Chapter 3: Habitats

This chapter presents updated information on the distribution and condition of key habitats in Colorado. The habitat component of Colorado's 2006 SWAP considered 41 land cover types from the Colorado GAP Analysis (Schrupp et al. 2000). Since then, the Southwest Regional GAP project (SWReGAP, USGS 2004) has produced updated land cover mapping using the U.S. National Vegetation Classification (NVC) names for terrestrial ecological systems. In the strictest sense, ecological systems are not equivalent to habitat types for wildlife. Ecological systems as defined in the NVC include both dynamic ecological processes and biogeophysical characteristics, in addition to the component species. However, the ecological systems as currently classified and mapped are closely aligned with the ways in which Colorado's wildlife managers and conservation professionals think of, and manage for, habitats. Thus, for the purposes of the SWAP, references to the NVC systems should be interpreted as wildlife habitat in the general sense.

Fifty-seven terrestrial ecological systems or altered land cover types mapped for SWReGAP have been categorized into 20 habitat types, and an additional nine aquatic habitats and seven "Other" habitat categories have been defined. SWAP habitat categories are listed in Table 4 (see Appendix C for the crosswalk of SWAP habitats with SWReGAP mapping units). Though nomenclature is slightly different in some cases, the revised habitat categories presented in this document are consistent with those defined in the 2006 SWAP with the following exceptions:

- Douglas Fir and White Fir, formerly stand-alone habitat categories, have been included in the Mixed Conifer category;
- Limber Pine and Bristlecone Pine have been combined into Subalpine Limber and Bristlecone Pine;
- Tallgrass Prairie and Midgrass Prairie have been combined into Mixed-grass and Tallgrass Prairies;
- Sand Dune Complex (Grassland) and Sand Dune Complex (Shrubland) have been combined into the Sandsage category, and a separate Sand Dunes category has been added to distinguish sandy prairie habitats from true sand dune habitats;
- Meadow Tundra and Shrub Tundra, formerly stand-alone categories, have been combined under Alpine;
- Exposed Rock has been split into Alpine (high elevation bedrock, screen, ice fields and fellfields) and Cliffs & Canyons (cliffs, canyons, outcrops, and tablelands of Rocky Mountains, Western Great Plains, and Intermountain Basins)
- A Riparian Woodlands and Shrublands category has been added to better distinguish terrestrial stream-side habitats from aquatic habitats.

A widely-accepted, broad-scale classification comparable to the NVC does not currently exist for aquatic habitats. For the 2006 SWAP, we defined aquatic habitat categories that had meaning for wildlife managers and stakeholders. For this iteration of the SWAP, we have revised the original aquatic habitat categories to more explicitly relate aquatic habitats to associated physiographic regions. Watershed characteristics such as elevation, vegetation and geology strongly influence key aspects of aquatic habitat such as gradient, temperature, and turbidity, which in turn shape aquatic species distributions within the state. Changes to aquatic habitat categories are:

- West Slope Rivers and West Slope Streams have been re-categorized as Colorado Plateau – Wyoming Basins Rivers and Streams;
- Rio Grande Valley Rivers and Streams have been added as unique habitat categories;
- Lakes and Open Water categories have been revised to distinguish natural lakes (still the Lakes category) from other types of open water and associated habitats (now split into the Reservoirs & Shorelines and Hot Springs categories).

Table 4. Wildlife habitats in Colorado.

Habitat Type	Habitat Community
Forest	Aspen
Forest	Lodgepole Pine
Forest	Mixed Conifer
Forest	Pinyon-Juniper
Forest	Ponderosa Pine
Forest	Spruce-Fir
Forest	Subalpine Limber-Bristlecone Pine
Shrub	Desert Shrub
Shrub	Greasewood
Shrub	Oak and Mixed Mountain Shrublands
Shrub	Sagebrush
Shrub	Saltbush
Shrub	Sandsage
Shrub	Upland Shrub
Grassland	Foothill and Mountain Grasslands
Grassland	Mixed and Tallgrass Prairies
Grassland	Shortgrass Prairie
Riparian and Wetland	Playas
Riparian and Wetland	Riparian Woodlands and Shrublands
Riparian and Wetland	Wetlands
Aquatic	Colorado Plateau - Wyoming Basins Rivers
Aquatic	Colorado Plateau - Wyoming Basins Streams
Aquatic	Eastern Plains Rivers
Aquatic	Eastern Plains Streams

Habitat Type	Habitat Community
Aquatic	Lakes
Aquatic	Mountain Streams
Aquatic	Rio Grande Valley Rivers
Aquatic	Rio Grande Valley Streams
Aquatic	Transition Zone Streams
Other	Agriculture
Other	Alpine
Other	Cliffs and Canyons
Other	Conservation Reserve Program (CRP)
Other	Hot Springs
Other	Reservoirs and Shorelines
Other	Sand Dunes

Distribution and Condition of Habitats

Figure 1 shows the distribution of terrestrial habitats dominated by native vegetation. Figure 2 shows the distribution of aquatic habitats. Some habitats that occur in small patches are not detectable when displayed on a letter-size statewide map. These include many lakes, wetlands, playas, and hot springs, as well as some riparian areas. Where data were available for these small-patch habitats, habitat features have been enhanced for readability in Figure 1. Finer scale mapping of wetlands in Colorado has been developed through a partnership between the U.S. Fish and Wildlife's National Wetland Inventory Program, U.S. Environmental Protection Program, the Colorado Natural Heritage Program, and Colorado Parks and Wildlife. Playas have been mapped by Playa Lakes Joint Venture and Rocky Mountain Bird Observatory[6]. Three types of agricultural land uses provide wildlife habitat in Colorado: rangeland, cropland, and Conservation Reserve Program (CRP) lands. Rangeland is included under the grassland habitat types. Cropland and CRP are treated as separate habitat types, but current spatial data at a statewide scale are not available; thus, these two habitats do not appear on Figure 1.

Brief descriptions of each habitat follow. Portions of habitat summaries have been excerpted, with permission, from Rondeau et al. 2011, CNHP 2005-2007, and NatureServe 2014, with modifications where necessary to accurately reflect revised SWAP habitat categories. Information related to general habitat condition has been summarized from these and other sources (e.g., Colorado's 2013 Forest Health Report), and from ecosystem experts at the Colorado Natural Heritage Program.

Tables 7 and 8 list the SGCN that are associated with each habitat type, by species and by habitat, respectively. SGCN for which the habitat is a primary habitat are marked. For the purposes of this SWAP, "primary habitat" refers to the habitat(s) in which a species is most typically found,

[6] For the most recent data available, contact the Colorado Natural Heritage Program, www.cnhp.colostate.edu for wetlands and Bird Conservancy of the Rockies, www.birdconservancy.org, for playas.

or that is crucial to the completion of one or more phases of the species' life cycle. Simplifying the complex factors that constitute "habitat" into broad categories that can be mapped at a statewide scale is always going to be an imperfect process. The species/habitats relationships in Tables 7 and 8 do not always recognize small-scale nuances. For example, grouse are known to use wet meadows interspersed within shrubland communities for brood rearing. However, these features are often not mappable at a statewide scale. Furthermore, these wet meadows are distinct from the statewide habitat category for "wetlands." So even though grouse require moist habitats, including the wetland habitat category, as defined for this SWAP, would be inappropriate. Local scale conservation work should always be based on site-specific conditions.

