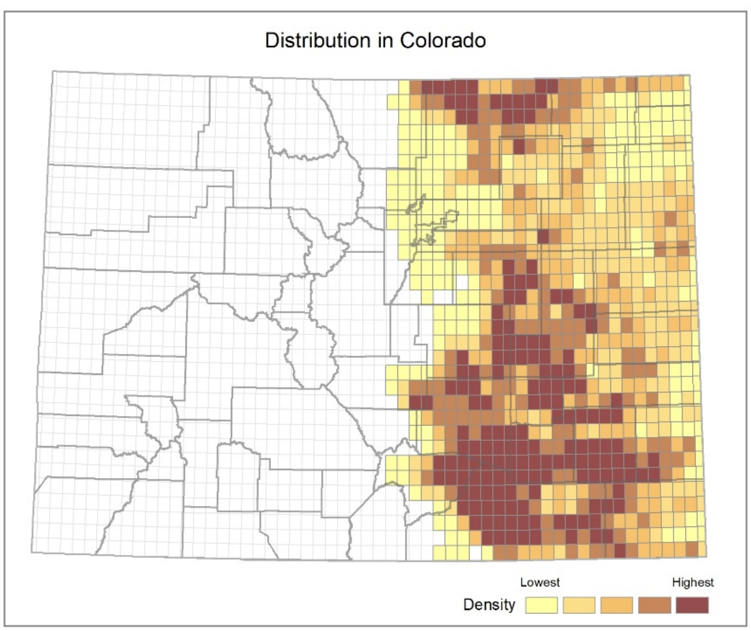
This system is characterized by extensive areas dominated by blue grama, and formerly, by buffalo grass. These low-stature perennial grasses are a unifying and persistent factor in shortgrass prairie of Colorado's eastern plains. Variation in the prevalence and composition of forb species, and patchy distribution of occasional trees, shrubs, and mesic swales gives these grasslands a constantly changing aspect both seasonally, and between years.

Similar Systems

Western Great Plains Sandhill Steppe: The matrix of shortgrass prairie includes areas of sandy soil and stabilized dune-fields where sand sagebrush (*Artemisia filifolia*) is common to dominant, but also include species common in the adjacent shortgrass prairie.

Range

This system is found in the southwestern portion of the Great Plains, lying to the east of the Rocky Mountains, and ranging from southern Wyoming and the Nebraska Panhandle south into Texas and New Mexico. In Colorado, the shortgrass prairie system is found at elevations from about 1,110 m (3,650 ft) at the eastern border, to around 1,830 m (6,000 ft) near the mountain front. Colorado's largest intact tracts are in the southeastern portion of the state.



Spatial pattern

Western Great Plains Shortgrass Prairie is a matrix forming system.

Environment

The climate of the shortgrass prairie is characterized by large seasonal contrasts, as well as interannual and longer term variability. The shortgrass prairie region is classified as a semi-arid. Annual precipitation is generally less than 50 cm (20 in), and soils are

periodically moist only in a shallow top layer typically less than half a meter (1-2 feet) deep.

Winters in the shortgrass prairie can be mild and dry when Pacific air masses are blocked by the Rocky Mountains under zonal flow conditions, or cold and snowy under meridional flow patterns that bring arctic air or upslope snow. Spring is transitional with warming conditions and lingering arctic air and possible heavy snow. Spring warming brings thermal instability and atmospheric mixing producing windy conditions, and thunderstorms become common. Tornados and slow-moving storms producing heavy precipitation may also occur. In summer a dryline separating humid Gulf air from dry desert southwest air forms in the western plains, and thunderstorms often form along this boundary. Summer thunderstorms can produce locally heavy precipitation. In late summer, the North American monsoon can bring moisture from the southwest. Typical autumn weather in the shortgrass region is relatively fair and dry, with periodic cool, wet weather and the possibility of early snow.

These grasslands occur primarily on flat to rolling uplands with loamy, ustic (dry, but usually with adequate moisture during growing season) soils ranging from sandy to clayey, at elevations generally below 1,830 m (6,000 ft). Organic matter accumulation in shortgrass prairie soils is primarily confined to the upper 20 cm. The action of a freeze-thaw cycle on these grassland soils increases their vulnerability to wind erosion in late winter and spring.

Vegetation

Shortgrass prairie is characterized by short-stature grasses, along with scattered mid-height grasses, a variety of perennial and annual forbs, and patches of shrubs or subshrubs. Prior to settlement, the shortgrass prairie was a generally treeless landscape characterized by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). In much of its range, shortgrass prairie forms the matrix vegetation with blue grama dominant. Other grasses include three-awn (*Aristida purpurea*), side-oats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*),needle-and-thread (*Hesperostipa comata*), June grass (*Koeleria macrantha*), western wheatgrass (*Pascopyrum smithii*), James' galleta (*Pleuraphis jamesii*), alkali sacaton (*Sporobolus airoides*), and sand dropseed (*Sporobolus cryptandrus*). Local inclusions of mesic or sandy soils may support taller grass species including sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium), Indiangrass (Sorghastrum nutans), and prairie sandreed (Calamovilfa longifolia), as well as scattered shrub species including sandsage (Artemisia filifolia*), prairie sagewort (*Artemisia frigida*), fourwing saltbush (*Atriplex canescens*), tree cholla (*Cylindropuntia imbricata*), spreading buckwheat (*Eriogonum effusum*), snakeweed (*Gutierrezia sarothrae*), pale wolfberry (*Lycium pallidum*), and soapweed yucca (*Yucca glauca*) may also be present. One-seed juniper (*Juniperus monosperma*) and occasional pinyon pine (*Pinus edulis*) trees are often present on shale breaks within the shortgrass prairie matrix.

Plant Associations

CEGL005800	Aristida purpurea Grassland
CEGL001749	Bouteloua eriopoda - Bouteloua hirsuta Grassland
CEGL001754	Bouteloua gracilis - Bouteloua curtipendula Grassland

CEGL001756	Bouteloua gracilis - Bouteloua dactyloides Grassland
CEGL001755	Bouteloua gracilis - Bouteloua hirsuta Grassland
CEGL005389	Bouteloua gracilis - Muhlenbergia torreyi - Aristida purpurea Grassland
CEGL001759	Bouteloua gracilis - Pleuraphis jamesii Grassland
CEGL001760	Bouteloua gracilis Grassland
CEGL004588	Cylindropuntia imbricata Ruderal Shrubland
CEGL001685	Sporobolus airoides Southern Plains Wet Meadow

Associated Animal species

Prior to European settlement, the shortgrass prairie supported abundant herds of bison (*Bison bison*), pronghorn (*Antilocapra americana*), and grassland birds, together with their predators. This system remains important to a number of bird and mammal species. Birds characteristic of the shortgrass prairie include Western Meadolark (*Sturnella neglecta*), Horned Lark (*Eremophila alpestris*), Lark Bunting (*Calamospiza melanocorys*), Lark Sparrow (*Chondestes grammacus*), Grasshopper Sparrow (*Ammodramus savannarum*), Mourning Dove (*Zenaida macroura*), Cassin's Sparrow (*Peucaea cassinii*), Killdeeer (*Charadrius vociferous*), Long-billed Curlew (*Numenius americanus*), Mountain Plover (*Charadrius montanus*), Common Nighthawk (*Chordeiles minor*), Burrowing Owl (*Athene cunicularia*), McCown's Longspur (*Rhynchophanes mccownii*), Chestnut-collared Longspur (*Calcarius ornatus*), Swainson's Hawk (*Buteo swainsoni*), Ferruginous Hawk (*Buteo regalis*), and Prairie Falcon (*Falco mexicanus*). Typical mammals include coyote (*Canis latrans*), badger (*Taxidea taxus*), swift fox (*Vulpes velox*), white-tailed jackrabbit (*Lepus townsendii*), desert cottontail (*Sylvilagus audubonii*), black-tailed prairie dog (*Cynomys ludovicianus*), and smaller rodents. Amphibians include green toad (*Anaxyrus debilis*) and Couch's spadefoot toad (*Scaphiopus couchii*); reptiles include Hernandez's short-horned lizard (*Phrynosoma hernandesi*), many-lined skink (*Plestiodon multivirgatus*), coachwhip snake (*Coluber flagellum*), glossy snake (*Arizona elegans*), massasauaga (*Sistrurus catenatus*), and prairie rattlesnake (*Crotalus viridis*).

Dynamic processes

Large-scale processes such as climate, fire and grazing influence this system. Drought in the shortgrass prairie region can occur during any season, and generally has its greatest impact during the growing season, when most annual precipitation occurs. Although severe droughts are often accompanied by high temperatures, paleoclimatic data indicate that severe drought has also occurred with cold temperatures, resulting in different types of stress on ecosystems. Although causes of widespread and lengthy drought are not compeletly understood, they are likely due in part to large-scale, low-frequency ocean and atmospheric circulation patterns.

Although fire is of somewhat lesser importance in shortgrass prairie compared to other prairie types, it is still a significant source of disturbance. The xeric climate of the shortgrass reduces overall fuel loads, but also dries vegetation sufficiently for it to become flammable. The generally open, rolling plains and often windy conditions in the shortgrass prairie facilitate the spread of fire when fuel loads are sufficient. With growing points below or near the surface, grasses are well protected from heat of most fires, and able to resprout, and regain dominance.

GRASSLAND

Shortgrass prairie developed in the presence of large grazers, especially bison, and grazing remaing the primary land use for most remaining shortgrass tracts. The overall species composition of shortgrass is influenced by grazing. Blue grama is considered tolerant of grazing, generally increasing under grazing except at the highest intensity, and buffalo grass is highly tolerant of disturbance, including heavy grazing. There is some evidence that the dispersal of both species is facilitated by large herbivore grazing. Where bluffs, breaks, or swales provide refuge from grazing, plant species that are rare in adjacent grazed areas become more common.

Management

Extensive portions of this ecosystem have been converted to cropland. Conversion to cropland replaces native shortgrass prairie with row crops, hay fields, and similar vegetation, with a consequent loss or fragmentation of habitat for native wildlife. Ground-water pumping of the Ogallala aquifer has already lead to aquifer drops of more than 15 m in parts of the central and southern Great Plains. Agricultural use of the remaining intact shortgrass prairie is dominated by domestic livestock grazing.

Effects of livestock grazing in shortgrass are not limited to changes in species composition, but can also impact ecosystem structure and function by changing litter accumulation rates, increasing soil compaction or erosion, decreasing moisture infiltration and removing biological soil crusts. Ancillary effects from livestock ranching in the shortgrass prarie include the disruption of the historic foodweb through removal of “problem animals” (e.g. wolves, bears, coyotes, prairie dogs, raptors, snakes, etc.) or biomass removal that eliminates resources for scavengers and decomposers. Fencing and roads associated with ranching have greatly fragmented the shortgrass prairie habitat, and allowed the invasion of exotic species.

Warmer summer nighttime low temperatures and/or extended periods of drought are likely to change the balance of warm- and cool-season grasses, and, if fire frequency remains low, allow the establishment of woody species, with the potential for conversion to a more arid grassland type or savanna. Shortgrass prairie is vulnerabe to the effects of climate change by mid-century. A primary contributing factor is the location of these grasslands on the eastern plains of Colorado, where the greatest levels of exposure for all temperature variables occur. Warmer and drier conditions would be likely to reduce soil water availability and otherwise have detrimental effects on ecosystem processes, while warmer and wetter conditions could be favorable. Furthermore, changing climate may lead to a shift in the relative abundance and dominance of shortgrass prairie species, giving rise to novel plant communities. Because woody plants are more responsive to elevated CO_2, and may have tap roots capable of reaching deep soil water, an increase of shrubby species (e.g., cholla, yucca, snakeweed, sandsage), or invasive exotic species, especially in areas that are disturbed (for instance, by heavy grazing) may also result.

Original concept authors: S. Menard, K. Kindscher, M. Pyne, L. Elliott and K.A. Schulz. May 2016.
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date September 2019

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SPARSELY VEGETATED & BARREN

Colorado Plateau Mixed Bedrock Canyon and Tableland

General Description

The distribution of this ecological system is centered on the Colorado Plateau, with limited extent in canyons and mesas of western Colorado. In Colorado elevations are primarily below 1,830 m (6,000 ft). Occurrences are barren and sparsely vegetated landscapes of massive sedimentary rock formations, characterized by steep cliffs, narrow canyons, and open tablelands. Vegetation is limited to cracks and potholes where soil accumulates and moisture is available. Woody vegetation is sparse and limited in height due to harsh conditions. Tree species include two-needle pinyon (*Pinus edulis*), ponderosa pine (*Pinus ponderosa*), and Utah juniper (*Juniperus osteosperma*), with sparse understory of short-shrub and herbaceous species, utilizing moisture from cracks and depressions where soil accumulates. Biological soil crusts may be a component of the community in small soil pockets. The federally-listed endangered Mancos milk-vetch (*Astragalus humillimus*) grows in this habitat in the southwestern corner of Colorado.

Diagnostic Characteristics

Colorado Plateau Mixed Bedrock Canyon and Tableland is characterized by extensive areas of bare rock where sparse vegetation is limited to cracks and small soil pockets. Massive sandstone

formations are most characteristic of this system, but other geological substrates may also form occurrences.

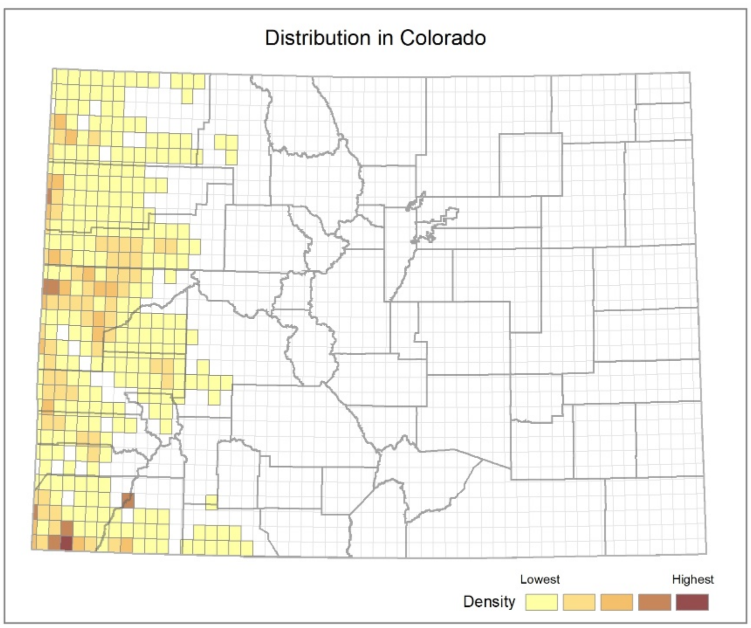
Similar Systems

Colorado Plateau Pinyon-Juniper Woodland & Shrubland: Sparsely vegetated areas within pinyon-juniper woodlands and shrublands may intergrade with the canyon and tableland habitat, but generally support more vegetation.

Inter-Mountain Basins Shale Badland: Eroding shale layers that form sparsely vegetated badlands may be interbedded between the harder rocks, but are not extensive.

Range

This ecological system is generally restricted to the Colorado Plateau, with the majority of occurrences in the four-corners region of Utah, Arizona, New Mexico and Colorado, possibly extending into southwestern Wyoming. Colorado occurrences are limited to the westernmost tier of counties in the state.



Spatial pattern

In the Colorado Plateau to the south and west, this is a matrix forming system. Colorado occurrences are large patches.

Environment

This system includes steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone, as well as areas of fixed bedrock forming the vertical or near-vertical parts on the plateau faces. The rocks forming such areas are predominantly limestone-capped plateaus. These highly erodible areas are generally too steep to allow any significant soil development. These areas are unstable and rocks are frequently rolling down onto the talus slopes below. Scattered plants maintain a precarious foothold in the crevices of the rocks. Often 90% of the exposed surface consists of barren rock.

Vegetation

For the most part, this system is sparsely vegetated. Small patches of scattered trees and shrubs may occur. These small vegetated patches are often dominated by conifers, and may include Utah juniper (*Juniperus osteosperma*), limber pine (*Pinus flexilis*), ponderosa pine (*Pinus ponderosa*), and

Douglas-fir (*Pseudotsuga menziesii*). If a shrub layer exists it may include Rocky Mountain maple (*Acer glabrum*), Utah serviceberry (*Amelanchier utahensis*), greenleaf manzanita (*Arctostaphylos patula*), mountain mahogany (*Cercocarpus montanus*), littleleaf mountain mahogany (*Cercocarpus intricatus*), common juniper (*Juniperus communis*), antelope bitterbrush (*Purshia tridentata*), and snakeweed (*Gutierrezia sarothrae).* The endangered Mancos milk-vetch (*Astragalus humillimus*) grows in this habitat in the southwestern corner of Colorado.

Plant Associations

CEGL002750	Acer negundo / Rhus trilobata Riparian Woodland
CEGL001287	Atriplex canescens - Ephedra viridis Talus Shrubland
CEGL002587	Cercocarpus intricatus Montane Shrubland
CEGL002977	Cercocarpus intricatus Slickrock Sparse Vegetation
CEGL002347	Chrysothamnus viscidiflorus Talus Shrubland
CEGL002349	Ephedra torreyana - (Atriplex spp.) / Nonvascular Gypsum Sparse Vegetation
CEGL002765	Fendlera rupicola Talus Shrubland
CEGL000729	Juniperus osteosperma / Artemisia nova / Rock Woodland
CEGL000733	Juniperus osteosperma / Cercocarpus intricatus Woodland
CEGL000779	Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland
CEGL002370	Pinus edulis - Juniperus osteosperma / Ephedra viridis - Gutierrezia sarothrae Woodland
CEGL002332	Pinus edulis - Juniperus osteosperma / Petradoria pumila Woodland
CEGL001666	Pseudoroegneria spicata - Cushion Plants Grassland

Associated Animal species

The high escarpments of this system provide excellent habitat for cliff-nesting birds such as Peregrine Falcon (*Falco peregrinus*) and Golden Eagle (*Aquila chrysaetos*). Bats also use cliffs, canyons, and rock outcrops throughout their life-cycle. Lizards are common in the tablelands. Typical species include long-nosed leopard lizard (*Gambelia wislizenii*), collared lizard (*Crotaphytus collaris*), desert spiny lizard (*Sceloporus magister*).

Dynamic processes

This ecological system has a naturally high rate of erosion. Freeze-thaw cycles are most pronounced on south-facing slopes. Soil development is limited. Infiltration rates are low and runoff high. Fires are infrequent and not an important ecological process.

Management

The inaccessible nature of many of these areas has limited disturbance, however, roads and non-native species may degrade the integrity of an occurrence. Increased climate variability could contribute to erosion potential in some areas, but is not likely to have extensive effects.

Original concept authors: NatureServe Western Ecology Team Feb 2003
Colorado version authors: Colorado Natural Heritage Program Staff: Renée Rondeau and Karin Decker
Version date: May 2019

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Inter-Mountain Basins Active and Stabilized Dune

General Description

Active and stabilized dune fields are found throughout the Intermountain West in areas where wind action has resulted in the accumulation of sand. Both actively migrating sand dunes and formerly active dunes now stabilized by vegetation growth are included in this system, and may be found together as a mosaic. In Colorado, active dune fields are currently limited to occurrences on the eastern edges of the San Luis Valley and North Park. Dune Elevations range from about 2,350 to 2,590 m (7,700-8,500 ft) in the Great Sand Dunes of the San Luis Valley, and from 2,500 to 2,620 m (8,200-8,600 ft) in North Park dune fields. Vegetation of active areas may include sparse cover of blowout grass (*Redfieldia flexuosa*), skeleton weed (*Lygodesmia juncea*), and lemon scurfpea (*Psoralidium lanceolatum*). In more stabilized areas rabbitbrush (*Ericameria nauseosa* or *Chrysothamnus* spp.), needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), and western wheatgrass (*Pascopyrum smithii*), are likely, in addition to occasional species from the surrounding landscape. Sandy areas of Great Sand Dunes National Park and Preserve are home to the endemic Great Sand Dunes tiger beetle (*Cicindela theatina*). The North Park dunes support the globally rare endemic plant North Park bugseed (*Corispermum navicula*).

Diagnostic Characteristics

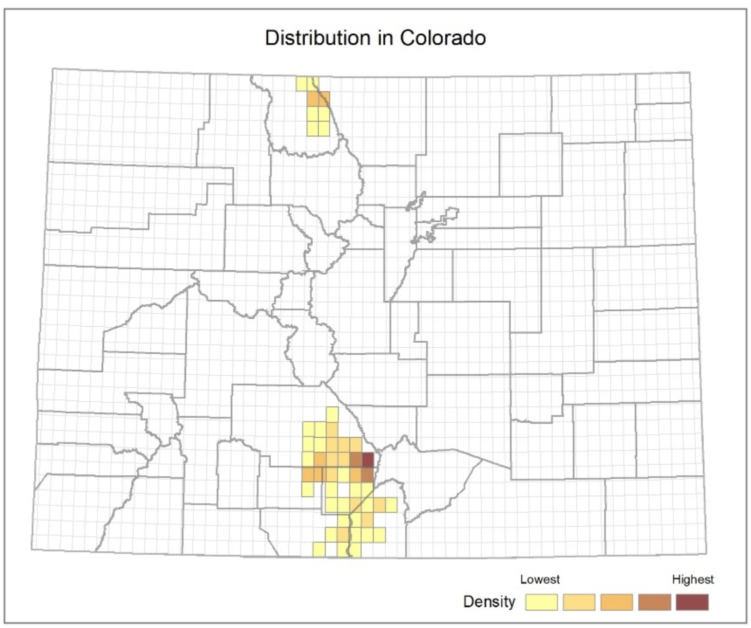
Occurrences are characterized by extensive open areas of bare, drifting sand. The active dune fields are adjacent to sandy areas that are more-or-less stabilized by vegetation.

Similar Systems

Western Great Plains Sandhill Steppe: Extensive stabilized sandy areas in eastern Colorado may experience areas of reactivation (blowouts) following severe drought, but are usually included in the sandhill steppe ecological system, often called sandsage shrubland.

Range

Active and stabilized dune fields occur throughout the Intermountain West from Mexico to Canada. Colorado occurrences are restricted to the intermontane basins of North Park and the San Luis Valley.



Spatial pattern

Active and stabilized dune fields are a large patch ecological system.

Environment

In Colorado, the North Park dunes are described as cold-climate, snow-influenced dunes with sedimentary structures characteristic of freeze, thaw, and snowmelt. In contrast, the Great Sand Dunes in the San Luis Valley, 200 miles to the south, have formed in a warmer, drier high-elevation desert climate. Precipitation patterns, together with the action of both surface and groundwater are key controlling factors in dune field formation and persistence. Prolonged dry periods reduce vegetation cover, and allow particles of fine sandy soil to be carried by prevailing winds across the valley floor until the effects of rising topography and opposing winds at the mountain front result in sand accumulation as winds slow. Surface runoff carries sand particles away from the mountain, and high groundwater levels can help stabilize soils.

The active dune fields of both areas are part of a larger, predominantly dormant dune system. The North Park dune field consists of aeolian deposits in an irregular band covering about 25 square miles at the foot of the Medicine Bow mountain range, extending southeast from the lower slopes of Sentinel Mountain at Kings Canyon to the junction of McKenzie Creek with the Canadian River. Within this area, there are currently two smaller areas of active dunes. The dune system at Great Sand Dunes in the San Luis Valley contains the active dune field covering 30 square miles between

Medano and Sand Creeks, as well as the sandsheet and sabkha. The sandsheet consists of sand that has been stabilized by vegetation (sparse grass and dwarf-shrubland). Small parabolic dunes form here and migrate northeasterly toward the main dunefield. A sabkha forms in places where sand is seasonally saturated by rising groundwater, here in the large wetland region south and west of the dunes. Subsequent evaporation forms areas of carbonate-cemented sand.

Vegetation

Vegetation on the active dunes is scattered, but may include sparse cover of blowout grass (*Redfieldia flexuosa*), sulphur-flower buckwheat (*Eriogonum umbellatum*), skeleton weed (*Lygodesmia juncea*), and lemon scurfpea (*Psoralidium lanceolatum*). In more stabilized areas rabbitbrush (*Ericameria nauseosa* or *Chrysothamnus* spp.), black greasewood (*Sarcobatus vermiculatus*), needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), and western wheatgrass (*Pascopyrum smithii*), are likely, in addition to species from the surrounding landscape. The North Park dunes support the globally rare endemic plant North Park bugseed (*Corispermum navicula*).

Plant Associations

CEGL001650	Achnatherum hymenoides - Psoralidium lanceolatum Grassland
CEGL001652	Achnatherum hymenoides - Sporobolus contractus Grassland
CEGL002697	Artemisia filifolia Colorado Plateau Shrubland
CEGL002980	Ericameria nauseosa Sand Deposit Sparse Shrubland
CEGL002363	Muhlenbergia pungens Grassland
CEGL001490	Pinus ponderosa / (Ericameria nauseosa) / Achnatherum hymenoides Woodland
CEGL002643	Populus angustifolia Sand Dune Riparian Forest
CEGL002917	Redfieldia flexuosa - (Psoralidium lanceolatum) Grassland
CEGL001364	Sarcobatus vermiculatus Dune Wet Shrubland

Associated Animal species

The dune sands provide good habitat for a number of burrowing insects and mammals. Hundreds of insect species have been documented from the Great Sand Dunes, including the Great Sand Dunes tiger beetle (*Cicindela theatina*) and other species that are endemic to the area. Pocket gophers (*Thomomys* spp.) and Ord's kangaroo rat (*Dipodomys ordii*) are also found there.

Dynamic processes

The dune fields of North Park and the Great Sand Dunes in the San Luis Valley are maintained by prevailing winds that transport sand toward the mountains to the east. In each case, the active dune field is found below a local topographic notch or low spot in the downwind mountain range that acts to funnel wind flow. Thus, the movement of sand is influenced by the topography of adjacent mountains, as well as by aridity levels, sand supply, and wind patterns. Long-term climatic trends are the primary source of change in the area of actively blowing sand. Even fairly sparse vegetation can prevent most sand movement, but prolonged drought or other factors that change or remove vegetation and reduce surface water will reactivate stabilized dunes.

Sparsely Vegetated & Barren

Although actively blowing sand suggests a highly mobile environment, the larger dunes maintain a fairly constant form and position over decades, in part because the sand is moist below the surface. Dune movement at Great Sand Dunes between the 1930s and 1970s was documented at 7.5-11 ft per year, in contrast to the almost negligible movement of dunes in North Park over a similar period. Parabolic dunes may form on the sandsheet in "blowout" areas of erosion. The arms of these dunes are anchored by vegetation but the center arc migrates toward the main dunefield.

Management

Activities such as domestic livestock grazing or recreational use that modify vegetation cover may allow active blowout areas to form in stabilized areas of the sandsheet. In the late 1800s the entire North Park dunefield was stabilized, with a covering of grama grass, in contrast to the current situation with two active sand fields and a sagebrush/rabbitbrush community on the stabilized portion. Increased severity and duration of drought would facilitate the expansion of this system into adjacent areas, with consequent increased management challenges.

Original concept authors: K.A. Schulz, M.S. Reid and G.P. Jones. April 2014
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: May 2019

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Inter-Mountain Basins Shale Badland

General Description

This widespread ecological system of the Intermountain western U.S. consists of barren and sparsely vegetated substrates (<10% plant cover). In Colorado, occurrences are found at elevations of 1,490 to 1,980 m (4,900 to 6,500 ft) in dry western valleys and mesa slopes. Soils are typically derived from marine shales, but also include those derived from siltstones and mudstones (clay). Landforms are typically rounded hills and plains that form a rolling topography, or steep talus slopes. The harsh soil properties and high rate of erosion and deposition prevent establishment of much vegetation beyond the sparse saltbush (*Atriplex*)or sagebrush (*Artemisia*) dwarf-shrubs and some herbaceous vegetation (often annual weedy species).

Diagnostic Characteristics

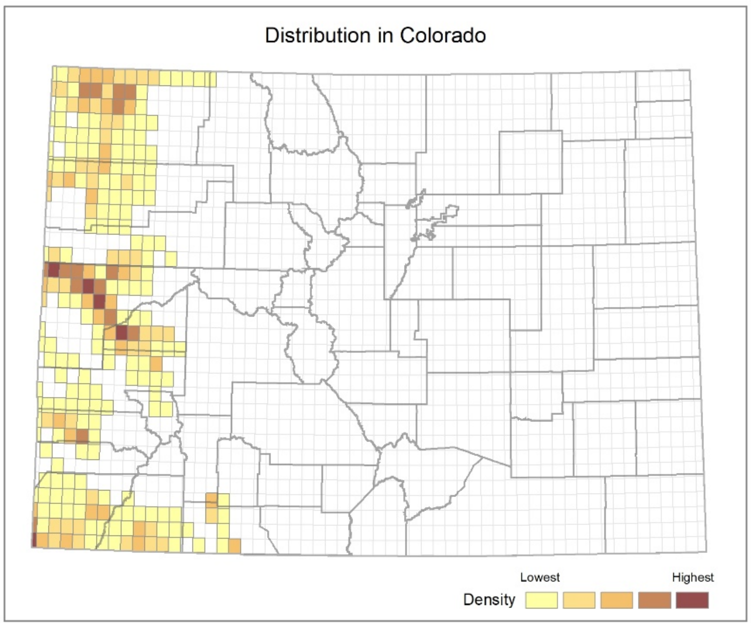
Although these badlands support species similar to those found in the Inter-Mountain Basins Mat Saltbrush Shrubland ecological system, they are distinguished by the active erosion and soil characteristics that act to maintain sparse vegetation.

Similar Systems

Inter-Mountain Basins Mat Saltbush Shrubland: These shrublands dominated by dwarf saltbush (*Atriplex* spp.) are often found adjacent to shale badlands, but are generally on flatter areas.

Range

These shale badlands are found throughout the intermountain western U.S., from Arizona and New Mexico north to Idaho and Montana. In Colorado occurrences are restricted to lower elevations on the western slope.



Spatial pattern

Inter-Mountain Basins Shale Badland is a large patch system in Colorado.

Environment

Shale badlands often occur on exposed ridges and steep (35-70%) colluvial slopes formed of eroded rock and sediment. Surfaces may include both fine soils, smaller rock fragments and larger rocks, depending on the source material. These badlands form where eroded material collects, such as at the base of steep cliffs or comparatively stable escarpments. Shale badlands may occur as or aprons at the base of steep areas or as barren badland hills with rolling topography. Soils are generally derived from shales or mudstones and are typically shallow, calcareous, alkaline, and clayey, often capped by a thin gravel layer. Total vegetative cover is relatively sparse and bare soil ranges from 75 to near 100 percent.

Vegetation

Vegetation in this ecological system is sparse to absent. When vegetation is present it may be dominated by either the dwarf saltbush species mat saltbush (*Atriplex corrugata*) or Gardner's saltbush (*Atriplex gardneri*), or sparse graminoid/forb herbaceous vegetation with scattered shrubs and trees. Small mature trees (pinyon or juniper) may be present. The dominant grass is often the perennial bunchgrass *Achnatherum hymenoides*, or saline wildrye (*Leymus salinus.* A sparse forb layer may also be present and will vary by topography and geography. Total vegetation cover is often less than 10%.

Plant Associations

CEGL001651	Achnatherum hymenoides Shale Barren Grassland

CEGL002585	Artemisia arbuscula ssp. longiloba / Elymus lanceolatus Shrubland
CEGL000990	Artemisia bigelovii / Achnatherum hymenoides Shrubland
CEGL001437	Atriplex corrugata Dwarf-shrubland
CEGL001316	Atriplex cuneata - Frankenia jamesii / Sporobolus airoides Shrubland
CEGL001444	Atriplex gardneri / Achnatherum hymenoides Dwarf-shrubland
CEGL001442	Atriplex gardneri / Leymus salinus Dwarf-shrubland
CEGL001441	Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland
CEGL001446	Atriplex gardneri / Xylorhiza venusta Dwarf-shrubland
CEGL001438	Atriplex gardneri Dwarf-shrubland
CEGL002349	Ephedra torreyana - (Atriplex spp.) / Nonvascular Gypsum Sparse Vegetation
CEGL002979	Eriogonum corymbosum Badlands Sparse Vegetation

Associated Animal species

None known.

Dynamic processes

Shale badland surface soils are subject to ongoing gravitational down-slope movement, especially after a rainstorm. Many plants actually get buried or uprooted due to silt movement. The loose colluvium, especially if over shale bedrock, is likely to result in landslides. The harsh soil properties and high rate of erosion and deposition are driving environmental variables maintaining these sparse dwarf-shrublands.

Management

These areas are little disturbed by anthropogenic activity, although some areas may be altered during energy development activities.

Original concept authors NatureServe Western Ecology Team; Jan 2007
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: July 2019

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Rocky Mountain Cliff, Canyon and Massive Bedrock

General Description

This ecological system is found throughout the Rocky Mountains and northeastern Cascade Range in North America. Occurrences are found from foothill to subalpine elevations (about 1,580 to 3,660 m; 5,200 to 12,000 ft in Colorado) and include barren and sparsely vegetated environments (generally <10% plant cover) of steep cliff faces, narrow canyons, and rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Unstable scree and talus slopes that typically occur below cliff faces are also included. Soil development is limited, as is herbaceous cover. There may be small patches of dense vegetation, but it typically only very scattered trees and/or shrubs are present. Vegetation is largely restricted to crevices, ledges, and small pockets. Species reflect those that are common in the surrounding landscape. Characteristic trees includes Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine *(Pinus ponderosa*), limber pine (*Pinus flexilis*), quaking aspen (*Populus tremuloides*), white fir (*Abies concolor*), and subalpine fir (*Abies lasiocarpa*), or two-needle pinyon (*Pinus edulis*) and juniper (*Juniperus* spp.) at lower elevations. Scattered shrubs present may include fivepetal cliffbush (*Jamesia americana*), creeping barberry (*Mahonia repens*), skunkbush sumac (*Rhus trilobata*), Saskatoon serviceberry (*Amelanchier alnifolia*), and species of rockspirea (*Holodiscus*), current (*Ribes*), and ninebark (*Physocarpus*).

Diagnostic Characteristics

Rocky Mountain Cliff, Canyon and Massive Bedrock occurrences are characterized by extensive exposure of rock surface, generally steep topography, limited soil development, and sparse foothill or montane vegetation that is generally confined to cracks, crevices, ledges and other small pockets.

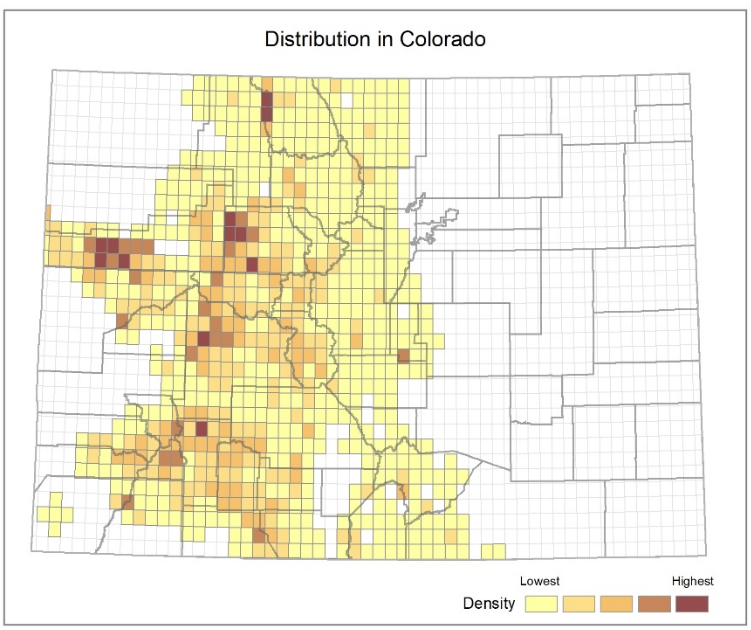
Similar Systems

Colorado Plateau Mixed Bedrock Canyon and Tableland: These rocky areas of Colorado's western slope are generally formed in massive sedimentary deposits where the sparse vegetation is typical of drier, lower elevation ecological systems of the Colorado Plateau.

