Mountain Big Sagebrush—Fire Regimes

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Estimates of historical fire regime parameters in mountain big sagebrush communities can be compared with current fire regimes and trends to establish general guidelines for ecological restoration. A synthesis of information on historical patterns and contemporary changes in fuels and fire regimes in mountain big sagebrush communities (Innes and Zouhar 2018) is available in the Fire Effects Information System (FEIS). This research brief summarizes information from that FEIS Fire Regime Synthesis.

Historical Fire Regimes

Historical Fire Ignitions. Presettlement fires in the sagebrush biome were lightning- and human-caused. Lightning frequency does not generally limit fire frequency in the sagebrush biome, although the frequency of lightning ignitions varies geographically and is influenced by climate and weather patterns, topography, and fuel characteristics. American Indians both started fires and benefitted from lightning-ignited fires. Fires were used to manage habitat for game animals, increase production of edible and medicinal plants, clear vegetation, control pests, communicate over distances, and defend against or attack intruders.

Historical Fire Season. Limited information from fire scars on adjacent and intermixed ponderosa pine trees suggests that fires in mountain big sagebrush communities were most common in summer and fall. Peak season for contemporary wildfires, and likely historical fires, occurs from April to October and varies geographically. Most wildfires occur in July and August throughout the western United States.

Historical Fire Frequency. Mountain big sagebrush communities occur over a productivity gradient driven by soil moisture and temperature regimes, and historical fire regimes likely varied across this gradient, with more frequent fire on more productive sites that supported more continuous fine fuels. However, because mountain big sagebrush is easily killed by fire and its postfire recovery depends on seedlings establishing and reaching reproductive maturity, large fires and fires frequent or severe enough to deplete on- and off-site seed sources and prevent plants from reaching maturity are likely to make mountain big sagebrush vulnerable to local extinction and favor grassland steppe over sagebrush steppe.

Key Findings

- **Historical fires in the sagebrush biome were both lightning- and human-caused.**
- **Wildfires were high-severity, stand-replacement fires that mostly occurred from April to October.**
- **Fires were most frequent on productive sites that supported more continuous fine fuels.**
- **Most fires were likely small (less than ~1,200 acres) and large fires (>24,000 acres) were infrequent.**
- **Fuels and fire regimes in many sagebrush ecosystems have changed since European-American settlement due to a combination of interrelated factors such as land management for livestock production, woodland expansion, nonnative plant invasions, and climate changes.**
- **The number of fires each year and total annual area burned have increased in the sagebrush biome since 1980. However, in most mountain big sagebrush communities, available data suggest that fire frequency has either not changed or has been reduced.**

Postfire recovery time (i.e., the length of time necessary for mountain big sagebrush canopy cover to return to prefire or unburned values) is sometimes used to estimate fire frequency in mountain big sagebrush communities. This is based on the premise that these communities did not burn, on average, more frequently than the time required for them to recover, but they did burn frequently enough to prevent succession to woodland. Our previous analysis of mountain big sagebrush postfire recovery data from 306 burned sites examined in 20 studies in 8 ecoregions indicated that few sites recovered within 25 years after fire, and most sites began reaching full recovery in about 26 to 30 years (Figure 1). However, variability was high: one site reached full recovery in 8 years, while another site had not recovered after 67 years. This broad range in postfire recovery rates suggests that a similarly broad range in fire frequencies would be compatible with mountain big sagebrush persistence and dominance within a landscape.

