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Woody Fuels Reduction in Wyoming Big Sagebrush Communities

Purpose: To discuss consequences and options for woody plant fuel reduction in Wyoming big sagebrush plant communities of the Intermountain West.

In Brief:

- Loss of understory herbaceous species, an increase in annual weed cover, and in many cases an increase in shrub cover have resulted in more fine fuels, greater fuel continuity, and more frequent fires in Wyoming big sagebrush communities.
- Fuel treatments can decrease woody fuels and fire severity and help restore the plant community, but the possibility of negative versus positive effects must be carefully evaluated.
- Thinking through a series of key questions that determine treatment response helps in deciding whether to proceed with woody fuels reductions and, if so, which treatment methods to use.
- Herbicides or mechanical treatments may be used, depending on impacts of treatment on the desirable herbaceous species and the degree of surface disturbance. Prescribed fire in Wyoming big sagebrush is extremely risky and, in general, is not recommended.

Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young) ecosystems historically have been subject to disturbances that reduce or remove shrubs primarily by fire, but occassionally due to insect outbreaks and disease. Depending on site productivity, fire return intervals occurred every 60-110 years. Following fire, perennial grass-dominated plant communities slowly underwent succession to return to a community co-dominated by sagebrush and perennial grasses. Due to historical and (in some cases) recent overgrazing, many Wyoming big sagebrush communities have undergone changes in plant community composition – primarily a decrease in the density and cover of native perennial grasses and forbs.

The consequences of this loss of understory herbaceous species have been an increase in annual weed cover and, in many cases, shrub cover. Increases in annual weeds such as cheatgrass (*Bromus tectorum* L.) result in more fine fuels, greater fuel continuity, and more frequent fires. These changes have led to more severe and larger fires during periods of extreme fire weather.

Management to address these changes in fuels and fire behavior is challenging in Wyoming big sagebrush communities because warm and dry conditions coupled with low productivity result in (1) low resilience and thus slow recovery following both wildfire and management treatments, and (2) low resistance to annual weeds.

Why Reduce Woody Fuels in Wyoming Big Sagebrush Communities?

Objectives for fuel management in Wyoming big sagebrush communities typically include both decreasing woody fuels and fire severity, and restoring ecosystem structure and function. Reducing woody plant cover has the potential to increase production of perennial grasses and forbs, improve habitat for some wildlife species, reduce intensity and severity of wildfires, increase fire suppression options, and reduce smoke particulate production harmful to human health (Pyke et al. 2014). In most cases shrub thinning is the most appropriate goal, but complete shrub removal may be appropriate for highly specific goals. For example, fuel breaks along roads can reduce the likelihood of wildfire spreading into adjacent sagebrush communities and provide a safer environment for fire suppression. (See “Fuel Breaks that Work” in the Great Basin Factsheet series.)

Potential Positive and Negative Consequences

Woody fuel treatments in Wyoming big sagebrush communities may have both positive and negative consequences. The likelihood of a positive response depends on the management goals, overall environmental context, pre-treatment condition of the community, and methods used.

A primary objective of thinning of sagebrush fuels is to release desirable perennial herbaceous vegetation from competition with sagebrush and promote increases in its density and cover (Pyke et al. 2014).

Increases in perennial herbaceous vegetation can increase resistance to weed invasion and resilience to future disturbances (e.g., wildfire), decrease the abundance of dry fine fuels produced by exotic annuals, decrease wind and water erosion, and increase water infiltration, soil organic matter, and soil carbon sequestration. However, perennial grass response to shrub removal or reduction depends on both the method used and the initial cover of native perennial grasses, and is not always positive (Davies et al. 2011). Shrub thinning can increase soil water and nutrient resources which can be used by desirable herbaceous perennials. However, the extra resources also can be monopolized by exotic weeds, especially if the treatment results in soil surface disturbance, increasing the likelihood of fire and habitat degradation. Shrub removal, even in the absence of ground disturbance, may decrease long-term resistance of plant communities to exotic annual grass invasion (Blumenthal et al. 2006).

