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Sagebrush Steppe
SageSTEP
Treatment Evaluation Project

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In this issue:

Sagebrush Steppe SageSTEP Treatment Evaluation Project
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PJ Control by Mastication

What happens to fuels, soils, and vegetation after shredding pinyon and juniper trees?

By Bruce Roundy, Range Scientist, Brigham Young University

Wildland managers have been masticating (or shredding) pinyon and juniper trees in Utah since about 2003. While shredding is implemented primarily to reduce canopy fuels and allow easier wildfire suppression, there are a number of other potential advantages. During mastication, live trees are shredded with a spiked, rotating drum attached to a large wheeled tractor or tracked excavator (Fig. 1). This can be done any time the soil is dry enough to avoid excessive compaction. This makes shredding more flexible, more controlled, and less risky than prescribed fire. Shredding produces woody mulch that covers former tree mounds and some space between them, which can increase water infiltration rates and reduce erosion (Cline et al. 2010). Shredding trees increases the time that soil water is available in the spring, which increases understory growth and cover. However, some important questions about shredding remain (Roundy et al. 2014, Roundy et al. 2014 [2]).

Figure 1. These photos show a typical toothed shredder for masticating pinyon and juniper trees and the resulting woody debris.

"Shredding trees increases the time that soil water is available in the spring, which increases under-story growth and cover. However, some important questions remain:"

1) How will reducing trees and adding woody debris to the soil surface affect soil moisture, temperature, carbon, and nutrients and, in turn, affect vegetation?

2) How does the amount of tree infilling or density at the time of treatment affect amount and distribution of fuels, as well as vegetation cover?

3) How do responses to shredding vary for Great Basin sites where trees have encroached onto former sagebrush/steppe communities compared to Colorado Plateau sites where trees have often been dominant prior to settlement times?

4) When shredding trees, at what pretreatment tree density or cover is seeding necessary to best encourage desirable plant growth?

To address these questions we conducted intensive and detailed controlled experiments and measured soil and plant responses for tree and interspace microsites on three sites in 2007 through 2011. In a more extensive study, we compared fuel, soil, and vegetation on untreated and shredded treatments across 44 sites for a wide range of tree canopy cover at the time of shredding. For this extensive study, we used pretreatment aerial imagery to locate untreated and shredded plots with similar initial tree cover and on the same ecological site type. Measurements were made in 2011 and 2012 on both untreated and treated plots where trees had been shredded 1-8 years previously. The intensive, detailed studies were a part of Joint Fire Science funding of SageSTEP, while the additional extensive-site studies were funded by a subsequent Joint Fire Sciences grant.

Phase I: Shrubs and grasses are dominant and influence ecological processes.

Phase II: Trees are co-dominant with shrubs and grasses.

Phase III: Trees are dominant.

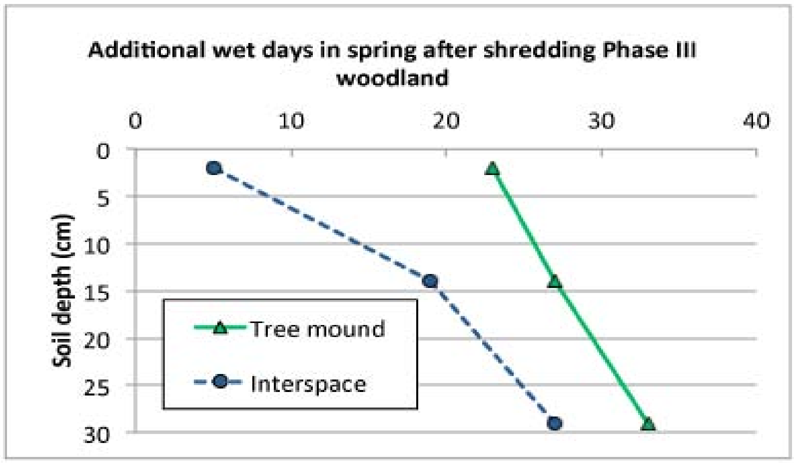

Figure 2. Additional wet days for tree mounds and interspaces between tree mounds when soil water is available for growth in spring after shredding highly infilled (high tree density or cover) pinyon-juniper woodland in Utah. Additional wet days were statistically significant except for interspace at 2 cm soil depth.

What did we learn?

