Montane and Subalpine Forest

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Habitat Description

Montane and subalpine forests cover about 22% of Wyoming and generally occur at elevations greater than 7,000 feet where temperature, moisture, and nutrient conditions are sufficient to allow for tree seedling establishment (Comer et al. 2003, Knight 1994). At higher elevations, snow accumulation combined with lower evaporation rates due to cooler temperatures create a more mesic environment than in lowland habitats. While there can be considerable overlap in vegetation zonation, vegetation communities within the montane and subalpine forest habitat type often follow a predictable elevational distribution. Douglas-fir generally can be found at lower elevations; lodgepole pine at mid-elevations; and Engelmann spruce, subalpine fir, and whitebark pine at higher elevations. Ponderosa pine is also found at low elevations, in eastern portions of the state, sometimes in association with Douglas-fir. Limber pine, which grows from low elevations up to treeline, is another subalpine tree species. Both ponderosa pine and limber pine are addressed in the Xeric and Lower Montane Forests section of the SWAP, page III-11-1. Intermingled with these coniferous forests in the montane and subalpine habitat type are mountain grasslands and meadows, aspen groves, wetlands, riparian areas, and mountain shrublands with mountain lakes and streams. Aspen is addressed in the Aspen and Deciduous Habitat Type, page III-1-1. Additional information and descriptions of the 10 ecosystem types listed in Table 9 are available from the NatureServe web site (2010).

Vegetation is largely influenced by temperature, given the short, cool, and often dry growing season which limits photosynthesis, with frosts possible throughout the year. Plant species such as evergreens have a number of adaptations for extended photosynthesis in spring and fall, and for cold tolerance. Additionally, all trees have mycorrhizae root systems to extract nutrients from the upper soil layers where nitrogen is more available in the young nutrient-poor mountain soils. Soil water, often frozen, with frequent freeze-thaw cycles can cause soil disturbance and displacement. Vegetation patterns are heavily influenced by elevation, aspect, soil type, snow accumulation, and major disturbances such as fire, windstorms, insect outbreaks, and human activities such as logging (Knight 1994). Due to solar effects, south slopes are generally warmer and drier, and north slopes are generally cooler and more mesic. Large stands of conifers with greater canopy cover are generally located on slopes with northerly aspects. Persistent aspen stands, low-density conifer stands, and mountain shrublands occur most often on south aspects.

In Wyoming, 53% of the forest land is administered by the U.S. Forest Service; 17% is privately owned, including Indian Trust land; 15% is administered by the National Park Service; 11% is administered by the Bureau of Land Management (BLM); and the remaining 4% is owned by state, county, and other federal agencies (Wyoming State Forestry Division 2009)[1]. Especially at lower elevations, land ownership in Wyoming is often a checkerboard pattern with considerable intermixing of federal, state, and private forested lands. This pattern can complicate management and create land-accessibility issues for management activities.

In 1976, 78% of forest products were derived from public lands, with only 22% derived from private lands. By the year 2000, the volume of materials harvested had declined by 78%, but most significantly, 73% of those materials came from private forests (Wyoming State Forestry Division 2009). The 2000 tree harvest equaled 15.4 million cubic feet, not including trees removed for land clearing or land use conversions (The Conservation Fund 2009). In that year, 66% of the saw log harvest was composed of ponderosa pine with lodgepole pine contributing only 21.3% (Wyoming State Forestry Division 2009).

Aside from its value for raw materials, because of its high wildlife, scenic and recreational qualities, Wyoming's montane and subalpine

[1] Forested lands cover all forests in Wyoming including those associated with the montane and subalpine, aspen and deciduous, xeric and lower montane, and riparian habitat types addressed in this document.

forest habitat type receives significant human use including hiking, camping, hunting, bird-watching, skiing, and snowmobiling. Most water in Wyoming, which is used by agriculture, industry, and municipalities, originates in montane and subalpine forests as snowfall.

Douglas-fir

Douglas-fir makes up 8% of the forested area in Wyoming (Wyoming State Forestry Division 2009). Douglas-fir and ponderosa pine coexist at low elevations, usually below 8,500 feet (Knight 1994). Typically, Douglas-fir is found at slightly higher elevations and more mesic sites than ponderosa pine and is also found on limestone or sedimentary soils. Ponderosa pine is not found in western Wyoming, where Douglas-fir forests usually occur above foothill vegetation and below or intermixed with lodgepole pine forests. Like ponderosa pine, mature Douglas-fir has a thick, fire resistant bark so it can survive many surface fires and it is often a pioneer species post-fire.

Douglas-fir forests can be separated into two groups: 1) cool dry Douglas-fir, and 2) moist Douglas-fir. Cool dry stands generally have scattered to open canopies and typically experience low-to moderate-intensity fires which rarely kill mature Douglas-fir. Fire frequency is usually 30–70 years (LANDFIRE 2007). Cool dry stands of Douglas-fir generally occur on steep, south-to southwest-facing slopes and ridges in the lower parts of drainages. They provide important big-game winter and spring habitat due to an understory of abundant grasses, forbs, and shrubs. Large mature trees provide important roost and nesting sites for raptors and cover for ungulates in winter and early spring.

Moist Douglas-fir sites have more variable fire frequencies and intensities. Lower intensity fires have been documented to occur every 50–100 years and stand-replacing fires at 200–400 year intervals (U.S. Forest Service 2004b). Overstory trees are relatively fire-resistant to low intensity surface fires due to a thick bark. Moist Douglas-fir types are different from the cool dry Douglas-fir types in terms of understory composition, stand structure, the type of sites they occupy, and how they function within disturbance regimes. Common understory species are Rocky Mountain maple, pinegrass, heartleaf arnica, pachistima, white spirea, and blue huckleberry (Steele et al. 1983). Lodgepole pine, aspen, and limber pine may be major secondary species (Bradley et al. 1992).

Lodgepole pine

Lodgepole pine forest is the most abundant forest type in Wyoming, covering over 2.6 million acres (23%) of forest land (Wyoming State Forestry Division 2009). Lodgepole pine is capable of growing over a broad range of environmental conditions including high soil temperatures, low air temperatures, and water-saturated soils (Volland 1984); however, forests dominated by this species occur most commonly at middle elevations of from 5,900 to 10,500 feet in northern Wyoming and 7,000 to 11,500 feet in southern Wyoming (Green and Conner 1989).