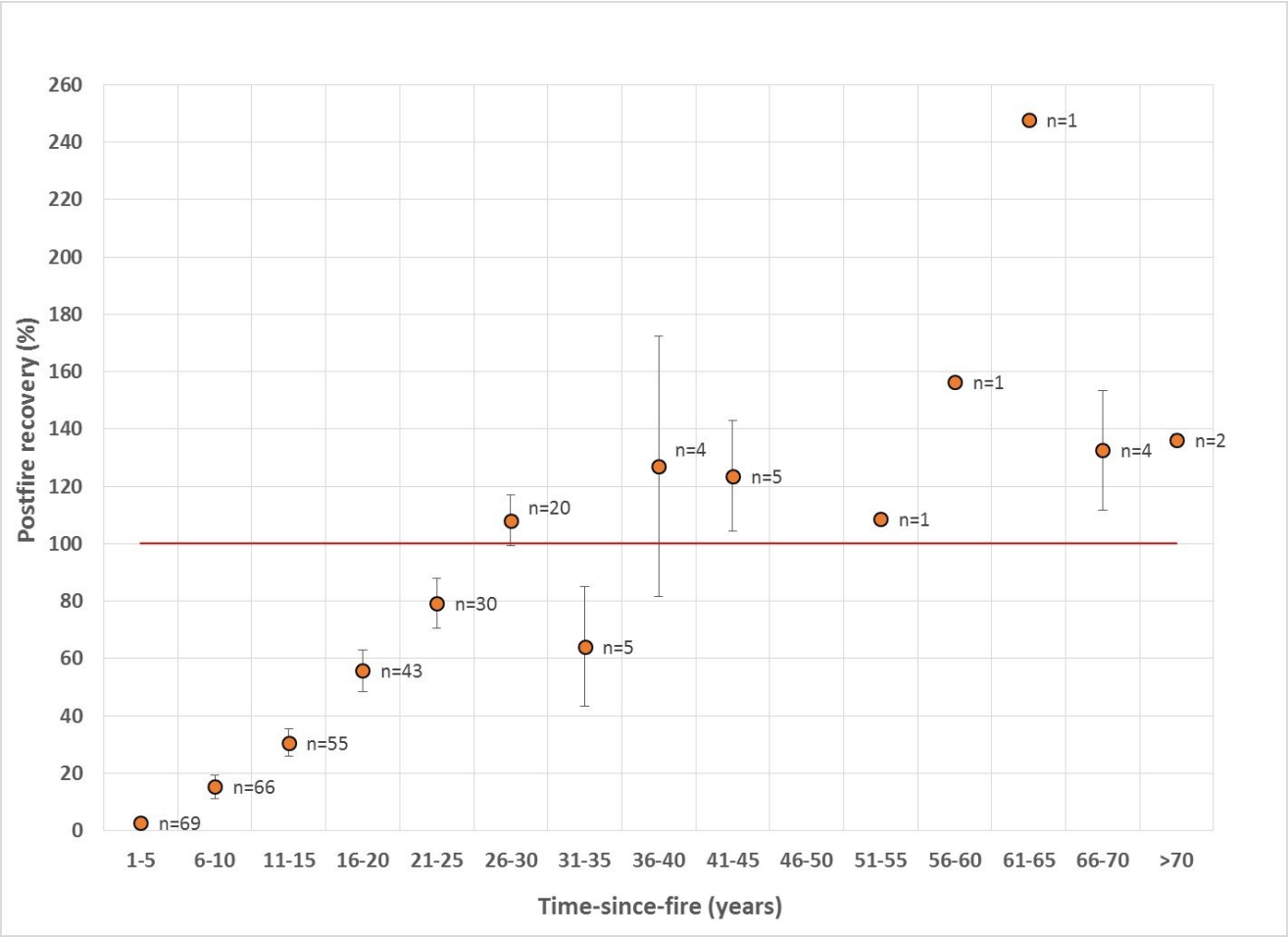

Figure 1. Points show the mean ratio of burned to unburned (or prefire) canopy cover (i.e., "postfire recovery") of mountain big sagebrush within 5-year, time-since-fire categories; error bars are standard errors. The red line indicates recovery to unburned (or prefire) canopy cover.

