

MOUNTAIN BIG SAGEBRUSH— FIRE ECOLOGY AND MANAGEMENT



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Nearly half of the area occupied by sagebrush (*Artemisia* spp.) ecosystems before European-American settlement has been lost due to conversion to other land cover types (e.g., barren, burn, nonnative grassland, nonsagebrush shrublands, and juniper woodlands) (35%), and agriculture, urbanization, and industrial development (10%). Thus, conservation and proper management of these ecosystems has been a priority, especially following the recent listing review of greater sage-grouse (*Centrocercus urophasianus*). An updated review (Innes 2017) of mountain big sagebrush (*Artemisia tridentata* subsp. *vaseyana*) is now available from the Fire Effects Information System (FEIS). This research brief summarizes the fire effects information from the FEIS species review regarding the biology and ecology of mountain big sagebrush, how fire affects it, and how mountain big sagebrush responds to fire.

Fire Effects and Succession

Wildfires in mountain big sagebrush steppe communities are typically high-severity, replacement fires that kill or top-kill most vegetation; however, fires can be patchy due to variation in fuels, topography, and weather resulting in a landscape mosaic of burned and unburned areas. Mountain big sagebrush plants are easily killed by fire and do not sprout. Post-fire establishment is from seed in the soil seed bank and from unburned plants in and adjacent to burns. The rate of recovery (i.e., the length of time necessary for mountain big sagebrush canopy cover to reach prefire or unburned levels) is driven by timing and abundance of post-fire seedling establishment.

Seedling establishment during the first few years after fire is highly variable because it depends on interacting factors including the abundance of viable seed in the soil seed bank, location of and seed production by unburned plants, post-fire moisture availability and weather, and post-fire herbivory. Fire timing, severity, size, and pattern affect the amount and distribution of unburned, seed-producing plants and soil-stored seed. Seeds must be within 0.6 inch (15 mm) of the soil surface to germinate; at this depth they are vulnerable to lethal temperatures during fire. Establishment of mountain big sagebrush after large, severe fires suggests that mountain big sagebrush seeds may persist in soil seed banks for 1 or more years.

Unburned mountain big sagebrush plants within and near the perimeter of the burn are an important seed source for post-fire seedling establishment, although seed production in mountain big sagebrush is highly variable and depends on weather, site, and plant characteristics (e.g., size, age, and genetics). Most mountain big sagebrush seeds disperse within 10 feet (3 m) of parent plants, so the distance from these seed sources to the burn affects the rate and distribution of post-fire seedling establishment. Seeds from unburned plants ripen after most wildfires occur (i.e., summer and early fall) and are dispersed primarily by wind in fall and winter. When ample seeds are present, post-fire water availability and browsing pressure greatly influence mountain big sagebrush seedling establishment, recruitment, and plant growth.

Key Findings

- **Disagreement in the published literature about the historical stand structure, distribution, and relative abundance of sagebrush communities and their historical fire regimes has led to opposing recommendations about the use of fire in mountain big sagebrush communities.**
- **Mountain big sagebrush is easily killed by fire and does not sprout, thus post-fire establishment depends on seed in the soil or dispersed from unburned plants.**
- **Rate and success of post-fire recovery depend on interactions among several variables: prefire vegetation; soil moisture and temperature regimes; fire timing, size, and severity; post-fire weather; and post-fire land use.**
- **Mountain big sagebrush sites often recover fully (to 27% shrub cover) within 26 or 30 years of burning, but they don't always recover. Cool, moist sites are likely to recover faster than warm, dry sites because they are more resilient to disturbance and more resistant to post-fire nonnative annual grass invasions.**
- **Site-specific management recommended to increase resilience to stress and disturbance and enhance the resistance to the establishment and spread of nonnative, invasive species is recommended.**

In the absence of fire or other large-scale disturbances, mountain big sagebrush can dominate shrub steppe communities. Other important large-scale disturbances in mountain big sagebrush communities include herbivory, freeze-kill, snowmold, and drought. Without these disturbances, mountain big sagebrush cover may become dense, and when the interval between fires is long enough (≥ 50 years) for trees to establish and mature stands adjacent to woodlands may succeed to woodlands. Woodland expansion is most common in mountain big sagebrush and other sagebrush communities with frigid to mesic soil temperature regimes and xeric soil moisture regimes. Increased cover of shrubs or trees diminishes cover of native grasses and forbs. Succession of mountain big sagebrush communities to late-successional shrubland or woodland communities also causes changes in wildlife habitat, fuel characteristics, fire behavior, and post-fire successional trajectories.



Figure 1. Wildfire adjacent to mountain big sagebrush steppe. Photo courtesy of WildlandFire.com.

Fire Management Considerations

Historically, prescribed fire, herbicides, and mechanical treatments were used to reduce cover and density of big sagebrush (*Artemisia tridentata*) and other woody plants and increase herbaceous plant cover and density. Mountain big sagebrush communities were one of the most frequently targeted sagebrush types. From the 1930s through the 1970s, and to a much lesser extent thereafter, land managers removed woody vegetation to increase grass production for livestock. Disagreement about the historical stand structure, distribution, and relative abundance of sagebrush communities and their historical fire regimes is prevalent throughout the published literature and has led to opposing recommendations about the use of fire in mountain big sagebrush communities. As well, management of mountain big sagebrush communities based on historical distribution and fire regime characteristics may not be realistic in landscapes impacted

by human development, nonnative plants, and climate change.