Western Great Plains Cliff, Outcrop and Shale Barren: Outcrops of Colorado's eastern plains occur as shale barren or small sandstone outcrops within the overall grassland matrix, generally not forming massive cliffs except at isolated buttes.

Range

The Rocky Mountain Cliff, Canyon and Massive Bedrock ecological system ranges from northern Arizona and New Mexico north throughout the Rocky Mountains and northeastern Cascade Range into western Canada. In Colorado this system is found throughout the mountainous portion of the state, from foothill to subalpine elevations.



Spatial pattern

Rocky Mountain Cliff, Canyon and Massive Bedrock is a large patch type.

Environment

The three basic parts of a cliff habitat include: 1) the relatively level plateau at the top, 2) the vertical or near-vertical cliff face, and 3) the pediment or talus at the bottom of the face. These three elements share some physical characteristics, are linked by similar ecological processes, and often support the same plants and animals. Within the larger cliff habitat, steep slopes, small terraces ledges, overhangs, cracks and crevices often form a mosaic of microhabitat types that appears to be the primary factor contributing to cliff biodiversity. In addition, the cliff rim is often windier than the surrounding plateau, providing a distinct microhabitat that differs from the nearby flatter areas. At cliff faces there is less hydraulic pressure retaining water within the rock, so liquid water is more consistently found than in the surrounding habitat types.

Vegetation

Vegetation is largely restricted to crevices, ledges, and small pockets. Species reflect those that are common in the surrounding landscape. Characteristic trees includes Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine *(Pinus ponderosa*), limber pine (*Pinus flexilis*), quaking aspen (*Populus tremuloides*), white fir (*Abies concolor*), and subalpine fir (*Abies lasiocarpa*), or two-needle pinyon (*Pinus edulis*) and juniper (*Juniperus* spp.) at lower elevations. Scattered shrubs present may include fivepetal cliffbush (*Jamesia americana*), creeping barberry (*Mahonia repens*), skunkbush sumac (*Rhus trilobata*), Saskatoon serviceberry (*Amelanchier alnifolia*), and species of rockspirea (*Holodiscus*), current (*Ribes*), and ninebark (*Physocarpus*). The rare plant species Black Canyon gilia (*Aliciella (Gilia) penstemonoides*) and Smith's draba (*Draba smithii*) are cliff habitat specialists.

Plant Associations

CEGL000890	Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus Scree Woodland
CEGL001948	Aletes anisatus - Scutellaria brittonii Scree Vegetation
CEGL002801	Holodiscus dumosus Rock Outcrop Sparse Vegetation
CEGL002783	Jamesia americana - (Physocarpus monogynus, Holodiscus dumosus) Rock Outcrop Shrubland
CEGL000893	Picea engelmannii / Saxifraga bronchialis Scree Sparse Vegetation
CEGL000902	Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland
CEGL000911	Pseudotsuga menziesii Scree Woodland
CEGL001124	Ribes cereum / Leymus ambiguus Shrubland
CEGL001134	Rubus idaeus Scree Shrubland

Associated Animal species

Occurrences of this system provide habitat for Peregrine Falcon (*Falco peregrinus*) and other cliff nesting birds. Bats (Family *Vespertilionidae*) also use cliffs and rock outcrops throughout their life-cycle.

Dynamic processes

Erosion by wind, water, and the force of gravity is the primary natural disturbance process in the cliff environment. The rate of erosion and the size of eroded rock particles have a strong influence over which organisms occur on cliffs and talus. Cliff environments are shaped by the parent rock type and strength, climate, aspect, and the weathering patterns produced by physical and chemical processes. Physical weathering includes the downward movement of rock and soil under the influence of gravity (mass wasting), including larger slips, slides and rockfalls, shrinking/swelling in response to changes in water content (mostly in shales and mudstones), direct pressure effects from the formation of ice and mineral crystals, thermal stress, and frost action. Chemical weathering in cliff environments is directly controlled by precipitation amount and chemistry, rock temperature, and the chemical composition of the rock. Chemical weathering is most prevalent under conditions of higher temperature and high precipitation, whereas physical weathering is more important at lower temperatures.

Management

Cliffs and bedrock outcrops are a habitat that is relatively free of anthropogenic disturbance, but the canyons where these often occur are rarely without roads. Human disturbance to this system may include road construction and maintenance, recreation (climbing), and the effects of mining. Increased climate variability could contribute to erosion potential in some areas, but is not likely to have extensive effects.

Original concept authors: M.S. Reid, April 2005
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: June 2019

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Western Great Plains Cliff, Outcrop and Shale Barren

General Description

Although the western Great Plains is generally characterized by relatively low topographic relief, there are numerous scattered hogbacks, ridges, rocky outcrops, shallow canyons, mesa slopes, shale breaks, and barrens that interrupt the relative flatness of the landscape. Colorado includes shale outcrops in this ecological system. In eastern Colorado, examples of these small patch habitats are found both along the mountain front, and further east throughout the plains. Substrates range from sandstone to limestone. Vegetation is typically restricted to shelves, cracks and crevices in the rock. Areas that are sheltered from fire may have trees or other woody vegetation including typical foothills species such as ponderosa pine (*Pinus ponderosa*), Rocky Mountain juniper (*Juniperus scopulorum*), mountain mahogany (*Cercocarpus montanus*), and skunkbush sumac (*Rhus trilobata*). Grasses and forbs are often those found in adjacent western Great Plains ecosystems, but a number of comparatively rare ferns and rosette-forming plants are more restricted to outcrop habitats. Occurrences of this ecosystem are highly variable, depending on geologic substrate, regional climatic conditions, and local vegetation types.

Diagnostic Characteristics

Examples of this ecosystem can be thought of as islands or archipelagos of contrasting habitat within the larger landscape. Vegetation is largely controlled by the exposed geology and lack of soil.

Naturally sparse vegetation (i.e., not due to repeated disturbance) in comparison with the surrounding landscape is an identifying feature of these habitats.

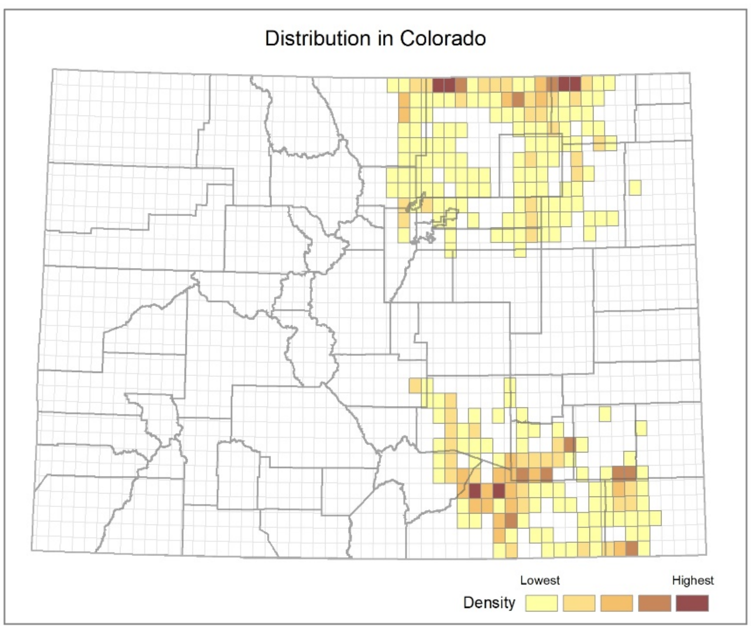
Similar Systems

Rocky Mountain Cliff, Canyon, and Massive Bedrock: these are sparsely vegetated cliff and rockface habitats of the foothills and montane areas, often formed in igneous or metamorphic rocks, but also typically associated with areas of more topographic relief than is found on the plains.

Other sparsely vegetated systems in Colorado are not found on the eastern plains.

Range

Cliffs and outcrops of the Western Great Plains range from Texas north into Canada, and can be found wherever rocky outcrops or shallow canyons appear. Colorado occurrences are found throughout the eastern part of the state. In northeastern Colorado this ecological system includes rimrock and erosional remnants of the High Plains escarpment stretching for many miles north of the South Platte River, as well as other isolated buttes and outcrops to the south. Further south, the Arkansas River and its tributaries flow through canyons excavated in the Cretaceous bedrock. The area between Pueblo and Cañon City contains a high frequency of shale barrens as well.



Spatial pattern

These outcrops and barrens are a small patch habitat.

Environment

The Western Great Plains landscape is generally characterized by relatively low topographic relief, but does include numerous scattered outcrops and erosional features that interrupt the relative flatness of the landscape. Topography ranges from steep rocky bluffs below the escarpments and buttes with intervening swales or gullies to smaller breaks and barrens with gentle slopes. The Ogallala, Arikaree, and White River Formations are the most common cliff and outcrop forming substrates in northeastern Colorado, consisting primarily of sandstones of varying hardness, and often interspersed with limestone, ashy claystone, or volcanic tuff. Shale barrens of the Niobrara and Pierre Formations are also found near the mountain front, where they are associated with conspicuous hogbacks along foothills of the Colorado Front Range. Aspects are often north and east facing, but the system can occur on other exposures. In southeastern Colorado, occurrences of this system are most often found on Cretaceous bedrock of the Middle and Upper Chalk members of the

Smoky Hills Member of the Niobrara Formation. Slope angles range from flat on summits to moderately steep on side slopes, and exposures are variable, depending on how uplift, regional erosion, or downcutting has occurred. Barrens are generally found on shales, soft limestone (chalk), or shale-derived soils, and are characterized by a high percentage of open, rocky ground between the low-growing shrubs and herbaceous cover.

Vegetation

Cliffs and outcrops support a variety of plant communities, depending on the steepness, exposure, and soil conditions of the site. The tops of the escarpment are often dominated by the adjacent shortgrass or mixedgrass prairie communities. Vegetation is typically sparse, and often restricted to shelves, cracks and crevices in the rock, or other areas where soil accumulation allows growth. The lack of vegetation on many sites protects them from fire, and in a few instances the rocky cliffs support disjunct populations of foothills species such as ponderosa pine (*Pinus ponderosa*), Rocky Mountain juniper (*Juniperus scopulorum*), limber pine (*Pinus flexilis*), and mountain mahogany (*Cercocarpus montanus*). Sheltered areas on the bluff slopes typically support sparse shrub cover of skunkbush sumac (*Rhus trilobata*), chokecherry (*Prunus virginiana*), current (*Ribes* spp.), sand sagebrush (*Artemisia filifolia*), broom snakeweed (*Gutierrezia sarothrae*), plains pricklypear (*Opuntia polyacantha*), and soapweed yucca (*Yucca glauca*), along with prairie grasses such as blue grama (*Bouteloua gracilis*), threeawn (*Aristida* spp.), needle-and-thread (*Hesperostipa comata*), sideoats grama (*Bouteloua curtipendula*), prairie sandreed (*Calamovilfa longifolia*) and sixweeks fescue (*Vulpia octoflora*). Claystone and limestone layers within the sandstone form gravelly barrens that support a characteristic "cushion plant" community that may include James' seaheath (*Frankenia jamesii*), Hooker's sandwort (*Arenaria hookeri*), tufted evening primrose (*Oenothera caespitosa*), spiny phlox (*Phlox hoodii*), stemless four-nerve daisy (*Tetraneuris acaulis*), silky milkvetch (*Astragalus sericoleucus*), and other species typical of the nearby grasslands.

Plant Associations

CEGL001951	Arenaria hookeri Barrens Vegetation
CPSAFRJA0A	Frankenia jamesii / Achnatherum hymenoides Shrubland
CCNHPXXX38	Frankenia jamesii / Hilaria jamesii - (Bouteloua gracilis) Shrubland

Associated Animal species

Cliff areas provide nesting sites for Peregrine and Prairie Falcon (*Falco peregrinus* and *F. mexicanus*), Townsend's big eared bat (*Corynorhinus townsendii pallescens*), and other bat species. Small mammals, including woodrats (*Neotoma* spp.) and mice may also make use of cracks and crevices as shelter for nesting. Reptiles include Hernandez's short-horned lizard (*Phrynosoma hernandesi*), Colorado checkered whiptail lizard (*Aspidoscelis neotesselatus,* south eastern Colorado only), and prairie rattlesnake (*Crotalus viridis*).

Dynamic processes

Cliffs, outcrops, and barrens often serve as refugia for endemic species adapted to the particular environmental conditions of the site. Although fire can be an important element that slows or eliminates tree establishment in many of these habitats, the shallow soils over bedrock, and

extremes of climate or microclimate, are important factors as well. For rock outcrop communities with extensive exposed bedrock, fire is typically not an important factor. Differences in microhabitat between rock outcrop sites and the surrounding habitats with deeper soils produce distinctive vegetation of these sites.

Management

Little is known about the system-level effects of disturbance, natural or anthropogenic, in many of these occurrences. Some barrens species are not well adapted to disturbance, so moderate disturbance produces distinctive plant communities dominated by species that tolerate these activities. Natural disturbance by wind and water erosion may have similar effects, leading to the differentiation of plant communities according to microsite characteristics.

Original concept authors: S. Menard and K. Kindscher, Oct 2014
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker
Version date: June 2019

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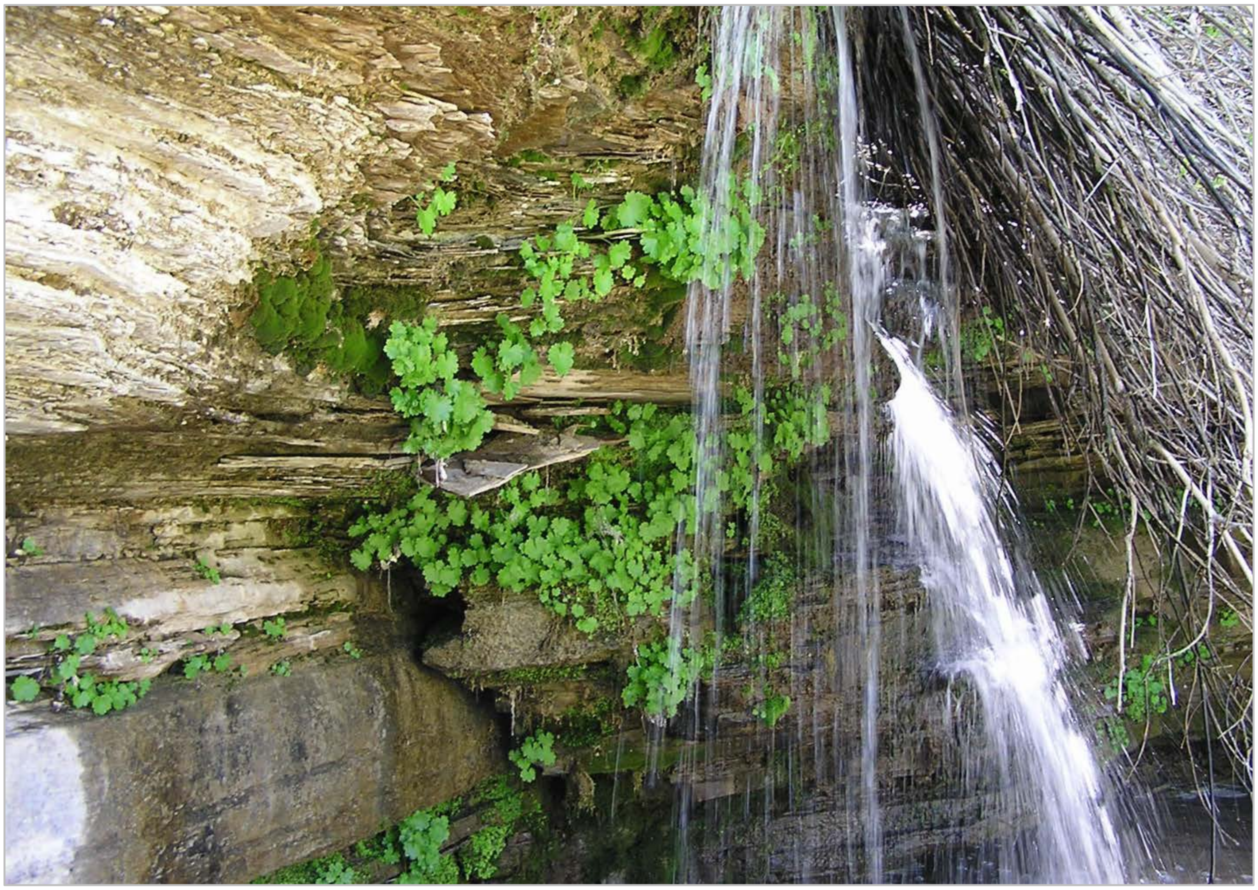
WETLAND & RIPARIAN

Colorado Plateau Hanging Garden



General Description

Hanging gardens are a small patch community type in the canyons of western Colorado. These highly restricted environments are found in canyonlands with perennial water sources (seeps) that form pocket wetlands, often with vegetation draped across wet cliff faces. Hanging gardens are variable in form depending on how water moves through joints in the surrounding rock formations. Most hanging gardens are dominated by herbaceous plants, and a number of regional endemic species are found in these communities. Common species include maidenhair fern (*Adiantum capillus-veneris*), Eastwood's monkeyflower (*Mimulus eastwoodiae*), seep monkeyflower (*Mimulus guttatus*), Purpus' sullivantia (*Sullivantia hapemanii* var. *purpusii*), oil shale columbine (*Aquilegia barnebyi*), and Mancos columbine (*Aquilegia micrantha*). In Colorado this system includes hanging gardens of the Utah High Plateau ecoregion, which differ somewhat in geology and species composition from those of the Colorado Plateau to the south.

Diagnostic Characteristics

Colorado Plateau Hanging Garden ecological systems are small communities of hydrophytic plants that occupy alcoves, seeps and springs in canyon walls where they grow on permanently wet soil and wet rock surfaces that originate from seeps. Typical plant species include southern maidenhair

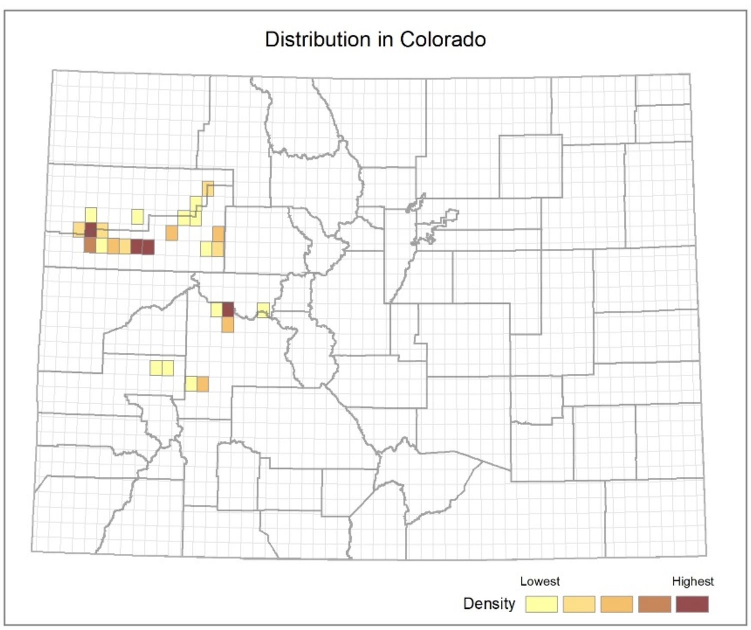
fern (*Adiantum capillus-veneris*), northern maidenhair fern (*Adiantum pedatum*), Eastwood's monkeyflower *(Mimulus eastwoodiae),* common large monkeyflower (*M. guttatus),* and Mancos columbine (*Aquilegia micrantha*). Utah High Plateaus examples are associated with waterfalls or cliff seeps, with typical species including Purpus' sullivantia (*Sullivantia hapemanii*), oil shale columbine (*Aquilegia barnebyi*), common large monkeyflower (*M. guttatus*), and an abundant moss component.

Similar Systems

Hanging gardens of the Utah High Plateaus have not been fully described as a separate ecological system, and are included here. The diversity of vegetation is generally higher in Colorado Plateau hanging gardens than in Utah High Plateaus hanging gardens. Occurrences in the Utah High Plateau ecoregion are associated with calcareous formations, especially shales of the Green River Formation, while those of the Colorado Plateau ecoregion are associated with massive sandstone deposits such as the Navajo and Entrada.

Range

Hanging gardens are found in canyons of the Colorado Plateau and Utah High Plateaus ecoregions. Colorado occurrences are restricted to the west slope. Colorado Plateau types are typical of sandstone canyons, while Utah High Plateaus types are generally restricted to the Green River Formation in the oil shale region, especially on the Roan Plateau.



Spatial pattern

Colorado Plateau Hanging Gardens are a small patch system.

Environment

Much of the Colorado Plateau is a landscape formed from thick horizontal sedimentary strata where the perpetual action of wind and water has carved complex canyons that provide habitat for hanging gardens. The hanging garden environment is characterized by perennially wet rock walls and/or wet shallow, colluvial soils at a seep from bedrock. Seeps occur where groundwater percolating through the stone reaches the surface along joints between impervious strata. Water that supplies the springs and seeps is derived from local sandstone aquifers that are primarily supplied by winter precipitation. Hanging gardens can occur in a variety of sites, typically where erosion has modified the steepness of the canyon wall, such as at alcoves or at seeps and

springs in canyon walls. Often these locations are in wet theater-headed valleys formed by enhanced weathering and erosion due to water seepage.

In the northern portion of the Colorado Plateau, however, and in the Southern Rocky Mountains, hanging gardens are associated with springs, seeps, and waterfalls formed in calcareous shales, primarily those of the Green River Formation. The vegetation grows in the cracks behind and beside the waterfall, where it often completely fills every available ledge. In the seeps adjacent to waterfalls and in the splash zones at the base of falls, the substrate is saturated during most of the growing season. Here the vegetation is continually wet, at least near the bases of the plants, and water can very commonly be seen dripping from leaves, exposed roots, and old stems. Although large occurrences of these hanging gardens are primarily associated with waterfalls, smaller occurrences can occur along cliff seeps above streams, especially in the Roan plateau area.

Vegetation

Hanging gardens are moist islands of vegetation embedded with expanses of bedrock. These moisture-loving plant communities can develop in these sites because of the microclimate created by groundwater seepage zones and related erosional processes that produce the physical hanging garden habitat characterized by perennially wet rock walls and/or wet, subirrigated colluvial soils. Often species diversity is low, although it is typically much greater in the gardens on the Colorado Plateau than in those of the Utah High Plateaus. Species may be shared with nearby riparian vegetation, but there are a series of species, including algae, that are unique to hanging gardens. The classic alcove type of hanging garden consists of an overhanging back wall, a vaulted face wall, a detrital slope, and a plunge basin. The back and face walls support clinging plants such as southern maidenhair fern (*Adiantum capillus-veneris*) and Eastwood's monkeyflower (*Mimulus eastwoodiae*). Species growing at the base of these seeps where soil development can occur include golden-fruit sedge (*Carex aurea*), Mancos columbine (*Aquilegia micrantha),* ditch reedgrass *(Calamagrostis scopulorum*), giant helleborine (*Epipactis gigantea*), and tapered rosette grass (*Dichanthelium acuminatum*). A fringing margin of netleaf hackberry (*Celtis laevigata* var*. reticulata*) and Gambel oak (*Quercus gambelii*) often occurs outward from the footslope where the plants tend to conceal the alcove base. In the Utah High Plateaus gardens, the dominants are usually Purpus' sullivantia (*Sullivantia hapemanii* var*. purpusii*) and Barneby's columbine (*Aquilegia barnebyi*) with large monkeyflower (*Mimulus guttatus*) common.

Plant Associations

CEGL002592	Aquilegia micrantha - Calamagrostis scopulorum Herbaceous Vegetation
CEGL002729	Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation
CEGL002751	Calamagrostis scopulorum Hanging Garden Herbaceous Vegetation
CEGL002762	Aquilegia micrantha Herbaceous Vegetation
CCNHPXXX36	Sullivantia hapemanii - (Aquilegia barnebyi) Herbaceous Vegetation

Associated Animal Species

The hydrology that enables the development of hanging gardens also provides resources for a wide diversity of native wildlife. Hanging gardens are also "hot spots" of biodiversity, with many species of endemic terrestrial and aquatic invertebrates as well as birds, mammals, and amphibians. Animal species associated with hanging gardens include Canyon Wren (*Catherpes mexicanus*), Rock Wren (*Salpinctes obsoletus*), Say's Phoebe (*Sayornis saya*), canyon treefrog (*Hyla arenicolor*), red-spotted toad (*Anaxyrus punctatus*), Colorado chipmunk (*Neotamias quadrivittatus*) bushy-tailed woodrat (*Neotoma cinerea*), desert woodrat (*Neotoma lepida*), Mexican woodrat (*Neotoma mexicana*), and Colorado forestfly (*Malenka coloradensis*).

Dynamic processes

The type of garden is determined by the nature of the geological formation and the presence or absence of joint systems. In general, the hanging gardens result from ancient swales or valleys in a sand dune-swale system that developed between the Cretaceous and Pennsylvanian periods (65–310 mya). The formations with the greatest development are the Navajo and Entrada, both of them cross-bedded, massive formations composed of wind-blown sand and containing ancient pond bottoms that serve as impervious bedding planes. Water percolating through the porous rock encounters the ancient bedding planes, still impervious and capable of holding water. When filled to overflowing, these bedding planes carry the water downward to the next bedding plane beneath or to another impervious stratum at the base of the formation. Joint systems within the rock act as passageways for water. Where the joint systems are exposed along canyon walls the water flows over the moist surfaces.

The complexity of the plant community in a hanging garden is a function of the quantity and quality of water, developmental aspects, and ability of plant species to disperse to it. Gardens vary in size, aspect, exposure to the elements, water quantity and quality, number of bedding planes, and amount of light received. Water quality, in some degree, controls the type of plants found in hanging gardens, which is dictated by the nature of the formations through which the water passes. Water is often of drinkable quality, but may be saline or laden with calcium, which results in tufa deposits in the gardens.

Management

Primary threats to this system are invasive plant species, trampling and hydrologic alteration. Some gardens are currently threatened by invasive exotic plants such as tamarisk (*Tamarix chinensis*). Historically, springs on the Colorado Plateau have been widely used as domestic and livestock water sources. At some springs the remnants of previous land use, such as water diversions and spring boxes, are still visible, and their impacts, including altered vegetation composition, are still evident. The effects of visitor use, including water pollution, social trailing, and trampling, are also a concern in some areas. For instance, the Mancos columbine-Eastwood monkeyflower plant association (G2G3/S2S3) occurs on seeping sandstone walls and alcoves where its location generally protects it from disturbance, but disturbance to the water source can eliminate the association.

Climate change, especially altered precipitation regimes, can change groundwater availability, resulting in altered spring flow and habitat availability. If winter precipitation declines, this may adversely affect the aquifers and their associated wildlife, including the hanging gardens. Climate change models applied to the Colorado Plateau predict significant changes in the next 30–100 years. By 2090, precipitation is predicted to decline by as much as 5 percent across the region. This reduction, while apparently small, is critical when looking at the already low amounts of precipitation most of the region experiences. Any declines in precipitation are likely to increase drought stress in existing native plant communities resulting in a greater susceptibility of existing ecosystems to replacement by noxious and other invasive weedy species.

Original concept authors: NatureServe Western Ecology Team, R. Rondeau. 2004.
Colorado version authors: Colorado Natural Heritage Program Staff: Dee Malone, Karin Decker
Version date: May 2019

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Inter-Mountain Basins Greasewood Flat

General Description

The Inter-Mountain Basins Greasewood Flats ecological system occurs throughout the Intermountain West and extends onto the western Great Plains and central Montana. Greasewood flats are a large patch system confined to specific environments defined by hydrologic regime, soil salinity and soil texture. These cold, semi-desert shrublands are typical of arid, continental environments with hot summers, cold winters and low annual average precipitation. This system typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most of the growing season. However, the water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities of open to moderately dense shrublands dominated or codominated by black greasewood (*Sarcobatus vermiculatus*). Other shrubs that may be present or codominant include four-winged saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*), Gardner's saltbush (*Atriplex gardneri*), Wyoming sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), Plains silver sagebrush (*Artemisia cana* ssp. *cana*), or winterfat (*Krascheninnikovia lanata*). Occurrences are often

surrounded by mixed salt desert scrub or big sagebrush shrublands. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of alkali sacaton (*Sporobolus airoides*), western wheatgrass (*Pascopyrum smithii*), inland saltgrass (*Distichlis spicata*), sand reedgrass (*Calamovilfa longifolia*), Kentucky bluegrass (*Poa pratensis*), Nuttall's alkali grass (*Puccinellia nuttalliana*), or creeping spikerush (*Eleocharis palustris*) herbaceous types.

Diagnostic Characteristics

This system is characterized by shrublands dominated or co-dominated by black greasewood (*Sarcobatus vermiculatus*) that occur in the lower foothills and valley bottoms of the Intermountain West. On alkaline soils, black greasewood can be found in nearly pure stands or, in less alkaline soils, black greasewood may intermix with other shrubs such as shadscale, four-winged saltbush, sagebrush or rabbitbrush.

Similar Systems

<u>Inter-Mountain Basins Playa</u>: Greasewood flats may occur adjacent to or near playa wetlands in the Intermountain West. Greasewood flats are differentiated from playas by topographic position and percent vegetation cover. Greasewood flats are valley bottom shrublands that occupy intermittently flooded alluvial terraces with saline soils and shallow water tables. In contrast, playas occur primarily in depressions where soils are saline and surface salt crusts are common. Playas may be intermittently flooded or maintained by a perennially high water table. Vegetation cover in greasewood flats is typically greater than 25% and is dominated or co-dominated by black greasewood (*Sarcobatus vermiculatus*) with other shrub species such as saltbush (*Atriplex* spp.). Vegetation cover in playas is sparse and generally less than 10%.

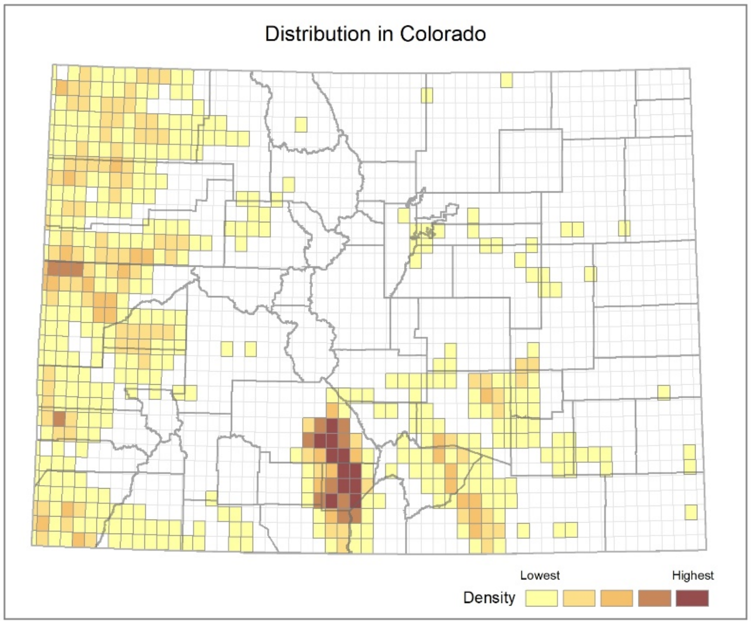
Similar systems also include upland sagebrush (*Artemisia* spp.) and saltbush (*Atriplex* spp.) shrub systems.

Range

This system occurs throughout the Intermountain West and extends onto the western Great Plains and central Montana. In Colorado, large occurrences are found in the lower elevations of Colorado's western valleys and throughout much of the San Luis Valley. In eastern Colorado, occurrences are primarily in the southwestern portion of plains.

Spatial Pattern

Inter-Mountain Greasewood Flats is a large patch system.



Environment

Greasewood flats are a large patch system confined to specific environments defined by hydrologic regime, soil salinity and soil texture. These systems are maintained by groundwater and are typically found near drainages on stream terraces and flats, on alluvial fans along streams or arroyos, or they may form rings around playas. Sites usually have saline soils, a shallow water table and flood intermittently, but remain dry for most of the growing season. The water table however remains high enough to maintain vegetation, despite salt accumulations. Environmental conditions in the cold deserts select for those few species that are adapted to moisture deficits, low temperatures and salinity. Black greasewood (*Sarcobatus vermiculatus*) is a facultative halophyte that is tolerant of alkaline and saline soil conditions, which allows the species to occur in sites with less interspecific competition. Greasewood is also found on arid, non-saline sites where it mixes with other shrubs such as shadscale, four-winged saltbush, rabbitbrush and winterfat.

Climate is distinctly continental and typified by warm summers and prolonged, cold winters with temperatures in January and February often well below freezing. Average precipitation is low, usually less than ten inches, with most precipitation falling in winter. Melting snow and spring rains result in the primary annual soil recharge although, except in years of unusually high summer rainfall, spring and summer precipitation is generally effective in only wetting the surface layers of the soil. Average temperatures and precipitation are similar between eastern and western regions of Colorado where this system occurs, but timing of precipitation differs; much of the annual precipitation on the Great Plains comes from convectional storms originating in the Gulf of Mexico during summer, while in western sites, summer precipitation is much less important. Seasonal photosynthetic activity is largely limited to spring and early summer, corresponding with the season of highest moisture, although, even during late summer, cold desert shrubs are able to extract moisture from soils with very low water potential.

Hydrologic regime is a key factor controlling vegetation composition and soil development in all wetlands. Greasewood flats are tightly associated with saline soils and groundwater that is near the surface, thus the primary hydrologic process that maintains greasewood flats is groundwater recharge. Black greasewood is phreatophytic and its distribution is well correlated with the distribution of groundwater but also with the amount of exchangeable sodium and the percent of water retained at field capacity. Black greasewood stands develop best where moisture is readily

available, either from surface or subsurface runoff, and is often found on sites with high water tables (less than 34 feet) that are intermittently flooded or that have a high water table at least part of the year. Water from brief summer thunderstorms does not easily infiltrate these shale soils, so runoff on slopes tends to accumulate in depressions. High evaporation rates during the hot, dry conditions lead to a concentration of salts, which may actually form a white crust on the soil surface where water accumulates in these low spots.

Soils supporting black greasewood are variable, but are typically alkaline or saline and can include silt-clays, clay-loams, silt-loams, or deep fine sand-loams, though this species is most commonly associated with heavy textured clay and silt soils of high salt content (0.05-1.6%). However, black greasewood can be found growing on non-saline soils and so is not an infallible indicator of high salt content. Plant species distribution in this system is often determined by degree of soil salinity and soil moisture. For instance, greasewood is extremely salt tolerant but is limited to moist habitats or areas with accessible ground water, whereas sagebrush (*Artemisia tridentata*) is only a moderately salt tolerant xerophyte and saltbush (*Atriplex* spp.) species can tolerate both the combined stresses of low soil moisture and salinity. In the inter-mountain basins, black greasewood is often confined to alkali soils on alluvial areas, floodplains, dry washes, and gullies where soil moisture is high, as compared to desert regions where it often dominates areas where runoff waters have accumulated.

Vegetation

This ecological system usually occurs as a mosaic of multiple communities of moderately dense shrublands dominated or codominated by black greasewood (*Sarcobatus vermiculatus*). On saline sites with consistently high water tables, greasewood may grow in nearly pure stands or in association with saltbushes (*Atriplex* spp.), whereas on less saline sites, greasewood may occur with several other shrub species. Shrubs commonly codominant or present with black greasewood include four-wing saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*), rabbitbrush (*Chrysothamnus nauseosus*), cholla (*Cylindropuntia imbricata*), or winterfat (*Krascheninnikovia lanata*). The herbaceous layer, if present, is usually dominated by graminoids such as alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata*), and blue grama (*Bouteloua gracilis*). Small patches of pure alkali sacaton, inland saltgrass, or creeping spikerush (*Eleocharis palustris*) herbaceous types may also be found within the shrubland system where water remains ponded the longest.