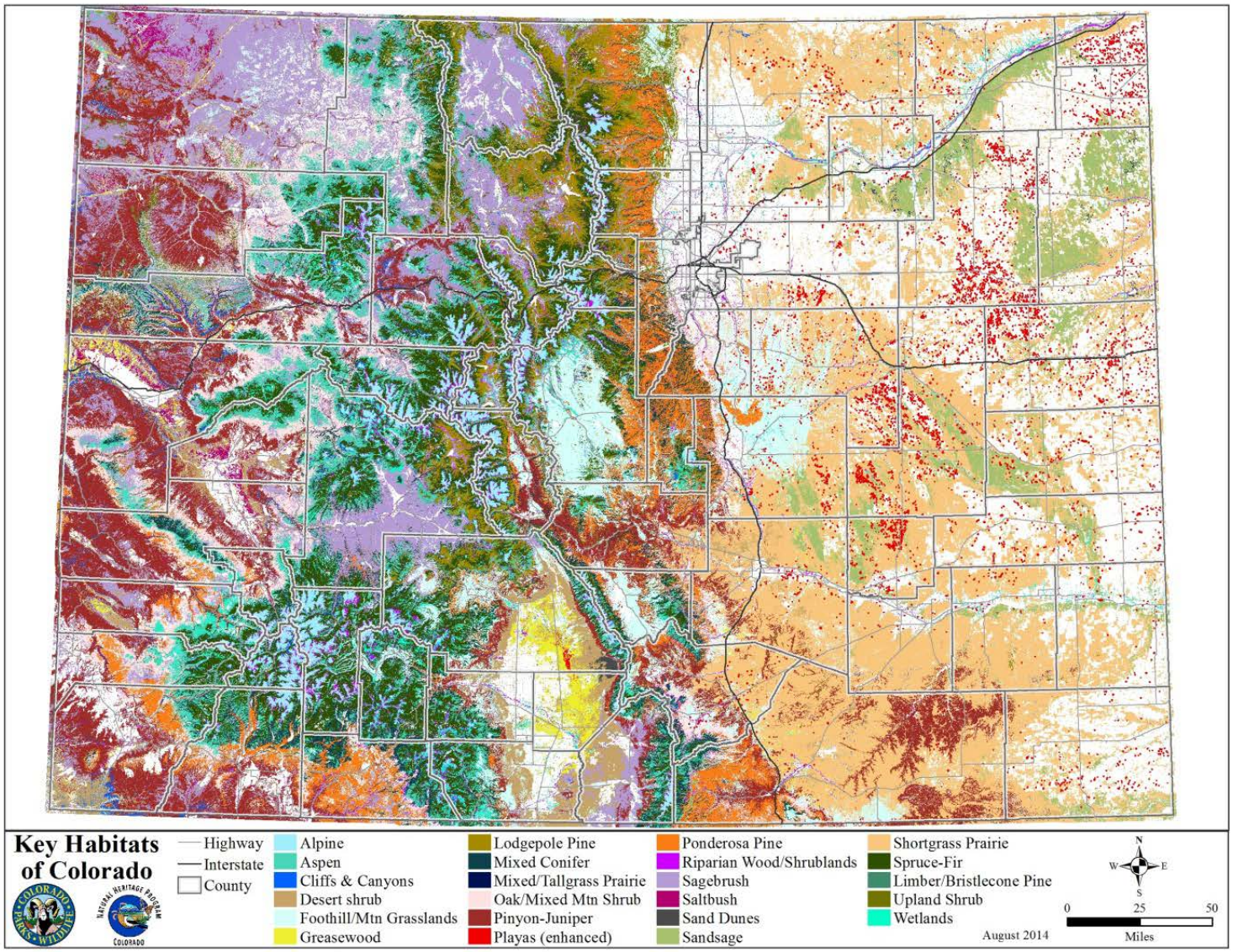

Figure 1. Distribution of key terrestrial habitats in Colorado.

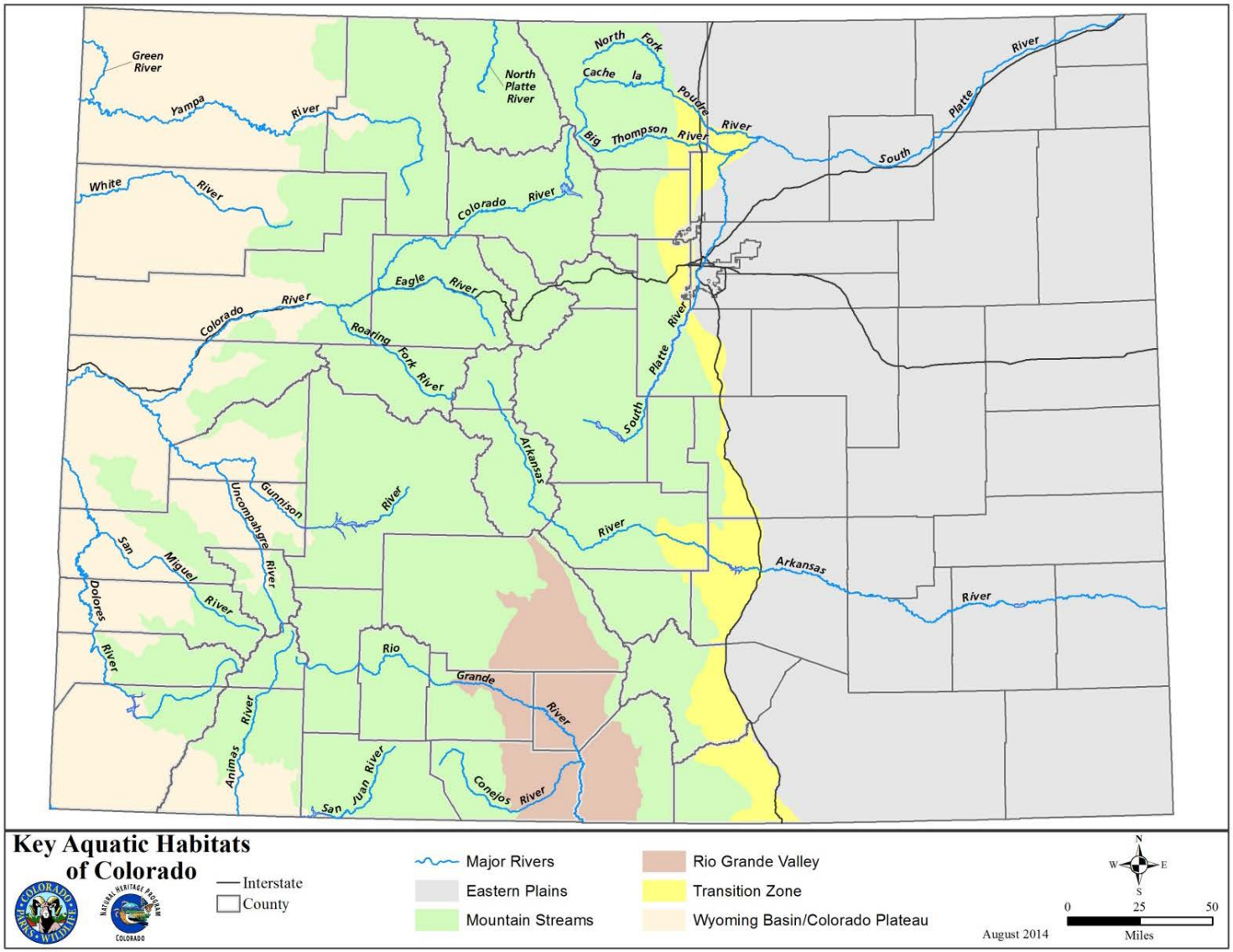

Figure 2. Distribution of key aquatic habitats.

FOREST AND WOODLAND HABITATS

Aspen

Aspen supports 29 SGCN (Table 8). In Colorado, aspen forests are quite common on the western slope, with smaller stands represented on the east slope. These forests cover more than three and a half million acres in Colorado, including one patch of more than a half million acres on the edges of the White River Plateau and Flat Tops. These are upland forests and woodlands dominated by quaking aspen (*Populus tremuloides*), ranging in elevation from about 7,500 to 10,500 feet. Aspen forests and woodlands usually contain a mosaic of many plant associations and may be surrounded by a diverse array of other ecological systems, including grasslands, wetlands, and coniferous forests.

Primary threats to aspen forests in Colorado include fire suppression, excessive browsing (especially by elk), and Sudden Aspen Decline (SAD), which is especially troublesome in the southwestern portion of the state (CSFS 2010). The cause(s) of SAD are unclear and research to identify stressors is on-going. Currently, SAD is not widely distributed across the state, but there is potential for this condition to pose a more significant threat to our aspen forests in the future if the underlying causes are exacerbated by changing climatic conditions. Aspens have increased susceptibility to episodic decline at lower elevations under warm and dry conditions (Worrall et al. 2008). SAD appears to be related to drought stress, and is typically greatest on the hotter and drier slopes, which are usually at the lowest elevations of a stand (Rehfeldt et al. 2009). Stands may undergo thinning, but then recover. Increasing drought with climate change is believed to be the primary vulnerability of this ecosystem (Worrall et al. 2013), and substantial loss of aspen can potentially be expected. However, from a statewide perspective, aspen forests are currently in generally good condition overall and threats are comparatively low.

Lodgepole

Lodgepole forests, which cover more than two million acres in Colorado, support 21 SGCN (Table 8). In Colorado, lodgepole is widespread between 8,000-10,000 feet in elevation, on gentle to steep slopes of the Rocky Mountains in the northern part of the state. Stands may be pure lodgepole pine (*Pinus contorta*), or mixed with other conifer species. Following stand-replacing fires, lodgepole pine rapidly colonizes and develops into dense, even-aged stands (sometimes referred to as "dog hair" stands). Lodgepole pine forests typically have shrub, grass, or barren understories, sometimes intermingled with aspen. Shrub and groundcover layers are often sparse in lodgepole pine forests. Diversity of plant species is also low, perhaps as a result of the uniform age and dense canopy of many stands.