Commonly considered a pioneer species, Lodgepole pine displays the characteristics of low shade tolerance, the ability to grow on almost any forest site, quick regeneration following a disturbance, and the rapid growth of young trees (Cole et al. 1985). Without disturbance, lodgepole pine forests often progress to a mixed-conifer community including subalpine fir, Engelmann spruce, Douglas-fir, and whitebark pine (Koch 1996a). Lodgepole pine forests can persist as a climax community on cool, dry, nutrient-poor sites, or where repeated disturbances or inadequate seed sources prevent other trees from becoming established (Cole et al. 1985, Koch 1996b).

Lodgepole pine possesses both serotinous and non-serotinous cones, providing the tree with a unique method of seed dispersal. Serotinous cones can remain closed for many years until opened by intense heat, typically fire or intense sunlight. Following a fire, large numbers of accumulated seeds are able to germinate with the exposure of bare mineral soil and low competition for resources from other plants, which creates favorable conditions for seedling survival. The rapid establishment of lodgepole pine after a disturbance can result in dense, structurally uniform, even-aged stands often referred to as dog-hair stands. Serotinous cones are especially important for the survival of lodgepole pines whose thin bark causes them to be easily killed by fire (Knight 1994).

Non-serotinous cones can release their seeds without the aid of fire, allowing them to regenerate following non-fire disturbance. There is evidence that younger trees, before the age of 20 to 30, tend to produce non-serotinous cones (Lotan 1976). The proportion of serotinous and non-serotinous cones varies between stands. Serotinous cones are in higher proportion in areas where the last disturbance was a stand-replacing fire (Lotan 1973, Tinker et al. 1994, Muir 1985, Nyland 1998).

The mean fire-return interval for lodgepole pine forests ranges from 100 to 300 years (Knight 1994). While most fires cover tens of acres, infrequent fires during dry years can cover thousands of acres and have major impacts on landscape vegetation patterns. With the mountain pine beetle epidemic that has been escalating in magnitude over the past decade, fire intervals and other natural ecosystem processes will likely be altered as the forest landscape changes (see Montane and Subalpine Habitats Threats – Disease and Insects).

Engelmann spruce-subalpine fir

Spruce-fir forests cover 1.8 million acres (16%) of Wyoming and are the second most abundant forest type (Wyoming State Forestry Division 2009). Engelmann spruce and subalpine fir can tolerate low temperatures and have relatively low water-use efficiency (Knight 1994). These attributes restrict their growth to cooler, wetter environments, such as timberline, on north-facing slopes, and along streams and ravines at lower elevations.

Spruce-fir forests are considered a climax community as both species are shade-tolerant and are frequently found in the understory as well as the overstory, meaning vegetation assemblages will progress to the dominance of these species following a disturbance. This attribute results in spruce-fir forests with uneven aged trees. As disturbances occur, lodgepole pine and aspen are often pioneer species and they can coexist with spruce and fir for a century or more (Knight 1994). Successional pathways for spruce-fir forests depend on the nature and intensity of disturbances, prior species composition, and site characteristics (Knight 1994). The rate of succession back to spruce-fir forest is influenced by fire suppression and the moisture level of the site (Romme and Knight 1981).

The proportion of spruce and fir varies. Subalpine fir is more common, and trees are often smaller and younger. Subalpine fir may have 10 to 20 times more seedlings than Engelmann spruce (Knight 1994). Subalpine fir is also capable of vegetative reproduction. When low branches are pressed into the ground by snow they begin to develop roots and the branch grows upright into a new tree (Knight 1994). Engelmann spruce compensate for their lower reproductive rate through longevity. They tend to be the oldest and largest trees and may live 500 years or more (Alexander 1987).

Stand-replacing fires are estimated to occur at intervals of about 300 years in dryer stands and longer intervals of 350 to 400 years for more mesic sites (Romme and Knight 1981). Fires in the subalpine forest are typically stand-replacing, resulting in the extensive exposure of mineral soil and initiating the regeneration of new forests. Modern fire suppression has increased the abundance as well as the homogeneity of these forests in terms of age and structure diversity. There is evidence in the pollen record that suggests a pattern of landscape dominance by spruce-fir alternating with dominance by lodgepole pine through several cycles reflecting climate changes or successional phases (Hanson 1940).

Whitebark pine

Whitebark pine comprises 5% of Wyoming's forests (Wyoming State Forestry Division 2009). Whitebark pine is a slow-growing, long-lived conifer of high-elevation forests and timberlines of the northwestern United States and southwestern Canada. In Wyoming, whitebark pine exists, often in association with limber pine, in the western part of the state from the Commissary Ridge area into Yellowstone National Park. Whitebark pine seeds are largely dispersed by Clark's nutcracker. The tree's multi-stem form results from seeds sprouting from Clark's nutcracker caches, commonly in burned areas or wind-swept ridges. The fire-return interval in whitebark pine communities is between 50–300 years (Arno 1986, Arno and Hoff 1989). Without fire, subalpine fir and Engelmann spruce increase and support fire events which can set back succession, again favoring whitebark pine. While its distribution is small, whitebark pine is considered a keystone species at high elevations throughout the northern Rocky Mountains due to its abundant seed production which is an important food source for wildlife. Recent surveys suggest that the mortality of whitebark pine in the Greater Yellowstone Ecosystem may be as high as 80% as a result of mountain pine beetle and blister rust infestations (see Montane and Subalpine Habitats Threats – Disease and insects, below).