The effect of Wyoming big sagebrush reduction on wildlife habitat depends on the species of wildlife and the method and amount of reduction. Although treatment results are variable, it has been suggested that sagebrush reduction can stimulate production of forbs important to brooding sage-grouse, wild ungulates, and pollinators. Sagebrush reduction by mowing has been found to increase Wyoming big sagebrush nutritional quality (Davies et al. 2009). Small patches of reduced sagebrush cover within sagebrush landscapes have improved sage-grouse brooding habitat in mountain big sagebrush, but these relationships have not been tested in Wyoming big sagebrush (Beck et al. 2012).

In contrast to the potentially beneficial effects, loss of structural habitat complexity with shrub reduction or removal may negatively impact shrub-dependent wildlife species and impair screening cover in sage-grouse breeding habitat (Beck et al. 2012). The degree of impact varies with treatment spatial scale. Small-scale reductions within a largely intact sagebrush landscape may have little negative impact and can even benefit birds whose habitat requirements are associated with spatial and seasonal availability of grass- and forb-dominated plant communities. However, if sagebrush reduction leads to reduced forb abundance, seasonal habitat for sage-grouse, wild ungulates, small mammals, and pollinators can be compromised. Habitat for both shrub and herbaceous-associated wildlife species is compromised if shrub reductions result in exotic annual grass increases. Loss of, or dramatic reduction in sagebrush cover can have negative impacts on the winter habitat of sage-grouse, pronghorn, mule deer, and elk. Also, reduction in sagebrush cover may reduce nesting cover for sage-grouse and nesting habitat availability for twig-nesting native bees, which are important pollinators.

Increasing the Chances of a Positive Outcome

Whether the response to fuels treatment is positive or negative depends on many factors, some of which can be controlled and some not. While responses are complex, thinking through a series of key questions that determine plant successional trajectories following treatment will help to determine whether to proceed with woody fuels reductions and, if so, which treatment methods to use (Table 1; Miller et al. 2014).

Table 1. The primary components that determine successional trajectories following fuels treatments, and the key questions used to evaluate those successional trajectories and consequently, management outcomes (adapted from Miller et al. 2014).

Primary Components	Key Questions
Ecological Site Characteristics	• Temperature regime? • Moisture regime? • Potential vegetation?
Current Vegetation	• Reference state & phase (seral state)? • Invaded state or phase-at-risk? • Invasive species seed source? • Need to seed? • Old-growth or woodland phase?
Disturbance History	• Types? • Past effects? • Current impacts?
Treatment Type & Severity	• Intensity and duration? • Crown or surface fire? • Size and complexity? • Time of year? • Surface disturbance?
Pre & Post Weather	• Fuel loads and moisture? • Seed banks? • Post treatment establishment? • Recent drought?
Post-Fire Grazing	• Deferment period? • Active management?
Monitoring & Adaptive Management	• Were the objectives met? • If not, what adjustments or follow-up management is required?

What is the ecological site type?
Ecological site descriptions provide information on climate, topography, and soils and can be used to help predict treatment outcomes. Favorable herbaceous responses are more likely on sites with relatively high productivity and cool (frigid) and moist (ustic or xeric) soil temperature and moisture regimes than on sites with warm (mesic) and moist or dry (aridic) regimes (Chambers et al. 2014; Miller et al. 2014).

What is the pre-treatment composition of the plant community?
The pre-treatment cover of perennial grasses and forbs is a primary determinant of the site's response to treatment. In general, the greater the cover of perennial grasses and forbs prior to treatment, the greater the likelihood of a favorable response. In Wyoming big sagebrush communities, about 15 to 20 percent pre-treatment cover of herbaceous perennial species appears necessary to prevent post-treatment increases in exotic annuals (Davies et al. 2008, Chambers et al. 2014).

What is the overall condition of the community as determined by its disturbance history?
If interspaces between perennial plants are predominantly covered by exotic annual grasses (as opposed to bare ground), or, if perennial bunchgrasses are located predominantly under shrub canopies, the apparent trend is downward and the site could be at high risk of annual grass increases following treatment or disturbances such as wildfire.