Although these forests are common across Colorado, most have experienced widespread damage from a severe outbreak of mountain pine beetle (*Dendroctonus ponderosae*). The pine beetle is a native species, and periodic outbreaks of this insect are part of the natural cycle that maintains our mountain forests. After killing approximately 3.4 million acres of lodgepole forests over the past decade, this recent outbreak is finally beginning to subside, primarily due to the fact that most susceptible host trees have been killed (CSFS 2013). Regeneration has been rapid in beetle-kill areas, and many large vegetation management projects have been completed and are underway on public lands to remove dead trees. Although there has been widespread mortality, and remaining lodgepole forests have been "re-set" to an early seral stage, this situation is part of the natural life cycle of a forest – thus, current condition cannot really be considered "bad."

Preliminary results of our climate change vulnerability assessment suggest that lodgepole may be moderately vulnerable through mid-century. Warming temperatures favor the growth of lodgepole pine, at least under conditions of increased precipitation, which may occur in some portions of the state. Warmer winters with drought are likely to increase mountain pine beetle outbreaks, but mortality is already widespread. Lodgepole habitat may be fairly resilient to climate change, and likely to persist, even if in an altered form.

Mixed Conifer

Mixed conifer supports 35 SGCN (Table 8). Mixed conifer forests occur at elevations ranging from 4,000 to 10,800 feet, and covers more than 850,000 acres in Colorado. Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the most common dominant trees, but as many as seven different conifer species may be present. Douglas-fir stands are characteristic of drier sites, often mixed with ponderosa pine (*Pinus ponderosa*). 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 (*Populus tremuloides*) stands. Natural fire processes in this ecological system are highly variable in both return interval and severity, with fire cycles ranging from 20 to more than 150 years. Stands in the Front Range are vulnerable to the impacts of housing development, and some are in degraded condition (i.e., denser, with more dead fuel) as a result of fire suppression (CSFS 2010). However, many of these habitats are generally in good condition, with minimal threats.

Pinyon-Juniper

Pinyon-juniper, which covers almost 7 million acres in Colorado, supports 67 SGCN (Table 8). Pinyon-juniper habitat includes juniper (*Juniperus* spp.) savannas and woodlands, woodlands and shrublands co-dominated by pinyon pine (*Pinus edulis*) and juniper, and some stands of juniper mixed with limber pine (*Pinus flexilis*) at lower elevations. Various forms of pinyon-juniper occur on mesas, dry mountains, and foothills across the western slope as well as in south-

central and southeastern Colorado. The understory is highly variable, and may be shrubby, grassy, sparsely vegetated, or rocky. Elevation ranges from 4,900 - 9,000 feet. In the canyons and tablelands of the southern Great Plains, juniper woodlands form extensive cover at some distance from the mountain front, at elevations from 4,100 to 6,200 feet.

For the purpose of analysis under the SWAP, the two major and four minor types of pinyon-juniper habitats classified under ReGAP have been lumped together. There are only two major pinyon-juniper systems – the Colorado Plateau system on the western slope, and the Southern Rockies system on the eastern slope. The Southern Rockies system is restricted to relatively discrete areas in the southeastern part of the state. The other four types can be significant on a local scale, but do not warrant separate treatment in statewide analyses such as the SWAP. Although localized threats exist, the size, juxtaposition, and broad distribution of this plant community affords a resiliency lacking in most other vegetation communities across Colorado.

Pinyon-juniper is influenced by climate, grazing, fires, and insect-pathogen outbreaks. Since the late 1800s, many of these woodlands have been significantly altered by changes in fire frequency, grazing patterns, habitat treatments, and climate cycles.

Recent studies (Eisenhart 2004; Romme et al. 2009) indicate that pinyon-juniper stands on the western slope are shaped predominantly by large, stand replacing fires that occur in 300-500 year intervals. Such fires would be followed by long recovery periods where the site is dominated by forbs and grasses, then shrubs, followed eventually by the re-establishment of a pinyon-juniper climax community. This scenario yields a very large range in historic variability and makes modeling past or future distribution of pinyon-juniper forests across the state difficult at best. In this habitat, 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, drought, overgrazing, and tree cutting can affect stand quality and the potential encroachment of trees into adjacent habitats.

Pinyon-juniper habitat quality has declined compared to historic norms, as significant acreage has been chained and burned in an effort to increase forage for livestock and big game on productive sites. Other threats include urban development, recreation (especially motorized recreation), invasive species (most notably an increase in cheatgrass (*Bromus tectorum*) in the understory, which has led to increasing fire ignitions), and energy development. In comparison with pinyon-juniper stands, Colorado's juniper-only woodlands have been much less impacted by human activities. However, the extent of juniper woodlands has historically been limited by fire, which kills juniper trees. Fire suppression and drought may have caused an expansion of juniper woodlands in some areas of southeast Colorado, where most of the junipers not associated with rimrock are young trees (<100 years old).

Pinyon-juniper habitats across Colorado are in generally fair to good condition, and are excellent in more remote, untreated or administratively protected areas. Some patches can be in poor condition in areas where incompatible grazing has reduced native bunch grasses and invasive species such as cheatgrass have become established. Overgrazing can also result in a complete lack of understory in mature pinyon-juniper stands. Oil and gas development, and chaining to improve livestock forage, have degraded the condition of some stands. Climate change may result in additional degradation of this habitat type, especially via an increase in frequency and/or severity of wildfire. In some previously burned areas, pinyon-juniper is not regenerating. For example, roughly 50% of Mesa Verde National Park burned in the early 1990s. At this time, there is still no sign of pinyon-juniper regeneration. Instead, burned areas have been invaded by cheatgrass and smooth brome (*Bromus inermis*). Preliminary results of our climate change vulnerability assessment suggest that pinyon-juniper may be moderately vulnerable to climate change through mid-century. The pinyon-juniper habitat has 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.

Although a large number of animal species in Colorado use pinyon-juniper habitats, few are wholly dependent upon them, with the exception of birds. It may be that the cyclic nature of these plant communities has forced many animals using them to remain adaptable. The primary mast crops produced in a pinyon-juniper community can vary widely from year to year, largely in response to precipitation and frost patterns. The best strategy may be to take advantage of this food source when available, but not to depend upon it for long term survival. This makes the pinyon-juniper forests of Colorado significant to wildlife, but more in a generalist, and not an obligate fashion. For birds, however, pinyon-juniper supports one of the highest proportions of obligate or semi-obligate bird species among forest types (Paulin et al. 1999). Thirty-nine percent of bird species found in pinyon-juniper are obligate or semi-obligate, second only to riparian forested communities (Paulin et al. 1999); 20% of bird species that use pinyon-juniper (roughly one-quarter of Colorado's native birds) are obligates (Kingery 1998).

Ponderosa Pine

Ponderosa pine supports 34 SGCN (Table 8). In Colorado, ponderosa pine (*Pinus ponderosa*) woodlands cover about 3.2 million acres in Colorado. They occur between about 6,000 and 9,000 feet, often at the lower treeline transition between grassland or shrubland and the more mesic coniferous forests above. These woodlands are especially prevalent along the eastern edge of the Rocky Mountains, and on the southern flank of the San Juan Mountains. Healthy ponderosa pine forests often consist of open and park-like stands of mature trees, with an understory of predominantly fire-tolerant grasses and forbs. Fire is the most significant ecological process

maintaining this ecological system; frequent, low-intensity ground fires are typical. Older trees drop their lower branches and develop thick, insulating bark as they age, which protects them from ground fires. In stands where the natural fire regime occurs, shrubs, understory trees and downed logs are uncommon. When fires are not allowed to burn, young trees continue to grow, and places that were once open savannas and woodlands become dense forests. Increased density of trees allows fires to reach the forest canopy, spread rapidly, and burn large areas.

In southwestern Colorado, the overall condition of ponderosa pine is generally good, except where exurban development has fragmented larger stands. On the Front Range, many stands have been lost to urban development, and some of the remaining stands are in degraded condition. The likelihood of future threats (primarily development and fire suppression) is high. Preliminary results from our climate change vulnerability assessment suggest that ponderosa pine may be moderately vulnerable through mid-century. Increased drought may drive fires and insect outbreaks, and relative proportions of component species in ponderosa stands may change. This habitat is well adapted to warm, dry conditions if precipitation is not reduced too much, and may be able to expand into higher elevations.