Greasewood dominated vegetation can occur as a narrow band along a channel, or in a mosaic of communities where composition and density of the shrub and understory species vary with depth to water table, salinity and alkalinity, soil texture, and past land use or disturbance. Occurrences may be surrounded by grasslands, stabilized sand dunes, wet meadow systems, mixed salt desert scrub, sandsage, or shortgrass prairie. Hanson (1929) described stands in south-central Colorado and found that pure stands of black greasewood (*S. vermiculatus*) and inland saltgrass (*D. spicata*) are more common on strongly saline/alkaline sites with fine-textured soil and shallow water tables, whereas stands with mixed shrubs such as rabbitbrush (*Chrysothamnus* spp.) or sagebrush (*Artemisia* spp.) are more common on drier, coarser textured, low-alkaline sites. Alkali sacaton (*S.*

airoides) is found on dry, strongly alkaline sites, and western wheatgrass (*Pascopyrum smithii*) is most common on less alkaline, moist sites in low lying areas.

Plant Associations

CEGL001313	Atriplex confertifolia - Sarcobatus vermiculatus Shrubland
CEGL001357	Sarcobatus vermiculatus Disturbed Shrubland
CEGL001359	Sarcobatus vermiculatus / Artemisia tridentata Shrubland
CEGL001360	Sarcobatus vermiculatus / Atriplex gardneri Shrubland
CEGL001361	Sarcobatus vermiculatus / Bouteloua gracilis Shrubland
CEGL001363	Sarcobatus vermiculatus / Distichlis spicata Shrubland
CEGL001368	Sarcobatus vermiculatus / Sporobolus airoides Shrubland
CEGL001370	Sarcobatus vermiculatus / Suaeda moquinii Shrubland
CEGL001479	Leymus cinereus Herbaceous Vegetation
CEGL001481	Leymus cinereus - Distichlis spicata Herbaceous Vegetation
CEGL001685	Sporobolus airoides Southern Plains Herbaceous Vegetation
CEGL001687	Sporobolus airoides - Distichlis spicata Herbaceous Vegetation
CEGL001770	Distichlis spicata Herbaceous Vegetation
CEGL001773	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
CEGL001799	Puccinellia nuttalliana Herbaceous Vegetation
CEGL001833	Eleocharis palustris Herbaceous Vegetation
CEGL001999	Salicornia rubra Herbaceous Vegetation
CEGL002918	Ericameria nauseosa / Sporobolus airoides Shrubland
CEGL002919	Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation

Associated Animal Species

Environmental conditions are rigorous in these cold, semi-desert shrublands. Regardless, numerous animal species thrive here due to distinct adaptations that enable survival in these regions. Common mammal species include black-tailed jackrabbit (*Lepus californicus*) for whom greasewood is an important forage, badger (*Taxidea taxus*), white-tailed antelope squirrel (*Ammospermophilus leucurus*), Gunnison's and white-tailed prairie dogs (*Cynomys gunnisoni* and *C. leucurus*), Ord's kangaroo rat (*Dipodomys ordii*), mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*). Reptile species are common and include sagebrush lizard (*Sceloporus graciosus*), side-blotched lizard (*Uta stansburiana*), western whiptail (*Cnemidophorus tigris*), striped whipsnake (*Masticophis taeniatus*), Great Basin gopher snake (*Pituophis melanoleucus deserticola*) and bullsnake (*Pituophis catenifer*).

Greasewood Flats provide a bounty of resources for avian fauna. Due to this system's structural and floristic simplicity, bird diversity and density are typically low, but in the washes where greasewood becomes dense and tall, the density and diversity of birds matches that of the mountain shrub zone. In the best developed greasewood habitat, typical nesting species include Horned Lark (*Eremophila alpestris*), Mourning Dove (*Zenaida macroura*), Western Meadowlark (*Sternella neglecta*), Northern Mockingbird (*Mimus polyglottos*), Loggerhead Shrike (*Lanius ludovicianus*), Black-throated Sparrow (*Amphispiza bilineata*), Lark Sparrow (*Chondestes grammacus*), Sage Thrasher (*Oreoscoptes montanus*), Sage Sparrow (*Artemisiospiza nevadensis*), and

Brewer's Sparrow (*Spizella breweri*). These shrublands provide important hunting grounds for a variety of raptors including Golden Eagle (*Aquila chrysaetos*), Ferruginous Hawk (*Buteo regalis*), Prairie Falcon (*Falco mexicanus*), Northern Harrier (*Circus cyaneus*), and Swainson's Hawk (*Buteo swainsoni*). Lark Buntings (*Calamospiza melanocorys*) are irruptive breeders in semidesert shrubland outside of their usual range. In a rare year these buntings suddenly appear on the desert, becoming locally common.

Dynamic Processes

Groundwater flows and depth of the water table are among the most important driving factors in maintaining this system. Successional status of black greasewood varies with moisture and soil conditions. Under moist-sodic edaphic conditions, black greasewood is described as a "stable dominant" and is probably the climax vegetation of very alkaline soils. A study of saline prairie sites in Canada found black greasewood occurred exclusively on undisturbed sites. However, black greasewood is also known to sprout after disturbance and will invade nearby rabbitbrush and saltbush stands if the water table of these stands rises, making it an early successional community in this situation. With increasing soil salinity (>1.08%) black greasewood is replaced by species such as inland saltgrass.

Black greasewood community types were historically subject to stand-replacing fire regimes with intervals estimated at <35 to <100 years. Historically, saltbush/black greasewood communities had sparse understories and bare soil in intershrub spaces, making these communities somewhat resistant to fire except in years of high fire hazard conditions such as may occur with drought. Fire return intervals have been altered by grazing and by weed invasion. Grazing results in increased biomass production due to sprouting and increased seed production, leading to greater fuel loads and an altered fire regime. Throughout vast areas of the western rangeland invasion by annual grasses, such as cheatgrass (*Bromus tectorum*) has also resulted in changes to the fire regime. In salt-desert shrublands, cheatgrass increases fine fuels, which increases fire frequency, which then results in long recovery periods and the prevention of the establishment of desert shrubs such as black greasewood.

Management

These shrublands have generally been used for grazing and some areas have been converted to agricultural production, such as has occurred in portions of the Grand Valley and the San Luis Valley. Livestock grazing in cold desert shrublands has often resulted in the breaking up of long-established soil crusts, enhanced erosion and contributed to the spread of non-native weeds such as cheatgrass. Cold deserts are often nitrogen poor. The major agent of atmospheric nitrogen fixation in cold deserts is the soil surface cryptogam crust, which is easily destroyed by livestock trampling. One of the greatest threats to biodiversity and system integrity is the introduction of non-native plants. Cheatgrass, a widespread non-native annual grass, is fire-prone and shortens fire return intervals, so native shrubs are replaced. Additionally, once cheatgrass becomes established on rangelands, it persists for decades and interferes with the reinvasion by native perennial plants, even when native taxa seed sources are present.

WETLAND & RIPARIAN

Global climate change in the southwest is resulting in increasing temperature, drought, wildfire, and invasive species that will accelerate transformation of the landscape. Trends in temperature regimes may alter the competitive relationships among plant species, and this will become a more urgent problem in the presence of invasive plant species such as cheatgrass. Record-setting wildfires are resulting from the rising temperatures and related reductions in spring soil moisture. Climate-fire dynamics will be affected by changes in the distribution of ecosystems and by increased availability of fine fuels. Increasing temperatures and shifting precipitation patterns will drive the expansion of drier ecological systems, another factor likely to increase fire risk.

Because this system is dependent on groundwater, groundwater depletion will likely impact system integrity. Development activities such as groundwater pumping and surface diversions will likely contribute to groundwater depletion. Groundwater recharge will also likely be impacted by global climate change which, in the southwest, is projected to experience longer and more severe droughts from the combination of increased evaporation and reduced precipitation.

Original Concept Authors: NatureServe Western Ecology Team. 2007.
Colorado Version Authors: Colorado Natural Heritage Program Staff: Dee Malone
Version Date: December 2016

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Inter-Mountain Basins Playa

General Description

The Inter-Mountain Basins Playa ecological system describes barren or sparsely vegetated playas (generally <10% plant cover) throughout the Intermountain West. These systems are intermittently flooded and water is typically prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Some are affected by high groundwater tables. Soil salinity varies with soil moisture and greatly affects species composition. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. Characteristic species in Colorado may include black greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Grayia spinosa*), Lemmon's alkali grass (*Puccinellia lemmonii*), Great Basin wildrye (*Leymus cinereus*), inland saltgrass (*Distichlis spicata*), and species of saltbush (*Atriplex* spp.). These wetlands are particularly important to waterfowl and shorebird and also support many rare and unique species.

Diagnostic Characteristics

This system describes playas throughout the Intermountain West with saline soils that are intermittently flooded or are maintained by a perennially high water table. They support a sparse cover (generally < 10%) of salt-tolerant vegetation that includes both shrubs and herbs.

Similar Systems

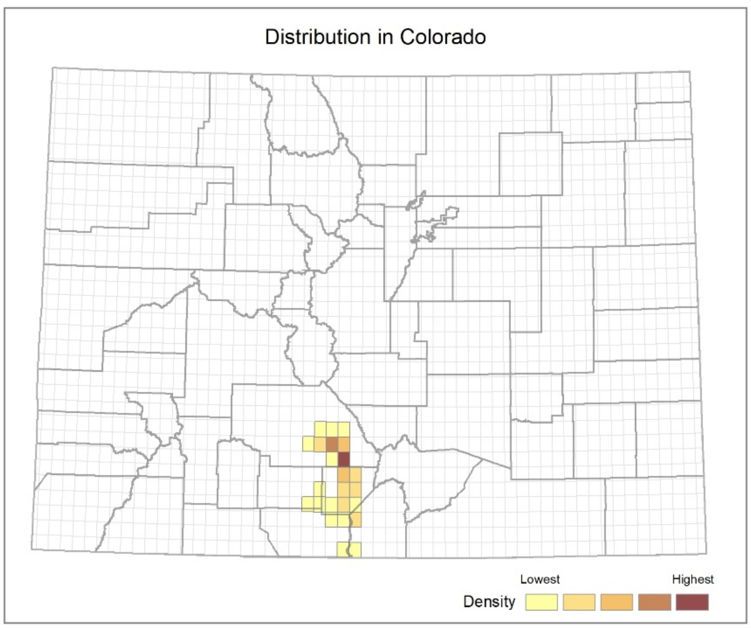
<u>Inter-Mountain Basins Greasewood Flat</u>: Greasewood flats may occur adjacent to or near playa wetlands in the Intermountain West. Greasewood flats are differentiated from playas by

topographic position and percent vegetation cover. Greasewood flats are valley bottom shrublands that occupy intermittently flooded alluvial terraces with saline soils and shallow water tables. In contrast, playas occur primarily in depressions where soils are saline and surface salt crusts are common. Playas may be intermittently flooded or maintained by a perennially high water table. Vegetation cover in greasewood flats is typically greater than 25% and is dominated or co-dominated by black greasewood (*Sarcobatus vermiculatus*) with other shrub species such as saltbush (*Atriplex* spp.). Vegetation cover in playas is sparse and generally less than 10%.

Western Great Plains Closed Depression and Western Great Plains Saline Depression: Depressional wetlands referred to as playas also occur in the Western Great Plains, which stretches across the eastern half of Colorado. Playas on the plains are not typically associated with high groundwater tables, but instead depend entirely on precipitation and surface run-off. Soils can be either saline or not.

Range

This system occurs throughout the Intermountain West.



Spatial Pattern

Inter-mountain Basins Playas are a small patch system.

Environment

The landscape of the Intermountain West is characterized by north-south trending mountains, with large alluvial fans at their base, separated by broad, sediment-filled valleys (basins), many of which have internal drainages. Mountain-building uplift and volcanism events with subsequent erosion and depositional processes created the inter-mountain basins that are now filled with deep alluvial deposits derived from erosional processes in the nearby mountains. Playas and similar saline wetlands occur in the inter-mountain basins, where the landscape provides the hydrogeomorphic template that enables their development. Playas are often described as closed basin systems whose hydrological inputs are limited to precipitation and surface runoff. On the surface, this definition makes sense for playas in the Intermountain West. For example, in the Closed Basin of the San Luis Valley, Colorado, playa systems form at the base of terminal streams flowing from nearby mountain ranges. However, many of the playas found in the Intermountain West, including those in the Closed Basin in the San Luis Valley, are also subject to groundwater discharge or capillary movement of water from seasonally high water tables. As a result, these wetlands are characterized by complex

interactions of surface and ground water. Regardless of their hydrological source, Inter-mountain Basin Playas share similar soil chemistry as well as floristics with many stereotypical, precipitation-fed playas such as those found in the Southern High Plains of Texas and New Mexico.

Climate within Colorado's inter-mountain basins is strongly influenced by the mountains, but also semi-arid with warm, dry summers and cold winters. Most precipitation occurs as snowfall (as much as 80% at high elevations) during the winter months and thus is the most important source of water for wetlands and riparian areas in the Southern Rocky Mountains. However, late-summer convective thunderstorms produce slight peaks in runoff in late summer. Evaporation generally exceeds precipitation, especially at lower elevations and in the inter-mountain basins. The ratio between evaporation and precipitation has a strong influence on the soils and hydrology of wetlands throughout the region.

Interaction of climate and geomorphology has a strong influence on local wetland hydrological processes. In Colorado, snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics. Inter-mountain basins receive surface water from snowmelt streams originating in the surrounding mountains. These streams can terminate in depressions or basins that have no drainage outlet and have impermeable soils, conditions that set the stage for playa formation. Many playas fill from snowmelt-fed streams in late spring but most are dry by late summer, although heavy monsoon precipitation can cause some plays to refill in late summer and some may wet up only during high precipitation years. Most water loss occurs by evaporation, as vegetation cover is sparse and losses to groundwater are low due to the characteristic alkali clay soils that prevent infiltration. High rates of evaporation results in a high concentration of evaporative salts in the upper soil profile, conditions which select for flora and fauna that are adapted to seasonal soil saturation and saline conditions.

Some playas are maintained by groundwater, with groundwater recharge ultimately dependent on subsurface or surface flows from adjacent mountains. For example, many of the playas in the San Luis Valley, Colorado, depend upon a complex interaction of surface and groundwater sources that undergo characteristic seasonal and inter-annual fluctuations. In these playas, when the groundwater table approaches the soil surface, capillary action can bring salts and water up to or near the soil surface. When this capillary water reaches the soil surface, high evaporation rates leave increased concentrations of salts in the upper soil horizons and on the soil surface as a salt crust. Salt concentrations in these wetlands can be up to 500 times that found in freshwater wetlands.

Vegetation

Species composition is strongly influenced by water and soil salinity. Thus playas exhibit distinct bands or zones of vegetation that vary according to soil salinity and water table levels or duration of inundation. Regularly flooded playas support well developed aquatic and shoreline emergent vegetation, such as pondweeds (*Potamogeton* spp.), horned pondweed (*Zannichellia palustris*), spikerush (*Eleocharis acicularis*), and hardstem bulrush (*Schoenoplectus acutus*). Sites that are

inundated for short durations (1 to 3 months) are characterized by emergent species, such as three-square bulrush (*Schoenoplectus pungens*) and common spikerush (*Eleocharis palustris*). Areas of seasonally high water tables and saline soils are characterized by shallow emergent species such as Nevada bulrush (*Amphiscirpus nevadensis*) and mountain rush (*Juncus balticus* var. *montanus*). Salt flats, where capillary action results in an abundance of salt crusts on the soil, are tolerated by only a few plant species such as western glasswort (*Salicornia rubra*) and alkali bulrush (*Schoenoplectus maritimus*). Seasonally saturated saline wet meadows are characterized by species such as inland saltgrass (*Distichlis spicata*), three-square bulrush (*Schoenoplectus pungens*), and Baltic rush (*Juncus balticus*). Mesic soils with various salinity levels support inland saltgrass (*Distichlis spicata*) while adjacent alkali flats and dunes dominated by greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamnus* spp.) respectively. Other plant species commonly found in playa systems include alkali sacaton (*Sporobolus airoides*), saltbush (*Atriplex* spp.), scratchgrass muhly (*Muhlenbergia asperifolia*) and saline plaintain (*Plantago eriopoda*).

Plant Associations

CEGL001016	Artemisia tridentata ssp. tridentata / Leymus cinereus Shrubland
CEGL001326	Krascheninnikovia lanata / Poa secunda Dwarf-shrubland
CEGL001357	Sarcobatus vermiculatus Disturbed Shrubland
CEGL001359	Sarcobatus vermiculatus / Artemisia tridentata Shrubland
CEGL001360	Sarcobatus vermiculatus / Atriplex gardneri Shrubland
CEGL001362	Sarcobatus vermiculatus / Ericameria nauseosa Shrubland
CEGL001363	Sarcobatus vermiculatus / Distichlis spicata Shrubland
CEGL001368	Sarcobatus vermiculatus / Sporobolus airoides Shrubland
CEGL001481	Leymus cinereus - Distichlis spicata Herbaceous Vegetation
CEGL001588	Spartina gracilis Herbaceous Vegetation
CEGL001687	Sporobolus airoides - Distichlis spicata Herbaceous Vegetation
CEGL001770	Distichlis spicata Herbaceous Vegetation
CEGL001773	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
CEGL001991	Suaeda moquinii Shrubland

Associated Animal Species

Playa wetlands support many rare plant and animal species. Playas of the San Luis Valley support large populations of the globally rare slender spiderflower (*Cleome multicaulis*), the Great Sand Dunes tiger beetle (*Cicindela theatina*), the San Luis sandhill skipper (*Polites sabuleti ministigma*) and two mammal subspecies, the plains pocket mouse (*Perognathus flavescens relictus*) and silky pocket mouse (*Perognathus flavus sanluisi*).

Playa wetlands are particularly important waterfowl and shorebird habitats. Variability in water levels and salinity and the subsequent vegetation types support a variety of aquatic and terrestrial invertebrates that then provide foraging resources for a variety of bird species. Six state rare bird species have been documented at the playas in Great Sand Dunes including Short-eared Owl (*Asio flammeus*), Snowy Plover (*Charadrius nivosus*), Long-billed Curlew (*Numenius americanus*), Black-crowned Night-heron (*Nycticorax nycticorax*), White-faced Ibis (*Plegadis chihi*), and Forster's Tern (*Sterna forsteri*). Other bird species that have been documented using playa wetland habitats

include Mallard (*Anas platyrhynchos*), Green-winged Teal (*Anas crecca*), Cinnamon Teal (*Spatula cyanoptera*), American Coot (*Fulica americana*), Blue-winged Teal (*Spatula discors*), Killdeer (*Charadrius vociferous*), Common Snipe (*Gallinago gallinago*), Sora (*Porzana carolina*), Spotted Sandpiper (*Actitis macularius*), Wilson's Phalarope (*Phalaropus tricolor*), American Avocet (*Recurvirostra americana*), Virginia Rail (*Rallus limicola*), Red-winged Blackbird (*Agelaius phoeniceus*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), Common Yellowthroat (*Geothlypis trichas*), Song Sparrow (*Melospiza melodia*), Brewer's Blackbird (*Euphagus cyanocephalus*), Savannah Sparrow (*Passerculus sandwichensis*), and Northern Harrier (*Circus cyaneus*).

Dynamic Processes

The role of disturbance processes for this system is largely unknown. Disturbance may include periodic high water periods, which can drown plants, as well as multi-year droughts, leading to high plant mortality. As wetlands dry out, salt concentrations can increase due to evaporation, eventually exceeding tolerance of some plant species, which may lead to community succession.

Disturbance from some native animal species is important to the survivability of some plant and animal species. Slender spiderflower (*C. multicaulis*) is restricted to very specific microhabitats of moist alkaline soils. The playas in the San Luis Valley provide these conditions. The slender spiderflower also appears to respond well to some forms of soil disturbance. These discriminating habitat requirements limit the slender spiderflower to the edges of alkaline playa lakes and wetlands. Digging by the Northern Pocket Gopher (*Thomomys talpoides macrotis*) provides the soil disturbance necessary for reproductive success of the slender spiderflower and also provides the burrows for Burrowing Owls, which occur at the San Luis Valley playa sites.

Management

Playa wetland ecosystems are intimately tied to specific runoff patterns and the water table which undergo characteristic seasonal and inter-annual fluctuations. Anthropogenic changes to the depth or duration of inundation can have profound effects on soil salinity and consequently wetland vegetation and by extension on wetland dependent fauna including waterbirds, amphibians, insects and mammals. Reservoirs, water diversions, groundwater withdrawal, ditches, roads, and human land uses in the contributing watershed which perturb the timing or magnitude of surface- and/or groundwater flows, are likely to affect playas detrimentally.

Non-native species can displace native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food for fauna. Numerous invasive and/or exotic species are known to occur in playas. Non-native species that are especially problematic in playa wetlands include common reed (*Phragmites australis*), whitetop (*Cardaria* spp.), goosefoot (*Chenopodium glaucum* and *C. rubra*), Canada thistle (*Cirsium arvense*), Russian thistle (*Salsola* spp.), ironweed (*Bassia hyssopifolia*), and kochia (*Kochia scoparia*).

Climate has a pivotal role in the maintenance of playas. Because playa wetland systems are dependent on both surface and groundwater, diminished surface flows and groundwater depletion

will likely impact system integrity. Surface flow and groundwater recharge are projected to likely be impacted by global climate change which is altering the timing and character of hydrological processes that maintain wetland systems. Human-induced warming is resulting in the loss of snowpack and earlier snowmelt which is projected to worsen, with trends indicating fundamental impacts on streamflow and water supplies across the western United States. The Southwest is projected to experience longer and more severe droughts from the combination of increased evaporation and reduced precipitation which is projected to impact both surface and groundwater.

Original Concept Authors: NatureServe Western Ecology Team. 2007.
Colorado Version Authors: Colorado Natural Heritage Program Staff: Dee Malone
Version Date: November 2017

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Inter-Mountain Basins Wash

General Description

This ecological system is found throughout the Intermountain western U.S., but appears to be highly variable across its range. In Colorado these narrow linear systems are drainages within semi-arid environments where surface flow, whether as sheetflow and braided channeling on unentrenched valley floors or in entrenched channels, is ephemeral or occasionally intermittent. Runoff from surrounding areas provides sufficient soil moisture to support a relatively more mesic vegetation community in comparison with generally sparsely vegetated adjacent uplands. Reaches of these ephemeral and discontinuous stream channels may be described variously as washes, swales, gullies, or arroyos, with edges variable from gently sloped to steep. These streams combine erosional and depositional reaches that vary over time, and are likely to occur within the same drainage area as well as sequentially along a contiguous stretch. Where aggradation (the process of sediment deposition) is dominant, channel floors are broad and may be densely vegetated. In reaches where eroding gullies merge, an entrenched vertical-walled channel (arroyo) may form. These two forms represent the opposing endpoints of a dynamic spectrum.

Vegetation structure is related to the area drained by a channel. The largest catchments support multi-layered riparian vegetation, mid-sized areas may support only shrubs or herbaceous riparian species, while the channel vegetation of very small catchments is generally indistinguishable from adjacent upland cover. In Colorado occurrences vegetation cover can be sparse to moderate, and characterized primarily by shrubs or herbaceous cover. Typical shrub species in Colorado include black greasewood (*Sarcobatus vermiculatus*), rubber rabbitbrush (*Ericameria nauseosa),* basin big sagebrush (*Artemisia tridentata* ssp*. tridentata*), and occasionally silver sagebrush (*Artemisia cana*). Herbaceous cover often includes patches of saltgrass (*Distichlis spicata*) or alkali sacaton (*Sporobolus airoides*). Extensive occurrences of this system are infrequent in Colorado, and are primarily confined to lower elevation areas near the western border of the state, or a few sites on the eastern plains. Soils are variable but generally less alkaline than those found in playa systems.

Diagnostic Characteristics

The Inter-Mountain Basins Wash system is most recognizable as narrow channels dissecting a bajada or broad alluvial apron below a mountain front or other adjacent high ground, but can occur in more confined valleys. The drainages support a corridor of vegetation that is in strong contrast to the generally more sparsely vegetated uplands. Occurrences are poorly documented in Colorado. Until additional information is available about occurrences of this system, small and sparsely vegetated drainages can be considered as part of the adjacent upland type. Likewise, broad sagebrush-dominated drainage bottom lands typical in the Piceance Basin are not currently considered part of this system. Instances of this system may also occur in the San Luis Valley and on Colorado's eastern plains; most washes and arroyos in southeastern Colorado are currently considered to be part of the Southwestern Great Plains Canyon system.

Similar Systems

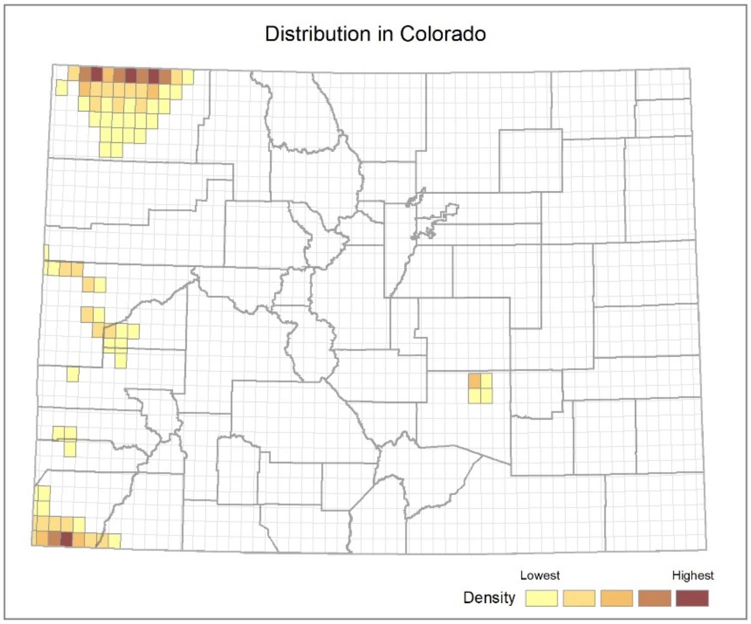
Some examples of this system may be more-or-less contiguous with or tributary to the lowest and driest shrub-dominated stretches of Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland.

Range

This system occurs throughout the Intermountain western U.S., extending east into the Western Great Plains in a few areas. In Colorado, occurrences are infrequent, and found on lower elevation drainages near the western boundary of the state, and are likely to occur in the San Luis Valley and possibly on the eastern plains. Currently known examples are in on lower elevation lands in Montezuma County and in Moffat County drainages in the vicinity of Vermillion Bluffs. Additional occurrences are probable in other eroded badlands of the westernmost tier of counties.

Spatial Pattern

Inter-Mountain Basins Wash is a linear system.



Environment

Inter-Mountain Basins Wash occurrences are usually in semi-desert badlands and shrublands. In Colorado, these occur in arid to semi-arid climates with warm to hot summers and freezing winters, where annual precipitation is normally less than about 35 cm (14 in). These areas receive a significant portion of their annual precipitation in July through October in conjunction with North American monsoon storms. To a great extent, flow in these drainages is a result of local precipitation events, and not due to groundwater discharge. In some reaches seasonal runoff may intermittently allow continuous flow for a period of time in some channel segments.

Adjacent dry uplands are sparsely vegetated, due to the harsh soils and low precipitation. Substrates are typically well-drained sandstone- or shale-derived soils. Soils are typically aridisols, which are dry for most of the year, even during the growing season, and there is little infiltration of water into the soil. Soil salinity depends on the amount and timing of precipitation and flooding.

Vegetation

Plant associations and cover characteristics in washes generally contrast with adjacent uplands and reflect the distinct environmental conditions of the wash. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into adjacent uplands. Typical shrub species include black greasewood (*Sarcobatus vermiculatus*), rubber rabbitbrush (*Ericameria nauseosa),* basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), and occasionally silver sagebrush (*Artemisia cana*). Herbaceous cover often includes patches of saltgrass (*Distichlis spicata*) or alkali sacaton (*Sporobolus airoides*).

Plant Associations

CEGL001773	Distichlis spicata - (Scirpus nevadensis) Alkaline Wet Meadow
CEGL001770	Distichlis spicata Alkaline Wet Meadow
CEGL002261	Ericameria nauseosa Desert Wash Shrubland
CEGL001360	Sarcobatus vermiculatus / Atriplex gardneri Wet Shrubland
CEGL001363	Sarcobatus vermiculatus / Distichlis spicata Wet Shrubland
CEGL001362	Sarcobatus vermiculatus / Ericameria nauseosa Wet Shrubland
CEGL001368	Sarcobatus vermiculatus / Sporobolus airoides Wet Shrubland
CEGL001370	Sarcobatus vermiculatus / Suaeda moquinii Wet Shrubland

CEGL001291 Atriplex canescens / Sporobolus airoides Shrubland

Associated Animal species
None known.

Dynamic Processes
These streams combine erosional and depositional reaches that vary over time, and are likely to occur within the same drainage area as well as along a contiguous stretch. Where aggradation (the process of sediment deposition) is dominant, channel floors are broad, with braided channels and/or sheetflow, and may be densely vegetated. In reaches where eroding gullies coalesce, an entrenched vertical-walled channel (arroyo) may form. These two forms represent the opposing endpoints of a dynamic spectrum.

Episodic channel dynamics are influenced by a variety of factors, including random variation in local conditions, longer term climate trends, and land use changes. Channel behavior is mediated by vegetation type, density, and condition, by soil characteristics, and by human activities.

Flood events can be key drivers of geomorphic, biogeochemical, and biological characteristics of these washes, but may occur very infrequently, if at all. Annual precipitation in the range of 100 to 500 mm (4 to 20 in) provides conditions that allow the deposition of valley fill by ephemeral streams. Drier areas lack sufficient vegetation to trap sediment; wetter areas support stabilizing riparian vegetation. Vegetation structure is related to the area drained by a channel. The largest catchments support multi-layered riparian vegetation, mid-sized areas may support only shrubs or herbaceous riparian species, while the vegetation of very small catchments is generally indistinguishable from adjacent upland cover.

Management
Although ephemeral or intermittent, these channels maintain connectivity within a larger drainage network, and therefore contribute water, sediment, nutrients, and organisms to downstream reaches and rivers through occasional flow and flooding. These streams provide many of the same ecological and hydrological functions as perennial streams but are often heavily disturbed ecosystems. Lowered groundwater tables have converted some formerly perennial to intermittently flowing reaches to ephemeral behavior. Livestock grazing and the spread of non-native species are ubiquitous on the southwestern semi-desert landscape. Heavy grazing may replace salt-tolerant grasses with exotic species such as cheatgrass (*Bromus tectorum*), tansy mustard (*Descurainia pinnata*), and halogeton (*Halogeton glomeratus*).

Original concept authors: K.A. Schulz. 2007.
Colorado version authors: Colorado Natural Heritage Program Staff: Karin Decker, Dee Malone
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Western North American Emergent Marsh

General Description

The Western North American Emergent Marsh system includes wetlands with permanent to semi-permanent standing water that support aquatic, submerged, and coarse emergent plants. For Colorado, this system is inclusive of both the concept of the North American Arid West Emergent Marsh as defined by NatureServe, as well as higher-elevaiton marshes in the Rocky Mountains, Colorado intermountain valleys, and other habitats that have greater annual precipitation than the arid west. Natural marshes may occur in depressions (impounded ponds or kettle ponds), on lake fringes, or within riparian and floodplain areas as beaver ponds, backwater channels, oxbows, or sloughs. Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Hydrologic inputs include direct precipitation, surface water inflows, and groundwater discharge. Marshes have distinctive soil characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of bulrush (*Scirpus* and/or *Schoenoplectus*),

cattail (*Typha*), rush (*Juncus*), pondweed (*Potamogeton*), smartweed (*Polygonum*), pondlily (*Nuphar*), and canarygrass (*Phalaris*). This system may also include areas of relatively deep water with floating-leaved plants such as duckweed (*Lemna*), and submerged and floating plants such as watermilfoil (*Myriophyllum*), hornwort (*Ceratophyllum*), and waterweed (*Elodea*). Marsh vegetation is occasionally bordered by woody species such as plains cottonwood (*Populus deltoides*) and willows (*Salix* spp.).

Diagnostic Characteristics

Marshes are permanent or semi-permanent wetlands with relatively deep standing water (>20 cm and up to 2 m). Marsh vegetation is typically dominated by coarse emergent and/or aquatic plant species. Soils are mineral and typically gleyed or reduced, but may have a high organic content in the A horizon.

Similar Systems

Rocky Mountain Alpine-Montane Wet Meadow: Wet meadows and marshes are both mineral soils wetlands that support herbaceous vegetation dominated by graminoids. The primary difference is that marshes have relatively deep standing water for an extended period during the growing, while wet meadows water tables at or just below the ground surface and typically lack deep standing water. Wet meadows may have small patches of marsh vegetation in areas where the water is deeper. These patches are generally smaller than 0.1 ha (0.25 acres) and are within a mosaic of other vegetation communities.

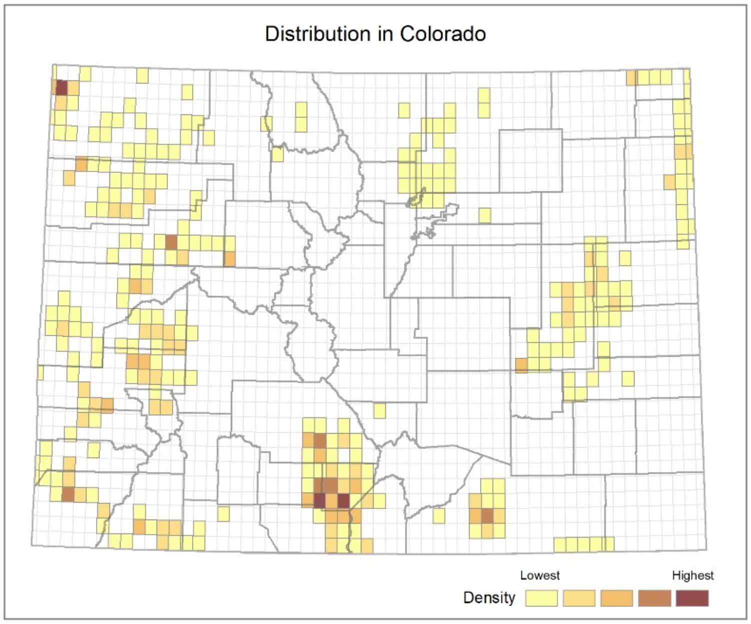
Rocky Mountain Subalpine-Montane Fen: Fens are distinguished from marshes by soil characteristics and water table depth. Fens are permanently saturated groundwater-fed wetlands with organic soil (peat) accumulations of 40 cm or greater. Marshes lack deep organic soils and experience deep inundation rather than saturation. Fens may have standing water on the soil surface or may have pockets of open water with coarse emergent or aquatic plant species, but these open water areas are surrounded by and often underlain by deep organic soils. In addition, water table fluctuations in marshes can be large (> 1 m), whereas water table fluctuations in fens are much less dramatic.

Range

This system occurs throughout much of the arid and semi-arid regions of western North America. In Colorado, it occurs throughout the state from the plains to upper elevations. There are particular concentrations along the Front Range, the South Platte and Arkansas River floodplains, and the San Luis Valley.

Spatial Pattern

Western North American Emergent Marsh is a small patch system.



Environment

Marshes occur throughout the entire state of Colorado, occupying a wide range of habitats from depressions, lake fringes, ponds, old channels, oxbows, and sloughs. In the plains, marshes occur along slow-moving streams, within backwater areas of the major floodplains, as well as along reservoir fringes. Within the Rocky Mountains, glacial and fluvial processes have sculpted kettle ponds and other depressions where marsh systems develop. Emergent marshes are also frequently found associated with excess runoff and elevated groundwater tables associated with irrigated agriculture or stormwater runoff. Marsh vegetation thrives wherever the water is impounded and above the ground surface for extended periods.