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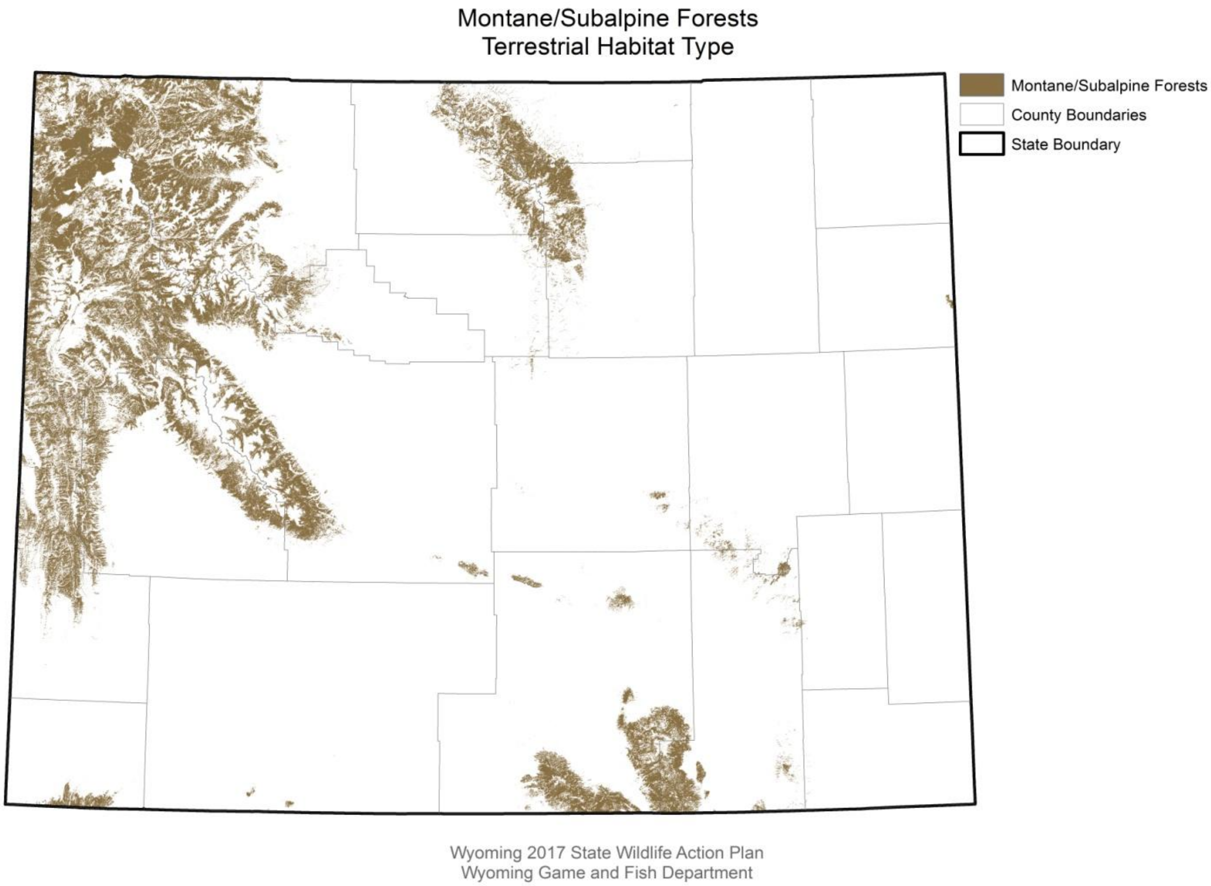


FIGURE 9. Wyoming Montane and Subalpine Forests

TABLE 9. Wyoming Montane and Subalpine Forests NatureServe Ecological Systems[2]

1. Northern Rocky Mountain Subalpine Woodland and Parkland
2. Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
3. Rocky Mountain Lodgepole Pine Forest
4. Rocky Mountain Subalpine Dry-mesic Spruce-Fir Forest and Woodland
5. Rocky Mountain Subalpine Mesic-wet Spruce-Fir Forest and Woodland
6. Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
7. Rocky Mountain Poor-site Lodgepole Pine Forest
8. Recently Burned Forest
9. Harvested Forest-tree Regeneration
10. Harvested Forest-grass Regeneration
11. Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland

[2] Descriptions of NatureServe Ecological Systems which make up this habitat type can be found at: NatureServe Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VA. http://www.natureserve.org/explorer.

TABLE 10. Wyoming Montane and Subalpine Forests Species of Greatest Conservation Need

Mammals
Abert's Squirrel
Canada Lynx
Dwarf Shrew
Eastern Red Bat
Fringed Myotis
Hayden's Shrew
Long-eared Myotis
Long-legged Myotis
Moose
Northern Flying Squirrel
Northern Long-eared Myotis
Pygmy Shrew
Uinta Chipmunk

Water Vole
Western Small-footed Myotis
Wolverine
Yellow-pine Chipmunk

Birds
American Kestrel
Bald Eagle
Black-backed Woodpecker
Boreal Owl
Calliope Hummingbird
Calrk's Nutcracker
Common Loon
Flammulated Owl
Great Gray Owl
Harlequin Duck
Lewis's Woodpecker
Northern Goshawk
Northern Pygmy-Owl
Red Crossbill
Rufous Hummingbird
Trumpeter Swan
Williamson's Sapsucker

Reptiles
Northern Rubber Boa
Smooth Greensnake

Amphibians
Columbia Spotted Frog
Wood Frog
Western Toad

Montane and Subalpine Forest Wildlife

Montane and subalpine forests in Wyoming contribute to the overall wildlife species diversity of the state, as higher elevation forests form a continuation of subarctic forests that extend across most of Canada and Alaska. A number of bird and mammal species in Wyoming that occur in this habitat type are at or near the southernmost extensions of their ranges. Many wildlife species only occupy this habitat in spring, summer, and fall, such as big game and passerine birds, which migrate to lower elevations and latitudes in the winter.

Because these forests are restricted to mountains they are regionally fragmented, and as a result, forest-adapted wildlife species are often genetically isolated. In fact, several Wyoming montane and subalpine forest mammals have evolved into distinct subspecies. Examples include Bighorn Mountain snowshoe hare (*Lepus americanus seclusus*), Bighorn Mountain montane vole (*Microtus montanus zygomaticus*), Black Hills marmot (*Marmota flaviventris dakota*), and Black Hills red squirrel (*Tamiasciurus hudsonicus dakotensis*).

Subalpine forests that include large components of course, woody debris and have high structural diversity are particularly important to forest carnivores such as pacific marten, wolverine, Canada lynx, and fisher. These habitats create subnivian spaces for thermoregulatory shelter and foraging sites in the winter.

Subalpine conifer forests are usually more diverse and provide more roost sites for bats than high-elevation forests. Some types of mid-elevation stands, especially lodgepole pine, sometimes form pure, dense, dog-hair stands of trees with small diameters and slow rates of growth. Stands in this condition probably do not provide ideal bat habitat (Hester and Grenier 2005).