Fourteen studies used proxy information to estimate historical fire frequency in mountain big sagebrush communities. Frequency estimates ranged from decades to centuries, depending on the applicable scale, methods used, and metrics calculated. However, some studies showed a similar geographic pattern: fire was most frequent in the western portion of mountain big sagebrush steppe's distribution in California and Oregon and least frequent in the central and eastern portions in Idaho, Montana, Wyoming, Colorado, Utah, and Nevada. Three studies presented information on fire activity derived from charcoal analyses. These were located in the Idaho Batholith and Middle Rockies ecoregions and suggest that fire activity in those landscapes was episodic and tended to peak during centuries and decades with higher than average precipitation. Eight studies estimated fire frequency from fire scars on trees adjacent to and intermixed with mountain big sagebrush communities. These studies reported mean fire intervals ranging from 6 to 61 years, and estimates varied among associated woodland types, site types, and ecoregions. Mean fire intervals reported in these studies were shortest (6-17 years) for sites in the Eastern Cascades Slopes and Foothills and the western portion of the Northern Basin and Range ecoregions, where mountain big sagebrush communities were adjacent to and intermixed with ponderosa pine communities, and longer in the Central Basin and Range (25 years), Colorado Plateaus (61 years), Middle Rockies (17-45 years), and Wasatch and Uinta Mountains (40 years) ecoregions, where mountain big sagebrush communities were adjacent to and intermixed with ponderosa pine, Douglas-fir, lodgepole pine, and other woodland or forest communities. Three studies presented estimates of historical fire rotations in mountain big sagebrush communities in eight ecoregions using vegetation reconstructions based on Government Land Office survey records from the late 1800s and early 1900s. These studies suggested that fire rotations were shortest in the Eastern Cascades Slopes and Foothills and western portion of the Northern Basin and Range (48-77 years) and longest in the Wyoming Basin (588-2,139 years) ecoregions.

Historical Fire Type, Severity, and Intensity. Historically, wildfires in mountain big sagebrush

communities were high-severity, stand-replacement surface and crown fires. Historical fire intensity was mostly low—based on the assumption that sagebrush communities typically had abundant, continuous fine fuels and widely scattered and patchy shrub cover—or moderate, presumably in areas with greater shrub cover.

Historical Fire Pattern and Size. Most historical fires were likely small (less than ~1,200 acres), and large fires (>24,000 acres) were infrequent. Large fires most likely occurred when fine fuels were abundant and continuous, such as after one or more relatively wet years or seasons. However, this relationship may not be as strong for relatively cool, moist mountain big sagebrush sites as for warm, dry Wyoming big sagebrush sites because fine fuels are less often limiting on mountain big sagebrush sites, especially prior to widespread heavy livestock grazing. Few studies provide information about historical fire patterns. Government Land Office survey records indicated that fires left little (<4%) unburned area within burn perimeters. Simulation models and habitat requirements of sagebrush obligates, however, suggest that large fires were mosaic fires, with many unburned patches.

Contemporary Fire Regimes

Since European-American settlement—beginning in the mid -1800s—fuels and fire regimes in many sagebrush ecosystems have changed due to a combination of interrelated factors, including livestock grazing and associated land management, land development for agriculture and energy, urbanization and infrastructure development, proliferation of nonnative invasive plants, woodland expansion, and climate changes. In total, about a third of the land formerly occupied by sagebrush communities has been converted to nonnative grasslands, conifer woodlands, and other cover types, and additional areas of big sagebrush are under threat of conversion.

Contemporary Fire Ignitions. While American Indian influence on historical fire regimes is not fully understood due to a scarcity of historical records, it is clear that this influence was reduced by the end of the 1700s. Decreases in American Indian ignitions contributed to less frequent fire in sagebrush communities in some areas. However, intentional ignitions by early European-American settlers to increase grass production for livestock and clear land for farming were thought to exceed historical ignition rates of American Indians in some sagebrush communities. These "indiscriminate" burning practices led to policies during the early 1900s that discouraged ignitions and required fire suppression. Nonetheless, land managers continued to use prescribed fire and other manipulations from the 1930s through the 1970s—and to a lesser extent thereafter—to reduce sagebrush cover and density in an effort to increase grass production for livestock and wildlife forage. Mountain big sagebrush communities were frequently targeted. Although humans still cause many fires, most contemporary wildfires in sagebrush communities are lightning-caused. Nonnative annual grasses may alter lightning ignition rates on invaded sagebrush sites.