Marsh hydrology is supported primarily by precipitation and surface water runoff and is particularly responsive to climatic fluctuations. Higher-elevation marshes may also include seasonal hydrologic contribution from snowmelt. Precipitation and evapotranspiration can determine water level fluctuation as well as soil chemistry due to evaporative salts in the soil. Marshes can have up to 2 m of standing water above the soil surface and fluctuation of the water table in marshes can be large (> 1 m). During drought years, many marshes may be significantly drier than during normal precipitation years. Water sources can also include groundwater, stream discharge, and overbank flow.

Marshes have distinctive soils that are typically mineral, but can also accumulate organic material depending on the duration of inundation and frequency of fluctuation. Because the water table in marshes fluctuates, the soil is periodically aerated allowing organic matter to decompose, preventing the accumulation of peat in many marshes. Soils often possess characteristics that result from long periods of anaerobic conditions in the soils such as gleyed soils, high organic content, and redoximorphic features.

Vegetation

Marsh vegetation is characterized by permanent to semi-permanently and seasonally flooded herbaceous vegetation types. Plant species are dominated by coarse emergent perennial and often rhizomatous graminoids. Vegetation height can range from 0.5–5 m. Cover can be dense or open, depending on location and management regime. Floating and submerged aquatic species are also often present. The forb component is typically sparse, ranging from 0-25% cover.

Emergent marshes can have distinct zonation according to the degree of inundation and soil moisture, and can even grade into the drier wet meadow systems. The most characteristic species include coarse emergents such as cattail (*Typha* spp.), bulrush (*Schoenoplectus* spp., *Bolboschoenus* spp.), arrowhead (*Sagittaria* spp.), sweet coltsfoot (*Petasites sagittata*). Marshes with deep open water often contain true aquatic species such as duckweed (*Lemna* spp.), pond lily (*Nuphar lutea*), pondweeds (*Potamogeton* spp.); watermilfoil (*Myriophyllum*), hornwort (*Ceratophyllum*), and waterweed (*Elodea*). Within the shallower edges, finer emergent species grow such as spikerush (*Eleocharis* spp.), sedges (*Carex* spp.), rushes (*Juncus* spp.), cordgrass (*Spartina* spp.), cutleaf water parsnip (*Berula erecta*), American speedwell (*Veronica anagallis-aquatica*), and roundleaf monkey flower (*Mimulus glabratus*). Marshes with a transitional zone from moist soil to upland may include drier sedges, rushes, tufted hairgrass (*Deschampsia cespitosa*), bearded sprangletop (*Leptochloa fusca*), reed canarygrass (*Phalaroides arundinacea*), foxtail barley (*Critesion jubatum*), saltgrass (*Distichlis stricta*), showy milkweed (*Asclepias speciosa*), wild mint (*Mentha arvensis*), mapleleaf goosefoot (*Chenopodium simplex*), and curlytop knotweed (*Persicaria lapathifolia*). In some marshes, woody species will border the inundated zones including cottonwood (*Populus* spp.), willows (*Salix* spp.), Western snowberry (*Symphoricarpos occidentalis*), and the noxious species Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix* spp.). Not all of these zones are present in every marsh, as shoreline gradient and hydrological regime varies between region and wetland.

Plant Associations

CEGL001474	Phalaris arundinacea Western Herbaceous Vegetation
CEGL001475	Phragmites australis Western North America Temperate Semi-natural Herbaceous Vegetation
CEGL001476	Spartina pectinata Western Herbaceous Vegetation
CEGL001559	Calamagrostis canadensis Western Herbaceous Vegetation
CEGL001562	Carex utriculata Herbaceous Vegetation
CEGL001569	Glyceria borealis Herbaceous Vegetation
CEGL001585	Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation
CEGL001586	Schoenoplectus americanus - Eleocharis spp. Herbaceous Vegetation
CEGL001587	Schoenoplectus pungens Herbaceous Vegetation
CEGL001588	Spartina gracilis Herbaceous Vegetation
CEGL001773	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
CEGL001813	Carex nebrascensis Herbaceous Vegetation
CEGL001833	Eleocharis palustris Herbaceous Vegetation
CEGL001838	Juncus balticus Herbaceous Vegetation
CEGL001840	Schoenoplectus acutus Herbaceous Vegetation
CEGL001841	Schoenoplectus americanus Western Herbaceous Vegetation
CEGL001843	Schoenoplectus maritimus Herbaceous Vegetation
CEGL001845	Typha domingensis Western Herbaceous Vegetation
CEGL001984	Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation
CEGL001990	Sparganium angustifolium Herbaceous Vegetation
CEGL001995	Triglochin maritima Herbaceous Vegetation

CEGL001999	Salicornia rubra Herbaceous Vegetation
CEGL002000	Myriophyllum sibiricum Herbaceous Vegetatio
CEGL002001	Nuphar polysepala Herbaceous Vegetation
CEGL002007	Potamogeton diversifolius Herbaceous Vegetation
CEGL002008	Stuckenia filiformis Herbaceous Vegetation
CEGL002010	Typha latifolia, Typha angustifolia Western Herbaceous Vegetation
CEGL002030	Schoenoplectus acutus - Typha latifolia - (Schoenoplectus tabernaemontani) Sandhills Herbaceous Vegetation
CEGL002623	Schoenoplectus tabernaemontani Temperate Herbaceous Vegetation
CEGL002660	Carex praegracilis Herbaceous Vegetation
CEGL002661	Carex vesicaria Herbaceous Vegetation
CEGL002742	Potamogeton foliosus Herbaceous Vegetation
CEGL002925	Potamogeton natans Herbaceous Vegetation
CEGL003059	Lemna spp. Permanently Flooded Herbaceous Vegetation
CEGL003323	Sparganium eurycarpum Herbaceous Vegetation
CEGL004144	Schoenoplectus americanus - Carex spp. Herbaceous Vegetation

Associated Animal Species

In Colorado, marshes and ponds support high priority bird species. Although native marshes have suffered extensive loss and have changed from native condition, they still provide key habitat for avifauna. In Colorado priority bird species that depend on wetlands for breeding include Northern Harrier (*Circus cyaneus*), Short-eared Owl (*Asio flammeus*) and Willet (*Tringa semipalmata*). Other marsh associated species include American Bittern (*Botaurus lentiginosus*), Black Rail (*Laterallus jamaicensis*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Common Snipe (*Gallinago delicata*), Marsh Wren (*Cistothorus palustris*), Red-winged Blackbird (*Agelaius phoeniceus*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), Wilson's Phalarope (*Phalaropus tricolor*), American Avocet (*Recurvirostra americana*), Killdeer (*Charadrius vociferous*), Savannah Sparrow (*Passerculus sandwichensis*) and a variety of waterfowl.

Marshes also provide critical habitat for a variety of herptofauna, including uncommon and rare species. Mountain marshes provide habitat for species such as tiger salamander (*Ambystoma tigrinum*) (ubiquitous), mountain toad (*Bufo boreas*) (formerly widespread now scarce), western chorus frog (*Pseudacris triseriata*) (ubiquitous), western terrestrial garter snake (*Thamnophis elegans*) (ubiquitous) and wood frog (*Rana sylvatica*). Lowland marshes provide habitat for tiger salamander, Woodhouse's toad (*Bufo woodhousii*), western chorus frog, plains and northern leopard frogs (*Rana blairi* and *R. pipiens*), bullfrog (*Rana catesbeiana*)(non-native), snapping turtle (*Chelydra serpentina*), painted turtle (*Chrysemys picta*), northern water snake (*Nerodia sipedon*), bullsnake (*Pituophis catenifer*) and garter snakes (*Thamnophis* spp.).

Dynamic Processes

Climate and basin morphology are the primary ecological drivers of marsh vegetation patterns and ecological function through their effects on hydrology. All natural wetland functions are closely related to the water cycle with hydroperiod as the principle factor that controls wetland structure

and function. Marshes are usually associated with a permanent water source, and have a water table close to the surface that persists for one or more months during the growing season. Hydrologic inputs include direct precipitation, surface water inflows, and groundwater discharge. Outflows can occur as surface water, direct evaporation, plant transpiration, or percolation into groundwater aquifers.

The hydrologic regime affects the rates of productivity, nutrient cycling, and species composition. The seasonality, depth, and, duration of inundation influence marsh function and vegetation dynamics and vary widely among different wetland types and within an individual class of wetlands such as marshes. Marsh development along riparian areas is driven by the magnitude and frequency of flooding, valley and substrate type, and beaver activity. Seasonal and episodic flooding scour depressions in the floodplain, create side channels and floodplain sloughs, and force channel migration which can result in oxbows. Marsh vegetation establishes in these landforms if semi-permanent to permanent water is adequate and available. Marshes also develop near the fringes of lakes and ponds where their occurrence is dependent on the gradient of the shoreline and fluctuation of lake or pond levels. Relatively flat or gently sloping shorelines support a much larger marsh system than a steep sloping shoreline. The frequency and magnitude of water level fluctuations determine the extent of each marsh zone (floating, submerged, emergent, etc.).

Management

Climatic conditions and management of surrounding land and water sources will impact marsh water quality, quantity, and plant communities. Impacts of global climate change are altering the amount, form, and seasonality of precipitation that maintain riparian and marsh wetland systems. Localized human management is also a major issue for marshes as they are intimately connected to the uplands in their watersheds therefore draining, ditching and conversion of land for crops or grazing will alter they hydrologic regime. Grazing, logging, post-fire soil erosion, upland development, and mining can introduce excess nutrients, pollutants, and sediments in runoff and degrade marsh integrity. Land disturbance such as heavy grazing, agriculture or change in water regimes may lead to invasion by many non-native species including purple loosestrife (*Lythrum salicaria*), barnyard grass (*Echinochloa crus-galli*), and reed canarygrass (*Phalaris arundinacea*). Pasture grasses such as Kentucky bluegrass (*Poa pratensis*), redtop (*Agrostis gigantea*), and timothy (*Phleum pratense*) as well as exotics species common to other wetland types such as Canada thistle (*Cirsium arvense*) and dandelion (*Taraxacum officinale*) may invade marsh margins. Also, dense stands of native plants such as broad-leaf cattail (*Typha latifolia*) and common reed (*Phragmites australis*) chokes out other native vegetation and makes animal movement impossible causing degradation of habitat and function in marshes. Land managers often implement removal of these monocultures to open up resources and space for plants and animals.

Original Concept Authors: NatureServe Western Ecology Team. 2012.
Colorado Version Authors: Colorado Natural Heritage Program Staff: Dee Malone, Joanna Lemly, Karin Decker, Cat Wiechmann
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Rocky Mountain Alpine-Montane Wet Meadow

General Description

Wet meadows in the Southern Rocky Mountains are herbaceous wetlands with mineral soils and a fluctuating water table. These wetlands are found throughout both the Rocky Mountain and Intermountain regions, occurring at elevations from the montane to the alpine (2,130–3,960 m or 7,000–13,000 ft). Wet meadows occupy wet sites with low-velocity surface and subsurface flows, typically on flat areas or gentle slopes, but they also may be found on sub-irrigated sites with slopes up to 10%. In montane and subalpine valleys, these wetlands occur as large open meadows, at the base of toeslope seeps, and as narrow strips bordering ponds, lakes, and streams. In the alpine, these wetlands typically occupy small depressions located below late-melting snow patches or snowbeds. Dwarf shrublands, typically dominated by willow (*Salix* spp.), often occur adjacent to or ring these alpine depressional wetlands, reflecting a change in the snowmelt regime. Wet meadow soil are mineral, but may have a top layer of organic matter known as a histic epipedon. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, and may be found adjacent to a variety of shrub communities. Wet meadows are often dominated by graminoids, although forb cover may be substantial in areas at higher elevations.

Characteristic species at the highest elevations include mountain sedge (*Carex scopulorum*), sheep sedge (*C. illota*), hair-like sedge (*C. capillaris*), black alpine sedge (*C. nigricans*), Drummond's rush (*Juncus drummondii*), marsh marigold (*Caltha leptosepala*), and brook saxifrage (*Saxifraga odontoloma*). At subalpine to upper montane elevations, water sedge (*Carex aquatilis*), and beaked sedge (*C. utriculata*), either separately or in combination, form a broadly distributed characteristic community. Other common species of this zone include smallwing sedge (*C. microptera*), analogue sedge (*C. simulata*), tufted hairgrass (*Deschampsia cespitosa*), fewflower spikerush (*Eleocharis quinqueflora*), bluejoint reedgrass (*Calamagrostis canadensis*), heartleaf bittercress (*Cardamine cordifolia*), tall fringed bluebells (*Mertensia ciliata*), arrowleaf ragwort (*Senecio triangularis*), elephanthead lousewort (*Pedicularis groenlandica*), and large leaf avens (*Geum macrophyllum*). At mid to lower montane elevations, clustered field sedge (*Carex praegracilis*), Nebraska sedge (*C. nebrascensis*), woolly sedge (*C. pellita*), common spikerush (*Eleocharis palustris*), and mountain rush (*Juncus balticus* var. *montanus*) are typical dominants.

Diagnostic Characteristics

Hydrologic regime is a key factor defining wet meadows and distinguishing them from other wetland types. Wet meadows occur were the soil is seasonally saturated and may be seasonally flooded, but high water tables do not persist throughout the growing season. Water tables are typically high early in the growing season and draw down by the end of the season. Thus wet meadows lack the perennially high water tables and organic soils found in fens and the large seasonal and inter-annual water table fluctuations characteristic of marshes. Wet meadows can be found in riparian corridors and on floodplains and may be hydrologically connected to the stream. However, they lack the influence of high velocity surface flows, scouring, and sediment deposition that characterizes the active riparian zone.

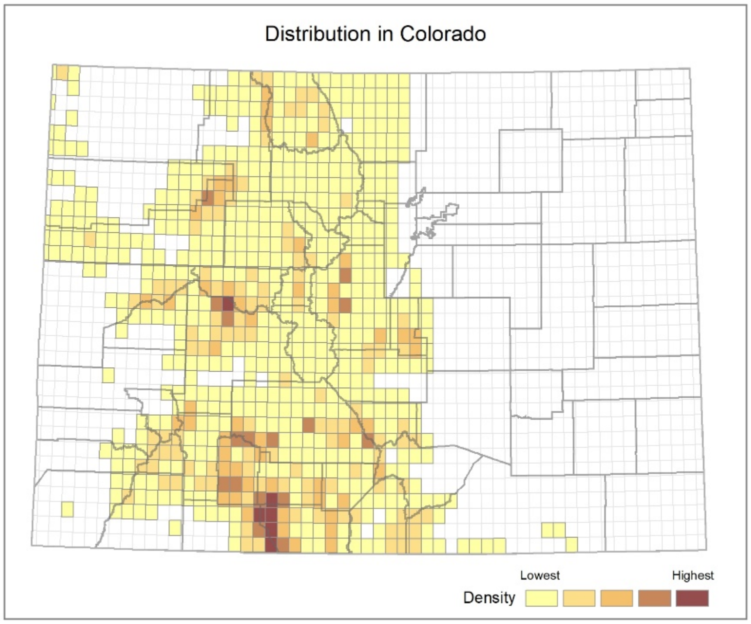
Similar Systems

<u>Rocky Mountain Subalpine-Montane Fen</u>: Unlike fens, wet meadows have a fluctuating water table that may drop to a meter or more below the surface in July and August, thereby allowing aeration and preventing the accumulation of peat. Fens, with the exception of dry years, are characterized by a summer water table that remains within 20-40 cm of the soil surface which enables the development of deep (greater than 40 cm) accumulations of peat.

<u>Western North American Emergent Marsh</u>: Wet meadows are distinguished from marshes based on the duration of saturation and/or flooding with wet meadows on the drier end of this gradient. Compared to marshes, wet meadows have stable water tables and do not experience deep inundation.

Range

Rocky Mountain Alpine-Montane Wet Meadow systems occur throughout the Rocky Mountains and Intermountain West regions, ranging in elevation from montane to alpine (1000-3600 m).



Spatial Pattern

Rocky Mountain Alpine-Montane Wet Meadow is a small patch system.

Environment

In Colorado, wet meadow systems are largely confined to the Southern Rocky Mountain and Intermountain regions, landscapes of generally high topographic relief shaped by glaciation, moving water, and mass wasting. These processes have strongly influenced the geomorphology of the landscape, providing the settings for wet meadow development. Sites occupied by wet meadows include large open meadows in high montane valleys; small openings in subalpine willow carrs or coniferous forests; saturated soils near lakes, low-order streams, and backwater areas of larger rivers; in and near running water of headwater streams, seeps, and springs; as narrow strips bordering ponds and streams at lower elevations; and small depressions located below late-melting alpine snow patches or snowbeds.

Wet meadow systems span a wide elevational range (7,000-13,000 feet) and occur in a wide variety of geomorphic settings, but always occupy wetter sites with very low-velocity surface and subsurface flows. Wet meadows have seasonally saturated conditions and most are supported, in part, by groundwater. Thus wet meadows are found in landscape settings where groundwater levels are near the soil surface. Water sources for wet meadows include surface water, groundwater, and direct precipitation, with the relative importance of each varying among individual wetlands. Generally, direct precipitation is the least important hydrologic input while groundwater is the most important contributor. The Rocky Mountain climate is continental and semi-arid with warm, with dry summers and cold winters. Average annual temperature ranges from 25o to 60o F, while average precipitation ranges from approximately 20 inches in the montane zone to 60 inches at higher elevations. Most precipitation occurs as snowfall during the winter months. The interaction of climate and geomorphology has a strong influence on local hydrological processes in wetlands. Snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics. Wet meadows are closely associated with snowmelt, which maintains a high water table, and are typically not subjected to high disturbance events such as flooding. In alpine tundra wet meadows, snowdepth and timing of melt are the most important determinants of vegetation patterns. Alternatively montane wet meadows may be seasonally flooded by overbank flooding or beaver activity.

Salinity and alkalinity are generally low due to the frequent flushing of moisture through meadows. Soils typically possess a high proportion of organic matter, but this may vary considerably depending on the frequency and magnitude of alluvial deposition and water table depth. Organic composition of the soil often includes a thin layer near the soil surface. Because high water tables do not persist throughout the growing season, organic matter accumulation in wet meadows is always less than 40 cm. Anaerobic conditions lead to the formation of hydric soils which may exhibit gleying and/or mottling and oxidized root channels. These features can be used to delineate wet meadows from dry meadows.

Vegetation

Wet meadows are characterized by herbaceous communities. They are often dominated by graminoids, although forb cover may be substantial, especially at higher elevations. Wet meadow can occur as part of riparian mosaics, interspersed with shrublands, or as large shrubless meadows. Plant communities in wetland meadow systems are adapted to soils that may be flooded or saturated throughout the growing season. They may also occur on areas with soils that are only saturated early in the growing season, or intermittently.

Because wet meadows occupy wide range of elevational and environmental gradients, plant communites and species composition is highly variable. While some communites and species are confined to the alpine, others are found only at montane elevations, and still others span the entire elevational range. Characteristic species in the alpine and upper subalpine include mountain sedge (*Carex scopulorum*), sheep sedge (*C. illota*), hair-like sedge (*C. capillaris*), black alpine sedge (*C. nigricans*), Drummond's rush (*Juncus drummondii*), marsh marigold (*Caltha leptosepala*),brook saxifrage (*Saxifraga odontoloma*), Parry's clover (*Trifolium parryi*) and icegrass (*Phippsia algida*). At subalpine to upper montane elevations, water sedge (*Carex aquatilis*), and beaked sedge (*C. utriculata*), either separately or in combination, form a broadly distributed characteristic community. Other common species of this zone include smallwing sedge (*C. microptera*), analogue sedge (*C. simulata*), tufted hairgrass (*Deschampsia cespitosa*), fewflower spikerush (*Eleocharis quinqueflora*), and bluejoint reedgrass (*Calamagrostis canadensis*). Combinations of heartleaf bittercress (*Cardamine cordifolia*), tall fringed bluebells (*Mertensia cilliata*), and/or arrowleaf ragwort (*Senecio triangularis*) form a common forb assosciation. Other characteristic forbs include elephanthead lousewort (*Pedicularis groenlandica*), American globe-flower (*Trollius laxus*), American speedwell (*Veronica americana*), fringed grasss of Parnassus (*Parnassia fimbriata*), American bistort (*Polygonum bistortoides*) and large leaf avens (*Geum macrophyllum*). Typical dominants at mid to lower montane elevations include clustered field sedge (*Carex praegracilis*), Nebraska sedge (*C. nebrascensis*), woolly sedge (*C. pellita*), common spikerush (*Eleocharis palustris*), mountain rush (*Juncus balticus var. montanus*). Low growing shrubby cinquefoil (*Dasiphora fruticosa* ssp. *floribunda* or *Pentaphylloides floribunda*) is one shrub that can represent significant cover within wet meadows.

Plant Associations

CEGL002653	Betula glandulosa / Mesic Forbs - Mesic Graminoids Wet Shrubland
CEGL001559	Calamagrostis canadensis Western Wet Meadow

CEGL002891	Calamagrostis stricta Wet Meadow
CEGL001954	Caltha leptosepala Wet Meadow
CEGL002662	Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Wet Meadow
CEGL001803	Carex aquatilis - Carex utriculata Wet Meadow
CEGL001802	Carex aquatilis Wet Meadow
CEGL001872	Carex capillaris - Polygonum viviparum Wet Meadow
CEGL001874	Carex duriuscula Grassland
CEGL001876	Carex illota Wet Meadow
CEGL001871	Carex lachenalii Wet Meadow
CEGL001877	Carex microglochin Fen
CEGL001792	Carex microptera Wet Meadow
CEGL002890	Carex nebrascensis Slope Wet Meadow
CEGL001813	Carex nebrascensis Wet Meadow
CEGL001818	Carex nigricans - Juncus drummondii Wet Meadow
CEGL001809	Carex pellita Wet Meadow
CEGL002660	Carex praegracilis Wet Meadow
CEGL001860	Carex pyrenaica Alpine Snowbed
CEGL001769	Carex saxatilis Fen
CEGL001823	Carex scopulorum - Caltha leptosepala Wet Meadow
CEGL001822	Carex scopulorum Wet Meadow
CEGL001825	Carex simulata Fen
CEGL001562	Carex utriculata Wet Meadow
CEGL001868	Carex vernacula Wet Meadow
CEGL002661	Carex vesicaria Wet Meadow
CEGL001107	Dasiphora fruticosa ssp. floribunda / Deschampsia cespitosa Wet Shrubland
CEGL003499	Dasiphora fruticosa ssp. floribunda Subalpine Wet Shrubland
CEGL001105	Dasiphora fruticosa ssp. floribunda Wet Shrubland
CEGL001880	Deschampsia cespitosa - Achillea millefolium var. occidentalis Wet Meadow
CEGL001882	Deschampsia cespitosa - Caltha leptosepala Wet Meadow
CEGL001883	Deschampsia cespitosa - Carex microptera Wet Meadow
CEGL001884	Deschampsia cespitosa - Geum rossii Wet Meadow
CEGL001885	Deschampsia cespitosa - Ligusticum tenuifolium Wet Meadow
CEGL001887	Deschampsia cespitosa - Mertensia ciliata Wet Meadow
CEGL001889	Deschampsia cespitosa - Potentilla diversifolia Wet Meadow
CEGL001599	Deschampsia cespitosa Wet Meadow
CEGL001832	Eleocharis acicularis Marsh
CEGL001833	Eleocharis palustris Marsh
CEGL001836	Eleocharis quinqueflora Fen
CEGL002241	Equisetum laevigatum Wet Meadow
CEGL001967	Geum rossii - Polygonum bistortoides Alpine Turf
CEGL001969	Geum rossii - Sibbaldia procumbens Alpine Snowbed
CEGL001569	Glyceria borealis Wet Meadow

CEGL003429	Glyceria grandis Wet Meadow
CEGL001838	Juncus arcticus ssp. littoralis Wet Meadow
CEGL001905	Juncus drummondii - Carex spp. Alpine Snowbed
CEGL005871	Juncus parryi / Sibbaldia procumbens Alpine Snowbed
CEGL001402	Kalmia microphylla / Carex nigricans Wet Dwarf-shrubland
CEGL002892	Phippsia algida Wet Meadow
CEGL001926	Poa glauca Wet Meadow
CEGL001983	Primula parryi Wet Meadow
CEGL001931	Rhodiola rhodantha Wet Meadow
CEGL002009	Rorippa alpina Wet Meadow
CEGL001985	Saxifraga odontoloma Wet Meadow

Associated Animal Species

Animal species reported for this wetland system include Nokomis Fritillary (*Speyeria Nokomis*), Wood Frog (*Rana sylvatica*),Western chorus frog (*Pseudacris triseriata*), Boreal toad (*Bufo boreas*), Sora (*Porzana Carolina*), Virginia Rail (*Rallus limicola*), common snipe (*Gallinago gallinago*), Northern Harrier (*Circus cyaneus*), Willet (*Catoptrophorus semipalmatus*), meadow vole (*Microtus pennsylvanicus*), western jumping mouse (*Zapus princeps*), masked shrew (*Sorex cinereus*), montane shrew (*S. monticolus*) and water shrew (*S. palustris*).

Dynamic Processes

Hydrologic regime is generally the most important factor influencing vegetation patterns and dynamics in wet meadows. Wet meadow development along riparian areas is driven by the magnitude and frequency of flooding, valley and substrate type, and beaver, while in other areas, development is mostly driven by the presence of a seasonally high water table. Flooding disturbance can alter channel morphology through erosion and deposition of sediment to produce floodplain landforms that can either eliminate or provide the template that influences wet meadow system development. Disturbances from animals can also have significant ecological influence on wet meadows. Livestock grazing can alter competitive interactions between plant species resulting in altered community composition. Beaver activity in broad valleys influences vegetation structure and composition and system hydrology. By impounding surface flows in dams, Beaver create open water habitat that is colonized by herbaceous vegetation. Depending on the duration of saturation and flooding these vegetation types are either marshes or wet meadows.

Non-native species can displace native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food for fauna. Wetland dominated by non-native, invasive species typically support fewer native animals. Wet meadows are susceptible to invasion by many non-native species, especially pasture grasses such as Kentucky bluegrass (*Poa pratensis*) and timothy (*Phleum pratense*) as well as exotics species common to other wetland types such as Canada thistle (*Cirsium arvense*) and dandelion (*Taraxacum officinale*). Reed canary grass (*Phalaris arundinacea*) and giant reed (*Phragmites communis*) are also common exotics in wet meadows. Native increasers such as mountain rush (*Juncus arcticus*), wild iris (*Iris missouriensis*),

silverweed (*Argentea anserina*), and shrubby cinquefoil (*Dasiphora floribunda*) often increase with overgrazing and or changes in the water table.

Management

Threats include hydrologic and vegetation alteration and landscape fragmentation. Anthropogenic activities that result in increased or decreased drainage, vegetation clearing, mining, excessive livestock grazing, and nutrient inputs all may diminish the condition of the wet meadow system. Activities that fragment the landscape, altering the movement of water or organisms through the system, disconnect wet meadows from their surrounding landscape and may change system composition, structure and function. Wet meadows are often highly vulnerable to invasion by nonnative plant species and are hotspots of exotic species richness Additionally, hydrologic or physical site disturbances, such as may occur from overgrazing, may result in an increase in species such as mountain rush (*Juncus balticus* var. *montanus*) and shrubby-cinquefoil (*Dasiphora fruticosa* ssp. *floribunda*). Beaver are important drivers of hydrologic function. Their loss from trapping or habitat degradation can lead to significant changes in hydrology and vegetation.

Global climate change is altering the snowmelt-driven hydrology of both mountain and intermountain basins. Snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics. Climate change is resulting in unprecedented snowpack declines, springtime warming, more precipitation falling now as rain rather than snow and earlier snowmelt. These changes may signal a fundamental shift from precipitation to temperature as the dominant influence on western snowpack. The increasing role of warming on large-scale snowpack variability and trends foreshadows fundamental impacts on streamflow and water supplies across the western United States.

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Colorado Version Authors: Colorado Natural Heritage Program Staff: Dee Malone, Joanna Lemly, Karin Decker
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Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

General Description

This riparian system is found throughout the Rocky Mountain region within a broad elevation range from approximately 1,525 to 2,750 m (5,000 to 9,000 ft). In Colorado, it is primarily found in the western half of the state and along the foothills of the eastern mountain front. Seasonal and episodic flooding is the primary driver of this ecosystem and is essential to maintaining a mosaic of plant associations. Vegetation in this system is characterized by a mosaic of multiple communities that are tree-dominated with a diverse shrub component. Component plant associations vary with elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include box elder (*Acer negundo*), narrowleaf cottonwood (*Populus angustifolia*), plains cottonwood (*P. deltoides* ssp. *monilifera*), Rio Grande cottonwood (*P. deltoides* ssp. *wislizeni*), lanceleaf cottonwood (*P. x acuminata*), balsam poplar (*P. balsamifera*), Douglas-fir (*Pseudotsuga menziesii*), blue spruce (*Picea pungens*), peachleaf willow (*Salix amygdaloides*), or Rocky Mountain juniper (*Juniperus scopulorum*). Dominant shrubs include Rocky Mountain maple (*Acer glabrum*), thinleaf alder (*Alnus incana*), river birch (*Betula occidentalis*), red-osier dogwood (*Cornus sericea*), river hawthorn (*Crataegus rivularis*), stretchberry (*Forestiera pubescens*), chokecherry (*Prunus virginiana*), skunkbush (*Rhus trilobata*), mountain willow (*Salix monticola*), Drummond's willow (*S.

drummondiana), narrowleaf willow (*S. exigua*), dewystem willow (*S. irrorata*), Pacific willow (*S. lucida*), buffaloberry (*Shepherdia argentea*), or snowberry (*Symphoricarpos* spp.). Exotic trees such as Russian olive (*Elaeagnus angustifolia*), crack willow (*Salix fragilis*), and tamarisk (*Tamarix* spp.) are common in some stands.

Diagnostic Characteristics

This riparian ecosystem is differentiated from other riparian systems by elevation, vegetation and hydrology. Hydrology in this system is primarily snowmelt driven with annual and episodic flooding. Vegetation is generally characterized by cottonwood (*Populus* spp.) woodlands, though other tree species can dominate. Common shrub species include willow (*Salix* spp.), thinleaf alder (*Alnus incana*), hawthorn (*Crataegus* spp.), red-osier dogwood (*Cornus sericea*), and river birch (*Betula occidentalis*).

Similar Systems

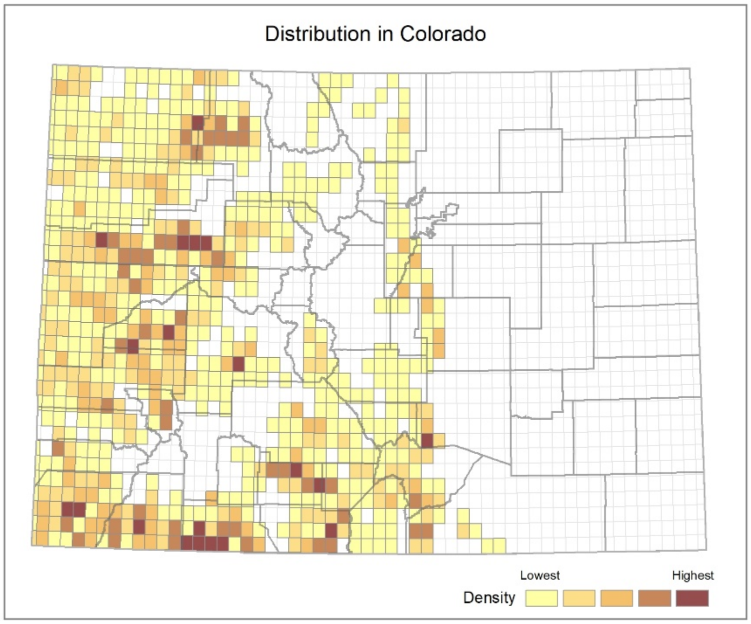
Western Great Plains Riparian: These riparian woodlands and shrublands of the eastern plains share dominant and canopy species, and may occur sequentially with the Lower Montane-Foothill type on those few streams that originate in the mountains but extend for some distance out onto the plains. This system is characteristic of streams that originate on the plains, with hydrology driven primarily by local precipitation and groundwater inflow. Vegetation in this system is characterized by plains cottonwood (*P. deltoides*), balsam popular *(Populus balsamifera*), or willows (*Salix* spp.), or can be dominated by herbaceous species.

Rocky Mountain Subalpine-Montane Riparian Woodlands: These tree-dominated riparian woodlands are characteristic of higher elevations (2,440 to 3,500 m; 8,000 to 11,500 feet), and typically include conifers in the canopy. Common tree species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), Douglas-fir (*Pseudotsuga menziesii*), and quaking aspen (*Populus tremuloides*).

Rocky Mountain Subalpine-Montane Riparian Shrublands: These higher elevation, generally treeless shrublands occur as either a narrow band of shrubs lining streambanks of steep V-shaped canyons *or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms. Shrub cover is typically dominant by willow (*Salix* spp.), alder (*Alnus* spp.), or birch (*Betula* spp.).

Range

This system is found throughout the Rocky Mountain and Colorado Plateau regions from New Mexico and Arizona north to Idaho and the island mountain ranges of central and eastern Montana. In Colorado this system is found primarily in the western half of the state within a broad elevation range from approximately 1,525 to 2,750 m (5,000-9,000 ft). A zone supporting instances of this system is also found along the foothills of the eastern mountain front.



Spatial Pattern

This is a linear system confined to narrow bands that generally parallel the linear and branching configuration of stream channels and lakes.

Environment

Riparian systems are dynamic and in an interdependent state of flux as they are intimately connected with surface or subsurface hydrologic systems and stream ecosystems. This ecological system is a linear continuum that is found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. It may also occur in upland areas of mesic swales and hillslopes below seeps and springs. These communities are also typical of canyon streams, which have generally steeper gradients and coarser soils than plains rivers or streams.

Climate in the range of this system is continental, with historically cold winters and hot summers and an overall semi-arid climate. Depending on elevation, the average annual temperatures vary from approximately 40^{o} to 60^{o} F while average precipitation ranges from approximately 6 to 10 inches at the base of the mountains to 40 inches at higher elevations. Most precipitation occurs as snowfall during the winter months (as much as 80% at high elevations) and thus is the most important source of water for wetlands in the Southern Rocky Mountains, although late-summer convective thunderstorms produce slight peaks in runoff in late summer.

Water for this system can originate as overland flow, shallow subsurface storm flow, direct precipitation, and recharge from local alluvial aquifers. Surface water flow and flooding is a function of snowmelt, watershed and valley topography and area, late-summer rainfall, and the extent of upstream riparian wetlands. Flooding from the stream channel recharges many alluvial aquifers and as stream flow decreases the trend is reversed as the alluvial aquifer begins to recharge stream flow.

Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Highly stratified profiles consist of alternating layers of clay loam and organic material with coarser sand or thin layers of sandy loam over very coarse

alluvium. Soils are fine-textured with organic material over coarser alluvium. Some soils are more developed due to a slightly more stable environment and greater input of organic matter.

Vegetation

This system consists of temporarily, seasonally and intermittently flooded woodlands and shrublands dominated by broad-leaved deciduous species, both in the tree and shrub canopy, as well as occasional conifers. At montane elevations (up to 2,750 m or 9,000 ft), narrowleaf cottonwood (*Populus angustifolia*) is the characteristic tree species and may intermix or give way to conifers such as Douglas-fir (*Pseudotsuga menziesii*) on north facing slopes of canyon floors or to blue spruce (*Picea pungens*) adjacent to streams. At foothill elevations (below 2,130 m or 7,000 ft), tree species such as Rio Grande cottonwood (*Populus deltoides* ssp. *wislizeni)* are typical of the west slope, while plains cottonwood (*P. deltoides* ssp. *monilifera*) occurs on the east slope. Cottonwoods often occur with the shrub coyote willow (*Salix exigua*), common on both slopes. At both montane and foothill elevations, the tall shrubs thinleaf alder (*Alnus incana*), river birch (*Betula occidentalis*), and red-osier dogwood (*Cornus sericea*) are common understory dominants. Although these three species are often found together or alternating along a reach, there is a slight tendency for alder to be more common at higher elevations and dogwood at lower. Other woody species that may be present include skunkbrush (*Rhus trilobata*), rockspirea (*Holodiscus dumosus*), roundleaf snowberry (*Symphoricarpos rotundifolius*), western snowberry (*Symphoricarpos occidentalis*), box elder (*Acer negundo*), golden currant (*Ribes aureum*), buffaloberry (*Shepherdia argentea*), poison ivy (*Toxicodendron radicans*), Wood's rose (*Rosa woodsii*), stretchberry (*Forestiera pubescens*) and a variety of tall willows (*Salix* spp.).