Spruce-Fir

Spruce-fir forests support 23 SGCN (Table 8). Spruce-fir forests cover about 5% of Colorado's landscape, forming the matrix vegetation of the sub-alpine zone at elevations of 9,500 to 11,500 feet. They are characterized by dense stands of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). This is one of the few Colorado forest types that is not fire-adapted – the typical fire return frequency is around 400 years. Areas with spruce-fir forest typically receive precipitation in the form of snowfall and frequent summer showers. When periods of drought occur, however, the stressed trees become susceptible to spruce-bud worm (*Choristoneura freemani*) and spruce beetle (*Dendroctonus rufipennis*) outbreaks, which can kill entire hillsides of trees in one summer. In the early 20th century, much of Colorado's old-growth spruce fir was cut for timber. Although much spruce-fir is now made up of younger trees, it is still possible to find very old, widely-spaced trees with yellow bark, as well as snags and downed trees that create perfect habitat for cavity-nesting birds and pine martens.

In 2013, spruce beetle infestations were identified on 398,000 acres, the majority of which are in the southwestern mountain ranges (CSFS 2013). However, from a statewide perspective, spruce-fir forests are generally healthy and intact, except that small stand size detracts from the overall quality of the habitat in some areas. Although this habitat is heavily used for recreation and other human activities, overall threats are relatively low at this time. Global climate change may have significant impacts on spruce-fir in the future. Preliminary results of our climate change vulnerability assessment suggest that spruce-fir is moderately vulnerable until mid-century. Under warmer conditions, spruce-fir is likely to expand into alpine areas, but the response would

be slow. The lower distributional limit of this habitat is likely to move higher under warmer, drier conditions. Change in species composition may occur in some areas. The vulnerability of this habitat might be higher if the analysis timeframe were further out than mid-century.

Subalpine Limber and Bristlecone Pine

Limber and bristlecone pine forests and woodlands support 12 SGCN (Table 8). This habitat occurs throughout the Rocky Mountains on dry, rocky ridges and slopes. Although it can be found near upper treeline above spruce-fir forests, it also occurs at lower elevations. These are typically woodlands of xeric, high elevation sites, but they may also extend down to the lower montane, particularly along the Front Range. Limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus aristata*) do not necessarily occur together, but the two species occupy a similar ecological niche. Where the two co-occur, limber pine is often confined to the lower portion of its potential habitat. Bristlecone pine is more-or-less endemic to the Southern Rocky Mountian ecoregion, reaching its northernmost station in Gilpin County, Colorado. Limber pine is more widely distributed and also occurs in mixed conifer systems. It largely replaces bristlecone pine north of I-70, and extends onto the plains in small but important habitat patches on the Pawnee National Grasslands.

This habitat occurs in harsh sites that are exposed to desiccating winds with rocky substrates and a short growing season that limit plant growth. Higher elevation occurrences are found well into the subalpine – alpine transition on wind-blasted, mostly south to west-facing slopes and exposed ridges. Bristlecone forests are typically found on steep, south-facing slopes from 8,850 to 12,140 feet. Limber pine woodlands occupy similar habitats, but may occur at lower elevations than bristlecone. Both bristlecone and limber pine are slow-growing, long-lived species in which individuals may live for 1,000 or more years. Fire is an important source of disturbance that facilitates stand regeneration in this system. Older woodlands are often broadly even-aged stands where seedlings are nearly absent, while areas that have recently burned may have abundant seedlings. Bristlecone is somewhat more tolerant of fire than is limber pine, but both species appear to depend on fire for regeneration. Regeneration of limber pine on burned areas is largely due to the germination of seeds cached by Clark's nutcrackers (*Nucifraga columbiana*). The slow growth and recruitment of bristlecone and limber pine will make it difficult for these habitats to colonize new areas under changing climate conditions. Furthermore, warmer conditions may increase the vulnerability of these pines to white pine blister rust.

SHRUBLAND HABITATS

Desert Shrub

Desert shrub supports 37 SGCN (Table 8). In Colorado, these semi-arid shrubby grasslands, sometimes referred to as shrub steppes, are found between 7,500 and 9,500 feet in elevation, on windswept mesas, valley floors, gentle slopes, and on shoulders of ridges. Our shrub-steppes are grass-dominated areas with an open shrub layer. Typical grass species include blue grama (*Bouteloua gracilis)*, needle-and-thread (*Hesperostipa comata*), galleta (*Pleuraphis jamesii*), saltgrass (*Distichlis spicata*), Indian rice grass (*Acnatherum hymenoides*), and alkali sacaton (*Sporobolus airoides*). Historically, the shrub layer was dominated by winterfat (*Krascheninnikovia lanata*), but this species has decreased under grazing pressure in many areas. Winterfat has been replaced by rabbitbrush (*Ericameria* and *Chrysothamnus*) species and other woody shrubs. In Colorado, this ecological system does not form extensive stands except in the San Luis Valley. Pinyon-juniper woodlands and sagebrush shrublands commonly occur adjacent to this ecological system at the upper elevations. Shrub steppe covers more than 750,000 acres in Colorado. Historically, it probably accounted for well over a million acres, but many areas were converted to agricultural use. Remaining stands are generally in good condition, except for altered species composition in areas where grazing has reduced or eliminated some native bunch grasses. Solar energy development in the San Luis Valley and continued alteration by grazing are the primary potential threats to this ecological system. Thus far, solar energy development has mostly occurred on land that was previously converted to cropland, so this activity does not yet necessarily constitute additional loss.

Greasewood

Greasewood supports 17 SGCN (Table 8). Shrublands dominated by black greasewood (*Sarcobatus vermiculatus*) account for less than 450,000 acres in Colorado, where they are typically found near drainages on stream terraces and flats, on alluvial fans along streams or arroyos, or as rings around playas. In eastern Colorado, greasewood stands are primarily in the southwestern portion of the plains. Large acreages are also found in the lower elevations of Colorado's western valleys and throughout much of the San Luis Valley. Greasewood flats usually have saline soils, a shallow water table and flood intermittently, but remain dry for most of the growing season. Because greasewood flats are tightly associated with saline soils and groundwater that is near the surface, groundwater recharge rather than surface water flow is critical for maintaining these shrublands. Elevations range from about 4,000 to 7,700 feet. These open to moderately dense shrublands are dominated by black greasewood, often with rabbitbrush (*Ericameria* and *Chrysothamnus* spp.), four-wing saltbush (*Atripelx canescens*), and alkali sacaton grass (*Sporobolus airoides*). Threats to greasewood include groundwater pumping,

conversion to cropland, and energy development. However, the condition of greasewood habitats in Colorado remains generally good.

Oak and Mixed Mountain Shrub

Oak and mixed mountain shrublands, which account for about 2.7 million acres in Colorado, support 30 SGCN (Table 8). Oak and mixed mountain shrublands generally occur at elevations from approximately 6,500 to 9,500 feet, where they are often adjacent to lower elevation pinyon-juniper woodlands. Gambel's oak (*Quercus gambelii*) is typically dominant, but very often mixed with other montane shrubs such as serviceberry (*Amelanchier* spp.), mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), chokecherry (*Prunus virginiana*), and snowberry (*Symphoricarpos* spp.). These shrublands intergrade with foothills shrublands (roughly equivalent to the Upland Shrub habitat category) because both types are often found on poor, dry soils. In Colorado, oak and mixed mountain shrublands are most common on the western slope, where they form extensive bands on the lower mountain slopes, plateaus, and dry foothills. In eastern Colorado, these shrublands are also found at the mountain front as far north as the Palmer Divide. They may form dense thickets, or occur as open shrublands with an herbaceous understory. Although this is a shrub-dominated ecological system, some trees may be present.

Fire typically plays an important role in oak and mixed mountain shrublands, causing shrub die-back in some areas, promoting re-sprouting from stumps or underground tubers and rhizomes in other areas, and controlling the invasion of trees into the shrublands. Healthy examples of this habitat contain shrubs of varying heights, a robust understory of native bunchgrasses and forbs, and relatively little bare ground (COPiF 2000). Shrubs that produce acorns and berries provide valuable food and cover resources for a variety of wildlife species.

Where oak and mixed mountain shrublands occur near the wildland-urban interface, they are often in degraded condition due to effects from fire suppression. Ongoing impacts include housing development and oil and gas development. However, oak and mixed mountain shrublands are in generally good condition from a statewide perspective. Preliminary results from our climate change vulnerability assessment suggest that oak and mixed mountain shrub habitats have low vulnerability in Colorado. Warmer temperatures may increase seedling survival.