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

Contemporary Fire Season. Contemporary fire seasons have lengthened due to human-caused fires, annual grass invasions, and climate change. Contemporary human-caused fires lengthen the fire season because they often occur outside the lightning season. Because cheatgrass matures and desiccates earlier than most native herbaceous species it replaces, wildfires in cheatgrass-dominated communities tend to occur earlier in the season, when native perennials are more susceptible to injury from fire. Cheatgrass can also carry fire 1 to 2 months later than native perennial grasses in fall. Climate changes in the late 1900s and early 2000s have lengthened fire seasons throughout the western United States; this is likely to continue. Climate changes may hasten the rate of type conversion from sagebrush types to cheatgrass grasslands by lengthening the period during which conditions are conducive to fire ignition and spread and furthering the invasive grass/fire cycle.

Contemporary Fire Frequency. In many mountain big sagebrush communities, available data suggest that fire frequency has either not changed or has been reduced, with the exception of an area in the Colorado Plateaus ecoregion where fire frequency may have increased. However, data on historical fire regimes are insufficient to accurately evaluate changes in fire frequency in many mountain big sagebrush communities, and differences among studies in the applicable scales, methods used, and metrics calculated further muddle the story. For example, a study of charcoal in sediments in the Middle Rockies indicated similar fire occurrence before and after European-

American settlement, while studies of fire scars on trees associated with mountain big sagebrush communities in the Eastern Cascades Slopes and Foothills, Middle Rockies, and Northern Basin and Range ecoregions indicate reduced fire frequency after European-American settlement. Fire rotations in most studied ecoregions appear unchanged, but may have increased in parts of the Colorado Plateaus, Middle Rockies, Northern Basin and Range, and Snake River Plain ecoregions and decreased in Dinosaur National Monument in the Colorado Plateaus ecoregion. Reduced fire frequency was attributed to a variety of causes, particularly elimination of American Indian ignitions, removal of fine fuels by heavy livestock grazing, and fire suppression. Increased fire frequency was attributed to frequent prescribed burning in the 1980s and 1990s (Figure 2).

Contemporary Fire Type, Severity, and Intensity. The cover and density of conifers have increased in many mountain big sagebrush communities. As tree crowns increase in size, continuity of crown fuels increases and surface fuel abundance, continuity, and density decrease. These changes in fuel characteristics reduce the potential for surface fires burning under moderate weather conditions and increase the potential for high-intensity crown fires burning under extreme weather conditions. As prefire cover of native shrubs and herbs decreases and that of conifers increases, postfire recovery of mountain big sagebrush communities becomes slower and postfire invasion by cheatgrass becomes more likely.

Figure 3. Fire spreading from a cheatgrass grassland (a site likely formerly dominated by Wyoming big sagebrush and perennial grasses) into a mountain big sagebrush community during the 2011 Constania Fire, Long Valley, California. Photo by Nolan Preece.

Contemporary Fire Type, Severity, and Intensity. While contemporary fire frequency has not changed or has been reduced in many mountain big sagebrush communities, since 1980, the number of fires each year and total annual area burned have increased in the sagebrush biome, overall. Available data on mountain big sagebrush communities suggest an upward trend in annual area burned in several parts of the western United States, including the Colorado Plateau and Southern Great Basin. These trends have been attributed to the establishment and spread of nonnative annual grasses (especially cheatgrass), but also to increased cover of sagebrush and other woody vegetation and increased grass cover following more conservative livestock management beginning late in the 20th century on some sites. Heavy livestock grazing during the late 1800s and early 1900s likely reduced fire sizes by reducing fine fuels in many mountain big sagebrush communities. However, cessation of heavy livestock grazing and fire suppression policies since that time have resulted in increases in fine fuels, and the number of large fires have also increased in some areas. When nonnative annual grasses establish and spread into big sagebrush communities the abundance and continuity of fine surface fuels is likely to increase—especially in years or seasons following those with abundant precipitation—which can increase fire activity on invaded sites. Fire activity may increase on mountain big sagebrush sites adjacent to cheatgrass-dominated sites because fire can spread into mountain big sagebrush sites from cheatgrass grasslands (Figure 3).

Additional Reading & Information

Innes, Robin J.; Zouhar, Kris. 2018. ***Fire regimes of mountain big sagebrush communities***. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). Available: https://www.fs.usda.gov/database/feis/fire_regimes/mountain_big_sagebrush/all.html [2019, February 25].

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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.