The herbaceous layer is relatively sparse and is typically graminoid dominated. Wet meadow or emergent marsh community types may occur in a mosaic with this system. Associated species may include mountain rush (*Juncus balticus* var. *montanus*), common spikerush (*Eleocharis palustris*), saltgrass (*Distichlis spicata*), wildrye (*Elymus* spp.), horsetail (*Equisetum* spp.), foxtail barley (*Hordeum jubatum*), bulrush (*Schoenoplectus* spp.), scratchgrass (*Muhlenbergia asperifolia*), western wheatgrass (*Pascopyrum smithii*), giant reed (*Phragmites australis*), Canada goldenrod (*Solidago canadensis*), starry false lily of the valley (*Maianthemum stellatum*), sedges (*Carex* spp.), and various non-native graminoids. The understory may contain substantial coverage of bare soil, gravel, cobbles, and boulders.

Plant Associations

CEGL002599	Acer negundo - Celtis laevigata var. reticulata Riparian Woodland
CEGL000627	Acer negundo - Populus angustifolia / Cornus sericea Riparian Forest
CEGL000936	Acer negundo / Betula occidentalis Riparian Woodland
CEGL000625	Acer negundo / Cornus sericea Riparian Forest
CEGL000626	Acer negundo / Equisetum arvense Riparian Forest
CEGL000628	Acer negundo / Prunus virginiana Floodplain Forest
CEGL002797	Acer negundo / Quercus gambelii Riparian Woodland
CEGL002750	Acer negundo / Rhus trilobata Riparian Woodland
CCNHPXXX46	Carex emoryi Herbaceous Vegetation

Wetland & Riparian

CEGL001809	Carex pellita Wet Meadow
CEGL002660	Carex praegracilis Wet Meadow
CEGL001085	Celtis laevigata var. reticulata / Pseudoroegneria spicata Wet Scrub
CEGL002889	Crataegus rivularis Wet Shrubland
CEGL001770	Distichlis spicata Alkaline Wet Meadow
CEGL001833	Eleocharis palustris Marsh
CEGL002760	Equisetum hyemale Wet Meadow
CEGL002241	Equisetum laevigatum Wet Meadow
CEGL001168	Forestiera pubescens Wet Shrubland
CEGL002752	Fraxinus anomala Riparian Woodland
CEGL001838	Juncus arcticus ssp. littoralis Wet Meadow
CEGL000746	Juniperus scopulorum / Cornus sericea Riparian Woodland
CEGL003550	Juniperus scopulorum Woodland
CEGL001481	Leymus cinereus - Distichlis spicata Alkaline Wet Meadow
CEGL001474	Phalaris arundinacea Western Marsh
CEGL001475	Phragmites australis ssp. australis Western Ruderal Wet Meadow
CEGL002638	Pinus ponderosa / Alnus incana Riparian Woodland
CRFDPOAC1A	Populus acuminata Forest
CEGL002640	Populus angustifolia - Juniperus scopulorum Riparian Woodland
CEGL000934	Populus angustifolia - Picea pungens / Alnus incana Riparian Woodland
CEGL000656	Populus angustifolia - Populus deltoides - Salix amygdaloides Riparian Forest
CEGL002641	Populus angustifolia - Pseudotsuga menziesii Riparian Woodland
CEGL002642	Populus angustifolia / Alnus incana Riparian Woodland
CEGL000648	Populus angustifolia / Betula occidentalis Riparian Woodland
CEGL002664	Populus angustifolia / Cornus sericea Riparian Woodland
CEGL002644	Populus angustifolia / Crataegus rivularis Riparian Woodland
CEGL000651	Populus angustifolia / Prunus virginiana Riparian Woodland
CEGL002804	Populus angustifolia / Quercus gambelii Riparian Woodland
CEGL000652	Populus angustifolia / Rhus trilobata Riparian Woodland
CEGL000653	Populus angustifolia / Rosa woodsii Riparian Forest
CEGL002645	Populus angustifolia / Salix (monticola, drummondiana, lucida) Riparian Woodland
CEGL002646	Populus angustifolia / Salix drummondiana - Acer glabrum Riparian Woodland
CEGL000654	Populus angustifolia / Salix exigua Riparian Woodland
CEGL002647	Populus angustifolia / Salix irrorata Riparian Woodland
CEGL000655	Populus angustifolia / Salix ligulifolia - Shepherdia argentea Riparian Woodland
CEGL002648	Populus angustifolia / Symphoricarpos (albus, occidentalis, oreophilus) Riparian Woodland
CEGL002643	Populus angustifolia Sand Dune Riparian Forest
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior) Floodplain Woodland
CEGL000939	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Distichlis spicata Riparian Woodland
CEGL005971	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Forestiera pubescens var. pubescens Flooded Forest
CEGL002685	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua Riparian Woodland
CEGL000660	Populus deltoides / Symphoricarpos occidentalis Floodplain Woodland
CEGL002336	Populus deltoides ssp. wislizeni / Acer negundo Flooded Woodland

CEGL003810	Populus deltoides ssp. wislizeni / Disturbed Understory Ruderal Flooded Woodland
CEGL000940	Populus deltoides ssp. wislizeni / Rhus trilobata Riparian Woodland
CEGL000944	Populus fremontii - Salix gooddingii Riparian Woodland
CEGL002639	Pseudotsuga menziesii / Betula occidentalis Riparian Woodland
CEGL000899	Pseudotsuga menziesii / Cornus sericea Riparian Woodland
CEGL001121	Rhus trilobata Moist Wet Shrubland
CEGL000947	Salix amygdaloides Riparian Woodland
CEGL002655	Salix exigua - Salix ligulifolia Wet Shrubland
CEGL001204	Salix exigua - Salix lucida ssp. caudata Wet Shrubland
CEGL005656	Salix exigua / Gravel Bar Wet Shrubland
CEGL001202	Salix exigua / Mesic Forbs Wet Shrubland
CEGL001203	Salix exigua / Mesic Graminoids Western Wet Shrubland
CEGL001197	Salix exigua Riparian Wet Shrubland
CEGL001218	Salix ligulifolia Wet Shrubland
CEGL001215	Salix lucida ssp. caudata Wet Shrubland
CEGL001128	Shepherdia argentea Wet Shrubland
CEGL001588	Spartina gracilis Wet Meadow
CEGL001476	Spartina pectinata Western Wet Meadow

Associated Animal Species

Lower elevation riparian woodlands and shrublands in this system have some of the richest avian species component of any of Colorado's habitats. Characteristic bird species here include American Kestrel (*Falco sparverius*), Western Screech Owl (*Megascops kennicottii*), Great Horned Owl (*Bubo virginianus*), Mourning Dove (*Zenaida macroura*), Northern Flicker (*Colaptes auratus*), Western Wood-Pewee (*Contopus sordidulus*), Western Kingbird (*Tyrannus verticalis*), Eastern Kingbird (*Tyrannus tyrannus*), House Wren (*Troglodytes aedon*), Black-billed Magpie (*Pica hudsonia*), American Robin (*Turdus migratorius*), Blue Grosbeak (*Passerina caerulea*), and Bullock's Oriole (*Icterus bullockii*). Characteristic species in foothills and lower montane riparian deciduous systems include Yellow Warbler (*Setophaga petechia*), Warbling Vireo (*Vireo gilvus*), Song sparrow (*Melospiza melodia*), and Broad-tailed Hummingbird (*Selasphorus platycercus*). In riparian coniferous communities in these elevations, commonly detected bird species include Cordilleran Flycatcher (*Empidonax occidentalis*), Ruby-crowned Kinglet (*Regulus calendula*), Golden-crowned Kinglet (*Regulus satrapa*), Swainson's Thrush (*Catharus ustulatus*), Mountain Chickadee (*Poecile gambeli*), Yellow-rumped Warbler (*Setophaga coronata*), and Western Tanager (*Piranga ludoviciana*). Birds identified as high priority species include Lewis's Woodpecker (*Melanerpes lewis*), Lazuli Bunting (*Passerina amoena*), and Western Kingbird (*Tyrannus verticalis*). The federally listed as threatened Preble's meadow jumping mouse (*Zapus hudonius preblei*) is found exclusively in foothill riparian areas of the eastern mountain front. Smooth green snake (*Opheodrys vernalis*), boreal chorus frog (*Pseudacris maculata*), and barred tiger salamander (*Ambystoma mavortium*) may also be found in this habitat.

Dynamic Processes

Vegetation in this riparian ecosystem is distinct from uplands because of the greater availability of water in an otherwise water-limited landscape. In a natural condition, this system often occurs as a

mosaic of multiple, tree-dominated communities with a diverse shrub component and a complete range of age-classes. Key variables driving vegetation dynamics in riparian sites include base and mean flow levels, the magnitude, seasonality, and frequency of peak flows, and the relative influence of groundwater. Episodic flood events and channel migration cause pulses of woody species establishment creating patches of different age classes. In areas where the water table drops below the stream channel, species composition is characterized by deep rooted phreatophytes like cottonwoods or upland species tolerant of low soil moisture.

Riparian ecosystems are, in general, maintained by an active natural disturbance regime of which floods are the most important disturbance type. Natural stream flow regimes in Rocky Mountain riparian systems are distinctive, with a strong annual peak discharge in spring driven by snowmelt and periodic large floods or debris flows from storm events that have the potential to move tremendous amounts of sediment. These interactions between hydrologic and geomorphic processes result in overbank flows, deposition, and lateral migration, creating a mosaic of landforms such as channels, floodplains, point bars and in-channel islands, which drive the spatial pattern and successional development of riparian vegetation. Riparian woodlands and shrublands thus grow within a continually changing, dynamic alluvial environment due to the ebb and flow of the river, and riparian vegetation is constantly being "re-set" by flooding disturbance.

Riparian zones respond to the process of flooding disturbance and sediment deposition by establishing successional stages of plant growth on the newly deposited sand and gravel bars. Thus these riparian ecological systems, as exemplified by cottonwood communities, contain early-, mid- and late-seral riparian plant associations as well as non-obligate riparian species. Cottonwood (*Populus* spp.) often forms extensive woodlands along streambanks of this system. Regeneration is dependent on flooding disturbance that occurs with appropriate timing and frequency and with sufficient magnitude and duration to deposit wet, bare alluvium in full sun to enable germination and establishment. Thus mature cottonwood occurrences do not regenerate in place, but by "moving" up and down a river reach with the meandering stream. Over time a healthy riparian area supports all seral stages of cottonwood communities.

Management

Primary threats to this system include hydrologic alteration, riparian and upland vegetation alteration and development, and removal of beaver. The primary abiotic ecological process necessary to maintain this ecological system is hydrology and more specifically surface flow. Global climate change is resulting in snowpack declines and earlier snowmelt due to unprecedented springtime warming foreshadowing fundamental impacts on streamflow across the western United States. Regional climate characteristics of particular importance for riparian ecosystems include the amount, form, and seasonality of precipitation, temperature and wind, and the timing of snow-melt. These factors influence stream flow regimes, including flow variability and characteristics such as base, mean, and peak flow volumes, and fluvial geomorphic processes such as sediment erosion and deposition.

Riparian woodlands are dependent on specific, natural hydrologic regimes, soils, as well as the physical space that provides the ability to move both up and down the stream as well as side to side within the floodplain. Development such as roads, that constrain the ability of the stream to migrate, or alteration of the natural flooding regime by development activities such as water impoundments and diversions may produce changes in plant composition and community structure and thus stream and riparian function. For instance, reduced magnitude and frequency of floods has allowed the invasion of invasion of drought tolerant exotics such as tamarisk (*Tamarix* spp.) and flood intolerant species such as rabbitbrush, and hastened the decline of mature cottonwood trees on floodplains.

Riparian ecosystems are functionally connected to upstream and downstream ecosystems and are laterally connected to upland and aquatic ecosystems. Alteration to upland landscapes by urban or agricultural uses often disconnects upland from riparian and aquatic habitat. Alteration of the riparian zone by activities, such as livestock grazing or urbanization, that disturb riparian community structure and/or species composition may destabilize streambanks, resulting in excessive bank erosion and downcutting thereby disconnecting the stream from its floodplain and riparian habitat.

Historically, one of the most important modifiers of stream/riparian ecosystems throughout the Rocky Mountains was the North American beaver. Their current ecological importance derives from the consequences of their extirpation by trapping. Beaver exert a strong influence on both stream and riparian habitat by building dams that slow flood flows, trap sediment, allow water to spread out into adjacent habitat and gradually fill in to create marsh or wet meadow systems. Thus the stepped profiles of beaver-influenced rivers maximize the diversity of riparian and aquatic habitats. The effect of the removal of beaver along rivers is a reduction in habitat diversity and stability as channels incise, snowmelt flood peaks increase, flood-related sediment transport increases and riparian and slow-velocity habitats are lost.

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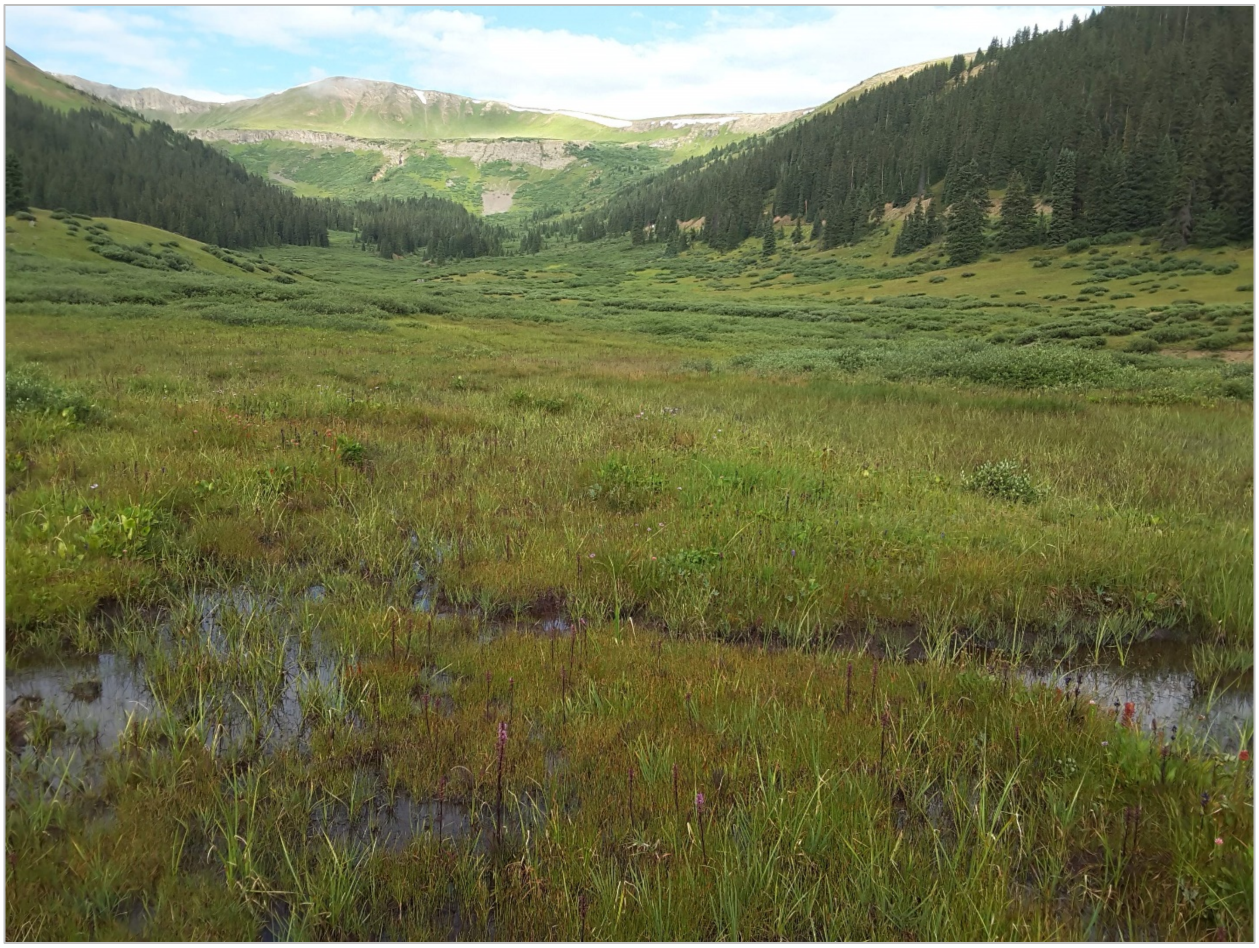
Rocky Mountain Subalpine-Montane Fen



General Description

Rocky Mountain Subalpine-Montane Fens are groundwater-fed, peat-accumulating wetlands with perennially saturated soils. This system is confined to specific environments where groundwater discharge is sufficient to generate peat (organic soil) accumulation of at least 40 cm. Fens form in natural depressions (basin fens) or at the base of slopes where groundwater intercepts the soil surface (slope fens). Fens are often classified by water chemistry and floristic composition into the categories of rich fens, intermediate fens, and poor fens, though Colorado's uncommon iron fens fall outside of the typical classification. Fens often occur as a mosaic of several plant associations and can support numerous rare species and community types. The most common dominants include water sedge (*Carex aquatilis*) and beaked sedge (*C. utriculata*), often accompanied by a diversity of other sedge species (*Carex illota, C. limosa, C. simulata, C. buxbaumii* and others) as well as spikerushes (*Eleocharis* spp.), bog sedges (*Kobresia* spp.), cottongrasses (*Eriophorum* spp.), and rushes (*Juncus* spp.). Common forbs include elephanthead lousewort (*Pedicularis groenlandica*), redpod stonecrop (*Rhodiola rhodantha*), marsh marigold (*Caltha leptosepala*), and felwort (*Swertia perennis*). Sites can contain a woody component dominated by shrubs (*Salix* spp. and *Betula*

glandulosa) or coniferous trees (*Picea engelmannii* or *Pinus contorta*). Bryophyte diversity is generally high and includes brown mosses and sphagnum (*Sphagnum* spp.).

Diagnostic Characteristics

Fens are characterized by at least 40 cm of peat (organic soil) and by perennial saturation maintained primarily by groundwater.

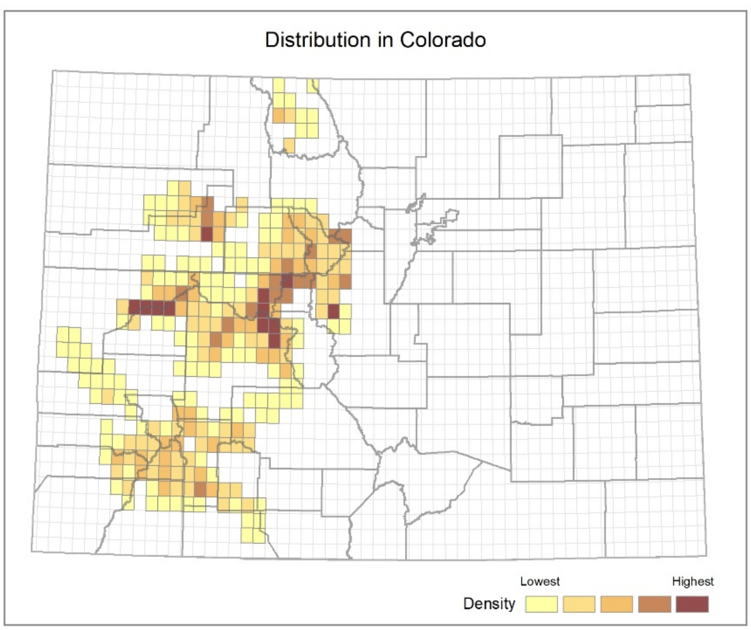
Similar Systems

Rocky Mountain Alpine-Montane Wet Meadow: Wet meadows have a more variable water table, which tends to decline in late-July and August, and lack deep organic soils. Fens have stable water supplies with water tables at or near the surface most of the year and accumulations of peat to greater than 40 cm.

Western North American Emergent Marsh: Marshes lack deep organic soils and, unlike fens or wet meadows, experience deep inundation.

Range

This system occurs infrequently throughout the Rocky Mountains from Colorado north into Canada. The vast majority of Colorado fens are found between 9,000-12,000 ft (2750-3350 m) in the upper montane to subalpine zone. However, small to medium fens can be found at lower elevations, including scattered locations in the plains where springs discharge sufficient groundwater. The map below was generated from several fen mapping projects, mostly on National Forest lands; however, the mapping data are not comprehensive across the state and there are undoubtedly fens in areas not shown on this map.



Spatial Pattern

Colorado fens are a small patch ecological systems.

Environment

Fens are confined to specific environments where groundwater discharge is sufficient to support the development of at least 40 cm of peat (organic soil). In these sites, groundwater inflows create constant the high water levels and perennially saturated soils that enable the development of deep peat soils. The lack of oxygen in saturated soils causes organic matter to accumulate faster than it

can be broken down. Over thousands of years, fens can develop organic layers up to two meters or more in depth.

The interaction of climate and geomorphology has a strong influence on local hydrological processes that shape fens. Generally, fens form either at low points in the landscape (basin fens) or near slopes where groundwater intercepts the soil surface (slope fens). In the high elevation mountains of Colorado, glaciers sculpted much of the landscape, creating wide level mountain valleys, moraines and kettle ponds that are conducive for fen formation. Fens often form in valleys due to large alluvial aquifers and nearby springs supplied by snowmelt from adjacent hillsides. Terminal or lateral moraines often create confined basins where impounded subsurface and/or surface water allows for peat accumulation, whereas kettle ponds create a permanent water body around which fens can form.

Climate influences the snowpack and timing of melt, which contributes a large proportion of water to fen wetlands through its influence on groundwater and surface water dynamics. Colorado's continental climate, with warm dry summers and cold winters, produces an overall semi-arid environment. Colorado's fens are generally restricted to high mountain valleys where cool temperatures, low evapotranspiration rates, and high precipitation create conditions amenable to peat formation. Based on several fen mapping efforts across the state, approximately 90% of Colorado's fens occur between 9,000-12,000 ft (2750-3350 m) elevation. At these high elevations, most precipitation occurs as snowfall during the winter months (as much as 80%). In many fens, snowmelt maintains sufficiently high water tables through June. However, only those areas with soil saturation or a water table within 30 cm of the soil surface through July and August accumulates peat. Late summer precipitation also contributes to fen maintenance by replenishing local aquifers and rising water tables.

Soil and water chemistry are among the most important factors structuring fen ecosystems. Southern Rocky Mountain fens receive much of their nutrients and salts (ions) from surface and groundwater inputs; groundwater picks up nutrients as it percolates through soils and bedrock in the contributing watershed. Thus fens can be classified according to water chemistry along a chemical gradient from poor fens with low pH and ionic concentrations to rich and extreme rich fens with high pH and ionic concentrations. There are three common types of Rocky Mountain fens by water chemistry. Intermediate to rich fens (pH ~5.0-6.5) are generally associated with granitic bedrock and occur throughout Colorado's mountains. Extreme rich fens (pH >~6.5 or 7.0) are found primarily in the open valley of South Park in Park County, Colorado, and are associated with calcareous bedrock. Iron fens (pH as low as 3.0) are found in the San Juan Mountains in southwestern Colorado associated with geologic sources of acid produced from water passing through highly mineralized outcrops of iron pyrite, which oxidizes to form sulfuric acid. Iron fens are outside the typical water chemistry classification becasue they have both low pH, but very high ionic concentrations.

Vegetation

Fen vegetation is quite diverse, both within and between fens. Species composition across fens is influenced by water chemistry (described in the preceding section), landscape position, and elevation. Within individual fens, vegetation often occurs as a mosaic of several plant associations, influenced by slope and water table depth.

Intermediate to rich fens are often dominated by graminoids, especially clonal sedges such as water sedge (*Carex aquatilis*) and beaked sedge (*C. utriculata*), although a wide variety of other sedges also may occur such as woollyfruit sedge (*C. lasiocarpa*), Buxbaum's sedge (*C. buxbaumii*) and small-winged sedge (*C. simulata*). Forbs are often present, but not dominant. Common forb species include include elephanthead lousewort (*Pedicularis groenlandica*), marsh marigold (*Caltha leptosepala*), large leaf avens (*Geum macrophyllum*), American speedwell (*Veronica americana*), fringed grass of Parnassus (*Parnassia fimbriata*), and alpine meadow-rue (*Thalictrum alpinum).* Low stature shrubs such as bog birch (*Betula glandulosa*), planeleaf (*Salix planifolia*) and Wolf willow (*S. wolfii*) are also commonly found in these fens. Mosses are an integral floristic as well as functional component to fens. Mosses provide a critical role in the accumulation of peat, formation of hummocks, and nutrient cycling. Most fens in the Southern Rocky Mountains are dominated by brown mosses, including *Aulacomnium palustre, Tomentypnum nitens,* and *Drepanocladus* spp. Sphagnum mosses (*Sphagnum* spp.) are not as common as brown mosses in intermediate and rich fens; however *Sphagnum* is an important and conspicuous component of iron fens

The extreme rich fens found in Park County, Colorado, are dominated by simple bog sedge (*Kobresia simpliciuscula*), Bellardi's bog sedge (*Kobresia myosuroides*), few-flowered spikerush, and arrowgrass (*Triglochin* spp.). The unusual water chemistry of extreme rich fens supports many rare plants such as Porter's feathergrass (*Ptilagrostis mongholica* ssp*. porteri*) and pale blue-eyed grass (*Sisyrinchium pallidum*). These fens also support several rare aquatic and semi-aquatic macroinvertebrates including aquatic beetles, a caddisfly (*Ochrotrichia susanae)* known from only one other location in the world and a glass snail (*Physa skinneri*).

Iron fens can support an open tree canopy of Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*), as well as shrubs including bog birch, dwarf blueberry (*Vaccinium cespitosum*), and creeping wintergreen (*Gaultheria humifusa*). Water sedge and bluejoint reedgrass (*Calamagrostis canadensis*) occur over a continuous carpet of mosses mainly dominated by species of Sphagnum. At the Mount Emmons Iron Fen in Gunnison County, CO, two unusual species of dragonfly (*Leucorhinea hudsonica* and *Sematochlora semicircularis*) are associated with the fen.

Basin fens, which have floating mats support rare wetland plants in the Southern Rocky Mountains, such as roundleaf sundew (*Drosera rotundifolia*), bog bean (*Menyanthes trifoliata*), marsh cinquefoil (*Comarum palustre*), and numerous uncommon sedges (*Carex buxbaumii*, *C. limosa*, *C. dioica*, etc.). Because these floating mats are often nutrient poor, many species of Sphagnum also occur in these areas.

Plant Associations

CEGL002899	Betula glandulosa / Sphagnum spp. Shrub Fen
CEGL002898	Carex aquatilis - Sphagnum spp. Fen
CEGL001802	Carex aquatilis Wet Meadow
CEGL001806	Carex buxbaumii Fen
CEGL002549	Carex diandra Wet Meadow Fen
CEGL001810	Carex lasiocarpa Fen
CEGL001811	Carex limosa Fen
CEGL001877	Carex microglochin Fen
CEGL001769	Carex saxatilis Fen
CEGL001825	Carex simulata Fen
CEGL001562	Carex utriculata Wet Meadow
CEGL001836	Eleocharis quinqueflora Fen
CEGL002900	Kobresia myosuroides - Thalictrum alpinum Fen
CEGL002901	Kobresia simpliciuscula - Trichophorum pumilum Fen
CEGL002665	Salix planifolia / Caltha leptosepala Wet Shrubland
CEGL001227	Salix planifolia / Carex aquatilis Wet Shrubland
CEGL001234	Salix wolfii / Carex aquatilis Wet Shrubland

Associated Animal Species

Fens provide critical habitat for amphibians and invertebrates. Subalpine fens in central Colorado are known to support the rare Rocky Mountain populations of the boreal toad (*Anaxyrus boreas boreas).* Extreme rich fens of Park County support several rare aquatic and semi-aquatic macroinvertebrates including aquatic beetles, a caddisfly (*Ochrotrichia susanae)* known from only one other location in the world and a glass snail (*Physa skinneri*).

Dynamic Processes

Fens form where the rate of plant growth exceeds the rate of litter decomposition. Thus, in the semi-arid Southern Rocky Mountains fens develop where saturated soils and cool temperatures slow decomposition, resulting in the accumulation of peat. Most Colorado fens began to develop following the last retreat of the glaciers, approximately 10,000 years ago. Colorado fens develop successionally, generally through lake-filling or by flow-through succession. Lake filling can create basin fens, which are found in confined basins that have often been created by the impoundment of subsurface (upwelling groundwater) and/or surface flow by terminal or lateral moraines or in wide, glacially carved valleys where there is typically no inlet or outlet. These fens are often characterized by the presence of floating mats and a ring of willow carr vegetation on the outer margin of the peatland. Flow-through succession creates slope fens which develop where a constant a constant inflow and outflow of water occurs along streams, slopes, benches and valley bottoms. Slope fens occur where groundwater discharges due to a beak in topography or a change in geology, or in valley bottoms where alluvial groundwater supports peat formation. In the Southern Rocky Mountains, fens generally do not succeed to upland forests but rather maintain a peatland climax due to dynamic processes associated with the oxidation and accumulation of peat in relation to fluctuating climatic conditions.

Management

Because groundwater provides the main water source for fens and fens are very sensitive to changes in groundwater supply. Fens are altered by on-site or off-site impacts. On-site impacts include filling, hydrologic alteration such as by drainage ditches that dewaters a fen, snow compaction such as occurs by ski runs or snowmobiles, trampling such as may occur by livestock or humans, and mining. Off-site impacts include upland habitat development that indirectly alters fen condition by altering hydrology, sediment and water chemistry inputs such as may occur with ski area development or logging; and direct hydrologic alteration that may occur with development activities such as water diversions and groundwater pumping. In Colorado, global climate change is resulting in increased temperatures, which is driving declines in the spring snowpack, earlier snowmelt and increased fraction of winter precipitation falling as rain. The sensitivity of fens to environmental change likely varies, with individual responses depending on both peatland type and the relative stability of hydrological conditions supporting peat accumulation.

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Rocky Mountain Subalpine-Montane Riparian Shrubland

General Description

Rocky Mountain Subalpine-Montane Riparian Shrublands are found throughout the Rocky Mountain cordillera from New Mexico north into Montana and the Canadian Rockies. In Colorado, these shrublands are found at montane to subalpine elevations from 2,280 to 3,410 m (7,500 to 11,200 ft). This riparian system is a seasonally flooded shrubland that occurs in a variety of geomorphic settings and with variable community structure, often forming a mosaic of shrub- and herb-dominated vegetation types. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Beaver activity is often associated with the development of these shrubland systems and can profoundly change vegetation structure and alter hydrologic regimes. Vegetation includes short to tall willow, or occasionally birch, alder, or other shrub dominated communities. Above treeline and at subalpine elevations the riparian shrublands typically occupy snowmelt-fed basins, wide glacial valleys and swales, low floodplains adjacent to streams or wet floodplains associated with beaver ponds. These subalpine communities are characterized by low-stature shrublands dominated by planeleaf willow (*S. planifolia)*, barrenground willow (*S. brachycarpa)*, and wolf willow (*S. wolfii*), or occasionally dwarf birch (*Betula nana*). With the transition to lower elevations, taller willows including Geyer willow (*S.*

geyeriana), mountain willow (*S. monticola)*, Booth's willow (*S. boothii)*, Drummond willow (*S. drummondiana)*, or other non-willow shrubs such as thinleaf alder (*Alnus incana)*, river birch (*B. occidentalis)*, and red-osier dogwood (*Cornus sericea)*, dominate. Throughout the range of elevations the herbaceous layer may be graminoid or forb dominated, and include many of the species that are also common in adjacent riparian forests and woodlands.

Diagnostic Characteristics

These riparian shrublands support vegetation with a canopy dominated by shrubs with sparse or no tree cover, lying generally adjacent to ephemeral, intermittent or perennial stream channels. Plant communities often form a mosaic of shrub- and herb-dominated vegetation types with species such as thinleaf alder (*Alnus incana)*, dwarf birch (*Betula nana)*, river birch (*B. occidentalis)*, red-osier dogwood (*Cornus sericea)*, and a number of different willows, including Bebb's willow (*S. bebbiana)*, Booth's willow (*S. boothii)*, barrenground willow (*S. brachycarpa)*, Drummond willow (*S. drummondiana)*, Geyer willow (*S. geyeriana)*, mountain willow (*S. monticola)*, planeleaf willow (*S. planifolia)*, and wolf willow (*S. wolfii)*.

Similar Systems

<u>Rocky Mountain Subalpine-Montane Riparian Woodlands</u>: These woodlands are characterized by a tree-dominated canopy that may include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), or quaking aspen (*Populus tremuloides*). Tall shrub species are also frequent community members. These woodlands are generally found as a narrow streamside forest at elevations similar to the Subalpine-Montane Riparian Shrubland.

<u>Rocky Mountain Subalpine-Montane Fen</u>: Fen systems, like riparian shrublands, can be dominated by willow (*Salix* spp.) and non-willow shrubs, but unlike riparian systems, fens have perennially high water tables and deep, organic, peat soils.

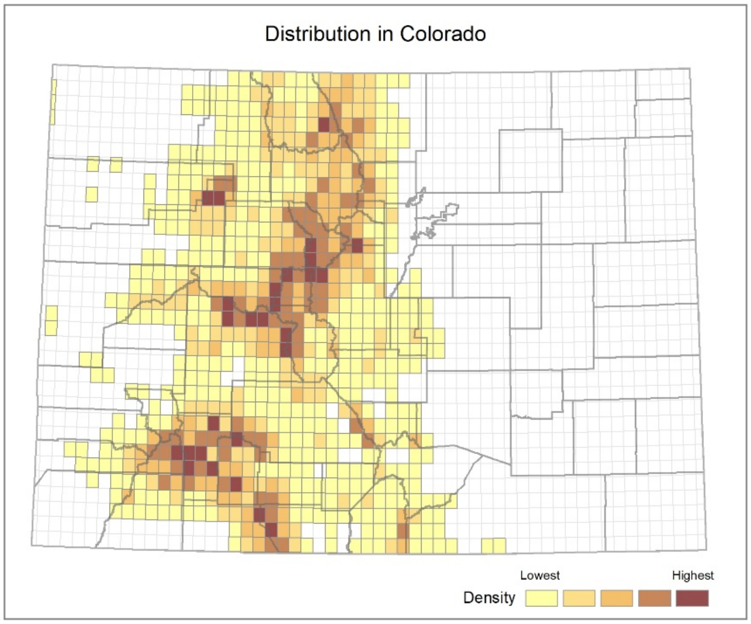
<u>Rocky Mountain Alpine-Montane Wet Meadow</u>: Wet meadows occur were the soil is seasonally saturated and can be found in riparian corridors and on floodplains and may be hydrologically connected to the stream. However, wet meadows lack the influence of high velocity surface flows, scouring, and sediment deposition that characterizes the active riparian zone occupied by riparian shrublands.

Range

This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana and the Canadian Rockies of Alberta and British Columbia, and also occurs in mountainous areas of the Intermountain West and Colorado Plateau. In Colorado, occurrences are found throughout the central mountainous portion of the state.

Spatial Pattern

Rocky Mountain Subalpine-Montane Riparian Shrublands are linear systems.