How will the treatment affect the recovery potential of the site and the likelihood of increasing exotic annuals like cheatgrass?
Treatments that reduce cover or density of herbaceous perennials or biotic crusts can threaten post-treatment recovery. Surface disturbance and associated biotic crust damage often favor cheatgrass and other exotic annuals. Also, herbicide treatments that reduce sagebrush or perennial grasses and forbs can increase resource availability and may favor annual invaders if post treatment cover of perennial herbaceous species is insufficient for recovery.

How will pre- and post-treatment weather influence treatment outcomes?
Weather conditions prior to, during, and following the treatment year can affect recovery of native perennials and the response of cheatgrass and other annual invaders. Consequently, weather can influence both the decision to treat and post-management actions such as length of grazing deferment.

Is a post-treatment management plan in place?
If perennial grass cover is limited prior to treatment, grazing should be deferred after treatment to allow perennial grasses to recover. The length of deferment depends on the productivity and soil temperature and moisture regime of the site, the pre-treatment cover of perennial grasses, treatment severity, and the post-treatment weather. Warm and dry sites with low productivity and sites with lower cover of perennial grasses and forbs will require longer periods of deferment, especially during drought periods.

Is a monitoring plan in place?
Post-treatment monitoring provides information on treatment outcomes that can be used to adjust future treatment prescriptions as well as post-treatment management.

What will the impacts be on other important resources?
Interdisciplinary teams including state agency wildlife biologist should be used to plan woody fuels reduction treatments (amount of removal, spatial pattern of treatments, etc.). This ensures that wildlife species of concern and other issues such as archaeological resources, threatened and endangered plant species, etc., are considered.

Methods of Woody Fuels Management

Managers must consider both the effects of shrub reductions and the particular methods used to achieve that reduction (Monsen et al. 2004). Methods should be evaluated in the context of the questions posed above and the guidance in Miller et al. (2014). For example, what are the impacts of treatment on the desirable herbaceous species and the degree of surface disturbance? Table 2 summarizes the relative effects of different shrub reduction techniques on factors of interest.

Herbicides – Areas treated with herbicides maintain some vertical plant structure due to dead shrubs that can persist for years, which benefits some wildlife. However, these areas also retain woody fuel vertical structure so fuel reductions occur over the long term, not short the term. Aerial application of herbicides minimizes surface disturbance from wheel tracks of the spray rig during ground application. Tebuthiuron is the herbicide most commonly used for reducing Wyoming big sagebrush cover.

Tebuthiuron is applied as dry pellets that dissolve and leach into the soil where it is absorbed by plant roots, inhibiting photosynthesis. It can be applied any time the soil is not frozen or covered by snow. Although it is non-selective, big sagebrush is particularly sensitive to its effects, so it can be applied at rates that selectively kill sagebrush with minimal impact on other plants in the community. Sagebrush usually begins to exhibit senescence and defoliation about one year following application. Leaves may grow back and die again before eventual death, usually by the third year. The half-life of tebuthiuron is 360 days, but it will remain active in the soil for up to seven years following treatment (depending on the initial application rates), inhibiting recruitment of sagebrush seedlings. (See the manufacture's instructions and Olson and Whitson 2002 for application information.)

Mechanical – Mechanical means are a commonly used option for Wyoming big sagebrush reduction (see rtec.rangelands.org/). The amount of surface disturbance can vary greatly depending on the technique. Incorporating seeding

Table 2. Summary of relative effects of the different shrub reduction techniques on factors of interest when making decisions about treatments. VH = very high, H = high, M = medium, L = low, VL = very low, EV = extremely variable.