Question 1: How will reducing trees and adding woody debris to the soil surface affect soil moisture, temperature, carbon, and nutrients and, in turn, affect vegetation?

Answer: Tree mortality and woody debris increase soil water and nutrient availability

Reducing trees decreases tree water use, and the debris created by shredding may shade the soil surface and reduce water evaporation. In our experiments reducing trees by shredding had much more effect on retaining soil water than did shading from tree litter or shredded debris. Reducing trees increased the time water was available (Young et al. 2014) in the soil most for Phase III woodlands (by 3 weeks), which had high initial tree cover and little understory cover, and least (by a few days or less) for Phase I woodlands with limited tree cover and high understory cover (SageSTEP News 21, Roundy et al. 2014 [2], and Fig. 2).

After shredding, soil nutrients are affected by reduced tree nutrient use, soil carbon and nutrient losses from living tree roots, or carbon and nutrient additions from decaying roots and shredded debris, as well as the response of soil microbes. However these effects are highly variable:

Shredding may increase available nitrogen for plant growth by removing the trees that use nitrogen and

by increasing the time that water is available, which allows nitrogen to diffuse to understory plant roots.

Tree mortality and additions of shredded debris may not increase total phosphorus, but may increase the amount of P [or phosphorus] available to plants.

Although soils under tree litter mounds are more fertile than interspace soils, litter from tree mounds and shredded debris may decrease the efficiency of microbes under former tree mounds in making nitrogen available. On the other hand, shredded debris may increase efficiency of microbes in interspaces to mineralize and make nitrogen available.

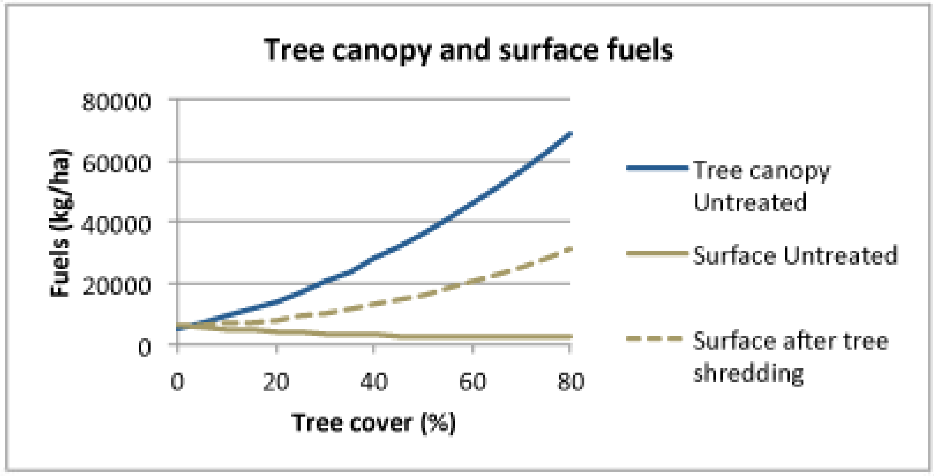

Figure 3. Fuel biomass of untreated tree canopies, and shrub, herbaceous, and woody debris biomass considered as surface fuels on untreated and shredded pinyon and juniper woodlands.

What this means:

Available water, nitrogen, and phosphorus are the resources that are most limiting to plant growth in cold desert sagebrush steppe in the spring and early summer when temperatures are warm enough for rapid growth. Shredding trees may increase the availability for all of these resources for growth of residual understory or seeded plants. The greater the degree of tree infilling, as indicated by greater initial tree density and cover, the greater the increase in soil water availability will be after shredding. Shredding trees at a higher phase of tree infilling results in the greatest increase in soil water availability, because there are fewer understory plants to use the soil water that was once used by trees. Because both weeds and desirable plants may use these resources, shredding at higher phases of infilling (higher tree density and cover) carries the risk of weed dominance on susceptible sites. Shredding trees when desirable understory plants are available to use these nutrients, or seeding to increase the number of desirable plants, should avoid weed dominance and give the best response after tree control.

Question 2: How does the amount of tree infilling at the time of treatment affect fuels and vegetation?

Answer: Canopy fuels increase while surface fuels (shrubs, herbaceous plants, and woody debris) decrease with infilling; shredding converts canopy fuels to 1 and 10-hour surface fuels, and overall increases surface fuels by maintaining shrubs and increasing herbaceous plant growth (Figs. 3-5).