Coarse, woody debris in the form of standing snags and downed logs is an important physical substrate for many forest species. Much of the primary productivity in forest stands is in the form of wood, which is indigestible to most vertebrates. Thus, wood-digesting invertebrates, fungi, and microbes often represent critical foods for many animals including the southern red-backed voles, red squirrels, and northern flying squirrels, all of which depend on forest fungi in their diets. Snags, which are dead standing trees, are important habitat for many cavity-nesting and insect-feeding birds. They also provide cavities, crevices, and exfoliating bark that serve as maternity colonies and roost sites for bats and may play a central role in determining the distribution and abundance of forest-roosting species (Hester and Grenier 2005). Additionally, dead wood is important in building forest soils.

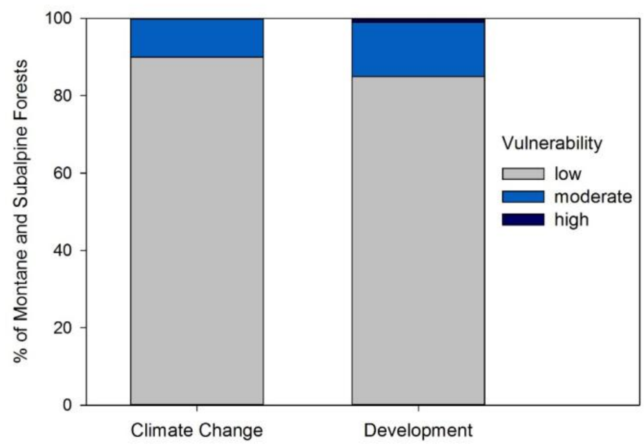
Whitebark pine seeds are an extremely important wildlife food in high mountain ecosystems for grizzly bears, red squirrels, black bears, ground squirrels, chipmunks, woodpeckers, nuthatches, Steller's jay, raven, and pine grosbeak (Kendall and Arno 1990). Whitebark pine also serves an important role as a nurse tree in facilitating the establishment of other types of vegetation. Its growth in alpine areas helps to stabilize soil and accumulate snow which retards spring runoff, reduces flooding, and improves water quality.

Spruce-fir forests provide hiding and thermal cover for moose and elk, forage for wintering moose, and important winter habitat for snowshoe hare, which is the principal prey of Canada lynx. Mule deer often use montane and subalpine forests as summer and transitional ranges.

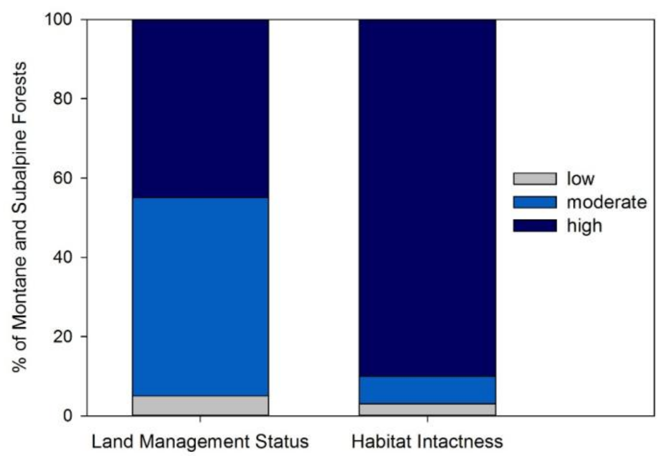
The Rocky Mountain Subalpine Dry-Mesic Spruce Fir Forest and the Rocky Mountain Mesic-Wet Spruce Fir Forest in conjunction with the lower-elevation mixed conifer and lodgepole pine forests are some of the most important ecological systems to Wyoming Species of Greatest Conservation Need (SGCN) occupying the montane and subalpine forest habitat type.

Montane and Subalpine Forest Habitat Threats

Figure 10. Montane and Subalpine Forests Vulnerability Analysis



The colored bars show the proportion of the habitat type that was identified as having low, moderate, or high vulnerability to climate change or development, based on classification of scores ranging from 0 to 1 into the following categories: low (<0.34), moderate (0.34-0.66), and high (>0.66). Rankings for climate change or development vulnerability were based on the land area of the habitat type classified as having high vulnerability: low (<10%), moderate (10-33%), or high (>33%). Vulnerability was calculated as exposure minus resilience. Development vulnerability includes existing and projected residential, oil and gas, and wind energy development. Further details are provided in the Leading Challenges section of this report and in Pocewicz et al. (2014).



The colored bars show the proportion of the habitat type that was identified as having low, moderate, or high land management status or habitat intactness. For land management status, high corresponds to the percent of the habitat occurring in GAP status 1 or 2, moderate to the percent occurring in GAP status 2b or 3, and low to the percent occurring in GAP status 4. Rankings for land management status were based on the land area of the habitat type classified as having high status or legal protection: low (<10%), moderate (10-33%), or high (>33%). For habitat intactness, scores ranging from 0 to 1 were assigned to categories as follows: low (<0.34), moderate (0.34-0.66), and high (>0.66). Rankings for intactness were based on the land area of the habitat type classified as having high intactness: low (<25%), moderate (25-75%), or high (>75%).

A "perfect storm" of the combined effects of fire suppression, drought, invasive plant establishment, and large-scale bark beetle infestations are currently resulting in landscape-scale changes to the flora in many Wyoming montane and subalpine forests. These threats are interrelated and often magnify the impacts of other disturbances.

Fire suppression – High to Low
Fire-suppression management strategies to protect timber, property, and human safety have been used since around 1890, shortly after European settlement of the West (Crisp, personal communication, 7 July 2010). Fire suppression has had a significant influence on montane subalpine habitat in some locations, although upper-elevation forests with infrequent fire regimes may have experienced variable impacts ranging from significant to negligible. Fire suppression has contributed to a loss of age, structural, and species diversity, increased stand densities, and the buildup of live and dead fuels. Timber patch size has remained unchanged, but due to suppression of surface and moderate intensity fires, forest openings or small breaks have either decreased in size or do not exist (Agee 1998).