Factors	Herbicide	Mow	Crush				Drag				Fire	Biological
	Tebuthiuron	Mower	Roller Chopper	Aerator	Discing	Imprinter	Smooth Chain	Ely Chain	Rail	Dixie Harrow	Prescribed Burn	Targeted Grazing
Undisturbed surface %	VH	H	L	M	L	M	M	L	L	L	H	M
Flexibility in % removal	H	H	L	M	M	L	L	L	L	L	VL	H
Seeding compatibility	VL	VL	H	H	VH	VH	M	H	H	H	M	M
Cost effectiveness	H	M	M	M	M	M	M	M	M	M	EV	L
Structure modification	L	VH	H	H	H	H	M	H	H	H	H	M
Treatment lifespan	VH	L	M	M	M	M	VL	L	L	L	EV	M
Ability to manage within patch diversity	H	VH	H	H	M	H	H	M	M	M	L	M
Ability to manage among patch diversity	H	VH	VH	VH	VH	VH	H	H	VH	VH	M	H
Certainty of woody fuels reductions	H	VH	H	H	H	H	H	H	H	H	EV	M

with a mechanical treatment is possible if the understory lacks perennial plants and does not have a cheatgrass understory. Seed must be incorporated into the soil and applied at the appropriate time for successful establishment (Monsen et al. 2004). All of the mechanical methods can modify plant community structure as well as change species composition. One limitation of all mechanical techniques is inaccessibility on steep slopes (over 30 percent with the exception of chains which can be used on slopes up to 50 percent).

Mowing with a large rotary mower (brush hog, rotary cutter) cuts off plants at the stem (Figure 1). Because sagebrush does not re-sprout, this can reduce plant density and cover, depending on the blade height which can be adjusted to obtain the desired level of sagebrush reduction. Herbaceous and some shrub components re-sprout and may increase or be unaffected. Increases in the rest of the community may be desirable (e.g., perennial grasses) or undesirable (e.g., rabbitbrush). Mowing is the least ground-disturbing of the mechanical methods, but it is difficult to combine with a seeding practice because of the lack of a way to ensure good seed-to-soil contact (Davies et al. 2011).

Crushing or cutting with land imprinters, aerators, roller choppers, and discs removes or reduces Wyoming big sagebrush by breaking and cutting stems, reducing cover, and causing varying levels of mortality. Herbaceous and some shrub species typically re-sprout and are minimally affected, depending on equipment settings. Aerators are less ground disturbing than other crushing or dragging mechanical methods.

Figure 1. Mowing treatment in Wyoming big sagebrush at Onaqui, Utah, with blade height set to thin sagebrush canopy cover approximately 50 percent. Photo: Summer Olsen.

All of these crushing methods are very compatible with seeding because of the abundance of seed-to-soil contact microsites created. Seed can be applied either before or after the treatment, depending on the seeding technique.

Figure 2. Fire burning up to a mowed line in a Wyoming big sagebrush plant community in southeast Oregon. Mowing alters the structure of woody fuels, reduces fire behavior, and increases the success of suppression efforts.

Dragging of chains, rails, or a 'Dixie Harrow' removes Wyoming big sagebrush through scraping and crushing. Brittle sagebrush stems are severed or broken while the rest of the plant species remain relatively intact. Sagebrush mortality is typically higher with summer treatment compared to a spring treatment. Degree of surface disturbance depends on the type of equipment, but they are all suited to combine with seeding. Smooth chains are the least surface disturbing, but also the least effective (30 percent reductions in Wyoming big sagebrush). Ely chain, rail, and Dixie Harrow result in greater sagebrush removal (50 to 75 percent) and greater surface disturbance. On sites with more than 25 percent pre-treatment sagebrush cover, using the rail and Dixie Harrow is difficult due to the tendency of sagebrush plants to accumulate and clog equipment.

Prescribed fire – Prescribed fire (Figure 2) can reduce woody fuels in Wyoming big sagebrush if there are sufficient fine fuels to carry the fire. However, prescribed fire in the warm and dry sites characteristic of Wyoming big sagebrush is extremely risky. Following fire, these sites exhibit (1) limited or slow recovery, (2) low resistance to invasive annual grasses, and (3) decreased habitat suitability for many wildlife species. Fire escape can consume excessive amounts of the landscape and increase cheatgrass invasion, both of which have detrimental effects on wildlife habitat. Prescribed burns should only be conducted if perennial grasses are adequate to compete with invasive annuals. Fire can still be risky if perennial grasses are predominantly located under shrub canopies, as shrubs generate high heat loads when burning, which can kill perennial grasses and reduce resistance to exotic annual grasses. Cool burning conditions (lower temperatures and higher humidity) and small burn patch sizes can help to reduce perennial grass mortality. The risk of an undesirable outcome decreases on cooler and moister sites with a greater herbaceous perennial plant component, but prescribed fire should still be used with extreme caution (Rhodes et al. 2010).