Sagebrush

Sagebrush supports 65 SGCN (Table 8). Sagebrush in Colorado includes the three subspecies of big sagebrush (basin big sagebrush, *Artemisia tridentata* ssp. *tridentata*; mountain big sagebrush, *A. tridentata* ssp. *vaseyana*; and Wyoming big sagebrush, *A. tridentata* ssp. *wyomingensis*) that

occur as shrublands and montane sagebrush steppe. These shrublands occur throughout much of the western United States. Although they can be found on Colorado's east slope, the largest occurrences are on the western slope. North Park, Middle Park, and the upper Gunnison Basin have extensive stands of sagebrush shrublands, as do Moffat and northwest Rio Blanco counties. Big sagebrush shrublands are characterized by dense stands of taller sagebrush species with a significant herbaceous understory, and are generally found at elevations from 5,000 to 7,500 feet. Big sagebrush shrublands are typically found in broad basins between mountain ranges, on plains and foothills. Montane sagebrush steppe shrublands are dominated by the shorter sagebrush *Artemisia tridentata* ssp. *vaseyana*, and are usually found at elevations from 7,000 to 10,000 feet. Montane sagebrush steppe primarily occurs on ridges, near flat ridgetops, and mountain slopes.

Many of Colorado's sagebrush shrublands are vulnerable to changes induced by domestic livestock grazing. Prolonged use can cause a decrease in the abundance of native grasses and forbs in the understory, and an increase in shrubs and non-native grasses such as Kentucky bluegrass (*Poa pratensis*). Trampling from livestock grazing significantly decreases the survival of sagebrush and grass seedlings. Over the past century, the condition of much of Colorado's sagebrush shrubland has been degraded due to fire suppression and heavy livestock grazing. Although many livestock operations are now more sensitive in their treatment of sagebrush shrublands than they once were, recovery in these ecological systems is slow. Furthermore, many remaining sagebrush patches are now being fragmented by fast-paced and widespread energy development.

Various climate change vulnerability assessments for sagebrush have produced differing results (e.g., Nydick et al. 2012; Schlaepfer et al. 2012; Pocewicz et al. 2014), with rankings ranging from highly vulnerable to likely to increase, depending on the scale, location, and method of assessment. The Colorado-specific climate change vulnerability assessment conducted for this SWAP suggested that sagebrush is not particularly vulnerable in Colorado. Seasonal timing of precipitation is important for sagebrush habitats. Summer moisture stress may be limiting if winter precipitation is low, and increased drought may increase fire frequency/severity, eliminating sagebrush in some lower elevation areas. However, the habitat is not expected to be limited by lack of cooler habitat, since it can move to adjacent higher elevations. While some stands of sagebrush, especially those dominated by the *wyomingensis* subspecies, may be vulnerable, overall, sagebrush has numerous life history strategies that may help it adapt (e.g., it is a relatively short-lived shrub, it produces numerous seeds, and it can tolerate some droughts). Note that while the sagebrush habitat within Colorado does not appear to be particularly vulnerable to climate change, some sagebrush obligate species – most notably the Gunnison sage-grouse – are thought to be extremely vulnerable (Neely et al. 2011).

Saltbush

Saltbush supports 33 SGCN (Table 8). Saltbush includes salt desert scrub, mat saltbush shrublands, and shale badlands. All of these ecological system types are typically dominated by saltbush (*Atriplex*) species or other shrubs tolerant of saline or alkaline soils. These sparse to moderately dense low-growing shrublands are widespread at lower elevations (generally from 4,500 to 7,000 feet) in Colorado's western valleys, and are also found in more limited distribution in the southern part of the eastern plains. In mixed salt desert scrub, the shrub layer may include winterfat (*Krascheninnikovia lanata*), wolfberry (*Lycium*), horsebrush (*Tetradymia canescens*), and various sagebrush (*Artemisia*) species. Grasses and forbs are generally sparse, and dominated by species tolerant of the harsh soils. Some areas are essentially barren, or very sparsely vegetated. Saltbush covers more than 750,000 acres in Colorado. Perhaps a quarter of the historic acreage of saltbush shrublands has been converted to agricultural use, especially in valley bottoms where irrigation is available. Remaining occurrences appear to be in good condition. Impacts and fragmentation from energy development are the most current threats to this habitat.

Sandsage

Sandsage supports 21 SGCN (Table 8). Sandsage shrublands dominate sandy areas on Colorado's eastern plains, where they often intermingle with shortgrass prairie to form a locally patchy sandsage-shortgrass matrix. Sandsage is characterized by sand sagebrush (*Artemisia filifolia*) with an understory of tall, mid- and short grasses and scattered forbs. Yucca (*Yucca glauca*) and snakeweed (*Gutierrezia sarothrae*) are common in some areas, which may be indicative of mismanagement. Fire and grazing are the most important dynamic processes for sandsage, although drought stress can impact this ecological system significantly in some areas. Sandsage covers nearly two million acres in Colorado. These sandy-soiled habitats have frequently been passed over while neighboring grasslands are converted to agriculture, but about 20% of historic acreage has been lost, and sandsage areas continue to be converted to row crop production. Although remaining sandsage tracts generally have good landscape context and connectivity, species composition in these areas is highly altered by long-term mismanaged grazing. Understory grasses have been converted to short grass or annual species, and historic mixed and tall grass components are lacking, with consequent detrimental effect on habitat quality for several SGCN. Sandsage is vulnerable to adverse impacts from energy development (including wind, oil, and gas).

Preliminary results from our climate change vulnerability assessment suggest that sandsage is moderately vulnerable through mid-century. This habitat is not vulnerable on sandy soils, and may be able to expand into adjacent areas under warmer, drier conditions. However, overall condition and composition of these shrublands may change.

Upland Shrub

Upland shrub habitats, which cover less than 400,000 acres in Colorado, support 27 SGCN (Table 8). Upland shrub habitats are found in dry, upland areas where oak is not present. This habitat is found in the Rocky Mountain foothills, ridges, canyons and lower mountain slopes, and on outcrops, mesas, and canyon slopes of the eastern plains. In general, mixed shrublands without oak are most common in the northern Front Range, as well as on drier foothills and prairie hills. Upland shrub occurs at elevations between 4,900-9,500 feet. Scattered trees may be present, but the vegetation is dominated by shrubs such as mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), skunkbush sumac (*Rhus trilobata*), or currant species (*Ribes* spp.). The dominant shrub species are generally well adapted to poor soils, dry sites, and disturbance by fire. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth. Threats to upland shrub include fragmentation by roads and development. These disturbances provide an unnatural fire break as well as a conduit for weed invasion.

Condition of upland shrub habitats is generally good across Colorado, with fair patches in some areas. The shrub layer is good to excellent, but the understory layer is generally fair to poor. This habitat is vulnerable to weed invasions. Where invasive species such as leafy spurge (*Euphorbia esula*) and cheatgrass (*Bromus tectorum*) have established, understories are highly altered.

GRASSLAND HABITATS

Foothill and Mountain Grasslands

Foothill and mountain grasslands support 48 SGCN (Table 8). This habitat type includes three non-shortgrass prairie grassland types: Western Great Plains Foothill and Piedmont Grassland, Southern Rocky Mountain Montane-Subalpine Grassland, and Inter-Mountain Basins Semi-Desert Grassland. Together these grasslands cover about three million acres in Colorado.

Foothill and piedmont 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. These grasslands typically occur at elevations between 5,250 and 7,200 feet. Typical species include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), needle-and-thread (*Hesperostipa comata*), and prairie sandreed (*Calamovilfa longifolia*).

Montane-subalpine grasslands in the Colorado Rockies are found at elevations of 7,200-10,000 feet, intermixed with stands of spruce-fir (*Picea engelmannii-Abies lasiocarpa*), lodgepole pine

(*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), and aspen (*Populus tremuloides*), or as the matrix community (e.g., in the large intermountain basin of South Park). Typical dominant grass species include fescue (*Festuca* spp.), muhly (*Muhlenbergia* spp.), oatgrass (*Danthonia* spp.), and others. Lower elevation montane grasslands are more xeric, while upper montane or subalpine grasslands are more mesic. Grasses of the foothills and piedmont may be included in lower elevation occurrences. Trees and shrubs are generally sparse or absent, but occasional individuals from the surrounding communities may occur.

Colorado's semi-desert grasslands are found primarily on dry plains and mesas of the western slope at elevations of 4,750-7,600 feet. These grasslands are typically dominated by drought-resistant perennial bunch grasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*), blue grama (*Bouteloua gracilis*), galleta grass (*Pleuraphis jamesii*), and needle-and-thread (*Hesperostipa comata*), and may include scattered shrubs.