Environment

In Colorado, Rocky Mountain Subalpine-Montane Riparian Shrublands are found at montane to subalpine elevations between 2,280 to 3,410 meters (7,500 to 11,200 feet). This system can occur as narrow to wide bands of shrub vegetation lining streambanks and alluvial terraces, or as extensive carrs (willow shrublands) of valley bottoms and slopes and typically as a mosaic of shrubland and herbaceous communities. Most precipitation occurs as snowfall (as much as 80% at high elevations) during the winter months. Snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics. In mountain valleys snowmelt and geomorphology are major factors controlling the extent, depth, and duration of saturation resulting from high groundwater levels and also exert controls on most aspects of the frequency, timing, duration, and depth of flooding along riparian areas.

Flooding in subalpine-montane streams occurs annually in May and June with the volume and duration affected by snowpack levels. Periodic flooding contributes nutrients to riparian areas as it deposits organic material and fine-sediment. Contribution to streamflow also comes from upstream wetlands which make an important input to streamflow during later-summer and periods of drought. Runoff from adjacent hillsides also contribute to the hydrological regime of riparian shrublands by recharging local alluvial aquifers and supporting wetland vegetation that is otherwise disconnected from stream flow.

Alluvial soils within riparian shrublands are of variable thickness and texture and often exhibit redoximorphic features such as mottling and gleying, indicating a fluctuating water table. Organic matter is also of variable thickness and the depth and degree of decomposition varies according to the stability of the water table, quality of detritus, and soil temperatures. However, shrub wetlands with 40 cm or greater organic matter accumulations are indicative of permanent saturation from groundwater input and not fluvial processes and should be classified as Rocky Mountain Subalpine-Montane Fens.

Vegetation

The Rocky Mountain Subalpine-Montane Shrubland system includes short to tall willow and non-willow shrub-dominated communities. These shrublands frequently occur as a mosaic of shrublands and herbaceous meadows. Dominant shrub species vary along elevational, soil,

hydrologic and topographic gradients. Above treeline and at subalpine elevations, short willow shrublands occupy snowmelt-fed basins, wide glacial valleys and swales, low floodplains adjacent to streams or wet floodplains associated with beaver ponds. Shrub species include planeleaf willow (*Salix planifolia*), barrenground willow (*Salix brachycarpa*), Wolf's willow (*Salix wolfii*), and bog birch (*Betula nana).* With the transition to lower, montane zone elevations, medium to tall willows and other non-willow deciduous shrubs become dominant. Drummond willow (*Salix drummondiana*) is found at low subalpine to upper montane elevations, while Geyer's willow (*Salix geyeriana*) and mountain willow (*Salix monticola*) dominate a broad variety of associations ranging from the mid subalpine to lower montane zones. In the lower montane, non-willow tall shrubs such as thinleaf alder (*Alnus tenuifolia*), water birch (*Betula occidentalis*), red-osier dogwood (*Cornus sericea*), and tall-willow species including Bebb willow (*Salix bebbiana*), strapleaf willow (*S. liguifolia*), and shining willow (*S. lucida*) may dominate associations within this system. Occasional scattered trees may occur.

The herbaceous layer may be graminoid or forb dominated. Common graminoids include water sedge (*Carex aquatilis*), beaked sedge (*C. utriculata*), smallwing sedge (*C. microptera*), woolly sedge (*C. pellita*), fowl mannagrass (*Glyceria striata*), bluejoint reedgrass (*Calamagrostis canadensis*), smallflowered woodrush (*Luzula parviflora*), mountain rush (*Juncus balticus* var. *montanus*), slimstem reedgrass (*Calamagrostis stricta*), tufted hairgrass (*Deschampsia cespitosa*), American mannagrass (*Glyceria grandis*), and rough bentgrass (*Agrostis scabra*). Common forbs include Jacob's ladder (*Polemonium* sp.), tall fringed bluebells (*Mertensia ciliata*), willowherb (*Epilobium* sp.), common cowparsnip (*Heracleum maximum*), starry false lily of the valley (*Maianthemum stellatum*), bluntseed sweetroot (*Osmorhiza depauperata*), angelica (*Angelica* spp.), monkshood (*Aconitum columbianum*), Parry's clover (*Trifolium parryi*), American bistort (*Polygonum bistortoides*), alpine bistort (*P. viviparum*), heartleaf bittercress (*Cardamine cordifolia*), Fendler's meadow-rue (*Thalictrum fendleri*), marsh marigold (*Caltha leptosepala*), elephanthead lousewort (*Pedicularis groenlandica*), Rocky Mountain hemlock parsley (*Conioselinum scopulorum*), Porter's licorice root (*Ligusticum porteri*), alpine meadow-rue (*Thalictrum alpinum*), common yarrow (*Achillea millefolium*), American vetch (*Vicia americana*), Richardson's geranium (*Geranium richardsonii*), arrowleaf ragwort (*Senecio triangularis*), Fendler's cowbane (*Oxypolis fendleri*), Virginia strawberry (*Fragaria virginiana*), largeleaf avens (*Geum macrophyllum*), Fendler's waterleaf (*Hydrophyllum fendleri*), brook saxifrage (*Saxifraga odontoloma*), subalpine larkspur (*Delphinium barbeyi*), bedstraw (*Galium* spp.), field horsetail (*Equisetum arvense*), scouringrush horsetail (*Equisetum hyemale*), and felwort (*Swertia perennis*).

Plant Associations

CEGL002651	Alnus incana - Salix (monticola, lucida, ligulifolia) Wet Shrubland
CEGL002652	Alnus incana - Salix drummondiana Wet Shrubland
CEGL001143	Alnus incana / Calamagrostis canadensis Wet Shrubland
CEGL001145	Alnus incana / Cornus sericea Wet Shrubland
CEGL001146	Alnus incana / Equisetum arvense Wet Shrubland
CEGL001147	Alnus incana / Mesic Forbs Wet Shrubland
CEGL001148	Alnus incana / Mesic Graminoids Wet Shrubland

WETLAND & RIPARIAN

CEGL002653	Betula glandulosa / Mesic Forbs - Mesic Graminoids Wet Shrubland
CEGL005828	Betula glandulosa / Salix brachycarpa Wet Shrubland
CEGL001161	Betula occidentalis / Cornus sericea Wet Shrubland
CEGL001162	Betula occidentalis / Maianthemum stellatum Wet Shrubland
CEGL002654	Betula occidentalis / Mesic Graminoids Wet Shrubland
CEGL001080	Betula occidentalis Wet Shrubland
CEGL001167	Cornus sericea / Heracleum maximum Wet Shrubland
CEGL001165	Cornus sericea Rocky Mountain Wet Shrubland
CEGL002903	Corylus cornuta Wet Shrubland
CEGL001107	Dasiphora fruticosa ssp. floribunda / Deschampsia cespitosa Wet Shrubland
CEGL002752	Fraxinus anomala Riparian Woodland
CRFAPOBA0A	Populus balsamifera Woodland
CEGL001176	Salix (boothii, geyeriana) / Carex aquatilis Wet Shrubland
CEGL001174	Salix bebbiana / Mesic Graminoids Wet Shrubland
CEGL001173	Salix bebbiana Wet Shrubland
CEGL001184	Salix boothii - Salix geyeriana Wet Shrubland
CEGL001175	Salix boothii / Calamagrostis canadensis Wet Shrubland
CEGL001178	Salix boothii / Carex utriculata Wet Shrubland
CEGL002904	Salix boothii / Deschampsia cespitosa - Geum rossii Wet Shrubland
CEGL001180	Salix boothii / Mesic Forbs Wet Shrubland
CEGL001181	Salix boothii / Mesic Graminoids Wet Shrubland
CEGL001244	Salix brachycarpa / Carex aquatilis Wet Shrubland
CRSBSAGL0A	Salix brachycarpa / Deschampsia caespitosa - Geum rossii Shrubland
CEGL001135	Salix brachycarpa / Mesic Forbs Wet Shrubland
CEGL002667	Salix drummondiana / Calamagrostis canadensis Wet Shrubland
CEGL002631	Salix drummondiana / Carex utriculata Wet Shrubland
CEGL001192	Salix drummondiana / Mesic Forbs Wet Shrubland
CEGL001247	Salix geyeriana - Salix monticola / Calamagrostis canadensis Wet Shrubland
CEGL001223	Salix geyeriana - Salix monticola / Mesic Forbs Wet Shrubland
CEGL001205	Salix geyeriana / Calamagrostis canadensis Wet Shrubland
CEGL001206	Salix geyeriana / Carex aquatilis Wet Shrubland
CEGL001207	Salix geyeriana / Carex utriculata Wet Shrubland
CEGL002666	Salix geyeriana / Mesic Forbs Wet Shrubland
CEGL001210	Salix geyeriana / Mesic Graminoids Wet Shrubland
CEGL001137	Salix glauca / Deschampsia cespitosa Wet Shrubland
CEGL001218	Salix ligulifolia Wet Shrubland
CEGL002621	Salix lucida ssp. caudata / Rosa woodsii Wet Shrubland
CEGL001215	Salix lucida ssp. caudata Wet Shrubland
CEGL001221	Salix monticola / Angelica ampla Wet Shrubland
CEGL001222	Salix monticola / Calamagrostis canadensis Wet Shrubland
CEGL002656	Salix monticola / Carex aquatilis Wet Shrubland
CEGL002657	Salix monticola / Carex utriculata Wet Shrubland
CEGL002658	Salix monticola / Mesic Forbs Wet Shrubland
CEGL002659	Salix monticola / Mesic Graminoids Wet Shrubland
CEGL001225	Salix planifolia / Calamagrostis canadensis Wet Shrubland

CEGL002665	Salix planifolia / Caltha leptosepala Wet Shrubland
CEGL001227	Salix planifolia / Carex aquatilis Wet Shrubland
CEGL001229	Salix planifolia / Carex scopulorum Wet Shrubland
CEGL005937	Salix planifolia / Carex utriculata Wet Shrubland
CEGL001230	Salix planifolia / Deschampsia cespitosa Wet Shrubland
CEGL002893	Salix planifolia / Mesic Forbs Wet Shrubland
CEGL002064	Salix wolfii / Calamagrostis canadensis Wet Shrubland
CEGL001234	Salix wolfii / Carex aquatilis Wet Shrubland
CEGL001237	Salix wolfii / Carex utriculata Wet Shrubland
CEGL001238	Salix wolfii / Deschampsia cespitosa Wet Shrubland
CEGL001239	Salix wolfii / Fragaria virginiana Wet Shrubland
CEGL001240	Salix wolfii / Mesic Forbs Wet Shrubland

Associated Animal Species

American beaver (*Castor canadensis*) are characteristic of these habitats. Dense willow thickets of high elevation riparian shrublands provide many protected nest sites and an abundance of insects, resulting in a high density of nesting birds. Bird species most commonly found in these areas are Broad-tailed Hummingbird (*Selasphorus platycercus*), Dusky Flycatcher (*Empidonax oberholseri*), Yellow Warbler (*Setophaga petechia*), MacGillivray's Warbler (*Geothlypis tolmiei*), Wilson's Warbler (*Cardellina pusilla*), Lincoln's Sparrow (Melospiza lincolnii), Song Sparrow (*Melospiza melodia*), White-crowned Sparrow (*Zonotrichia leucophrys*), Fox Sparrow (*Passerella iliaca*) and American Dipper (*Cinclus mexicanus*). Boreal toad (*Anaxyrus boreas boreas*) and northern leopard frogs (*Lithobates pipiens*) are found in these areas.

Dynamic Processes

Rocky Mountain rivers are characterized by a steep average channel gradient, turbulent flow and sediment movement, and high spatial variability because of elevation differences in rock type, vegetation and sediment supply. The annual flow regime is distinctive with strong seasonal peak flows driven by snowmelt over the course of one to two months that have the potential to move tremendous amounts of sediment. Groundwater-influenced base flow conditions dominate the hydrograph for the remainder of the year.

Key disturbance regimes in this system are annual and episodic flooding and beaver activity. Riparian ecosystems rely on natural disturbance regimes to maintain function and structure. Natural physical disturbance agents include floods, fire, landslides, avalanches, and channel migration. Seasonal and episodic flooding erode and/or deposit sediment resulting in complex patterns of soil development which subsequently have a strong influence on the distribution of riparian vegetation. Beaver have historically been an important hydrogeomorphic driver of Rocky Mountain Subalpine-Montane Riparian Shrublands. Beaver-modified systems have numerous zones of open water and vegetation, large accumulations of detritus and nutrients, more wetland areas, more anaerobic biogeochemical cycles, and in general are more resistance to disturbance. Watersheds with active beaver colonies have increased water storage capacity. Beaver dams modify stream channel form and habitat structure. Beaver ponds resulting from beaver dams elevate local water tables, dissipate energy associated with flood events, reduce stream erosion,

enhance nutrient cycling and store fine sediment. Plant establishment and sediment build-up behind beaver ponds raises the channel bed and creates a wetland environment. Beaver in that way create a heterogenous complex of wet meadows, marshes and riparian shrublands that provides valuable habitat for wetland-dependent plants and animals.

Management

Threats to wetland and riparian ecosystems include anthropogenic hydrologic changes associated with flow regulation or alteration of the natural flooding regime, as well as vegetation alteration and the removal of beaver. With the removal of beaver, the gradual loss of beaver dams has had repercussions that include a likely increase in stream gradient, increased stream sediment and nutrients which altered sediment transport and nutrient cycling and loss of riparian habitat and associated biological diversity.

Anthropogenic activities that contribute indirectly to hydrologic alteration include land use in adjacent uplands that affects hillslope runoff and erosion processes, and habitat fragmentation that results in barriers to natural processes or species movements. Direct impacts result from anthropogenic alteration to the floodplain and riparian zone by activities such as ditching, agricultural use, livestock grazing and urbanization or by alteration to the stream channel from dams and diversions, mining especially placer mining, and channelizing activities such as road building or streambank armoring. Water developments by impoundment or diversion significantly alter flow regimes, habitat structure and biological communities of affected rivers.

Livestock grazing can lead to significant changes in vegetation structure and composition which can negatively impact wildlife and fish habitat as well as processes such as precipitation infiltration and soil erosion. Effects of overgrazing include vegetation removal and compacting streambanks, bank erosion, wider and shallower channel cross-sections, finer stream bed substrates, increased nutrient input to rivers, warmer water temperatures, and impaired aquatic and riparian habitat. In sites where there is prolonged disturbance, willow coverage will decrease resulting in a more open canopy. Herbaceous vegetation is likely to include more non-native species such as Kentucky bluegrass (*Poa pratensis*) and timothy (*Phleum pratense*) as well as exotics species common to other wetland types such as Canada thistle (*Cirsium arvense*) and dandelion (*Taraxacum officinale*).

Climate factors including the amount, form, and seasonality of precipitation, temperature and wind, and the timing of snow-melt influence stream flow regimes, including flow variability and characteristics such as base, mean, and peak flow volumes, and fluvial geomorphic processes such as sediment erosion and deposition. Global climate change is altering the timing and character of processes that maintain riparian systems. Human-induced warming is resulting in the loss of snowpack which is projected to worsen and trends indicate fundamental impacts on streamflow and water supplies across the western United States.

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Rocky Mountain Subalpine-Montane Riparian Woodland

General Description

Conifer and aspen trees characterize these seasonally flooded mountain riparian woodlands which are confined to sites with specific hydrology and riparian environments at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. In Colorado, stands are generally found at elevations between 2,280 and 3,660 m (7,500-12,000 ft) bordering mountain streams. Subalpine-Montane Riparian woodlands occur on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. These riparian plant communities are dependent on high water tables or overbank flooding to meet their moisture requirements and are also dependent on flooding for the deposition of substrates and nutrients necessary for regeneration, establishment and maintenance of component plant communities. Dominant tree species vary by elevation, and to a lesser extent with latitude. At the highest elevations, Colorado occurrences of these forests are dominated by a mixed subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) tree canopy with a sparse shrub layer and a dense forb cover lining stream banks. With decreasing elevation, quaking aspen (*Populus tremuloides*) may begin to characterize the tree

canopy, replacing subalpine fir and Engelmann spruce, and the streamside forb layer may be replaced by Drummond willow (*Salix drummondiana*) and/or thinleaf alder (*Alnus incana*). In the lower elevations of this system, montane zone riparian woodlands are characterized by Colorado blue spruce (*Picea pungens*) or, in the southern part of the state, white fir (*Abies concolor*) with understory vegetation dominated by a shrubs such as thinleaf alder and river birch (*Betula occidentalis*) that is confined to streambanks.

Diagnostic Characteristics

Coniferous and deciduous tree species characterize the canopy in these high elevation riparian woodlands. Common tree species include subalpine fir (*Abies lasiocarpa)*, Engelmann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), Douglas-fir (*Pseudotsuga menziesii*), and quaking aspen (*Populus tremuloides*). This system occurs as a narrow band of forest lining streams at montane to subalpine elevations.

Similar Systems

<u>Rocky Mountain Subalpine-Montane Riparian Shrubland</u>: Although Subalpine-Montane Riparian Shrublands also occur along high elevation streams, the canopy is dominated by short and tall shrubs and tree cover is sparse or absent.

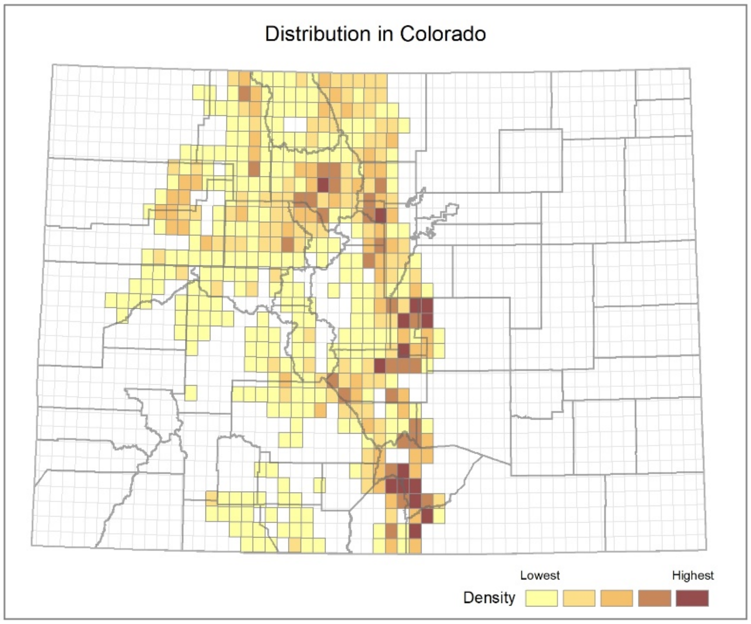
<u>Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland</u>: These riparian communities occur along lower elevation streams between 1,680 and 2,440 m (5,500-8,000 ft), and the suite of dominant species is unlike higher elevation woodland species. Dominant tree species in the lower elevation woodlands are often cottonwood species (*Populus* spp.) including narrowleaf cottonwood (*Populus angustifolia)*, balsam poplar (*Populus balsamifera*), plains cottonwood (*P. deltoides*), and Fremont cottonwood (*P. fremontii*).

Range

These riparian woodlands are found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. In Colorado, occurrences are found throughout the central mountainous portion of the state.

Spatial Pattern

Rocky Mountain Subalpine-Montane Riparian Woodlands are linear systems.



Environment

Rocky Mountain Subalpine-Montane Riparian Forests and Woodlands are found throughout the Southern Rocky Mountain ecoregion at elevations between approximately 2,280 and 3,660 m (7,500-12,000 ft). These forests and woodlands are common in the floodplains and terraces of confined V-shaped, narrow valleys and canyons. Less frequently, they are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, adjacent to willow carrs, and on pond or lake margins. Soils are generally poorly developed with texture that varies from fine silts on level floodplains to coarse gravels and cobbles interspersed with boulders in steeper canyon bottoms.

Vegetation

Occurrences often contain a mosaic of communities that differ in structure and species composition. Communities in this system may be dominated by white fir (*Abies concolor*), subalpine fir (*A. lasiocarpa*), Engelmann spruce (*Picea engelmannii*), blue spruce (*P. pungens*), or quaking aspen (*Populus tremuloides*). Community composition is determined by a combination of characteristics including elevation, floodplain width and steepness, streamflow volume and flooding patterns, and adjacent upland vegetation. At the highest elevations, these forests are characterized by a mixed subalpine fir - Engelmann spruce canopy and are often heavily shaded, lacking shrubs, and have a thick cover of mesic forbs lining the stream edge. With decreasing elevation, quaking aspen (*Populus tremuloides*) may begin to replace subalpine fir and Engelmann spruce, and the streamside forb layer may be replaced by dense thickets of Drummond willow (*Salix drummondiana*) and/or thinleaf alder (*Alnus incana*). In the lower elevations of this system, montane zone riparian woodlands are characterized by Colorado blue spruce (*Picea pungens*) or, in the southern part of the state, by white fir (*Abies concolor*) with understory vegetation dominated by a shrub such as thinleaf alder and river birch (*Betula occidentalis*). Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), aspen, narrowleaf cottonwood (*Populus angustifolia*), box elder (*Acer negundo*), and Rocky Mountain juniper (*Juniperus scopulorum*) may also be present.

Shrub layer cover ranges from sparse to moderate (0-70%) and may include both tall and short shrub species. Associated understory shrub species include Rocky Mountain maple (*Acer glabrum*), red-osier dogwood (*Cornus sericea*), currant (*Ribes* spp.), Geyer willow (*Salix geyeriana*), mountain willow (*Salix monticola*), twinberry honeysuckle (*Lonicera involucrata*), whortleberry, (*Vaccinium* spp.), and occasionally other willows (*Salix* ssp.) present in adjacent carrs. Herbaceous cover varies

from sparse to dense depending on shading from the tree and canopy cover. Characteristic forb species include Richardson's geranium (*Geranium richardsonii*), Fendler's cowbane (*Oxypolis fendleri*), tall fringed bluebells (*Mertensia ciliata*), common cow parsnip (*Heracleum maximum*), heartleaf bittercress (*Cardamine cordifolia*), field horsetail (*Equisetum arvense*), arrowleaf ragwort (*Senecio triangularis*), Rocky Mountain hemlock parsley (*Conioselinum scopulorum*), starry false lily of the valley (*Maianthemum stellatum*), cutleaf coneflower (*Rudbeckia laciniata*), Virginia strawberry (*Fragaria virginiana*), Columbian monkshood (*Aconitum columbianum*) bluntseed sweetroot (*Osmorhiza depauperata*), Fendler's meadow-rue (*Thalictrum fendleri*), common yarrow (*Achillea millefolium*), largeleaf avens (*Geum macrophyllum*), brook saxifrage (*Saxifraga odontoloma*), heartleaf arnica (*Arnica cordifolia*), and red baneberry (*Actaea rubra ssp. arguta*). The graminoid layer may be sparse to dense and include bluejoint reedgrass (*Calamagrostis canadensis*), smallflowered woodrush (*Luzula parviflora*), sedges (*Carex* spp.), and rushes (*Juncus* spp.).

Plant Associations

CEGL000255	Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest
CEGL000296	Abies lasiocarpa - Picea engelmannii / Alnus incana Swamp Forest
CEGL002663	Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Swamp Forest
CEGL000327	Abies lasiocarpa - Picea engelmannii / Salix drummondiana Swamp Forest
CEGL002636	Abies lasiocarpa / Carex aquatilis Swamp Forest
CEGL000339	Abies lasiocarpa / Trautvetteria caroliniensis Swamp Forest
CEGL000367	Picea engelmannii - Populus angustifolia / Heracleum maximum Swamp Forest
CEGL002678	Picea engelmannii / Calamagrostis canadensis Swamp Forest
CEGL000357	Picea engelmannii / Caltha leptosepala Swamp Forest
CEGL002677	Picea engelmannii / Cornus sericea Swamp Woodland
CEGL005927	Picea engelmannii / Equisetum arvense Swamp Forest
CEGL000894	Picea pungens / Alnus incana Riparian Woodland
CEGL002637	Picea pungens / Betula occidentalis Riparian Woodland
CEGL000388	Picea pungens / Cornus sericea Riparian Woodland
CEGL000389	Picea pungens / Equisetum arvense Riparian Woodland
CEGL001150	Populus tremuloides / Alnus incana Riparian Forest
CEGL002650	Populus tremuloides / Betula occidentalis Riparian Forest
CEGL000574	Populus tremuloides / Calamagrostis canadensis Riparian Forest
CEGL000582	Populus tremuloides / Cornus sericea Riparian Forest
CEGL000583	Populus tremuloides / Corylus cornuta Forest
CEGL000598	Populus tremuloides / Quercus gambelii / Symphoricarpos oreophilus Forest
CEGL000600	Populus tremuloides / Ribes montigenum Riparian Forest
CEGL002902	Populus tremuloides / Salix drummondiana Riparian Forest
CEGL000590	Populus tremuloides / Senecio bigelovii var. bigelovii Riparian Forest
CEGL000621	Populus tremuloides / Veratrum californicum Riparian Forest

Associated Animal species

Mammal species reported from these higher elevation riparian woodlands include montane and water shrew (*Sorex monticolus* and *S. palustris*), snowshoe hare (*Lepus americanus*), western

jumping mouse (*Zapus princeps*), meadow and montane vole (*Microtus pennsylvanicus* and *M. montanus*), lynx (*Lynx canadensis*), and beaver (*Castor canadensis*). Bird species commonly found in these areas are Broad-tailed Hummingbird (*Selasphorus platycercus*), Dusky Flycatcher (*Empidonax oberholseri*), Yellow Warbler (*Setophaga petechia*), MacGillivray's Warbler (*Geothlypis tolmiei*), Wilson's Warbler (*Cardellina pusilla*), Lincoln's Sparrow (*Melospiza lincolnii*), Song Sparrow (*Melospiza melodia*), Fox Sparrow (*Passerella iliaca*), Cordilleran Flycatcher (*Empidonax occidentalis*), Red-naped Sapsucker (*Sphyrapicus nuchalis*), Hermit Thrush (*Catharus guttatus*), Ruby-Crowned Kinglet (*Regulus calendula*), Mountain Chickadee (*Poecile gambeli*), Warbling Vireo (*Vireo gilvus*), Western Wood-Peewee (*Contopus sordidulus*), and American Dipper (*Cinclus mexicanus*). Boreal toad (*Anaxyrus boreas boreas)* wood frog (*Lithobates sylvatica*), and western terrestrial garter snake (*Thamnophis elegans*) may also occur.

Dynamic Processes

Hydrologic processes, particularly flooding events, are key drivers of geomorphic, biogeochemical, and biological processes in riparian systems. Snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics. Snowmelt saturates soils, recharges shallow groundwater and produces surface flow and stream flooding, which, in this system, historically has occurred in May and June with volume and duration affected by snowpack levels. Surface flows and flooding are important processes in the formation and maintenance of riparian habitat.

Flood disturbance is the primary driver of this system. Flooding inundates vegetation and supplies water to adjacent floodplain wetlands which store runoff water and can recharge groundwater, and flooding alters channel morphology through lateral erosion and deposition of sediment. Additionally, groundwater recharge from snowmelt creates shallow water tables or seeps that support vegetation for a portion of the growing season. The disturbance processes of overbank flow and erosion and deposition are essential in forming the floodplain and providing habitat for the development of riparian vegetation. Coarse sediments accumulate as gravel bars at or near the surface of the river. These are quickly colonized, eventually creating bands of mixed vegetation representing different stages of succession.

Beaver were historically, and continue to be, an important factor in these woodlands, except in reaches with very steep gradients. Beaver are a keystone species whose pond-building activities change adjacent forest structure, elevate local water tables, decrease net flow velocity, and reduce stream erosion and provide valuable habitat for wetland dependent plants and animals. Beaver ponds and associated elevated water tables eliminate most trees in the floodplain as long as ponds are maintained. As beaver colonies fail or move, trees gradually reestablish.

Management

An unaltered hydrologic regime is crucial to maintaining the diversity and viability of the riparian area. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology as well as biotic integrity of riparian woodlands. All of these stressors can induce downstream erosion and channelization, reduce

changes in channel morphology, reduce base and/or peak flows, lower water tables in floodplains, and reduce sediment deposition in the floodplain. Vegetation responds to these changes by shifting from wetland and riparian dependent species to more mesic and xeric species typical of adjacent uplands (typical of herbaceous species) and/or encroaching into the stream channel.

Human land uses both within the riparian area as well as in adjacent and upland areas can fragment the landscape and thereby reduce connectivity between riparian patches and between riparian and upland areas. Roads, bridges, and development can contribute to fragmentation thereby adversely affecting the movement of surface/groundwater, nutrients, and dispersal of plants and animals. Land use in adjacent uplands, such as forest harvest and grazing, can affect ecosystem processes such as precipitation infiltration and runoff, nutrient cycling and soil erosion. Overgrazing in western riparian systems has left a legacy of riparian ecosystem-level damage that has fundamentally altered ecosystem integrity and function.

Climate factors including the amount, form, and seasonality of precipitation, temperature and wind, and the timing of snow-melt influence stream flow regimes, including flow variability and characteristics such as base, mean, and peak flow volumes, and fluvial geomorphic processes such as sediment erosion and deposition. Global climate change is altering the timing and character of processes that maintain riparian systems. Human-induced warming is resulting in the loss of snowpack which is projected to worsen and trends indicate fundamental impacts on streamflow and water supplies across the western United States.

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Colorado version authors: Colorado Natural Heritage Program Staff: Dee Malone, Renée Rondeau, Karin Decker
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Western Great Plains Closed Depression Wetland & Playa

General Description

Western Great Plains Closed Depressions occur in the High Plains region of the Great Plains, which includes eastern Colorado's shortgrass prairie. Also referred to as *playas* or *playa lakes,* these closed depressions are characterized by clay-lined pond bottoms, shallow topography, and hydrology that is fed strictly from precipitation and local runoff. These wetlands are most often isolated from groundwater sources and do not have extensive watersheds, although they often occur within a larger complex of depressional wetlands. Playas experience drawdowns during drier seasons and years, and are replenished by heavy rains. They have an impermeable soil layer, usually dense hardpan clay, which restricts to water movement and induces ponding after heavy rains. These wetlands experience irregular hydroperiods and can go months or years without filling and the out ring can dry quickly after wetting. Playa vegetation commonly grows in successive zones that are associated with inundation patterns and water levels, with the most hydrophytic species occurring in the wetland center where ponding persists the longest. Plant composition and diversity also varies from site to site depending on how often it wets, surrounding land use, and micro-topography. Common vegetation in the wetter zones and playas include needle spikerush (*Eleocharis acicularis*), pale sprikerush (*Eleocharis macrostachya*), foxtail barley (*Critesion jubatum*), along with common forbs such as spreading yellowcress (*Rorippa sinuata*), wedgeleaf (*Phyla cuneifolia*), and woolyleaf bur ragweed (*Ambrosia grayi*). Shallower zones or sites that do not

wet as frequently are often occupied by western wheatgrass (*Pascopyrum smithii*) and buffalo grass (*Buchloe dactyloides*). It is not uncommon for playas to exhibit barren, cracked ground between wetting cycles, and this cracking is indicative of a healthy, functioning wetland. Threats to system integrity include hydrologic changes, overgrazing, and conversion to agricultural use.

Diagnostic Characteristics

Closed depressions are hydrologically isolated from the regional groundwater system and strictly dependent on rainwater and runoff as water sources. Impermeable clay-lined pond bottoms and shallow topography induce ponding. Vegetation density and diversity is highly dependent on wetting cycles, and often exhibits zonation. These systems are dynamic, as they respond quickly to moist and dry conditions, landscape changes, and localized used.

Similar Systems

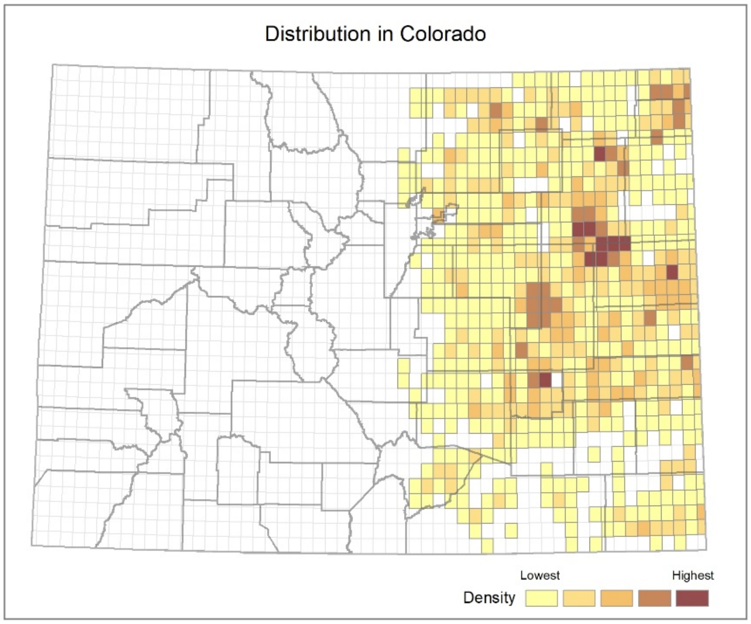
<u>Western Great Plains Saline Depression</u>: Saline depressions are also considered playas or playa lakes, however strongly saline soils cause these depressions and the surrounding areas to be more brackish. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as saltgrass (*Distichlis spicata*), alkai sacaton (*Sporobolus airoides*), and foxtail barley (*Hordeum jubatumSalicornia rubra*), threesquare (*Schoenoplectus pungens*), western sea-purslane (*Sesuvium verrucosum*), seepweed (*Suaeda* spp.), cordgrass (*Spartina* spp.), seaside arrowgrass (*Triglochin maritima*), and shrubs such as greasewood (*Sarcobatus vermiculatus*) and winterfat (*Krascheninnikovia lanata*).

<u>Inter-Mountain Basins Playa</u>: This system describes playas throughout the Intermountain West, rather than the Great Plains. Inter-mountain Basin Playas have saline soils that are intermittently flooded or are maintained by a perennially high water table. They support a sparse cover (generally < 10%) of salt-tolerant vegetation that includes both shrubs and herbs. Characteristic species of Inter-mountain Basin Playas include greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Grayia spinosa*), Lemmon's alkali grass (*Puccinellia lemmonii*), Great Basin wildrye (*Leymus cinereus*), saltgrass (*Distichlis spicata*), and species of saltbush (*Atriplex* spp.).

<u>Great Plains Prairie Pothole</u>: Playa lakes share characteristics with prairie pothole systems, but are of dissimilar geologic origin and function. Prairie potholes are characterized as depressional wetlands carved out by glaciers located in northern Montana and Midwestern states. Like playa lakes hydrology, precipitation and snowmelt are a primary water source, but unlike playa lakes, groundwater inflow is a secondary water source. Prairie pothole soil can range from silt to clay, and topography is gradual or steep. Prairie potholes do not occur in Colorado.

Range

Western Great Plains Closed Depressions are located throughout the Western Great Plains, however they are most prevalent in Nebraska, Kansas and Oklahoma. In Colorado, they are found in the shortgrass prairie of eastern Colorado.



Spatial Pattern

Western Great Plains Closed Depression Wetlands are small patch wetlands.

Environment

This system is typified by depressional basins found in flat to undulating regions of the Western Great Plains in Colorado. Climate and basin physiography and morphology are key drivers of this system. Specific climatic variables most important to formation and function of these wetlands are temperature and precipitation. Climate on the Western Great Plains is semi-arid with dry, warm and sunny summers and temperatures of 95 F or above. Rainfall is below twenty inches per year, with most (70-80%) occurring in the spring and early summer during the growing season. Wind speeds are high, and their drying effects, coupled with high temperatures, cause soil drying and summer drought.

Playas form in shallow basins with an impermeable soil layer, usually dense hardpan clay, which restricts to water movement and induces ponding after heavy rains. They are temporarily or intermittently flooded and receive their water nearly exclusively as direct precipitation or surface runoff. Outflows in this system occur primarily by direct evaporation and plant transpiration, which on the plains can be high due to high temperatures and wind speed. The amount of runoff feeding each playa depends on soil hydraulic properties, soil porosity, and the size of the surrounding watershed. In northeastern Colorado, some playas may go years without filling, while others in southern Colorado may fill almost yearly. Playas experience wide water level fluctuation, which results in variation and potentially successional change of wetland plant communities.