Contemporary management of mountain big sagebrush communities is primarily focused on increasing resilience to stress and disturbance and enhancing resistance to establishment and spread of nonnative, invasive species in order to create and maintain sufficient habitat for threatened, endangered, and numerous other wildlife species that rely on mountain big sagebrush communities for food and cover during all or part of the year. Big sagebrush communities differ in their resilience to disturbance and resistance to nonnative plant invasion (largely along climatic and elevational gradients, but also due to a number of interacting factors), and researchers have emphasized the importance of site-specific management actions. Decision tools including management guidelines, field guides, state-and-transition models, and web-based tools are available and described in the FEIS Species Review (Innes 2017). In general, fire is considered an appropriate and effective management tool only in communities where mountain big sagebrush is abundant, an understory of native perennial grasses and forbs are present, and cheatgrass and other nonnative plants are absent or sparse. Successful prescribed burns require consideration of fuel and fire characteristics, ways to promote native plant growth and recovery, prevention of nonnative plant establishment and spread, and careful management of post-fire livestock grazing.

Wildlife Considerations. Challenges of managing mountain big sagebrush communities for wildlife species include maintaining sufficient cover of mountain big sagebrush and native herbaceous species while reducing opportunities for nonnative plant and conifer spread and establishment. Prescribed fire may be a useful tool for enhancing wildlife habitat in mountain big sagebrush communities where objectives include reducing cover of woody plants and increasing cover of native perennial grasses and forbs, particularly for sage-grouse and wild ungulates. Prescribed burning can result in increases in abundance and productivity of herbaceous species for up to 10 years, but results vary. In addition, mountain big sagebrush provides important forage and cover for many wildlife species, particularly in winter, and its cover is reduced by fire for many years. A mosaic of successional stages on the landscape can provide areas with diverse, productive forage near areas with security and thermal cover and is considered beneficial to many wildlife species, including a broad range of ground-, foliage-, and aerial-feeding birds, small mammals, and wild ungulates, depending on the ratio of forage to cover over time.

Conifer Management. Prescribed fire is sometimes recommended to reduce conifer establishment in mountain

big sagebrush communities because cover of mountain big sagebrush and native herbaceous species decline with increasing conifer cover and because conifers are generally detrimental to sagebrush-obligates. However, these trees are also important ecosystem components and may be beneficial to facultative wildlife species if tree density is low enough to allow a healthy understory of shrubs and grasses. For example, abundance, diversity, and richness of avian and small mammal populations increases with low densities of western juniper (*Juniperus occidentalis*) in shrub-steppe communities, and small, scattered stands of trees may provide thermal cover for wintering ungulates. However, as tree abundance increases, wildlife abundance, species richness, and diversity tend to decline. Researchers generally only advocate for conifer removal in areas where trees were historically absent and tree density has increased since presettlement times. Several authors recommended that priority for conifer removal be given to mountain big sagebrush sites in early stages of woodland succession, before trees become dominant because they are likely more resilient than sites in later stages of woodland succession.

Nonnative Species. Mountain big sagebrush communities are among the least susceptible of sagebrush communities to invasion by nonnative annual grasses. Nonetheless, cheatgrass (*Bromus tectorum*) can dominate mountain big sagebrush communities after fire, especially if post-fire cover of perennial grasses is low and weather conditions are favorable for cheatgrass establishment and growth. Areas with a history of overgrazing by livestock or a high density of conifers are likely to have low cover of native perennial grasses and therefore less resistance to the establishment and spread of nonnative annual grasses. In areas where native perennial plant cover is depleted, seeding after fire may help stabilize soils, increase recovery of native plants, and prevent establishment and spread of nonnative species. Prescribed fire should be used only in areas unlikely to convert to cheatgrass or other nonnative plants.

Post-fire Grazing. Livestock tend to concentrate on burned mountain big sagebrush communities. To protect regenerating plants, many researchers and managers recommended excluding livestock for at least 1 or 2 years after fire, or until perennial grasses have recovered and are producing viable seeds equal to that of prefire or unburned levels.

Prescribed Fire. Researchers recommend that any prescribed fire in big sagebrush communities take place while plants are dormant, either in the spring or fall, with the objective of producing a patchy burn that reduces big sagebrush and increases herbaceous plant production. Some researchers recommended that fires in mountain big



Figure 2. Prescribed fire in mountain big sagebrush steppe. Photo courtesy of Kenneth Fulgham, Humboldt State University.

sagebrush communities be frequent enough to prevent tree establishment and succession to conifer woodland. On the other hand, fires in sagebrush communities should not be more frequent than the amount of time required for sagebrush to reach prefire or unburned canopy cover and density. Analysis of mountain big sagebrush post-fire recovery on 269 burned sites in 15 studies revealed most data (85%) came from burns less than 25 years old, and few sites (11%) had fully recovered. Sites tended toward full recovery of 27% canopy shrub cover 26 to 30 years after fire; however not all burns older than 25 years were fully recovered. Post-fire recovery varied within and among seven ecoregions. Sites in the Snake River Plain recovered relatively fast, while sites in Montana, Idaho, and Wyoming recovered more slowly, a result attributed at least in part to heavy post-fire browsing by wild ungulates. Post-fire recovery of mountain big sagebrush communities is likely to be faster if fires are small or patchy, with unburned plants inside burn perimeters.

Additional Reading & Information

Innes, R.J. 2017. *Artemisia tridentata* subsp. *vaseyana*, mountain big sagebrush. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). Available: www.fs.usda.gov/database/feis/plants/shrub/arttriv/all.html [2017, November 22].

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The Northern Rockies Fire Science Network (NRFSN) serves as a go-to resource for managers and scientists involved in fire and fuels management in the Northern Rockies. The NRFSN facilitates knowledge exchange by bringing people together to strengthen collaborations, synthesize science, and enhance science application around critical management issues.