Targeted Grazing – Targeted grazing is the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. Wyoming big sagebrush reduction with targeted grazing can range from 10-70 percent. It is manageable and scalable.

The effect on other plant community components is minimized when applied in the dormant season, preferably after a hard freeze, and when adequate rest during the growing season follows treatment. Targeted grazing to reduce sagebrush cover requires a higher level of management, supervision, labor, and knowledge compared to typical grazing practices. It is a deliberate and focused effort rather than a byproduct or side effect of existing grazing practices.

Sheep and goats are natural browsers and can be encouraged to increase use of sagebrush in the fall or winter with supplemental feed. Cattle forage selection can be shifted to include a significant amount of sagebrush through conditioning. Logistics such as assembling an adequate number of animals in the right place at the right time under the right conditions typically limit the applicability and magnitude of this technique.

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References

Beck, J. L., J. W. Connelly, and C. L. Wambolt. 2012. Consequences of treating Wyoming big sagebrush to enhance wildlife habitats. *Journal of Rangeland Management* 65:444-455.

Blumenthal, D. M., U. Norton, J. D. Derner, and J. D. Reeder. 2006. Long-term effects of tebuthiuron on *Bromus tectorum*. *Western North American Naturalist* 66:420-425.

Chambers, J. C., R. F. Miller, D. I. Board, D. A. Pyke, B. A. Roundy, J. B. Grace, E. W. Schupp, and R. J. Tausch. 2014. Resilience and resistance of sagebrush ecosystems: Implications for state and transition models and management treatments. *Rangeland Ecology and Management* 67: 440-454.

Davies, K. W., J. D. Bates, D. D. Johnson, and A. M. Nafus. 2009. Influence of mowing *Artemisia tridentata* ssp. *wyomingensis* on winter habitat for wildlife. *Environmental Management* 44: 84-92.

Davies, K. W., J. D. Bates, and A. M. Nafus. 2011. Are there benefits to mowing Wyoming big sagebrush plant communities? An evaluation in southeastern Oregon. *Environmental Management* 48:539-546.

Miller R. F., J. C. Chambers, and M. Pellant. 2014. A field guide to selecting the most appropriate treatments in sagebrush and pinyon-juniper ecosystems in the Great Basin: evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response. Fort Collins, CO, USA: U.S. Department of Agriculture, Forest Service, RMRS-GTR-322.

Monsen, S., R. R. Stevens, and N. Shaw. 2004. Restoring western ranges and wildlands. Gen. Tech. Rep. RMRS-GTR-136. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Olson, R. A., and T. D. Whitson. 2002. Restoring structure in late-successional sagebrush communities by thinning with tebuthiuron. *Restoration Ecology* 10:146-155.

Pyke, D. A., S. E. Shaff, A. I. Lindgren, E. W. Schupp, P. S. Doescher, J. C. Chambers, J. S. Burnham, and M. M. Huso. 2014. Region-wide ecological responses of arid Wyoming big sagebrush communities to fuel treatments. *Rangeland Ecology and Management* 67: 455-467.

Rhodes, E. C., J. D. Bates, R. N. Sharp, and K. W. Davies. 2010. Fire effects on cover and dietary resources of sage-grouse after fire. *Journal of Wildlife Management* 74:755-764.

Shaner, D. L., J. J. Jachetta, S. Senseman, I. Burke, B. Hanson, M. Jugulam, S. Tan, J, Reynolds, H. Strek, R. McAllister, J. Green, B. Glenn, P. Turner, and J. Pawlak, editors. 2014. Herbicide Handbook, 10th edition. Weed Science Society of America. 513 pp.