Vegetation

Vegetation composition and structure in playas are heavily driven by wetting patterns, pond morphology, soil processes, and land use. The ephemeral nature of playa wetting impacts the vegetation community; species composition adapts as conditions change from wet to moist to dry. During pond flooding, vegetation is made up of emergent and submergent aquatic species. Playas with moist, but not inundated, soil conditions support annual species that produce high quantities of seeds. When playas are dry, forbs and grasses associated with surrounding uplands areas, and sometimes weedy species, will populate the open ground.

In regularly wetted closed depression wetlands, zonation patterns of vegetation are a common feature. Although zonation can be the result of a multitude of factors, hydrology, especially water

depth and length of inundation, are the most important influences. Hydrophytic species occupy the center of these sites where ponding lasts the longest, while more facultative plant species occupy outer perimeters and many persistent species may be upland species. Common vegetation in these wetter areas include needle spikerush (*Eleocharis acicularis*), pale sprikerush (*Eleocharis macrostachya*), and hairy waterclover (*Marsilea mucronata*). Vegetation adapted to moist, but not inundated, zones are yellowcress (*Rorippa sinuata*), wedgeleaf (*Phyla cuneifolia*), spotted evening primose (*Oenothera canescens*), foxtail barley (*Critesion jubatum*), and woolyleaf bur ragweed (*Ambrosia grayi*). Transitional zones between playa and upland often include species such as buffalograss (*Buchloe dactyloides*), bigbract verbena (*Verbena bracteata*), povertyweed (*Iva axillaris*), woolly plantain (*Plantago patagonica*), short-ray prairie coneflower (*Ratibida tagaetes*), and western wheatgrass (*Pascopyrum smithii*). Soil salinity also influences species composition and may fluctuate depending on moisture availability. For instance, foxtail barley (*Critesion jubatum*) is moderately salt tolerant and often occupies a zone of intermediate salinity between halophytic vegetation dominated by species such as saltgrass (*Distichlis stricta*) and non-saline mesic prairie vegetation. Although this zonation patterns can appear unambiguous, research shows that these growing patterns are the outcome of the complex interaction between environmental factors and seed germination, seedling recruitment dynamics, and plant dispersal.

Non-native species are very common in these sites, including Russian thistle (*Salsola australis*), kochia (*Bassia sieversiana*), cheatgrass (*Anisantha tectorum*), oval-leaf knotweed (*Polygonum arenastrum*), and prickly lettuce (*Lactuca serriola*).

Plant Associations

CEGL001573	Panicum obtusum - Buchloe dactyloides Herbaceous Vegetation
CEGL001581	Pascopyrum smithii - Eleocharis spp. Herbaceous Vegetation
CEGL001582	Pascopyrum smithii - Hordeum jubatum Herbaceous Vegetation
CEGL001586	Schoenoplectus americanus - Eleocharis spp. Herbaceous Vegetation
CEGL005286	Hordeum jubatum Great Plains Herbaceous Vegetation

Associated Animal Species

Playa lakes create unique microclimates that support diverse wildlife and plant communities. When these wetlands are resupplied with water, they teem with life and provide habitat for a variety of wildlife including frogs, toads, clam shrimp, bird, and aquatic plants. During wet years playas provide nesting, feeding or resting grounds for an abundance of waterfowl, wading birds and shorebirds.

Bird species reported from prairie wetlands include Long-billed Curlew (*Numenius americanus*), Mallard (*Anas platyrhynchos*), Green-winged Teal (*Anas crecca*), Cinnamon Teal (*Anas cyanoptera*), American Coot (*Fulica americana*), Blue-winged Teal (*Anas discors*), Killdeer (*Charadrius vociferous*), Common Snipe (*Gallinago delicate*), Spotted Sandpiper (*Actitis macularius*), Wilson's Phalarope (*Phalaropus tricolor*), American Avocet (*Recurvirostra americana*), Red-winged Blackbird (*Agelaius phoeniceus*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), Common Yellowthroat (*Geothlypis trichas*), Northern Harrier (*Circus cyaneus*), and Short-eared Owl (*Asio*

flammeus). Two species identified as high priority for wetland habitats in this region are Northern Harrier and Short-eared Owl.

Herptofaunal species reported from this system include tiger salamander (*Ambystoma tigrinum*), Great Plains toad (*Anaxyrus cognatus*), Woodhouse's toad (*Anaxyrus woodhousei*), Plains spadefoot (*Spea bombifrons*), and Plains Gartersnake (*Thamnophis radix*).

At risk flora and fauna species reported from this system include linear-leaf Bursage (*Ambrosia linearis*), Wolf's spikerush (*Eleocharis wolfii*), and Fairy Shrimp (*Branchinecta potass*).

Dynamic Processes

The origin of playas is not well understood. Hypotheses include dissolution of calcic soils resulting in land subsidence, bison wallowing, wind erosion, and a combination of these depositional, geomorphic and hydrological processes. These wetlands and playas are characterized by irregular hydroperiods and exhibit wide water level fluctuations; many fill with water only occasionally and dry quickly. These fluctuations in water availability often promote diverse herbaceous plant growth, with community structure and composition shaped by the timing and length of inundation or dryness.

Prairie fires were once an important component of grasslands ecosystems, occurring during the dry season when they did not damage already dormant grasses. Fire is a key disturbance influencing vegetation patterns in upland prairie ecosystems but little is known regarding its historic role in prairie playa systems. However, because playas exist in a fire-prone landscape, fires likely had impacts on playa species composition.

Management

The primary threats influencing these wetlands are hydrologic alterations, livestock grazing and conversion to agricultural use. Because playas are defined by their hydrology, impacts to their subtle topography or impermeable soils can have dramatic impacts on their function and condition. A major threat to these systems in eastern Colorado is hydrologic alterations for irrigation and stock pond purposes. The use of playas as stock ponds or detention ponds is a common practice because they form in basins and has been identified as a major impact that alters species composition. Water is divert both into and out of playas throughout the region, causing unnatural periods of inundation or drying, in turn impacting vegetation composition and seed bank dynamics. Deep pits are often dug in playas to concentrate water for agricultural uses, a practice known as "pitting". Pitting increases the duration of surface water in the center of the playa, removes water from the outer rim, and has negative implications for playa function. In addition, diverting irrigation water into playas for prolonged periods can alter the hydroperiod and can decrease characteristic plant and invertebrate species. Runoff laden with herbicides and fertilizers may impair water quality and also alters the diversity and abundance of plants and invertebrates. Other indirect hydrologic alterations are cause from soil deposition from agricultural erosion, local development that alters surface flow patterns, and pugging (mounding derived from cattle traffic).

Livestock grazing can have significant impacts on playa soil, flora, and hydroperiods. Due to the dry climate of Colorado's eastern plains, it is not uncommon for cattle to concentrate activity around playas when they are flooded or saturated, and especially if they are pitted. When the use is light and for a short duration, impacts are minimal, but occasionally, grazing is so intensive that both direct effects life herbivory and trampling, and indirect effects like nutrient enrichments through fecal and urine deposits can be damaging. When cattle trample soil during wet periods, "pugging" occurs in which the clay substrate is consolidated into undulating mounds, in turn impacting the subtle topography of the pond bottom, which impacts flow and ponding dynamics. Livestock can also serve as a vector for non-native and weedy species.

Playas are strongly dependent on precipitation for their water source, therefore these depression wetlands may be especially sensitive to major shifts in temperature or precipitation due to global climate change. Increased warming and changes in the water cycle are projected. On the Great Plains, temperatures are projected to continue to increase while precipitation is anticipated to increase in the north and decrease in the south. However, due to rising temperatures and increased evaporation, projected increases in precipitation are unlikely to be sufficient to offset decreasing soil moisture and water availability in the Great Plains. Changing climate systems will only had to the stress already placed on these delicate ecosystems.

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Colorado Version Authors: Colorado Natural Heritage Program Staff: Dee Malone, Joanna Lemly, Karin Decker, Cat Wiechmann
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Western Great Plains Floodplain

General Description

The Western Great Plains Floodplain system is confined to the floodplains of medium and large rivers of the Western Great Plains. In Colorado, this system is limited to the South Platte and Arkansas Rivers and Fountain Creek. These are the perennial big rivers of the region and their hydrology is largely driven by snowmelt in the mountains instead of local precipitation events. Seasonal and larger episodic flooding events (every 5–25 years) redistribute alluvial soils and are essential to the maintenance of this system. Plains floodplains are characterized by a linear mosaic of wetland and riparian communities that are linked by soils and flooding regime. Dominant communities include open to closed gallery forests, dense shrublands along the river's edge, open wet and mesic meadows and sparsely vegetated gravel and sand flats. Dominant native woody species include plains cottonwood (*Populus deltoides*) and willow (*Salix* spp.) species. Native herbaceous cover is a mix of saltgrass (*Distichlis spicata*), western wheatgrass (*Pascopyrum smithii*), and tallgrass species, including switchgrass (*Panicum virgatum* and *P. obtusum*), intersperses with pockets of marsh vegetation. Invasion of non-native species is one consequence of anthropogenic alteration of the plains floodplain system. These areas have often been subjected to heavy grazing and/or agriculture and can be heavily degraded. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from examples of this system and

less desirable or exotic grasses and forbs have displaced the native understory. In many locations, the canopy also contains or is dominated by non-native woody species, including tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*).

Diagnostic Characteristics

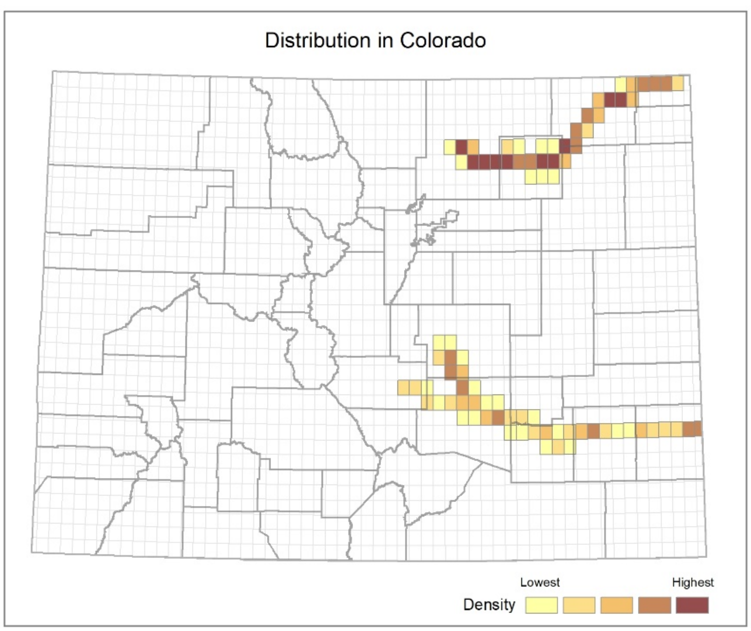
Seasonal and larger episodic flooding are key drivers of floodplain systems and act to differentiate floodplains from other wetland and riparian ecosystems. Meandering channels create dynamic alluvial bars, depressions. Vegetation is a characterized by mosaic of floodplain forests, wet meadows and sparsely vegetated gravel and sand flats and occurs in zones reflective of past deposition and flooding.

Similar Systems

Western Great Plains Riparian: The Western Great Plains Riparian system is distinguished by stream order and hydrology. Plains riparian systems occur along ephemeral, intermittent, and small- to mid-order perennial streams on the plains. Plains riparian hydrology is primarily driven by local precipitation and groundwater inflow rather than the snowmelt-driven hydrology of perennial rivers. In riparian zones, substrates vary from silty clay to well-drained sands with mixtures of cobbles and gravels. The riparian zone is narrower than that of floodplain systems and less physically complex. Dominant vegetation overlaps in riparian and floodplain systems, but large floodplain systems are more defined by cottonwood galleries than riparian systems.

Range

This system is found along the major river floodplains of the Western Great Plains (Colorado, Kansas, Nebraska, Oklahoma, Texas) on the middle to lower reaches of the North and South Platte, Platte, Arkansas, Republican and Canadian rivers.



Spatial Pattern

Western Great Plains Floodplain is a linear system.

Environment

In Colorado, the Western Great Plains Floodplain system occurs primarily along the South Platte and Arkansas Rivers, as well as Fountain Creek. The floodplains adjacent to these large rivers can be physically complex with long periods of seasonal flooding, lateral channel migration, oxbow lakes in old river channels, and diverse wetland communities. The surrounding

upland terrain varies from level to gently rolling hills but also contains some deep canyons and dramatic escarpments, buttes, mesas and volcanic peaks.

The Colorado plains are situated in the rain shadow of the Rockies causing dry, warm and sunny summers with temperatures often 95o F or above. Rainfall is below twenty inches per year, with 70-80% falling in the spring and summer during the growing season. Wind speeds are high, and their drying effects, together with high temperatures, cause soil drying and summer drought. Climate in floodplain wetlands is similar to the surrounding upland habitat, however the increased cover from the tree canopy moderates intense winds and sunlight and provides protected habitat to support a diverse faunal community.

Dynamic and episodic flood events are the key drivers of floodplain systems, with hydrology largely driven by snowmelt from the mountains rather than local precipitation events. Floodplains of these rivers are continually changing in response to dynamic overbank flows. Where streams remain un-channeled they meander across their floodplain creating depressions, oxbows, backwaters, ponds, and sloughs that support a complex mosaic of wetland and non-wetland riparian vegetation. Flooding from the stream channel recharges many alluvial aquifers and as stream flow decreases, the alluvial aquifer begins to recharge stream flow. Floodplain soils are young and moist, with a high water table and poor drainage. They are primarily formed from relatively recent deposits of coarse gravel, silt and sand.

Vegetation

The Western Great Plains Floodplain system is a mosaic of wetland and non-wetland plant communities characterized by cottonwood gallery forests, willow shrublands, and herbaceous communities responding to dynamic and meandering rivers. Common native tree species include plains cottonwood (*Populus deltoides ssp. monilifera*), green ash (*Fraxinus pennsylvanica var. lanceolata*), and peach-leaf willow (*Salix amygdaloides*). Common native shrubs include narrowleaf willow (*Salix exigua*), red-osier dogwood (*Cornus sericea*), and western snowberry (*Symphoricarpos occidentalis*). Native graminoid species include switchgrass (*Panicum virgatum*), prairie cordgrass (*Spartina pectinata*), sand dropseed (*Sporobolus cryptandrus*), western wheatgrass (*Pascopyrum smithii*), slender wheatgrass (*Elymus trachycaulus*), blue grama (*Chondrosum gracile*), inland saltgrass (*Distichlis spicata*), foxtail barley (*Hordeum jubatum*), annual rabbitsfoot grass (*Polypogon monspeliensis*), with wetland sedges (*Carex* spp.), bulrushes (*Schoenoplectus* spp.), and cattail (*Typhya latifolia* and *T. angustifolia*) in wetter zones. Native forb species include Cuman ragweed (*Ambrosia psilostachya*), showy milkweed (*Asclepias speciosa*), thymeleaf sandmat (*Chamaesyce serpyllifolia*), Canadian horseweed (*Conyza canadensis*), American licorice (*Glycrrhiza lepidota*), common sunflower (*Helianthus annuus*), and California nettle (*Urtica gracilis*).

Alteration of the flooding regime and disturbances such as overgrazing and agriculture have enabled the invasion of numerous non-native plant species. In the South Platte Basin, native cottonwoods remain the dominant woody canopy, but the understory composition of most floodplain systems is dominated by cheatgrass (*Bromus tectorum*), barnyard grass (*Echinochloa crus-galli*), smooth brome (*Bromus inermis*), and quackgrass (*Elytrigia repens*). Common non-native

forbs include kochia (*Bassia sieversiana*), Russian-thistle (*Salsola australis*), Canada thistle (*Cirsium arvense),* curly dock (*Rumex crispus*), poison hemlock (*Conium maculatum*), lambsquarters (*Chenopodium album*), sweetclover (*Melilotus* spp.), and moist sowthistle (*Sonchus arvensis* ssp. *uliginosus*). In the Arkansas Basin, dense tamarisk now dominates the canopy of most floodplain systems, despite eradication efforts.

Plant Associations

CEGL001813	Carex nebrascensis Wet Meadow
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior) Floodplain Woodland
CEGL002017	Populus deltoides - (Salix nigra) / Spartina pectinata - Carex spp. Floodplain Woodland
CEGL000939	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Distichlis spicata Riparian Woodland
CEGL002685	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua Riparian Woodland
CEGL005977	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Sporobolus airoides Flooded Woodland
CEGL002649	Populus deltoides / Carex pellita Floodplain Woodland
CEGL000678	Populus deltoides / Muhlenbergia asperifolia Flooded Forest
CEGL001454	Populus deltoides / Panicum virgatum - Schizachyrium scoparium Floodplain Woodland
CEGL005024	Populus deltoides / Pascopyrum smithii - Panicum virgatum Floodplain Woodland
CEGL000660	Populus deltoides / Symphoricarpos occidentalis Floodplain Woodland
CEGL005656	Salix exigua / Gravel Bar Wet Shrubland
CEGL001203	Salix exigua / Mesic Graminoids Western Wet Shrubland
CEGL002030	Schoenoplectus acutus - Typha latifolia - (Schoenoplectus tabernaemontani) Sandhills Marsh
CEGL001685	Sporobolus airoides Southern Plains Wet Meadow
CEGL001131	Symphoricarpos occidentalis Shrubland
CEGL002010	Typha (latifolia, angustifolia) Western Marsh

Associated Animal Species

The Western Great Plains Floodplain system provides protected migration routes and abundant nesting, foraging and protected resources for many wildlife species. Mammal species include white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis virginiana*), muskrat (*Ondatra zibethicus*), western harvest mouse (*Reithrodontomys megalotis*), and fox squirrel (*Sciurus niger*). Beavers (*Castor canadensis*) use plains cottonwood for food and for buildings dams and lodges. Cottonwoods stabilize streambanks and thereby provide fish with thermal cover, and protected undercut bank habitat. Plains cottonwood is the most important browse species for mule deer in the fall.

In Northeastern Colorado, plains cottonwood stands provide habitat for 82% of all of the bird species breeding in northeastern Colorado (Taylor 2001). Birds closely associated with cottonwoods on the Great Plains of Colorado include Wild Turkey (*Meleagris gallopavo*), Bald Eagles (*Haliaeetus leucocephalus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*) which nest in cottonwood, Golden Eagles (*Aquila chrysaetos*), Lewis's Woodpecker (*Melanerpes lewis*) which breed predominantly in old decadent cottonwoods, Bullock's Oriole (*Icterus bullockii*), Yellow Warbler (*Setophaga petechia*), Western Kingbird (*Tyrannus verticalis*), Great Horned Owl (*Bubo virginianus*), Eastern Kingbird (*Tyrannus tyrannus*), American Kestrel (*Falco sparverius*), and Blue Grosbeak (*Passerina caerulea*).

Abundant shelter, insects and warm temperatures make lowland floodplain and riparian ecosystems important habitat for reptiles and amphibians. Common reptiles and amphibians include tiger salamander (*Ambystoma tigrinum*), plains leopard frog (*Rana blairi*), striped chorus frog (*Pseudacris triseriata*), Woodhouse's toad (*Bufo woodhousii*) and Great Plains toad (*Bufo cognatus*), painted and snapping turtle (*Chrysemys picta* and *Chelydra serpentina*), plains and red-sided garter snake (*Thamnophis radix* and *T. sirtalis*) and bullsnake (*Pituophis melanoleucus*) – many of which are restricted to the eastern side of the Rocky Mountains.

Dynamic Processes

Floodplains are highly dynamic. When a stream overflows its banks, natural levees form from the deposited sediments, water is supplied to the adjacent riparian wetlands and groundwater is recharged. When a stream erodes its channel, it moves laterally and downwards resulting in a meandering pattern. These processes of overbank flow, deposition and lateral migration are the most significant forces in the formation of a floodplain. Interactions between hydrologic and geomorphic processes result a mosaic of landforms including channels, floodplains, point bars and in-channel islands, which drive the spatial pattern and successional development of riparian vegetation. Floodplain woodlands and shrublands grow within a continually changing, dynamic alluvial environment due to the ebb and flow of the river, and are constantly being reset by flooding disturbance.

Regeneration and establishment of cottonwoods woodlands is dependent on flooding disturbance that occurs with appropriate timing and frequency, sufficient magnitude and duration, and slow regression in order to deposit wet, bare alluvium in full sun to enable germination and establishment. Additionally, seed dispersal must coincide with the timing of peak, snow-melt driven floods and sufficient soil moisture must be present throughout the late summer months when seedlings are vulnerable to water stress. Periodic flooding disturbance also maintains a diversity of age classes. Thus, functioning floodplain communities are a mosaic of various age classes containing early, mid- and late-seral associations. In fact, evidence form the South Platte Basin suggests that the floodplain naturally supported far fewer mature cottonwoods, as extreme floods prevented the establishment of large stands. Without flooding disturbance, floodplains become dominated by late-seral communities that are primarily upland species.

Management

In many floodplain and riparian systems, anthropogenic development has resulted in degradation or extirpation of floodplain wetland and prairie communities. Flow manipulation for flood control, urban water supplies and irrigation limits the flood events that cottonwoods need for seedling establishment and results in changes to plant and community composition. Where flow regulation has altered the timing of floods, cottonwood establishment may be constrained due to a lack of synchrony between seed dispersal and the availability of suitable substrates for germination.

Western Great Plains floodplains have often been subjected to concentrated grazing and/or agriculture and can be heavily degraded. Invasion of exotic species is one consequence of the anthropogenic alteration of the river and surrounding land. Non-native plant species include

saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) and less desirable or exotic grasses and forbs which displace native species. Non-native species do not provide the same essential ecosystem functions as do native species. For instance, saltcedar, unlike cottonwood, do not adequately stabilize stream banks nor do they provide appropriate nesting and foraging habitat for many native bird species. Further, saltcedar increase soil salinity thereby inhibiting revegetation by native species.

Global climate change has produced significant and changing trends in regional climate over the last few decades. Increased warming and changes in the water cycle are projected and the prospect of future droughts becoming more severe due to warming is a serious concern. In the mountains global climate change is altering the timing and magnitude of mountain snowmelt due to unprecedented springtime warming. Mountain snowmelt is the key driver of hydrology in this floodplain system. Because cottonwood seeds are only viable for 1 to 2 weeks after dispersal, appropriate timing of flooding flows are essential to seed germination and earlier snowmelt may result in dis-synchrony between flooding and seed dispersal. On the Great Plains, temperatures are projected to increase while precipitation is anticipated to increase in the north and decrease in the south. However, due to rising temperatures and increased evaporation, projected increases in precipitation are unlikely to be sufficient to offset decreasing soil moisture and water availability in the Great Plains. Current water use on the Great Plains is unsustainable as the aquifers continue to be tapped faster than the rate of recharge. Climate change projections will add more stress to overtaxed water sources impacting both agricultural and natural systems.

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Western Great Plains Riparian

General Description

The Western Great Plains Riparian system is found in the riparian zones of along moderate-sized woody rivers, streams, and ephemeral drainages throughout the western Great Plains, including eastern Colorado's shortgrass prairie region. This system occurs on alluvial soils and is driven by periodic flooding and site capacity for tree establishment. Plains riparian systems can contain seasonally flowing open water channels or ephemeral and often sandy, sparsely vegetated washes. The landscape setting can be highly variable, ranging from incised canyon ravines to wide, braided streambeds. Hydrology of wash occurrences tends to be flashy and entire streambeds can be dry for some portion of the year. Primary inputs to this system are local precipitation events, overland flow, subsurface interflow from adjacent uplands, and groundwater discharge. Seasonal and episodic flooding is the primary driver of this ecosystem and is essential to maintaining a mosaic of plant associations. Communities within this system can intersperse along a single reach and include riparian forests and shrublands, tallgrass and mixed grass mesic meadows, herbaceous wetland swales and seep/springs, and gravel/sandbars. Some systems have a layered forest canopy, while others have scattered open trees, shrub patches, and herbaceous zones near the channel, outer floodplain, or short herbaceous reaches within a larger wooded landscape. Dominant species

include plains cottonwood (*Populus deltoides*), willow (*Salix* spp.), silver sagebrush (*Artemisia cana*), western wheatgrass (*Pascopyrum smithii*), switchgrass (*Panicum virgatum*), vine mesquite (*Panicum obtusum*), sand dropseed (*Sporobolus cryptandrus*), foxtail barley (*Critesion jubatum*), blue grama (*Chondrosum gracile*), and saltgrass (*Distichlis stricta*). Localized marsh communities may occur within or adjacent to riparian zones, with plant species such as cattail (*Typha* spp.), bulrush (*Schoenoplectus* spp.), spikerush (*Eleocharis* spp.), and other sedges (*Carex* spp.). Hydrologic alteration, livestock grazing and/or agricultural activities are common anthropogenic impacts. Consequences of flow reductions and changes diminish riverine ecosystem function and lower water tables. This degrades altered vegetation composition and structure, and the invasion of non-native species including saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), green ash (*Fraxinus pennsylvanica*) and nonnative grasses and forbs. Impacts can reduce site connectivity by channel downcutting, narrowing of wetland zones, vegetation infilling within the channel bank, and soil drying.

Diagnostic Characteristics

In Colorado, seasonal and episodic floods are key drivers of Western Great Plains riparian areas and create conditions for woody vegetation establishment. Localized flashy precipitation events regularly deposit sandy alluvium and wrack on vegetated riparian areas. Primary inputs to this system are groundwater discharge, local precipitation events, overland flow, and subsurface interflow from adjacent upland. In Colorado, Western Great Plains Riparian systems occur throughout the eastern plains occupying the riparian zone of 1st to 4th order streams, including ephemeral and intermittent streams. Vegetation can include a tree canopy dominated by plains cottonwood (*Populus deltoides*), a shrub layer dominated by willow, and/or an herbaceous layer with a variety of graminoids. Sites can contain a mix of wetland and upland species, depending on stream duration. Some reaches of plains riparian areas can resemble marshes, with pools of slow moving water dominated by coarse emergent vegetation.

Similar Systems

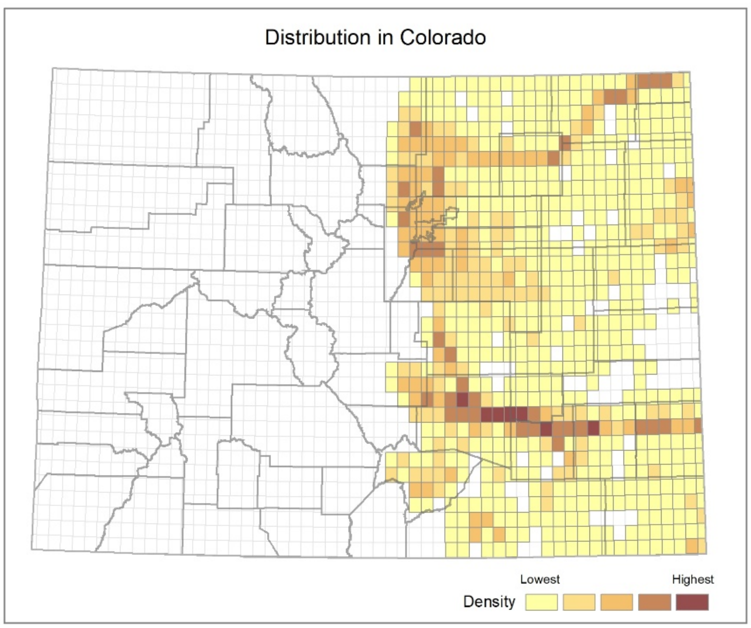
<u>Western Great Plains Floodplain</u>: The Western Great Plains Floodplain system is distinguished by stream order and size of the riparian area. Plains floodplains occur along mid- to high-order streams (4th order and above). Plains riparian systems are narrower than plains floodplain systems and less physically complex.

<u>Western Great Plains Wet Meadow and Marsh Drainage Network:</u> This headwater and small stream system is generally herbaceous and encompasses small streams before their processes transition from throughflow to overbank flooding. Colorado’s plains riparian system is intermediate in energy and watershed position between the wet meadow and marsh network and plains floodplain, where sites can support trees, but the floodplain is less developed. Riparian native herbaceous patches are more commonly mesic to upland grasses such as bluestem and needle-grasses, versus the dominant wetland graminoids in the wet meadow and marsh drainages. However, separate small patches of wetland herbaceous and marsh cover can exist in plains riparian seeps and swales, and prior to hydrologic alterations, woody understory composition likely had substantial components of native wetland species.

Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland: Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland systems occupy slightly higher elevations than Western Great Plains systems, ranging from 5,000-9,000 feet. Whereas plains riparian systems are primarily driven by local precipitation and groundwater inflow, foothill riparian zones are driven more by snowmelt in the mountains. Plains riparian systems are generally characterized by a tree canopy dominated by plains cottonwood (*P. deltoides*) and/or peachleaf willow *(S. amygdaloides),* and a shrub zone dominated by coyote willow *(S. exigua);* whereas foothills riparian systems tend to have higher shrub and tree cover, diversity, and vertical complexity. The transition between plains riparian and foothills riparian can be ambiguous where lower stream reaches that originate in the mountains extend far into the plains.

Range

This system is found in riparian areas of ephemeral to medium-sized streams and rivers throughout the western Great Plains. It is most common in Central Shortgrass Prairie and Southern Shortgrass Prairie ecoregions but extends west as far as the Rio Grande in New Mexico and into the Wyoming Basins. In Colorado, this system occurs on tributaries to the South Platte, Arkansas, Cimarron, and Republican rivers.



Spatial Pattern

Western Great Plains Riparian is a linear system.

Environment

Plains riparian systems are found within the floodplains of rivers, and on islands, sand or cobble bars, and immediate streambanks where they are intimately connected with surface or subsurface hydrologic processes. Water source for these streams systems varies by stream and even by reach, from flashy reaches driven by summer precipitation to perennial reaches connected to alluvial groundwater aquifers. Stream flow regimes are highly variable and are often water-limited for at least part of the year. Most plains streams are dominated by local rainfall events that typically produce low-volume, short-duration flows, and are generally dry or wadeable by mid-summer due to evapotranspiration and lack of precipitation.

The surrounding landscape of the western Great Plains has generally low topographic relief with level and gently rolling hills, but is occasionally punctuated by deep canyons and dramatic escarpments, buttes, mesas and volcanic peaks. Numerous streams and rivers dissect the landscape,

flowing north, south, and eastward into the major rivers of the region. The Colorado plains are situated in the rain shadow of the Rockies, causing dry, warm and sunny summers with daytime temperatures often 95° F or above. Rainfall is below twenty inches per year, with 70-80% falling in the spring and summer during the growing season. Wind speeds are high, and their drying effects, together with high temperatures, cause soil drying and summer drought. Climate in riparian zones is similar to the surrounding upland habitat, however the increased cover from the tree canopy moderates intense winds and sunlight and provides protected habitat to support diverse flora and fauna.

Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Highly stratified profiles consist of alternating layers of clay loam and organic material with coarser sand or thin layers of sandy loam over very coarse alluvium. Some soils are more developed due to a slightly more stable environment and greater input of organic matter.

Vegetation

Western Great Plains Riparian systems are characterized by narrow to wide stands of riparian forests or woodlands dominated by plains cottonwood, alternating sparsely wooded and grassland areas with shrublands dominated by willows, or open wooded washy gravel/sand flats. Riparian forest and woodland communities of this system are often dominated by plains cottonwood (*Populus deltoides* ssp. *monilifera*) but may include the hybrid lanceleaf cottonwood (*Populus* x *acuminata*), peachleaf willow (*Salix amygdaloides*), and occasionally oneseed juniper (*Juniperus monosperma*) in canyon systems. Other deciduous trees such as box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*) may contribute to the canopy. Willow species (commonly *Salix exigua*) may form a conspicuous layer with cottonwood saplings near the stream channel, or may form the overstory layer. The understory composition and structure are variable. A shrub layer may be present, with species such as willow (*Salix* spp.), western snowberry (*Symphoricarpos occidentalis*), silver sagebrush (*Artemisia cana*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and Woods' rose (*Rosa woodsii*).

The herbaceous stratum is variable. Drier sites contain graminoids such as blue grama (Bouteloua gracilis), foxtail barley (*Horedeum jubatum*), saltgrass (Distichlis *spicata*), Canada wildrye (*Elymus canadensis*), western wheatgrass (*Pascopyrum smithii*), and sand dropseed (*Sporobolus cryptandrus*). Wetter sites with a groundwater connection may contain Nebraska sedge (*Carex nebrascensis*), pale spikerush (*Eleocharis macrostachya*), common threesquare (*Schoenoplectus pungens*), or hardstem bulrush (*Schoenoplectus lacustris*). Subirrigated sites may support tallgrass meadows dominated by switchgrass (*Panicum virgatum*) or prairie cordgrass (*Spartina pectinata*). Common forbs species include poison ivy (*Toxicodendron rydbergii*), field horsetail (*Equisetum arvense*), showy milkweed (*Asclepias speciosa*), Canadian horseweed (*Conyza canadensis*), Canada goldenrod (*Solidago canadensis*), and American licorice (*Glycyrrhiza lepidota*).

Historically, most Western Great Plains streams and the surrounding grasslands appeared much differently than they do today. These historical riparian systems were a complex mosaic of plant

communities, which served as an oasis for wildlife that provided shelter, nesting and foraging resources. Today the grasslands have largely been replaced by agricultural fields and open range, some rivers have been narrowed into single-thread channels and in many places, cottonwood communities are decadent and have been replaced by mixed community type that consists of cottonwood, peach-leaved willow (*Salix amygdaloides*), box elder (*Acer negundo*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix ramosissima*) – of which the last four are non-native, introduced species. Other common non-natives include cheatgrass (*Bromus tectorum*), smooth brome (*Bromus inermis*), quackgrass (*Elytrigia repens*), redtop (*Agrostis gigantea*), Canada thistle (*Cirsium arvensis*), burning bush (*Kochia scoparia*), sweetclover (*Melilotus* spp.), dandelion (*Taraxacum officinale*), and yellow salsify (*Tragopogon dubius*). Planted hayfields and irrigated areas can lack trees but still can experience flooding. Reed canary-grass (*Phalaris arundinacea*) can invade sites with altered hydrology.

Plant Associations

CEGL002708	Panicum obtusum Grassland
CEGL001484	Panicum virgatum – (Pascopyrum smithii) Herbaceous Vegetation
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior) Floodplain Woodland
CEGL002685	Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua Riparian Woodland
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CEGL000660	Populus deltoides / Symphoricarpos occidentalis Floodplain Woodland
CEGL001203	Salix exigua / Mesic Graminoids Western Wet Shrubland
CEGL001476	Spartina pectinata Western Wet Meadow
CEGL001131	Symphoricarpos occidentalis Shrubland

Associated Animal Species

Plains riparian systems provide protected migration routes and abundant nesting, foraging and resources for many wildlife species including white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis virginiana*), muskrat (*Ondatra zibethicus*), western harvest mouse (*Reithrodontomys megalotis*) and fox squirrel (*Sciurus niger*). Cottonwood is an important forage, nesting and cover resource. Beavers (*Castor canadensis*) use plains cottonwood for food and for buildings dams and lodges. Cottonwood stabilize streambanks and thereby provide fish with thermal cover and protected undercut bank habitat. Plains cottonwood the most important browse species for mule deer in the fall. Abundant shelter, insects and warm temperatures make lowland riparian ecosystems important habitat for reptiles and amphibians and more of these species occur here than do other ecosystems in the region. Reptiles and amphibians most closely associated with riparian corridors include northern cricket frog (*Acris crepitans*), plains and northern leopard frog (*Rana blairi* and *R. pipiens*), smooth green snake (*Liochlorophis vernalis*), northern water snake (*Nerodia sipedon*), and common garter snake (*Thamnophis sirtalis*); the red-spotted toad (*Bufo*

punctatus) and canyon treefrog (*Hyla arenicolor*) occur primarily in riparian zones in rocky canyon bottoms.