A significant portion of historic occurrences of lower elevation foothill and piedmont grasslands on the eastern slope have been lost through conversion to cropland and commercial and residential development. Some remaining patches are in fair condition, but others – especially along Colorado's Front Range – are highly fragmented and invaded by cheatgrass (*Bromus tectorum*), leafy spurge (*Euphorbia esula*), Dalmatian toadflax (*Linaria dalmatica*), Canada thistle (*Cirsium arvense*), and other exotic species. Current impacts from human activity other than domestic livestock grazing are low in the montane grasslands; condition of these grasslands is generally good to excellent. Low elevation grasslands on the western slope are generally fair, but are poor in some areas where native grasses have been replaced by invasive species such as cheatgrass.

Mixed and Tallgrass Prairies

Mixed-grass and tallgrass prairies support 37 SGCN (Table 8). Mixed-grass habitats are characterized by mid-height or tall native grasses including sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Hesperostipa comata*). Tallgrass is characterized by the dominance of big bluestem. Due to its position on the periphery of the range of the mixed-grass prairie, Colorado has probably never supported extensive tracts of these types. Habitats characterized by mid- to tall-grass species are limited in Colorado, and most commonly occur as small patches interspersed among shortgrass prairie and sandsage, or in mesic areas near the foothills. The eastern plains mixed-grass remnants are generally in degraded condition, lacking the diversity and extent of mid- to tallgrass species that would have historically been present. Historically, foothills valleys and swales (now frequently filled with reservoirs or houses) would have supported tallgrass communities in Colorado. Now tallgrass prairie only occurs in small, scattered patches where moist soils are present, such as upland terraces above floodplains. Fire,

grazing, and drought are the primary ecological processes. The diversity within this habitat likely reflects both the short- and long-term responses of the vegetation to these often concurrent disturbance regimes. Fire suppression and overgrazing can lead to the invasion by woody species such as juniper and ponderosa pine. Conversion to agriculture likewise has probably decreased the range of these habitats within the state. Ongoing wind energy development may have some impact.

Shortgrass Prairie

Shortgrass prairie supports 52 SGCN (Table 8). Shortgrass prairie, characterized by blue grama (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), and other short to mid-height species, once covered most of Colorado east of the mountain front, at elevations below 6,000 feet. Today, nearly 50% of our historic shortgrass prairie has been converted to row crop agriculture or other uses – the largest loss of any of Colorado's habitats. Remaining tracts have often been managed for domination of blue grama and exclusion of other grasses, with a consequent loss of native forb diversity. In the early 1800s, the shortgrass prairie was home to massive herds of free-ranging bison and pronghorn, as well as huge prairie dog colonies, deer, elk, and top predators such as the gray wolf and grizzly bear. Pronghorn and prairie dogs still inhabit Colorado's prairies in reduced numbers, and the former top predators have been replaced by coyotes.

Large-scale ecological processes such as drought, fire, and grazing by large animals exert strong influences on shortgrass. The short grass species that dominate this ecological system are tolerant of drought and grazing. Ongoing impacts include renewable and non-renewable energy production (wind, solar, geothermal, oil and gas, and biofuels) and continuing expansion of urban and exurban communities, especially along the Front Range. The continued presence of shortgrass prairie in our state may also be threatened by changing climate. Preliminary results from our climate change vulnerability assessment indicate that shortgrass prairie is highly vulnerable. Soil moisture is a key driver for this habitat; change in precipitation seasonality, amount, or pattern will affect soil moisture. Although these grasslands are adapted to warm, dry conditions, increasing warmer and drier conditions are likely to favor increasing growth of shrubby species (e.g., cholla [*Cylindropuntia imbricata*], snakeweed [*Gutierrezia sarothrae*]), especially in areas that are disturbed.

RIPARIAN AND WETLAND HABITATS

Playas

Playas support 16 SGCN (Table 8). Playas are shallow, temporary wetlands that occur throughout the shortgrass prairie on Colorado's eastern plains, as well as in limited distribution

on the western slope. They are ephemeral in nature, filling with water only after heavy rainfall. As would be expected of wet habitats in a dry environment, playas are very important habitat components for many species that inhabit or migrate through Colorado. Playas are threatened by conversion of surrounding native habitat to urban and/or agricultural uses, as well as indirect effects of such development (for example, road construction, sedimentation, pollution and runoff, deliberate filling). The current condition of playas is variable, but is generally fair to poor.

Riparian Woodlands and Shrublands

Riparian woodlands and shrublands support 26 SGCN (Table 8). Riparian woodlands and shrublands occur throughout Colorado. At montane to subalpine elevations, riparian shrublands may occur as narrow bands of shrubs lining streambanks and alluvial terraces, or as extensive willow carrs in broad floodplains and subalpine valleys. They can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Dominant shrubs within this elevation zone include alder (*Alnus tenuifolia*), birch (*Betula occidentalis*), dogwood (*Cornus sericea*), and willow (*Salix*) species. Generally the upland communities surrounding these riparian systems are either conifer or aspen forests. Many higher elevation riparian shrublands are associated with beaver (*Castor canadensis*) activity, which can be important for maintaining the health of the riparian ecosystem (historically this would have been true for lower elevation streams as well). Beaver dams abate channel down cutting, bank erosion, and downstream movement of sediment. They also raise the water table across the floodplain and provide year-round saturated soils. Plant establishment and sediment build-up behind beaver dams raises the channel bed and creates a wetland environment.

Montane to subalpine riparian woodlands are comprised of seasonally flooded forests and woodlands throughout the Rocky Mountains. They include the conifer and aspen woodlands that line montane streams. They are most often confined to specific riparian environments, occurring on floodplains or terraces of rivers and streams or in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, high elevation riparian woodlands are found in moderate to wide valley bottoms, on large floodplains along broad, meandering rivers, and on pond or lake margins. Riparian woodlands are tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season.

At lower elevations on the western slope, riparian woodlands and shrublands are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. They often occur as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. Forests are typically dominated by cottonwood (*Populus angustifolia*, *P. deltoides*) and willow (*Salix* spp.), but may include maple (*Acer glabrum*), Douglas fir (*Pseudotsuga*

menziesii), spruce (*Picea* spp.), and juniper (*Juniperus* spp.). Shrublands are primarily dominated by willow, alder, and birch. Lower elevation riparian woodlands and shrublands are dependent on a natural hydrologic regime, especially annual to episodic flooding. These woodlands and shrublands grow within a continually changing alluvial environment due to the ebb and flow of the river, and riparian vegetation is constantly being "re-set" by flooding disturbance. In some areas, Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamarix* spp.), and other exotic species are common.

On the eastern plains, riparian woodlands and shrublands are generally dominated by plains cottonwood (*Populus deltoides*) and willow species, but also occur as a mosaic of multiple communities interspersed with herbaceous patches. They are found along small, medium and large streams on the plains, including the wide floodplains of the South Platte and Arkansas Rivers. Hydrologically, smaller rivers tend to have greater seasonal variation in water levels with less developed floodplain than the larger rivers, and can dry down completely for some portion of the year. Plains riparian areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Tamarisk and less desirable grasses and forbs have invaded degraded examples throughout eastern Colorado. Groundwater depletion and lack of fire have created additional species changes.

Riparian woodlands and shrublands at higher elevations are in good to excellent condition. At lower elevations, however, conditions are only fair overall and can be poor in areas subjected to intense grazing, agricultural use, urban development, and/or hydrological alteration. Many of these communities have degraded understories, with weedy herbaceous layers and Russian olive and tamarisk invading the shrub layers. Cottonwood die-offs related to prolonged, intense drought and hydrological alterations have affected some stands.

Wetlands

Non-riparian wetlands support 53 SGCN (Table 8). In Colorado, non-riparian wetland habitats include moist to wet meadows, emergent marshes, fens, and seeps and springs.

Meadows occur throughout Colorado, but most natural wet meadows are found within the montane to subalpine zone. Natural wet meadows are tightly associated with snowmelt or subsurface groundwater discharge, and are typically not subjected to high disturbance events such as flooding. Within mountain valleys and at lower elevations, extensive acres of wet meadows are also linked to irrigation practices, including flood irrigation and seepage from irrigation ditches. Natural wet meadows are dominated by native sedges and grasses, while those influenced by irrigation may be dominated by non-native pasture grasses.

Emergent marshes are wetlands that experience frequent or prolonged ponding. Marshes occur in depressions and kettle ponds, as fringes around lakes, along streams and rivers, and behind many types of impoundments. They can be found at all elevations, but are more common at mid to lower elevations. Standing water restricts the dominant species to robust wetland plants, such as cattail (*Typha*), bulrush (*Scirpus* and *Schoenoplectus* spp.), and large sedges (*Carex* spp.). At lower elevations, marshes can become densely vegetated if they are not periodically flushed by floodwater or mechanical thinning.