Shredding may increase annual weed fuels on some sites. Understory cover and fuel responses to shredding can be highest when shredding is done where trees are most dominant.

What this means for fuels and fire:

As infilling proceeds and canopy fuel loads increase, the risk of catastrophic canopy fire increases. Shredding places these woody canopy fuels on the ground in the form of coarse woody debris. It also retains shrub biomass and increases herbaceous fuels. The result of these fuel changes is that wildfire spread may be reduced by bringing potential canopy fire to the ground and by permitting easier suppression. However, increasing surface fuels could increase wildfire temperatures and severity, thereby increasing potential damage to desirable plants and seeds. This occurred on our SageSTEP Stansbury site, as reported in the Summer 2013 SageSTEP Newsletter, #21. A possible solution to this risk is to reduce surface fuels after shredding with cool-season prescribed fire by igniting patches of woody debris and avoiding shrubs.

What this means for desirable vegetation and invasive weeds:

As infilling proceeds and tree cover increases, shrub cover, then perennial herbaceous cover decrease (Fig. 4). To best maintain and increase shrub cover, trees should be treated before tree cover approaches 20-40%, depending on the site. Perennial herbaceous cover increases after shredding, even at high tree

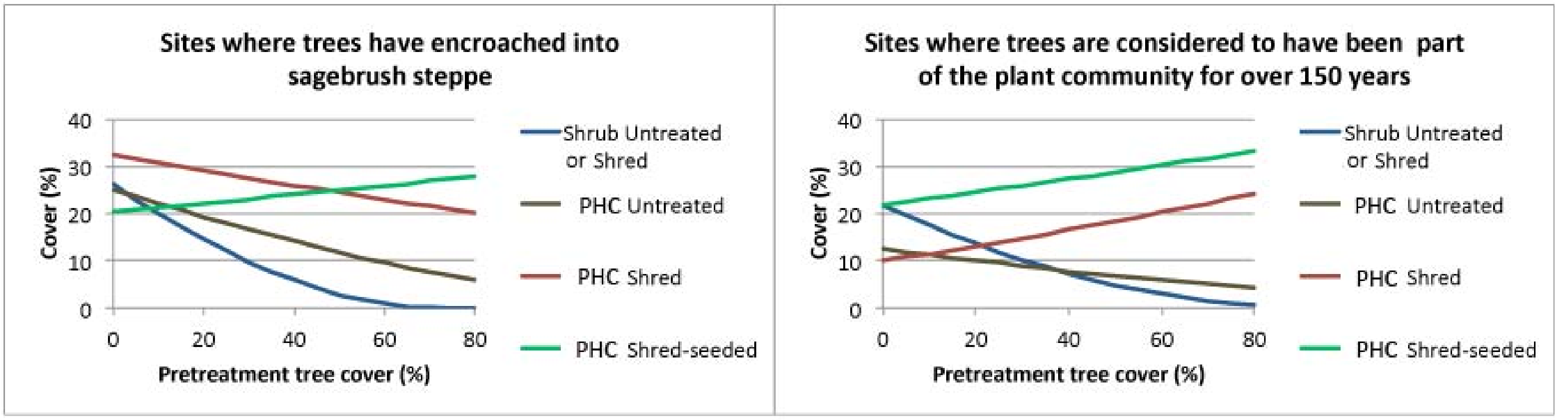

Figure 4. Shrub cover was similar on untreated and shred plots, while perennial herbaceous cover (PHC) increased on shredded and shredded-seeded plots.

cover (Fig. 4). Even sites with advanced infilling may respond positively to shredding. However, the risk of treating sites with low perennial herbaceous cover is that they could become dominated by invasive weeds. Perennial grasses are critical for resisting weed dominance. They use the soil water and nutrient resources that were made available by tree reduction, so that these become less available for growth and seed production of weeds.

Question 3: How do responses to shredding vary for Great Basin sites where trees have encroached onto former sagebrush/steppe communities compared to Colorado Plateau sites where trees have often been dominant prior to settlement times?

Answer: Shredding maintains shrubs and increases herbaceous cover on both encroached and tree sites.

The Natural Resources Conservation Service considers that sites with soil water capacity limited by soil depth (shallower than 0.5 m), very sandy texture, or high amount of coarse fragments generally lack sufficient understory to carry fire frequently enough to limit trees. Such sites are considered tree sites and are generally not dominated by sagebrush and grasses. However some of these sites have been experiencing tree infilling in recent years.