In Northeastern Colorado Plains cottonwood stands provide habitat for 82% of all of the bird species breeding in northeastern Colorado. Birds closely associated with cottonwoods on the Great Plains of Colorado include Wild Turkey (*Meleagris gallopavo*), Bald Eagles (*Haliaeetus leucocephalus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*) which nest in cottonwood, Golden Eagles (*Aquila chrysaetos*), Lewis's Woodpecker (*Melanerpes lewis*) which breed predominantly in old decadent cottonwoods, Bullock's Oriole (*Icterus bullockii*), Yellow Warbler (*Setophaga petechia*), Western Kingbird (*Tyrannus verticalis*), Great Horned Owl (*Bubo virginianus*), Eastern Kingbird (*Tyrannus tyrannus*), American Kestrel (*Falco sparverius*), and Blue Grosbeak (*Passerina caerulea*).

Dynamic Processes

In a natural condition, this system often occurs as a mosaic of multiple communities with variable age-classes of woody species and floodplain features. Key variables driving vegetation dynamics in riparian sites include base and mean flow levels, the magnitude, seasonality, and frequency of peak flows, and the relative influence of groundwater on water tables. Episodic flood events and channel migration cause pulses of woody species establishment creating patches of different age classes. In areas where the water table drops below the stream channel, species composition is characterized by deep rooted phreatophytes like cottonwoods or dominance by upland grasses and weedy forbs tolerant of low soil moisture.

Fluvial processes play an integral role in the dynamics of Western Great Plains Riparian systems. The nature of these processes is often indicated by channel morphology. Meandering occurs in shallow gradient channels with low flow variability and fine-particled substrate, whereas braided channels have steep gradients, high flow variability and sediment dominated by coarse-particled material. Alluvial streams continually change their position as a consequence of hydraulic forces that result in bank erosion and sediment deposition which causes gradual, downstream movement of the overall stream pattern and a complete reworking of the floodplain/riparian zone.

Management

Riparian areas in the Colorado Western Great Plains have been substantially altered by anthropogenic land use and resource management. Alteration of natural hydrologic regimes by dams, diversions, ditches, roads, and groundwater usage have considerably changed channel morphology, riparian vegetation, and natural processes from pre-settlement conditions. When systems lack natural flooding due to human management, vegetation responds by shifting from wetland/riparian species to upland species, and systems may become dominated by later-seral communities due to the inability of pioneer species like cottonwoods and willow to establish. The floodplain feature can iteratively contract as channels downcut, and while wetland area may concentrate in the channel, overall support of characteristic wetland and riparian hydrology is reduced. Many systems in the plains are connected to groundwater, and as water is concentrated and stored in dams, and as ranching and agricultural adjacent land uses accumulate, underground

water reserves are being replenished less and less causing stream flow loss. Climatic drought also impacts moisture conditions in the unsaturated zones, and decreases streamflow and water table recharge. Increased nutrients from agricultural runoff can alter species composition by prompting aggressive, invasive species to displace native species. Concentrated, extended grazing impacts vegetation establishment and composition as well as bank conditions and erosion patterns. In addition, non-native woody species such as saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) are replacing willow and cottonwood stands throughout the plains. Lastly, the removal of beaver (*Castor canadensis*) has reduced habitat diversity and stability as channels incise, snowmelt flood peaks increase, sediment is altered and riparian and slow-velocity habitats are lost.

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Western Great Plains Saline Depression Wetland

General Description

In Colorado, Western Great Plains Saline Depressions are partially to fully isolated saline depressional basin herbaceous wetlands. Saline depressions are dispersed across the eastern Colorado plains river basins, sometimes directly adjacent to freshwater playas with a different water source or geologic influence. These closed depressions range from small playa-like basins to larger saline reservoirs and lakes, characterized by relatively impermeable-once-wetted clayey pond bottoms, shallow depressional topography, central sparsely vegetated zones or complete coverage of salt pans, and hydrology fed by both heavy precipitation events and groundwater discharge. Dominant, moderately salt-tolerant species include saltgrass (*Distichlis spicata*), common threesquare (*Schoenoplectus pungens*), and foxtail barley (*Hordeum jubatum*). Halophytes are generally also present with low to high cover in the active wetting/drying zones. Halophytic indicator species include red swampfire (*Salicornia rubra*), Mojave seablite (*Suaeda moquinii*), Pursh seepweed (*Suaeda calceoliformis*), verrucose seapurslane (*Sesuvium verrucosum*), salt heliotrope (*Heliotropium curassavicum*), and seaside arrowgrass (*Triglochin maritima*). Salt-tolerant shrubs such as greasewood (*Sarcobatus vermiculatus*), fourwing saltbush (*Atriplex*

canescens), and winterfat (*Krascheninnikovia lanata*) may be present in low cover or around the saline wetland fringe. Concentric vegetation zonation is also related to duration of inundation.

Saline basins and lakes are discharge wetlands, with dynamic ponding regimes that vary from ephemeral and predominately dry, to perennially saturated and semi-permanently flooded. Hydroperiod depends on wetland size, proportion of groundwater vs. surface water sources, and human hydrologic alterations. Water depths are often shallow but can be deep in larger lakes and irrigated occurrences, and the surface substrate surrounding ponded areas can be soft muck in saline basins, unlike the hardened saturated substrate around the ponded zone of freshwater playas.

Diagnostic Characteristics

These are small- to lake-sized, highly saline depressional basins lacking a surface water outlet, often with visible salt crusts and saline water chemistry, presence of halophytes, and vegetation with concentric zonation in response to wetness and salinity. Saline depressions can occur in semi-isolated depressions similar to freshwater closed depressions, but are characterized by high salinity soils, an outer ring of halophytic (salt-tolerant) vegetation, and a central unvegetated zone.

Similar Systems

Western Great Plains Closed Depression Wetland & Playa: The dominant native vegetation species in Colorado's Western Great Plains closed depression wetlands and playas are mostly freshwater associates. Saline depressions can occur in isolated locations similar to closed depressions and playas, but are characterized by high salinity soils, an outer ring of halophytic vegetation, and a central unvegetated zone due to water levels or higher salinity.

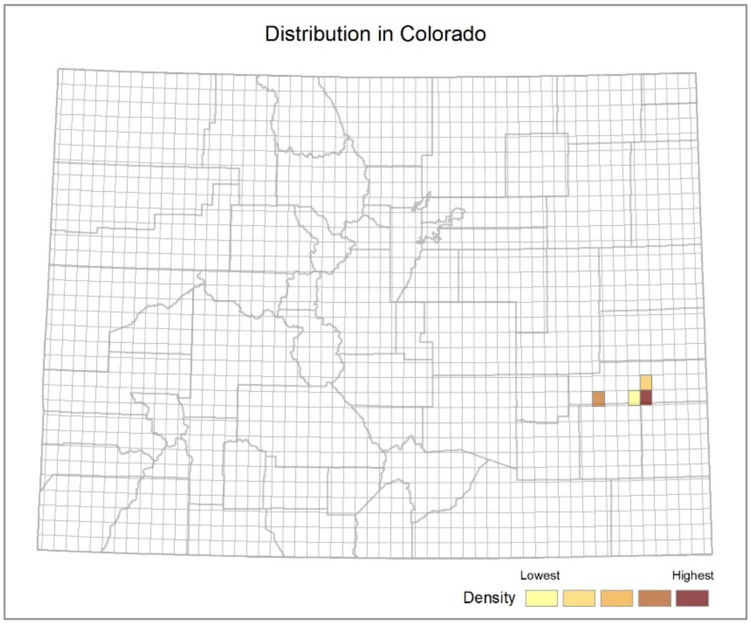
Western Great Plains Wet Meadow and Marsh Drainage Network: In Colorado, the wet meadow and marsh drainage network system can be saline but has linear outflow within a drainage network. Playa-like saline depressions generally do not have natural surface water outlets. However, several natural larger saline depressions in Colorado, including the Great Plains Reservoirs in the Arkansas basin, are used as water storage reservoirs and have ditches that connect the lakes to each other.

Inter-Mountain Basins Playas: Inter-mountain playas occur throughout the Intermountain West rather than the Great Plains.

Inter-Mountain Basins Greasewood Flat: Greasewood flats are shrub-dominated systems that can occur in mesic landscapes adjacent to herbaceous saline depressions. The two systems are often closely associated and there is some overlap in the vegetation composition between the two. Saline depressions are herbaceous wetlands, whereas greasewood flats are shrub-dominated with patches of herbaceous vegetation.

Range

This system can occur throughout the western Great Plains from Texas north into Canada but is likely more prevalent in the south-central portions of the division. Its distribution extends as far west as central Montana and eastern Wyoming where it occurs in the matrix of Northwestern Great Plains Mixedgrass Prairie, and south to Texas and New Mexico. In Colorado, this system occurs more prevalently within the Arkansas river basin north of the floodplain, specifically over the calcareous Niobrara formation. A more complete census is needed to determine the full distribution in the Western Great Plains.



Spatial pattern

Western Great Plains Saline Depression Wetland is a small patch type.

Environment

Saline lakes occur in similar landscapes to freshwater closed depressions and playas in the shortgrass prairie, and also occur in depressions below rolling vegetated sandhills and within salt-tolerant shrublands. They can occur as small herbaceous wetlands in saline headwater landscapes, or in larger complexes of saline groundwater discharge near large Colorado plains river floodplains. There are clustered occurrences north of the Arkansas River, such as the saline lakes known as the Great Plains Reservoirs. The surrounding environment can be stabilized sandhills and deflating dunes, shortgrass prairie, or irrigated areas outside of larger floodplains, and thus their substrate texture is more variable than freshwater playas with a mixture of coarse sandy and fine loamy to clayey soil textures. When wetted, soils in minimally altered saline depressions are relatively impermeable.

Vegetation

Species composition during the wet phase can be diagnostic most years. Species richness can be limited to very few species at any site, or restricted by species salinity tolerance, hypersaline water chemistry, and site conditions even where least altered. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some examples of this system and allow for less salt-tolerant species to occur. Conversely, species composition may fluctuate with lack of wetting, and upland species will populate and persist during dry phases.

Common species dominants are moderately salt-tolerant such as saltgrass (*Distichlis spicata*), common threesquare (*Schoenoplectus pungens*), and foxtail barley (*Hordeum jubatum*). Halophytes are generally also present with low to high cover where characteristic hydrology is intact. Halophytic indicator species are red swampfire (*Salicornia rubra*), Mojave seablite (*Suaeda*

moquinii), Pursh seepweed (*Suaeda calceoliformis*), verrucose seapurslane (*Sesuvium verrucosum*), salt heliotrope (*Heliotropium curassavicum*), and seaside arrowgrass (*Triglochin maritima*). Salt-tolerant shrubs such as greasewood (*Sarcobatus vermiculatus*), fourwing saltbush (*Atriplex canescens*), and winterfat (*Krascheninnikovia lanata*) may be present in low cover or around the saline outer wetland fringe. Other common species are common spikerush (*Eleocharis palustris*), cosmopolitan bulrush (*Bolboschoenus maritimus*), chairmaker's bulrush (*Schoenoplectus americanus*), goosefoot (*Chenopodium* spp.), scratchgrass (*Muhlenbergia asperifolia*), and dropseed (*Sporobolus* spp.). Tamarisk (*Tamarix* spp.) and burningbush (*Bassia* scoparia) can invade the outer vegetation zones, particularly when hydrology is altered. Some freshwater-origin playas can have similar vegetation and salt accumulation to saline depressions, especially when irrigation leaches salts from surrounding upland soils into the feature. Saltgrass (*Distichlis spicata*) is the most consistently observed species in surveyed eastern Colorado occurrences, where it forms a wet meadow ring outside of the unvegetated salt-crust area, or a wide wet meadow fringe to saline lakes, similar in appearance to saltgrass-dominated eastern Colorado river floodplain meadows.

Saline depressions can be closely associated with greasewood and saltbush plant associations outside of the ponding zone. In addition to the surface water source, many or potentially all of the saline depressions in this region, including saline wet meadows, appear to receive groundwater input or subsurface irrigation secondary to their surface water source.

Plant Associations

CEGL001843	Bolboschoenus maritimus Marsh
CEGL001770	Distichlis spicata Alkaline Wet Meadow
CEGL001582	Distichlis spicata – Hordeum jubatum – Puccinellia nuttalliana – Suaeda calceoliformis Wet Meadow
CEGL001582	Pascopyrum smithii - Hordeum jubatum Wet Meadow
CEGL001799	Puccinellia nuttalliana Salt Marsh
CEGL001999	Salicornia rubra Salt Flat
CEGL004144	Schoenoplectus americanus - Carex spp. Marsh
CEGL001587	Schoenoplectus pungens Marsh
CEGL001688	Sporobolus airoides Monotype Wet Meadow
CEGL002040	Schoenoplectus pungens – Sueda calceoliformis Alkaline Marsh
CEGL001685	Sporobolus airoides Southern Plains Wet Meadow

Associated Animal species

Numerous birds species flock to the larger and managed saline reservoirs, especially shorebirds, gulls, terns, and waterfowl, such as: piping plovers (*Charadrius melodus*), American coots (*Fulica americana*), American avocets (*Recurvirostra americana*), American white pelicans (Pelecanus erythrorhynchos), northern pintails (*Anas acuta*), grebes (*Aechmorphorus* spp.), and the ring-billed gulls (*Larus delawarensis*). Information is lacking on wildlife use in the non-irrigated saline playa-like basins in eastern Colorado. Saline depressional wetlands likely support unique invertebrate and brine-associated aquatic species, and provide habitat for a number of at-risk wildlife species outside of Colorado.

Dynamic processes

Saline depression hydrology is governed by wet and dry phases. Water sources are a combination of perched water from precipitation and groundwater discharge. Storm events or consistent wet years can cause water to pond on the surface of fine textured soils. Basin topography prolongs inundation, and as discharge wetlands, significant water is lost to evaporation. Microbial and algae mats can occur on the surface and their presence plays a role in water dynamics, photosynthesis, and salt concentrations. Natural saline basins and lakes function as discharge wetlands, with water from groundwater sources or downslope regional groundwater movement concentrating in shallow depressions.

There is little study on saline depressional wetland hydrodynamics in eastern Colorado. In more studied saline wetland regions of Canada and the southern United States, some wetlands depend on local artesian spring discharge, and plant establishment is associated with groundwater discharge areas. Other water sources include high water tables associated with unconsolidated surficial aquifers, lateral groundwater flow, and possibly shallow bedrock aquifers. The mineral and sediment sources supporting saline water chemistry can be highly diverse, with composition influenced by regional factors, basin geomorphology, and groundwater source and flow paths. Geologic studies outside of Colorado have attributed salt sources to deep bedrock geology rather than surface soil chemistry.

Management

Maintaining an intact surrounding landscape with native plant cover is important to supplying overland runoff to small saline playas. Groundwater depletion poses a significant threat to all saline ecosystems, which can be compounded by droughts and increased evaporation associated with climate change. Water withdrawals and additions, and ditches in large saline playas can alter the timing and duration of wetting, which increases ecosystem sensitivity to sedimentation and exotic invasion. The larger examples of this system often have altered hydrology influenced by management and ditches or pipes. Some occurrences have evidence of declining groundwater levels and retracting wetted occurrence size Long-term irrigation and groundwater pumping can cause trends of increased salinity across the saline wetland populations.. However, if lowered water tables result in loss of wetland connection to an artesian spring source in salina wetlands (or groundwater-dependent saline wetlands), the wetland can dry or transform to a surface water-fed wetland with reduced hydrology.

Sedimentation from nearby tilled or irrigated land can impact wetland hydroperiods and water storage. Large saline reservoirs are frequently managed for irrigation storage, and in those cases, managing reservoir levels and fluctuations to mimic natural hydroperiods contributes to overall system health. Hydrologic alterations can also transform the substrate and support temporary herbaceous and long-term woody invasive species establishment. Due to the semi- to isolated nature of these features, chemical weed treatment has the potential to have cascading impacts on species composition. Overall, recognition and conservation of the wetland resource, groundwater inputs, and contributing basin landscape connectivity is needed for long-term sustainability. More research on the eastern Colorado saline wetlands is needed to better describe and understand their

driving ecosystem processes, associated flora and fauna assemblages, and their importance for wildlife.

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Western Great Plains Wet Meadow and Marsh Drainage Network

General Description

The Colorado Western Great Plains Wet Meadow and Marsh Drainage Network Ecological System includes wetland types in NatureServe's Western Great Plains Open Freshwater Depression Wetland system. This Western Great Plains herbaceous-dominated wetland system includes submergent and emergent marshes, wet meadows, fens, and narrow drainages set in the headwaters of prairie streams and along small tributary drainages. Shrub patches may also occur on slope seeps and along low-gradient riparian reaches that do not support trees. These drainage networks originate in the plains or lower foothills grasslands and are fed by groundwater, seep/springs, surface runoff, precipitation, and ephemeral to intermittent channel flow. This wetland ecological system has patchy vegetation and hydrology with zones of marshes, ponds, wet meadows, salt crusts, and swales, which align with points of groundwater discharge and topographic features that support moisture retention.

Herbaceous wetland species characterize this system, including emergent species of cattail (*Typha* spp.), sedge (*Carex* spp.), spikerush (*Eleocharis* spp.), bullrush (*Schoenoplectus* spp.), rush (*Juncus* spp.), and cordgrass (*Spartina* spp.), as well as floating species such as pondweed (*Potamogeton* and *Stuckenia* spp.), arrowhead (*Sagittaria* spp.), duckweed (*Lemna* spp.), and horned pondweed

(*Zannichellia palustris*). Nebraska sedge (*Carex nebrascensis*), pale spikerush (*Eleocharis macrostachya*), and American licorice (*Glycyrrhiza lepidota*) are common freshwater species; foxtail barley (*Hordeum jubatum*) and saltgrass (*Distichlis spicata*) are common in alkaline zones. Willow (*Salix* spp.) and other short-statured shrubs can be present with low cover.

This ecological system encompasses herbaceous drainage networks nested within the surrounding prairie ecosystems. Plains wet meadow and marshes can occur as zones of outer wet meadow and central marsh vegetation along a slope with a seasonal to perennial groundwater source. They can also occur as linear complexes of herbaceous vegetation within the stream bed, semi-permanent groundwater-fed ponds, and surface water-fed pools perched by fine-textured soil in channel depressions. Peat-accumulating wet meadows and fens, marshes, and shrub wetlands occur on or within headwaters, lowland open basins, points of spring discharge, tributary confluences, alluvial fans, and transition zones between losing and gaining stream reaches along geologic gradients. Altered examples include saturated wet meadows or marsh fringes that surround excavated or impounded ponds and small reservoirs that have been developed within drainage networks.

Diagnostic Characteristics

In eastern Colorado, these are herbaceous riparian and groundwater-fed wetland complexes of prairie headwaters and small streams. They are distinguished by low-energy dynamics that favor herbaceous vegetation on slopes or within channels with hydrology sustained by groundwater, or ephemeral channels with open depressional topography that seasonally ponds surface water.

Similar Systems

Western Great Plains Wet Meadow and Marsh Drainage Network: this Colorado system includes wetland types in NatureServe's Western Great Plains Open Freshwater Depression Wetland system. Research on the processes that influence wetland salinity and hydrology of intermittent ponds and wet meadows in eastern Colorado could increase our understanding of differences between the various plains wetland ecological systems.

Western Great Plains Riparian: The Western Great Plains Riparian ecological system is differentiated by higher energy flooding dynamics, site capacity for tree establishment, and seasonally flowing open water channels or ephemeral and often sandy sparsely vegetated washes and floodplains. In contrast, wet meadow and marsh drainage network wetlands have a higher watershed position, stronger ground-water influence, open depressional landform, and lower-energy wetland processes than riverine flooding-driven ecosystems.

Western Great Plains Closed Depression Wetland & Playa: Closed depressions and playas are distinguished by their closed topography. There can be within-channel depressions within the wet meadow and marsh drainage network system, but these depressions are clearly linked within the drainage network.

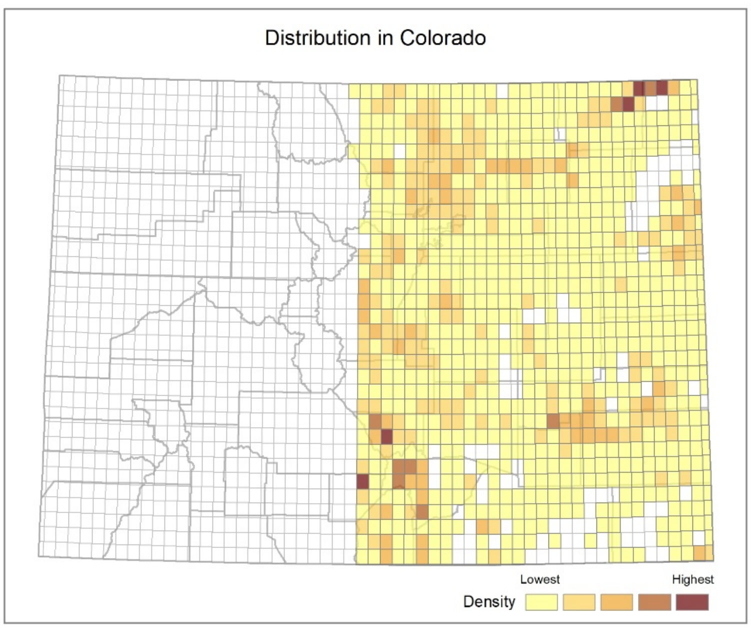
Western Great Plains Saline Depression: Some eastern Colorado headwater wetlands within the Western Great Plains Wet Meadow and Marsh Drainage Network have variable soil water alkalinity

from freshwater to moderately alkaline within the same wetland complex, and this Colorado system may overlap with open (vs. closed) occurrences of Western Great Plains Saline Depressions. For Colorado, the Western Great Plains Saline Depression system is focused on saline depressions with generally closed topography.

<u>Western North American Emergent Marsh</u> and <u>Rocky Mountain Subalpine Montane Wet Meadow:</u> The Western Great Plains Wet Meadow and Marsh Drainage Network describes wet meadows and marshes in the prairie and lower foothill grassland landscape in contrast to higher elevations. Marshes and wet meadows in the large river floodplains of eastern Colorado belong as herbaceous patch types within the Western Great Plains Floodplain system. Some of the vegetation communities also occur in the larger riparian and floodplain systems and should not be considered a separate system in that case.

Range

This system occurs widely throughout the western Great Plains from Texas north to Canada, east of the Rocky Mountains and generally west of the Mississippi River. In eastern Colorado occurrences are widely distributed in mesic to wet prairie habitats in headwaters and small order drainages.



Spatial pattern

Western Great Plains Wet Meadow and Marsh Drainage Network is a small patch type.

Environment

Set in the semi-arid Western Great Plains, in Colorado this ecological system is the drainage network of headwaters and small streams within grasslands of the state's eastern plains and lower foothills. Wetlands of this network result from distinct increases in site moisture in response to groundwater discharge and prolonged surface water retention in local depressions within drainage networks. Regional annual precipitation is generally less than 20 inches and varies with regular wet and drought year climatic cycles. Groundwater availability is a major driver in the sustenance of the wet meadow, marsh, and open depressional wetlands, many which have areas of perennial surface saturation or inundation. Seasonal wet meadow and herbaceous riparian zones alternate between wetland and non-wetland riparian areas, and surface runoff into and through in-channel depressions is a water source for the drainage network.

Vegetation

Herbaceous wetland species characterize this system, including emergent species of cattail (*Typha* spp.), sedge (*Carex* spp.), spikerush (*Eleocharis* spp.), bullrush (*Schoenoplectus* spp.), rush (*Juncus* spp.), and cordgrass (*Spartina* spp.), as well as floating species such as pondweed (*Potamogeton* and *Stuckenia* spp.), arrowhead (*Sagittaria* spp.), duckweed (*Lemna* spp.), and horned pondweed (*Zannichellia palustris*). Nebraska sedge (*Carex nebrascensis*), pale spikerush (*Eleocharis macrostachya*), and American licorice (*Glycyrrhiza lepidota*) are common freshwater species; foxtail barley (*Hordeum jubatum*) and saltgrass (*Distichlis spicata*) are common in alkaline zones. Willow (*Salix* spp.) and other short-statured shrubs can be present with low cover. Less typical sedge species of the Colorado plains occur in peat-accumulating plains wetlands, such as analogue sedge (*Carex simulata*), bottlebrush sedge (*C. hystericina*), Northwest Territory sedge (*C. utriculata*), and golden sedge (*C. aurea*). Dominant cover of Nebraska sedge (*C. nebrascensis*) or wooly sedge (*C. pellita*), or presence of marsh skullcap (*Scutellaria galericulata*), cutleaf water parsnip (*Berula erecta*), blue-eyed grass (*Sisyrinchium* spp.), and monkeyflower (*Mimulus* spp.) are often indicators of sites with organic soils. Peat-accumulating wetlands can have unique vegetation diversity and assemblages, where plains species intermix with species more typical of montane and western Colorado, including fowl mannagrass (*Glyceria striata*), violet (*Viola* spp.), avens (*Geum* spp.), goldenrod (*Solidago* spp.), and poison ivy (*Toxicodendron rydbergii*).

Plant Associations

CEGL001802	Carex aquatilis Wet Meadow
CEGL001813	Carex nebrascensis Wet Meadow
CEGL002254	Carex pellita - Calamagrostis stricta Wet Meadow
CEGL001825	Carex simulata Fen
CEGL002268	Carex spp./ Triglochin maritima/ Eleocharis quinqueflora marl fen
CEGL001562	Carex utriculata Wet Meadow
CEGL002634	Eleocharis palustris – Carex praegracilis – Berula erecta Marsh
CEGL005291	Eleocharis palustris Great Plains Marsh
CEGL001569	Glyceria striata Wet Meadow
CEGL001838	Juncus arcticus ssp. littoralis Wet Meadow
CEGL005286	Hordeum jubatum Great Plains Wet Meadow
CEGL001484	Panicum virgatum – (Pascopyrum smithii) Herbaceous Vegetation
CEGL001581	Pascopyrum smithii – Eleocharis spp. Wet Meadow
CEGL003321	Sagittaria latifolia Aquatic Vegetation
CEGL001202	Salix exigua/Mesic Forbs Wet Shrubland
CEGL002225	Schoenoplectus acutus – (Schoenoplectus fluviatilis) Freshwater Herbaceous Vegetation
CEGL002030	Schoenoplectus acutus - Typha latifolia - (Schoenoplectus tabernaemontani) Sandhills Marsh
CEGL002623	Schoenoplectus tabernaemontani Temperate Marsh
CEGL001478	Spartina pectinata – Schoenoplectus pungens Wet Meadow
CEGL002010	Typha (latifolia, angustifolia) Western Marsh
CEGL002033	Typha latifolia – Equisetum hyemale – Carex (hystericina, pellita) Seep Herbaceous Vegetation
CEGL002389	Typha spp. Great Plains Herbaceous Vegetation
CEGL002389	Typha spp. – Schoenoplectus spp. – Mixed Herbs Great Plains Herbaceous Vegetation

Associated Animal species

Semi-permanent refuge pools within intermittent streams and saturated to shallow water plains wet meadows and marshes provide habitat for wildlife species that require perennial water. Leopard frogs (*Lithobates blairi* and *L. pipiens*) frequent perennially saturated wet meadows. Colorado plains fishes of conservation concern such as Arkansas darters (*Etheostoma cragini*), plains topminnows (*Fundulus sciadicus)*, brassy minnows (*Hybognathus hankinsoni*), and the southern redbelly dace (*Chrosomus erythrogaster*) are found in within-channel groundwater-fed marshes and intermittent ponds, along with other native plains fish such as plains killifish (*Fundulus zebrinus*), fathead minnows (*Pimephales promelas*), and Iowa darters (*Etheostoma exile*). A targeted wildlife inventory for wet meadow and marsh drainage networks in eastern Colorado would help better understand the non-fish wildlife species of common guilds such as birds, snakes, frogs and toads, turtles, small mammals, and mollusks and other invertebrates that depend on this system.

Dynamic Processes

Along with drought and groundwater influences, processes that historically influenced wetland ecosystems in the Western Great Plains included natural disturbance regimes such as flooding and surface runoff during spring snowmelt and storm events, landslides, native ungulate grazing, fire, and beaver activity in some drainages. Groundwater depletion, stream flow alteration and floodplain disconnection, and agricultural conversion have resulted in wetland loss, and many remaining occurrences have lowered water tables. More research is needed, particularly on groundwater sources and natural disturbance regimes in herbaceous wetlands of the Colorado plains.

Few studies have examined the distribution and formation of groundwater-dependent, often peat-accumulating wetlands in the Colorado Plains. These wetland types have similarities in vegetation and hydrology to ciénegas of the southwest that are described throughout New Mexico. Multiple occurrences are documented in the Arkansas Basin Piedmont between the Palmer Divide and north of the Arkansas River in watersheds such as Chico Basin, Horse Creek, and Black Squirrel Creek. Field surveys and indicators of saturation in aerial imagery suggest that peat-accumulating wetlands are scattered throughout the Arkansas, Republican, and South Platte river basins in relatively intact grassland areas of the western Great Plains. In the larger peat-accumulating wet meadows and marshes, intermediate sandy layers that influence groundwater hydraulics indicate a dynamic formation history. Some occurrences are located in historical eolian sand dune areas, while others have shallow groundwater access from sandy alluvial sheet flow. Locations below paleo sand dune-bridges and other land formations restricting outflow, similar to the Nebraska sandhill fens, may also drive wetland formation. Steeper side-slope organic soil wetlands are also found where groundwater discharges into small depressions at the top of bank slumps, as documented in Chico Basin. Dense herbaceous graminoid wetland vegetation that transpires shallow groundwater in a basin contributes to increased site microclimate humidity and the moisture levels needed for organic soil. Hydraulic and geologic controls also play a role in retaining moisture in an otherwise semi-arid landscape.

Management

Groundwater-fed wet meadows, marshes, and fens are inherently sensitive ecosystems that need intact hydrologic and geomorphic processes to maintain wetland hydrology in regions with high evapotranspiration rates. Land use activities such as grazing, mowing, ditching, surface water impoundment, and groundwater withdrawals can compact and oxidize organic soil layers, and reduce the density and diversity of associated native plant communities. Precipitation and runoff-fed riparian depressions and drainages can experience exotic plant invasion and wetland drying if stream channels and surrounding landscapes no longer provide sufficient flow and surface runoff due to impoundments, stream flow diversions, soil tillage, and prairie conversion to irrigated or dryland crops. Ditching and filling contributing seeps and springs is common in the plains and can cause wetlands to contract and transition to uplands, often dominated by weedy plant species. Headwater seeps lose biodiversity and ecological function when excavated or impounded and transformed into ponds.

Groundwater-fed herbaceous wetlands and intact intermittent small streams are biodiversity hotspots and corridors in the Western Great Plains. They provide critical habitat for native fish and amphibians, support unique vegetation diversity, and provide refugia for many wildlife species that rely on aquatic resources within prairie grassland habitat. Groundwater dependent, organic soil wetlands in the Great Plains are estimated to be thousands of years old, but have ongoing loss by drainage and drying from a long history of cumulative land use, groundwater depletion, loss of stream-floodplain connectivity, and potentially from higher temperatures and more severe drought events due to climate change. Targeted surveys are needed to document and map the remaining groundwater-dependent wetlands of the Colorado plains, especially peat accumulating wetlands and fens. As wetland resources of high conservation value, these prairie groundwater ecosystems would benefit from fine-scale inventory across the Colorado plains, in order to monitor impacts from climate change and land/water use, and evaluate their candidacy for protection. Preserving and improving wetland condition and hydrologic and surrounding upland landscape connectivity is key for preventing further loss of wet meadow and marsh drainage networks of the Colorado plains.

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GLOSSARY OF TERMS

Dwarf-shrub: low-growing, short-statured woody plant (shrub), often with buds and branches lying on or close to the ground. See also Subshrub.

Element occurrence: an area of land and/or water in which a species or natural community is, or was, present.

Facultative Upland Plants (FACU): Usually occur in non-wetlands, but may occur in wetlands.

Facultative Wetland species (FACW): Usually occur in wetlands (67-99% of occurrences), but may occasionally be found in non-wetland areas. Usually a hydrophyte. These plants predominately occur with hydric soils, often in geomorphic settings where water saturates the soils or floods the soil surface at least seasonally.

Forb: Any herbaceous flowering plant, other than a grass or other graminoid.

Graminoid: any grass or grass-like plant (e.g. sedges and rushes).

Herbaceous: With the characteristics of an herb; having the texture and color of a foliage leaf; a plant with no persistent woody stem above ground.

Hydric soil: Undrained, wet soil which is anaerobic, or lacks oxygen in the upper levels.

Hydrophyte: a plant that grows either partly or wholly submerged in water; also, a plant growing in waterlogged soil.

Large patch ecological system: an ecological system that may form the dominant vegetation type in stands of several thousand acres, but is often interspersed with other system types.

Linear ecological system: an ecological system that occurs along a landscape feature such as a stream, river, drainage, or other linear feature. Occurrences may be small to large.

Matrix-forming: in the case of ecological systsems, indicates widespread, dominant vegetation types that cover large areas of thousands to millions of acres. Other ecological system types may occur on smaller areas within the overall matrix.

Natural Vegetation: in general, plants and naturally occurring plant communities that have not been cultivated by people, and which reproduce and establish via normal dispersal, although in some instances (e.g., restoration) vegetation establishment may have received anthropogenic assistance.

Obligate Wetland species (OBL): Occur almost always (99% of occurrences) under natural conditions in wetlands. Almost always a hydrophyte. Plants are submerged, floating, floating-leaved, or emergent types.

GLOSSARY

Riparian: Pertaining to the banks of a river, stream, waterway, or other, typically, flowing body of water as well as to plant and animal communities along such bodies of water. This term is also commonly used for other bodies of water, e.g., ponds, lakes, etc., although Littoral is the more precise term for such stationary bodies of water.

Small patch ecological system: an ecological system type whose characteristic vegetation is generally found in small, often discrete patches of one to several hundred acres, and is typically embedded within a mixture of types that may be small, linear, large, or matrix-forming.

Subshrub: a dwarf shrub, a perennial plant that is woody only at the base

Terrestrial: Living or growing on land rather than in water or air.

Upland: The ground above a floodplain; that zone sufficiently above and/or away from transported waters as to be dependent upon local precipitation for its water supplies. Land which is neither a Wetland nor covered with water.

Upland Plants (UPL): Almost never occur in wetlands. These plants occupy mesic to xeric non-wetland habitats. They almost never occur in standing water or saturated soils. Typical growth forms include herbaceous, shrubs, woody vines, and trees.

Wetland: An area that is periodically inundated or saturated by surface or groundwater on an annual or seasonal basis, that displays hydric soils, and that typically supports or is capable of supporting hydrophytic vegetation. Wetlands, also Wetland (General) — Wetlands are those areas where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. The identification of wetlands and associated habitats is regulated by complex federal legislation. The U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (COE), the (U.S. Department of Agriculture) Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service — SCS), and the (Department of the Interior) U.S. Fish and Wildlife Service (USFWS), have developed definitions of wetlands in response to their regulatory responsibilities. The single feature that all wetlands have in common is a soil or substrate that is saturated with water during at least a part of the growing season. These saturated conditions control the types of plants and animals that live in these areas. Other common names for wetlands are Sloughs, Ponds, Swamps, Bogs, and Marshes. Basically, all definitions of wetlands require that one or more attributes be met: [1] Wetland Hydrology — At some point of time in the growing season the substrate is periodically or permanently saturated with or covered by water; [2] Hydrophytic Vegetation — At least periodically, the land supports predominantly water-loving plants such as cattails, rushes, or sedges; [3] Hydric Soils — The area contains undrained, wet soil which is anaerobic, or lacks oxygen in the upper levels.

Woody: A seed plant that develops persistent, hard, fibrous tissues, basically xylem; e.g., trees and shrubs.

Definition sources:

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