Fens are wetlands with thick organic soils that are supported by stable groundwater discharge. Fens are typically found within the montane to subalpine zone, generally above 7,000 feet, and can form along the edges of valley bottoms, at breaks in slope, around hillslope seeps, in shallow basins or anywhere where sufficient ground water emerges to perennially saturate soils. Fens are considered "old growth" wetlands, as the accumulation of thick organic soils can take thousands of years. Fen vegetation is generally characterized by a dense cover of sedges and moss, often intermixed with forbs and short to dwarf shrubs such as willow and bog birch (*Betula nana*).

Seeps and springs include small wetlands that are hydrologically supported by groundwater discharge. They are found throughout Colorado and can be a component of the previously described wetland types, but are most notable within the cliff and canyon country of the Colorado Plateau and the Lower Arkansas River basin.

Montane to subalpine wetlands are generally in good condition, though many acres are impacted by water diversions, groundwater pumping, and grazing of both domestic and wild animals. The condition of lower elevation wetlands, however, is far worse. Non-native species, including noxious weeds, are prevalent and may dominant many wetlands. Intensive water management and human development have greatly altered the timing and magnitude of flooding. In some locations, water has been diverted from natural wetlands. In others, storm water runoff and irrigation return flows have created or expanded wetland acres, but these systems experience flashy hydroperiods and degraded water quality.

AQUATIC HABITATS

Colorado Plateau - Wyoming Basins Rivers

Colorado Plateau – Wyoming Basins rivers support 31 SGCN (Table 8). This habitat includes the big rivers within the Colorado Plateau and Wyoming Basin ecoregions of Colorado's western slope: the Colorado, Gunnison, Green, Yampa, White, Dolores, San Juan and Animas Rivers. Larger-order rivers contain habitat features that are unavailable in smaller streams, particularly deep pools and runs, and large backwaters and inundated floodplain areas during high water. As

a result, they comprise the core habitat for several big-river fish species, though these species are also occasionally found in smaller streams. Condition of this habitat type varies, but is moderately or highly impacted for most of these rivers. Dams and diversions have altered the natural hydrograph to varying degrees. In most of these rivers, snowmelt-driven peak flows are greatly reduced, as are base flows in many cases. Peak flow timing may be altered such that these flows no longer coincide with the life-history requirements of big river fish species. Extensive flow management efforts are being made to redress that situation in some rivers. Additionally, dams and diversion structures function as barriers preventing upstream movement of fishes (though fish passage structures have been constructed at some). A number of these species are highly migratory and require many miles of unfragmented habitat in order to move between spawning and rearing, foraging, and overwintering areas. These changes, combined with channelization and bank hardening, impacts from energy development, bank stabilization by non-native vegetation (tamarisk, Russian olive), and other anthropogenic stressors, have degraded the condition of associated riparian habitats as well.

Colorado Plateau – Wyoming Basins Streams

Colorado Plateau – Wyoming Basins streams support 27 SGCN (Table 8). This habitat includes tributaries to the big river systems within the Colorado Plateau and Wyoming Basins ecoregions of Colorado's western slope. Condition varies widely, with some streams in excellent condition, but the majority of streams are moderately or severely impacted. Dams and, especially, diversions have altered the natural hydrograph and fragmented habitat, to the extent of entirely dewatering some stream reaches. Other anthropogenic impacts include gravel mining and grazing within the riparian corridor, channelization and bank hardening, impacts from energy development, and encroachment of non-native vegetation (tamarisk, Russian olive), all of which have the potential to degrade water quality and the condition of associated riparian habitats.

Eastern Plains Rivers

Eastern Plains rivers support 33 SGCN (Table 8). This habitat includes the mainstems of the South Platte and Arkansas Rivers, and the lower portions of major tributaries such as the Cache la Poudre River and St. Vrain Creek. These larger-order rivers contain habitat features generally not found in smaller plains streams, including occasional deep pools, secondary channels and backwaters, and inundated floodplain areas during high water. As a result, they comprise the core habitat for several plains fishes, though these species are also sometimes found in smaller tributaries. Condition is heavily impacted in terms of both water quality and water quantity. Dams and numerous large diversions have greatly altered the timing and magnitude of both peak and base flows, as well as other components of the natural hydrograph. In many reaches, treated municipal waste water and/or irrigation return flows maintain base flows at higher levels than

pre-alteration. A plethora of stressors from extensive urban and exurban development, and from agriculture, degrade both water quality and the condition of associated riparian habitats.

Eastern Plains Streams

Eastern Plains streams provide primary habitat for 44 SGCN (Table 8). This habitat includes the tributaries to the big rivers of Colorado's eastern plains, and the Republican River and its tributaries. Most of these streams rise on the plains and thus have a hydrograph and temperature regime distinct from streams originating in the mountains. Streams in this region are of a diverse character. Many rise from springs and flow consistently in headwaters areas but subside into intermittency further downstream, only becoming more perennial again when they reach the alluvium of the mainstem. The more intermittent portions of these systems only fully connect during flood events, and at other times consist partly or entirely of isolated pools within a dry channel. Some plains fishes appear to be specifically adapted to this hydrologic regime, preferring or requiring standing-water, pond-like habitat, and utilizing periods of connectivity to redistribute and re-colonize habitat patches. A number of such naturally-occurring pools have been impounded, enlarged or otherwise made into more permanent ponds or small lakes, for stock watering or other human uses. These areas, though modified, comprise some of the most important habitat for several plains fish species, especially northern redbelly dace, and also plains topminnow, southern redbelly dace, and Arkansas darter. Streams in the Republican basin tend to be more historically perennial, as are a few larger tributaries such as the Purgatoire and St. Charles Rivers. Diversions and habitat degradation threaten all these streams to varying degrees. A more pressing threat throughout most of the region is drying and fragmentation due to groundwater irrigation depleting underlying aquifers. This threat is particularly dire in the Republican Basin, but is imminent throughout the Eastern plains.

Lakes

Lakes support 25 SGCN (Table 8). This habitat type includes only natural lakes, the majority of which occur in the subalpine and montane zones. Very few lower-elevation natural lakes exist within Colorado; most of these are oxbow lakes, former river channels that became isolated, and are quite small. Because this habitat type occurs mostly at high elevations where human impacts and natural disturbances are limited, its condition is generally excellent.

Mountain Streams

Mountain streams support 30 SGCN (Table 8). Mountain stream habitat includes high elevation streams on both sides of the Continental Divide. These streams are characterized by high gradient, cold temperatures, and a snowmelt-dominated hydrograph. Though few waterways in

Colorado have escaped some level of disturbance, mountain streams remain in good condition overall.

Rio Grande Valley Rivers

Rio Grande Valley rivers are primary habitat for two Tier 1 SGCN (Table 8). This habitat consists of the mainstem Rio Grande and the Conejos River. The high elevation and distinct climate of this watershed differentiate it from other east slope drainages. Within the watershed, these larger-order rivers contain habitat features infrequently found in the tributaries, particularly deep pools and runs. Historically the Rio Grande and Conejos are known or believed to have been primary habitat for several endemic species. Native fish populations have been lost because of water diversions for irrigation, stream drying, and habitat degradation. Additionally, competition, predation, and hybridization by nonnative fish have contributed to extirpation of native fish populations in the Rio Grande and Conejos.

Rio Grande Valley Streams

Rio Grande Valley streams are primary habitat for two Tier 1 SGCN (Table 8). This habitat includes the tributaries to the Rio Grande, the Conejos River, and the closed-basin streams of Saguache Creek and San Luis Creek. Condition of these streams varies, but most have low to moderate levels of impact. Diversions, mainly for agricultural use, have altered the natural hydrograph and fragmented streams to varying degrees, in some cases entirely dewatering stream reaches. The closed-basin streams remain less disturbed, although some are threatened by drying of the aquifer.

Transition Zone Streams

Transition zone streams support 33 SGCN (Table 8). The abrupt transition from mountains to plains along the Front Range and east slope give rise to this habitat. At this juncture streams rapidly lose gradient, increase in sinuosity and acquire other characteristics of plains streams, but continue to have a snowmelt-driven hydrograph, colder temperatures and coarser cobble-gravel substrate, reflective of their origin in the mountains, for some distance downstream. These relatively short reaches of intermediate character comprise the sole habitat within Colorado for several "glacial relict" SGCN—species adapted to lower-gradient waters that are cooler than most Colorado plains streams—which are believed to have been "stranded" in this zone as glaciers receded. Because most Front Range cities were established along rivers at the base of the mountains, the transition zone is heavily impacted by many effects of urban development, and is among the most imperiled of aquatic habitats in Colorado. Additionally, it is likely especially vulnerable to climate change, with the prospect of species being "pinched" between warmer water downstream and unfavorable gradient upstream.