These changes have resulted in a more homogeneous forest landscape pattern (Barrett 2004), which has contributed to a number of forest health concerns including intensifying the bark beetle outbreaks (see Montane and Subalpine Habitats Threats – Disease and insects). Tree mortality from bark beetles has occurred on an unprecedented scale within the montane and subalpine forest habitat type. High fuel loads create conditions more favorable to large-scale, high intensity fires. Such fires may cause significant impairment to regeneration, loss of valuable seed trees, loss of relict stands of mature trees and remnant populations of locally uncommon wildlife and floral species, aid in establishment of invasive plants, and further promote homogeneous landscape patterns. In some areas, catastrophic fires may result in the long-term conversion to non-forest landscapes. For some important forest community types, such as whitebark pine and aspen, perpetuation is dependent on occasional disturbance, most commonly by fire.

Disease and insects – High
Montane and subalpine forest habitats are home to a variety of beetles, which under normal circumstances are a natural component of forest ecology and serve the purpose of renewing a forest by killing older trees. However, in recent decades, the populations of several types of beetles have exploded to epidemic levels affecting trees in a variety of age classes.

Continued high population levels of bark beetles have resulted in large-scale tree mortality among several pine species, Douglas-fir, true firs, and Engelmann spruce forests in the Rocky Mountain region (U.S. Forest Service 2004a). Bark beetle-caused tree mortality has significantly affected the Medicine Bow, Shoshone, Uinta-Wasatch-Cache, Bridger-Teton, Bighorn, and Black Hills National Forests. Surrounding state and private lands are also experiencing increasing levels of tree mortality caused by bark beetles (Wyoming State Forestry Division 2009). In some locations, there is a near complete loss of mature forests and considerable mortality in immature stands (U.S. Forest Service 2004a).

Bark beetle outbreaks are believed to be facilitated by a combination of factors. Years of successive droughts have likely weakened some trees. Additionally, many forests consist of significant amounts of aging, denser stands, which are susceptible to bark beetles. Some historic logging practices and large fires, especially fires during the European settlement era 100–150 years ago, contributed to large areas dominated by even-aged stands of lodgepole pine. Activities such as thinning, sanitation, salvage, and regeneration harvest, associated with commercial timber management, have also been discontinued in some areas. Finally, fire suppression can also lead to increased stand densities by allowing understory trees to survive and mature. Adding to these forest conditions are warmer winter temperatures and earlier snow melt, which increases tree moisture demand and may allow bark beetle populations to expand rapidly (see Montane and Subalpine Habitats Threats – Drought and climate change).

Bark beetle-caused tree mortality can provide important habitat for some species of wildlife, provide coarse woody debris to streams, and contribute to nutrient recycling. Mountain pine beetle epidemics could result in increased aspen regeneration in many parts of the state as competition from conifers is reduced (Wyoming State Forestry Division 2009). However, large-scale bark beetle outbreaks may also have negative effects on wildlife, including loss of hiding cover and older tree habitat that is crucial for some species of threatened and endangered wildlife (Samman and Logan 2000).

Lodgepole and ponderosa pine are attacked and killed most often by mountain pine beetle and pine engraver beetles. Mountain pine beetle activity has declined across much of Wyoming after impacting over 3.47 million acres since the late 1990's. The epidemic has run out of suitable hosts in many areas across the state, but remains active in the southern Bridger-Teton and Shoshone National Forests, as well as the Wind River Reservation (2015 US Forest Service). Tree mortality resulting from epidemics can affect water flows and watersheds, future timber production, wildlife habitat, recreation sites, transmission lines, and scenic views. Where succession is more advanced, some beetle-killed stands of lodgepole pine may be replaced mainly by subalpine fir, although future fires may take stands back to lodgepole pine where serotinous cones predominate (Perry and Lotan 1979). If high-intensity fires occur in lodgepole pine stands with low numbers of serotinous cones, the seed source may be lost and it may take decades before lodgepole pines return (Schoennagel et al. 2003).

The most important insect impacting mixed forests of Engelmann spruce and subalpine fir is the spruce beetle. Usually these beetles are restricted to recently wind-thrown trees or trees weakened by root disease, but they can reach epidemic levels if the right stand structure and climatic conditions are present (Romme et al. 2006). There is significant scientific evidence that epidemics of spruce beetles have killed trees over extensive areas in past centuries (Veblen et al. 1991, Veblen et al.1994). Douglas-fir beetle has affected scattered stands that have been stressed by drought, fire, root rot, defoliation by western spruce budworm, or windfall. Noted outbreaks have occurred in the North Fork of the Shoshone River, on the west side of the Bighorn National Forest, and in lower elevations of the North Platte watershed on the Medicine Bow National Forest (Wyoming State Forestry Division 2009).

Mountain pine beetle is killing mature whitebark pine at a high rate similar to the 1930s outbreak which killed most of the mature whitebark pine in Yellowstone National Park (Gibson 2006). Mountain pine beetle usually kills larger cone-producing trees thus reducing regeneration potential (Keane 2001).

White pine blister rust (*Cronartium ribicola*) is either well established or becoming established within almost all Wyoming whitebark pine and limber pine stands. Only five percent of whitebark pine trees have genetic resistance to white pine blister rust (Tomback 2009). Historically, mountain pine beetle mortality would cause an increase in fuel loads and large fires that would create opportunities for natural regeneration. Blister rust has changed this normal progression by killing young whitebark pine and reducing cone crops by killing cone-bearing branches and tops. The U.S. Fish and Wildlife Service was petitioned to list the whitebark pine as a threatened or endangered species due to white pine blister rust, mountain pine beetles, and climate change. However, as of July 2011, the whitebark pine remains a candidate species eligible for protection under the Endangered Species Act, as listing was found to be warranted but precluded.

In combination, white pine blister rust and mountain pine beetle form a decline complex. Both seed production and the opportunity for germination have been reduced. Since whitebark pine regeneration is reduced, less natural selection for blister rust occurs (Waring and O'Hara 2005). Some tactics for decreasing blister rust include blister rust-resistant breeding programs and removal of alternate plant hosts (*Ribes* spp.) However, blister rust is a significant threat because no feasible tactics are available to limit its spread on a broad scale.

