Fire on the Mountain:

Optimizing post-fire restoration of cheatgrass invaded core sagebrush steppe of the Greater Yellowstone Ecosystem

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Wildfire, climate change, and invasive species are among the greatest threats to the Greater Yellowstone Ecosystem (GYE). One of the most concerning invasive species is cheatgrass (*Bromus tectorum*), an annual grass that reproduces rapidly, dries out early, and acts as a fine fuel altering fire regimes that can permanently degrade the sagebrush steppe. Sagebrush steppe of the GYE, dominated by mountain big sagebrush (*Artemesia tridentata ssp, vaseyana*) at higher elevations, is key winter and migration habitat for mule deer, elk, and pronghorn; summer habitat for migratory birds; and year-round habitat for imperiled greater sage. The Defend and Grow the Core strategy argues managers should first focus on intact core sagebrush that are of immediate high value to wildlife and grow them by working outward towards more degraded areas, rather than focus on degraded areas first. Little is known about how to address cheatgrass invasion into higher elevation, core mountain big sage habitats, controlling invasion before it becomes irreversible. To address this gap, we are developing management recommendations for post-fire restoration in the recently invaded sagebrush steppe of the GYE. Two common herbicide treatments for cheatgrass are imazapic (Plateau and Cadre), and indaziflam (Rejuvra and Esplanade). Imazapic is a selective herbicide for both pre- and post-emergent control of annual and perennial grasses and broadleaf weeds. Indaziflam, a selective pre-emergent herbicide, effectively controls annual grasses and annual broadleaf plants. This study aims to improve methods to mitigate cheatgrass invasion by testing the effectiveness of these two aerial cheatgrass herbicide treatments and subsequent restoration of native vegetation that improves wildlife habitat, especially forbs in the greater sage-grouse diet. This evaluation is conducted in comparison to a "leave it alone" control. Additionally, we test different seeding times (1- or 2-years post-herbicide treatment), comparing three seed mixes comprised of the same 11 species but with different genetics and origins, and two seeding techniques (broadcast and deep-furrowing). The three seed mixes include (1) commercially available, (2) local genetics, and (3) Regional Admixture of half locally sourced seeds and half from a warmer, drier climate. Our results demonstrate the effectiveness of indaziflam to reduce cheatgrass cover below 1%, and maintain native plant cover, diversity, richness, and forbs in the sage grouse diet comparable to the control. Alternatively, imazipic reduces cheatgrass cover while also significantly reducing native plant cover, richness, and diversity. Results demonstrate benefits of re-seeding in certain post-fire scenarios, with little differences between seed mixes. The best seedling emergence and survival was found in the deep furrowing treatments compared to broadcast or untreated. In conclusion, this study presents a portfolio of restoration techniques to apply in post-fire scenarios of core sagebrush habitat in the wake of climate change and cheatgrass invasion in the GYE.

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