OTHER HABITATS

Alpine

Alpine habitats, which cover over 1.5 million acres in Colorado, support 32 SGCN (Table 8). Alpine includes high-elevation dry tundra, fellfield, wet-meadow, and rock and scree communities. Alpine tundra is found at the highest elevations in our state, usually above 11,000 feet. Here the long winters, abundant snowfall, high winds, and short summers create an environment too harsh for permanent human habitation. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season.

Old privately-owned mining claims are scattered throughout, but there are very few active mines operating today. In general, alpine tundra in Colorado is currently in excellent condition. The primary threat to this ecological system is global climate change, which could have significant impacts in the future. Preliminary results from our climate change vulnerability assessment suggest that alpine habitats are moderately vulnerable through mid-century. Snowpack patterns are important for this habitat. Thus, if Colorado experiences an increase in winter precipitation, alpine areas may be able to withstand some increase in temperature, at least in the short term, and especially in areas where it is difficult for trees to advance. At a longer time frame, however, alpine is likely to largely disappear from Colorado.

Cliffs and Canyons

Cliffs and canyons support 34 SGCN (Table 8). Mountain cliffs and canyons habitats are found from foothill to subalpine elevations. They include barren and sparsely vegetated landscapes comprised of steep cliff faces, narrow canyons, and open tablelands, as well as the unstable scree and talus slopes that typically occur below cliff faces. Widely scattered trees and shrubs may be present. These highly erodible areas are generally too steep to allow any significant soil development. Erosion by wind, water, and the force of gravity is the primary natural disturbance process in the cliff environment. Cliffs and canyons have a naturally high rate of erosion; infiltration rates are low and runoff high. 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 (Larson et al. 2000). 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 (Graham and Knight 2004). Cliffs and bedrock outcrops are 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 (especially climbing), and the effects of mining.

On the eastern plains, this habitat type includes cliffs, outcrops, breaks and barrens, rimrock and erosional remnants of the High Plains escarpment, as well as other isolated buttes and outcrops to the south. Drought and wind erosion are the most common natural dynamics affecting this prairie system. Wind energy development is increasing on prairie cliff/canyon habitats, but in general, condition of cliff and canyon habitats is good. Many cliff and canyon habitats are virtually inaccessible and in excellent condition.

Hot Springs

Hot Springs are the primary habitat for one Tier 2 SGCN (Table 8). These habitats are limited to physical settings that allow groundwater heated by geothermal processes to rise to the surface. Many of Colorado's hot springs have been developed for human recreation. Presumably this has had deleterious effects on habitat quality, but detailed condition of Colorado's hot springs has not been evaluated.

Reservoirs and Shorelines

This habitat, though man-made, is significant for 10 of Colorado's Tier 2 SGCN (Table 8), most notably the federally listed Least tern and Piping plover. Reservoir and shoreline habitat is distributed across Colorado. The largest and most important from a habitat perspective include John Martin and other reservoirs in southeastern Colorado. The future of reservoir and shoreline habitats in Colorado is difficult to predict. It seems reasonable to assume that under a warming and drying climate scenario (the likeliest future for the eastern plains), water resources will become scarcer. This situation could potentially change the management of dams and reservoirs. If water levels recede, the amount of plover or tern nesting habitat varies with the topographic contours of the reservoir. Some might gain more isolated islands with lower water, while the opposite may also be true (more dry areas connected to shoreline). Depending on how and when such changes were made, impacts to SGCN are possible but currently unknown.

Sand Dunes

Sand dunes are a primary habitat for four SGCN (Table 8). In Colorado, small sand dunes habitats occur in North Park and Middle Park, but the majority of sand dunes habitat occurs in the San Luis Valley. These environments are comprised of shifting, coarse-textured substrates and patchy or open grasslands or shrublands. Active and stabilized dune areas include a range of sparsely vegetated plant communities as well as barren or near barren (<5% total plant cover) portions of active sand dunes and sandsheet blowouts, where scattered individuals of early seral species such as blowout grass (*Redfieldia flexuosa*) and lemon scurfpea (*Psoralidium lanceolatum*), and (rarely) Indian ricegrass (*Achnatherum hymenoides*), are the only vegetation. The sandsheet may also include limited areas with woodlands of narrowleaf cottonwood or

ponderosa pine on otherwise sandy areas, as well as both shrubby and grassy areas where vegetation is acting to anchor dunes. Shrub dominated plant communities of the sandsheet are shrub steppe or shrublands dominated by rabbitbrush and other shrubs with a typically sparse herbaceous layer dominated by bunchgrasses. In early seral stages, vegetated dunes and sandsheet areas where shrubs are absent may be characterized by an herbaceous layer typically dominated by scurfpea and/or blowout grass, while in late seral stages Indian ricegrass, needle-and-thread or sand muhly (*Muhlenbergia arenicola*) are typical. The condition of most sand dune habitats in Colorado is very good, with the exception of those in North Park, where the dunes are impacted by recreational vehicle use and weeds.

Agriculture

For the purposes of the SWAP, this habitat type is restricted to no-till and conventional till agriculture in both irrigated and dryland (non-irrigated) situations, including croplands and orchards. Though rangelands are an important component of our state's agricultural system, native rangelands are included under relevant grassland and shrubland habitat types and omitted from this section. Agricultural fields constitute a man-made environment, but they now serve as important habitat for 39 SGCN (Table 8).

The major cropping regimes in Colorado can be broken into three regions: the Eastern Plains, the northwest, and the southwest. Crops on the Eastern Plains include irrigated and dryland situations where the major crops are wheat, corn, millet, milo, and alfalfa. Some of these cropping systems will include a fallow year. Aside from tall grasses, growing wheat provides some of the most available nesting cover on the Eastern Plains for ground nesting birds, including northern bobwhite. Additionally, CPW has recently documented successful nesting of lesser prairie-chickens in growing wheat via GPS transmitters. Corn, millet, and milo provide loafing and foraging cover for a wide suite of wildlife, and can also provide good winter cover if adequate stubble heights are left after harvest. The fallow period in some cropped or the non-cropped portion of the year can provide habitat components for low structure and bare-ground associated species like mountain plover and burrowing owl. CPW research on mountain plover has documented significant use and successful nesting on fallow agricultural fields.

Northwest region crops consist mainly of irrigated grass hay, wheat, and alfalfa. Irrigated grass hay and alfalfa fields can provide a variety of wildlife cover, but are especially important brood-rearing cover for greater sandhill cranes and greater sage grouse. Wheat fields in the northwest provide much of the same cover as those on the Eastern Plains and are especially important for Columbian sharp-tailed grouse. Irrigated hayfields and meadows also mimic native wet meadows and provide substantial benefits to SGCN using that habitat type, particularly in the three significant mountain parks (North Park, Middle Park, and South Park). Again, the fallow

cover that is left as part of the cropping rotations provides nesting, brood-rearing, and foraging cover for wildlife.

Southwest region crops consist primarily of irrigated alfalfa, grown for seed and hay, and barley, with relatively smaller amounts of sunflower, corn and potato. Each of these crops provide some cover for wildlife during the growing season, but generally these crops do not provide much winter cover due to harvesting and other treatments that reduce stubble heights and residual cover. A significant percentage of crops grown within the southwest region are dependent on irrigation; there are not many acres of tilled ground in this region.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is a federal program executed by the U.S. Department of Agriculture's Farm Service Agency. The program pays landowners to retire cropped lands for 10 to 15 years at a time to address soil erosion, water quality and wildlife habitat concerns. The retired fields are planted to a perennial cover of grasses, forbs and/or shrubs. These lands, which frequently provide critical wildlife cover and are often in areas where production cropland is the primary land use, support 26 SGCN. CRP lands are important for sustaining populations of Gunnison sage grouse, plains and Columbian sharp-tailed grouse, lesser and greater prairie-chickens, and a suite of grassland nesting birds as well as many other species. Currently, Colorado has approximately 1.8 million acres of land enrolled in the CRP, down from a high of 2.2 million. Most CRP lands are in eastern Colorado, east of Interstate 25, but pockets of CRP west of the Continental Divide also support locally and regionally important wildlife populations such as the Dove Creek population of Gunnison sage-grouse, Columbian sharp-tailed grouse in Routt County, and an experimental transplant population of Columbian sharp-tailed grouse in Dolores and Montezuma counties.

Many CRP lands were planted in the late 1980s during the first program sign-up. Because of their age and low diversity seed mixes focusing only on soil erosion during the early sign-up periods, Colorado's CRP fields generally lack plant species and structural diversity, and often may be monotypic stands of smooth brome, sideoats grama, or crested wheatgrass. Thus, most of the state's fields would benefit from management efforts designed to enhance plant diversity and increase wildlife habitat benefits.