The occurrence and severity of fire following an insect infestation will depend on the forest type, intensity of the outbreak, and time since the last outbreak (Black et al. 2010). Although it is widely believed that insect outbreaks set the stage for severe forest fires, the scientific evidence for this is mixed. A few studies that support this idea report only a small effect, while other studies have found no increase in fire following outbreaks of spruce beetle and mountain pine beetle (Black et al. 2010). It has been hypothesized that the risk of fire may increase only during and immediately after outbreaks of bark beetles when the dry red needles are still on the trees, or that two periods of increased fire risk occur, with an additional peak when trees begin to fall in large numbers, which may occur decades after mortality (Romme et al. 2006). Once large amounts of fuel accumulate on the ground, the risk of fire and the resulting damage to other resources such as soils and water are expected to be greater than pre-epidemic risk (Hayes and Lundquist 2009). While there is mixed evidence for insect infestation leading to more fire on a broad scale, there remains ample evidence connecting insect-caused tree mortality and fire dynamics. For more information on bark beetle in the Rocky Mountain Region, visit http://www.fs.fed.us/r2/bark-beetle/index.html.

Drought and climate change – High
Elevated temperatures reduce beetle winter mortality as well as the time needed for beetles to complete a life cycle, both of which allow populations to grow quickly (Bentz et al. 2008). Increasing temperatures associated with climate change may fundamentally alter beetle-forest dynamics through significantly increasing beetle population numbers and enabling beetles to attack healthier trees (Bentz et al. 2008) at higher elevations and latitudes. Some climate models for Wyoming predict a continued trend of warming seasonal temperatures (Christensen et al. 2007), which, regardless of changes in precipitation patterns, may result in more frequent and severe drought and increasing frequency and extent of wildfire (see Wyoming Leading Wildlife Conservation Challenges – Climate Change). Some researchers have predicted that climate warming will increase the scope of mountain pine beetle infestations in whitebark pine (Six 2010, Tomback 2009).

Conflicting timber-harvesting practices and forest-management objectives – Moderate
In some locations, past timber-management practices such as commercial harvest, thinning, post-harvest treatments, and road construction have resulted to varying degrees in the loss and fragmentation of mature and old-growth forest habitats outside of wilderness areas and national parks in Wyoming. Some historic harvesting activities selectively removed the most productive stands of larger trees that were easily accessible and located at lower elevations on moderate slopes, habitat that is preferred by several wildlife species.

Timber-management plans are constructed to take into account numerous natural resource considerations. The effects of timber harvesting vary by method and by wildlife species and can have both negative and positive consequences. Negative consequences that can occur for certain species include: loss of habitat for cover, nesting, denning, and foraging; loss of certain tree and understory species for decades following treatments; decreased patch size of mature and old growth forests; invasion of exotic plant species; increase in more open country and common species that compete or prey on forest species; loss of travel and dispersion corridors; and increased disturbance resulting from the creation of roads that remain open for use in summer and winter.

It is not well understood how most montane and subalpine forest-associated species respond to habitat alteration and fragmentation. Also, it is often difficult to analyze harvest activities using a regional landscape perspective, which is needed for wildlife species that exist at low densities and have large home ranges. Timber-management treatments may result in long-term benefits to wildlife if based on ecological principles and landscape-level analysis. Without proper safeguards, salvage logging following wildfires may negatively affect nutrient recycling and snow retention, and remove and reduce important habitat features that affect some wildlife species including Canada lynx and its prey, and post-fire dependent woodpeckers.

Tree-dwelling bats, forest owls, northern goshawk, red-backed voles, snowshoe hare, Canada lynx, and other wildlife species may be negatively impacted by forest-management practices that favor even-age, monospecific stands, have short rotation times, decrease the proportion or alter the structure of old-growth stands, and selectively remove snags and older, larger trees (Nicholoff 2003, Hester and Grenier 2005).

Current Montane and Subalpine Forest Conservation Initiatives

The Wyoming State Forestry Division completed a Statewide Forest Resource Assessment in 2009 and a Statewide Forest Resource Strategy in 2010. Completion of both the assessment and strategy were requirements of the 2008 Farm Bill in order to receive State and Private Forestry (SPF) funds. Both the assessment and the strategy were to incorporate existing state plans including State Wildlife Action Plans. As states are proceeding with assessments, there is also a national assessment process. The national assessment will be used to establish broad-scale priorities for the future investment of SPF funding and resources.

Required elements of statewide forest resource assessments include an evaluation of forest resource conditions, trends, threats, and priorities. In Wyoming, this was completed largely through GIS analysis and shared with a variety of stakeholders, including the Wyoming Game and Fish Department (WGFD), for input.

The Wyoming Statewide Forest Resource Strategy outlines long-term comprehensive, coordinated strategies for investing state, federal, and local resources in addressing priority landscapes identified in the Statewide Forest Resource Assessment and designated national priorities. National priorities include conserving working forest lands for multiple uses; protecting forest from catastrophic events including fire, insect and disease outbreaks, and invasive species; and enhancing public benefits from forests: including air and water quality, biological diversity, forest products, renewable energy, and wildlife. Threats and conservation actions identified in Wyoming's Statewide Forest Resource Assessment and Forest Resource Strategy were reviewed in developing this habitat section of the SWAP.

Given the impact of the threats discussed above and the ecological, economic, social and cultural importance of Wyoming's forest-lands, Governor Matt Mead created the Task Force on Forests in 2013. The Task Force studied the benefits that forests provide, using their findings to analyze and consider new response strategies and recommendations for proactively managing Wyoming's forests in both the short- and long-term. The final Task Force Report was completed in January 2015 and gave further support to the Wyoming Forest Action Plan as well as 12 major recommendations, comprising 53 sub-recommendations for the Governor's consideration. These fall under three main themes: fire and other disturbance; resource management, and economic opportunities and innovation (GTFOF 2015).

Both the U.S. Forest Service and Bureau of Land Management (BLM) develop multi-resource management plans for the lands they administer including forested habitats. Under the 1976 National Forest Management Act (NFMA) and the 1969 National Environmental Policy Act (NEPA), forest land and resource management plans, generally referred to as forest plans, are to be developed by the U.S. Forest Service for each national forest and/or grassland and are to be revised every 10–15 years. Since forest plans are practical documents with recommendations and actions that are meant to be implemented on national forest land, an Environmental Impact Statement (EIS) is necessary.

Forest plans serve several functions: they establish forest-wide multiple-use goals and objectives, standards and guidelines, and management area direction; they determine areas that may be used for timber production, rangeland uses, recreation, and oil and gas leasing; they establish monitoring and evaluation requirements; and they recommend wilderness designations, wild and scenic river designations, and other special designations.

Forest plans set forth general guidelines and management directives; however, implementing the plan requires both decision-making at a more local level and site-specific analyses to evaluate the potential impacts of specific actions on resources including wildlife. Timber-harvesting on national forest land may be included in the forest plan, but the potential impacts of slash disposal, road construction, and general habitat disturbance must be considered for a range of species that inhabit the harvest area. Similarly, the forest plans allow for the development of recreation projects such as campsite construction, facility buildings, and trail building. Site-specific research is needed to determine the potential impacts of these actions, including increasing numbers of human visitors and subsequent anthropogenic impacts, on local wildlife and habitat.

The BLM is directed to develop land use plans by the Federal Land Policy Management Act (FLPMA) of 1976 and also NEPA. BLM land-use planning is guided by many principles including managing the land for multiple uses and sustained yield, using an interdisciplinary approach to consider all aspects of public land management, and identifying, designating, and protecting areas that are deemed to be areas of critical environmental concern. The agency must balance the use of the land for its economic values such as energy development and recreation, its biological value to wildlife, its physical open-space value, and social values for human enjoyment of natural landscapes and aesthetics. Each of Wyoming's BLM field offices has a resource management plan (RMP) that guides agency land-management activities throughout the state.

In Wyoming, the BLM and U.S. Forest Service, along with state cooperators, utilize the National Fire Plan (NFP) as the overarching plan to guide all fire-management activities. The NFP primarily focuses on ensuring state capacity to address wildfire prevention, fire preparedness and suppression, and post-fire stabilization and rehabilitation. As one of many objectives, the NFP includes elements of both duplicating historic fire regimes and benefitting wildlife habitat (see Wyoming Leading Wildlife Conservation Challenges – Disruption of Historic Disturbance Regimes – Fire). Community Wildfire Protection Plans (CWPP) have been developed at the county level for 20 of Wyoming's 23 counties. The CWPPs identify priority areas for wildfire mitigation and fuel reduction projects and make recommendations for how projects should be implemented.

There is a regional effort involving the U.S. Forest Service, BLM, National Park Service (NPS), Colorado State University, and the Rocky Mountain Research Station to identify and grow white pine blister rust-resistant limber pine and whitebark pine through seed collection and breeding. It is expected that it will initially take five or six years to develop seedlings for planting

Of the approximately 1.9 million acres of private forest lands in Wyoming, 410,295 acres (~22%) have management plans developed through the Assistance Forestry program (Wyoming State Forestry Division 2009). Management plans have been developed as a guide for landowners to help achieve their stated objectives. The information gathered through initiating this program has contributed to the development of the State Forest Resource Assessment. Recently, the U.S. Forest Service has collaborated with the Ruckelshaus Institute of Environment and Natural Resources at the University of Wyoming to develop a Private Lands Conservation Toolkit for Wyoming's public land managers. The toolkit is intended to encourage public land managers to participate, partner, and assist with local and county land-planning processes and voluntary, private land conservation efforts.

The Forest Legacy Program (FLP) was established in the 1990 Farm Bill to identify and protect environmentally important working forests from conversion to non-forest uses through voluntarily acquired conservation easements. The program is administered by the U.S. Forest Service in cooperation with state, regional, and local agencies. Timber harvesting is allowed on properties conserved through the Forest Legacy Program, but must be done in compliance with a State Forest Stewardship Plan and, for this state, Wyoming State Forestry's Best Management Practices for road construction and timber harvesting (The Conservation Fund 2009).

Recommended Montane and Subalpine Forest Conservation Actions

Efforts should be made to maintain, restore, and or duplicate the effects of historic fire regimes.

Increased human and property safety concerns resulting from greater development in and adjacent to forest lands has restricted the use of fire as a forest habitat management tool in many areas. This trend, along with unprecedented high fuel loads, will require forest managers to continue to develop alternative methods to duplicate the desirable effects of fire where appropriate and to be more strategic in the application of the following methods.

- In consultation with appropriate fire authorities and with a fire-use plan approved by all affected parties, utilize natural fires under approved burning conditions to duplicate historic fire regimes. In designated areas, allow surface and moderate severity fires to play their natural role in breaking up homogeneous landscape patterns. In order to maintain stand-replacing dependent ecosystems, including serotinous-cone lodgepole pine stands, large infrequent severe fires should be considered in fire-management plans (Turner et al. 2003).
- Use prescribed fires to reduce fuel loads and increase tree age-class diversity across the landscape. Increasing age- and size-class diversity will reduce the potential for whole landscapes being replaced by a single stand-replacing event such as a bark beetle outbreak or fire. Furthermore, it is desirable to set back succession in some areas to maintain aspen communities. Younger age classes generally produce more herbaceous and browse forage than advanced aged communities, which is needed for maintaining high quality big game transition and winter ranges. Agencies and landowners must work collaboratively to facilitate cross boundary implementation of prescribed fire, including the use of "Good Neighbor Authority."[3] Wyoming's Statewide Forest Resource Strategy (2010) contains recommendations to enhance the use of prescribed fire treatments in Wyoming.
- The wildland-urban interface is expanding in Wyoming, as in most of the West, which reduces opportunities for both natural and prescribed fires. In these circumstances, duplicating the desired effects of historic fire regimes can sometimes be better obtained through mechanical treatments that allow managers to determine residual stand complexity and density as well as species and age selection, including retaining valued stand components such as snags. Thinning can accelerate the development of structural characteristics typically found in old-growth stands, preserve the largest and

[3] Good Neighbor Authority refers to Congress authorizing the U.S. Department of Agriculture's Forest Service to allow the State Forestry Agencies to conduct certain activities, such as reducing hazardous vegetation, on U.S. Forest Service land when performing similar activities on adjacent state or private land. Efforts are being made to expand "Good Neighbor Authority" to other western states including Wyoming.

most valuable roost trees and snags, and create natural gaps in the canopy used by bat species that forage in more open habitats (Hester and Grenier 2005).

Develop and implement bark beetle management strategies.
Most direct bark beetle control efforts, such as spraying and removal of infected trees, have had little effect on the final size of outbreaks, although they may have slowed beetle progress in some cases and prolonged outbreaks in others (Hughes and Dreveri 2001). While control of such outbreaks is theoretically possible, it would require treatment of almost all infected trees (Hughes and Dreveri 2001), which may be possible only for localized areas. Long-term bark beetle management actions that can help restore forests, lessen negative impacts to wildlife, and reduce susceptibility to future beetle outbreaks include:

- Evaluate sites as they regenerate after beetle epidemics to determine appropriate long-term species composition.
- Evaluate future management of regenerated stands, post-beetle epidemic, to determine management strategies to avoid the development of another generation of large-scale, old, even-aged stands.
- Carefully plan the management of residual stands of larger trees to keep those stands healthy. Active management may be needed to achieve overall forest health objectives in those stands.
- Intensively manage younger regenerated stands to accelerate growth into larger size classes and promote long-term diversity.
- Where practical, use artificial regeneration where natural regeneration has failed.
- Reduce beetle-induced fuel loads to protect vulnerable regeneration, seed trees, remnant populations of mature trees, and isolated populations of locally sensitive wildlife species and uncommon flora.
- Manage stands to reduce future tree densities to lessen the risk of future bark beetle epidemics.
- Monitor salvage operations and fuel reduction projects on the landscape level. Road closures or removals would have to be carefully managed to avoid negative impacts on some wildlife species.

Encourage timber-management practices that benefit wildlife.

- Promote active forest management on suitable lands across all ownerships to achieve and/or maintain natural ecological processes and functions and associated appropriate age class, structural distribution, and plant diversity. Manage for vertical and horizontal heterogeneity, multiple layers of native plants, forest floor complexity, and a variety of age classes in forest and woodland habitats to provide for a diverse insect community, nesting and foraging sites, and roosting opportunities needed by birds and bats (Nicholoff 2003, Hester and Grenier 2005).
- For landscape-level planning, incorporate planning for species associated with older forests such as northern goshawk, forest owls, and Canada lynx to make sure that remaining patches of older forests are adequate in size and connectivity to support viable populations of these low-density wildlife species and their prey (Reynolds et al. 1992). Review management actions proposed by federal agencies in mature and old-growth forests and work closely with agency staff during early stages of project planning.
- Retain large-diameter snags and roost trees for cavity-nesting birds and bats. Where possible, it is recommended that all snags used by bats and cavity-nesting birds, all soft snags, and at least six hard snags per 2.5 acres (1 hectare) are retained (Oakleaf et al. 1996). Retain both evenly distributed snags and those in clusters to maximize diversity and mimic historical conditions (Nicholoff 2003). A minimum 500-feet radius buffer

of intact forest around roosts is recommended to avoid altering airflow and thermal regimes at roost sites (Hester and Grenier 2005).

- Research the effects of past logging and increased recreational levels on SGCN species occupying the Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and the Rocky Mountain Mesic Spruce-Fir Forest NatureServe ecological systems.
- Promote species diversity on lands capable of growing multiple tree species.

Conduct direct management and intervention activities to ensure the future persistence of whitebark pine and reverse recent losses.
Management actions that should be considered include:

- Restoration and maintenance of native fire regimes. This recommendation could be the single most important management action to ensure persistence of whitebark pine (Keane and Arno 2001).
- Management of adjacent stands that are being impacted by bark beetles through timber harvest and prescribed or natural fire to reduce the impacts from beetles on whitebark and limber pine stands.
- Collection and archiving of seed from isolated whitebark pine communities that may possess rust-resistance genetics, and planting of rust-resistant seedlings.
- Propagation of naturally rust-resistant trees where possible. Increase natural regeneration for greater selection of possible rust resistance and in areas where cone-bearing trees are at risk.
- Thinning whitebark pine stands to improve individual tree vigor, reduction of interspecies competition, increasing individual tree resistance to white pine blister rust, and decreasing disease transmission.
- Disseminating information on the status and distribution of whitebark pine.
- Selectively retaining whitebark pine in aspen enhancement projects.

Begin preparing for the potential influences of climate change on Wyoming's forests.

- Encourage research and monitoring to better understand the extent and effects of climate change on Wyoming's forests.
- Forest management should focus on maintaining healthy, diverse forests which are naturally resilient to many threats including climate change. Use adaptive management strategies to mitigate impacts resulting from climate change and to account for species adaptation.
- Adapt water-management techniques to accommodate changes in flow and timing as a result of climate change.
  - Manage forests to increase snow capture and retention, as well as to reduce the risk of flooding and excessive runoff. Manage canopy closure to influence snow accumulation. In created openings, maintain sufficient surface roughness to allow snow capture and retention.
  - On currently drier sites, manage for species with the greatest tolerance for dry conditions.
  - Adjust residual stocking levels to promote healthy forest conditions and promote water retention.
  - Adjust slash disposal requirements, utilization standards, and harvest design to accommodate any biomass utilization opportunities.
- Prepare for a likely increase in fire frequency and severity.

Encourage management agencies and research organizations to conduct studies on the ecology of snowshoe hare, forest grouse, tree squirrels, pocket gophers, and other species that form the base of the predator food chain in the montane and subalpine forest habitat type.

Montane and Subalpine Forest Monitoring Activities

Continue monitoring population trends or changes in distribution of montane and subalpine forest SGCN and other obligates in order to infer changes in habitat quality or other threats.
The U.S. Forest Service should be encouraged to survey for northern goshawks, boreal owls, great gray owls, and northern pygmy-owls using systematic survey techniques at least two years prior to proposed timber harvest treatments, prescribed fire, or other large-scale management activities.

Monitor the landscape distribution and habitat intactness of montane and subalpine forests through remote sensing.
Remote sensing is useful in tracking the size, distribution, and fragmentation level of montane and subalpine forest habitat in Wyoming. Information gathered would be helpful in determining the cumulative impacts of activities and events such as insect outbreaks, invasive plant establishment, logging, fires, and forest regeneration and succession. This technique may require the further development of monitoring protocols and identification of sample sites.

In cooperation with research entities, monitor the effects of climate change including extended periods of drought. Special attention should be given to the effects of climate change on hydrologic regimes, insects and disease outbreaks, and fire frequency.

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