In our extensive study, tree sites occurred almost exclusively in the Colorado Plateau physiographic province. On the other hand, most of our Great Basin sites had soil depths ≥ 0.5 m and were considered to be sagebrush steppe sites encroached by trees. Tree encroachment on these sites is associated with fire frequency that is reduced, not by a lack of understory associated with soil limitations, but rather due to fire

Figure 5. Shredding pinyon and juniper trees maintains shrubs and increases perennial herbaceous cover and growth. Left- Onaqui site, 1700 m elevation (note juniper trees regrowing from live limbs of shredded trees, as well as from seed); right Goslin Creek site, 2030 m elevation.

suppression and reduced understory fuels from grazing.

Although sagebrush cover was slightly lower on tree, compared to encroached sites in our study, shredding did not reduce sagebrush or total shrub cover on either type of site. Even though measured shrub cover was not higher on shredded plots compared to untreated plots, leader growth of shrubs on tree-controlled plots was observed to be much greater than that on untreated plots. This suggests that, over time, shrub cover will increase on shredded areas. Also, sagebrush seedlings were found on about 60% of our sites, with an average of 0.7 seedlings per m^2 on untreated plots and 6 seedlings per m^2 on plots where trees were shredded.

Shredding had much more effect on tall rather than short perennial grass (e.g., Sandberg bluegrass) cover, which was limited on encroached (<8%) and tree (< 2%) sites. On encroached sites, shredded plots had 4-7% (mean= 6.3%) higher perennial grass cover than untreated plots across the range of 0-80% pretreatment tree cover. On tree sites, shredding increased tall grass cover by 0-16% (mean= 7%) from 0-80% pretreatment tree cover.

As with tall perennial grasses, total perennial herbaceous cover increased most on tree sites after shredding, and at higher pretreatment tree cover (Figs. 4 and 5). Bare ground followed the opposite pattern, decreasing as perennial herbaceous cover increased.

Cheatgrass cover increased after shredding with increasing pretreatment tree cover (Fig. 6). After shredding, encroached sites had higher cheatgrass cover (30%) than tree sites (20%) at maximum pretreatment tree cover.

What this means:

Shredding maintains and should eventually increase shrub cover. It increases tall perennial grass and total perennial herbaceous cover on both encroached and tree sites, even at high pretreatment tree cover. It can also increase cheatgrass cover on some sites, especially when the site has high cheatgrass cover before treatment and is an advanced state of infilling. Shredding produces desirable increases in perennial herbaceous plants on both encroached and tree sites.

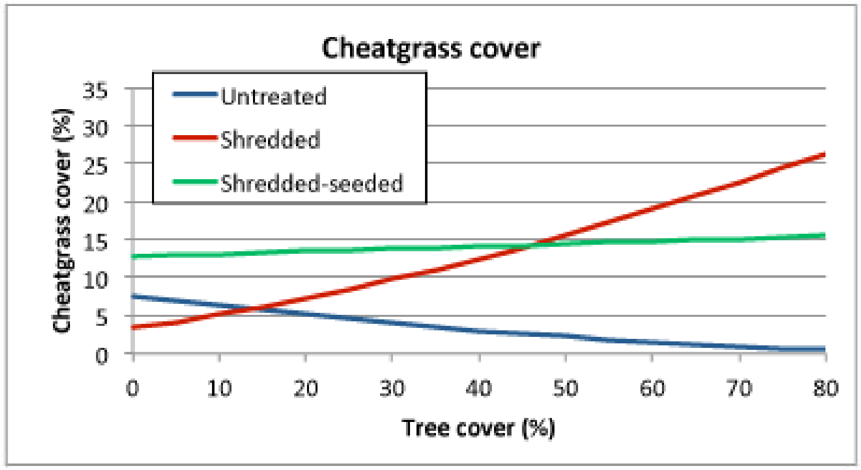

Figure 6. Cheatgrass cover in relation to untreated or pretreatment tree cover for untreated, shredded, and shredded-seeded plots on sagebrush steppe encroached sites.

Question 4: At what pretreatment tree cover is seeding necessary to encourage desirable plant growth after shredding?

Answer: Shredding and seeding increased perennial herbaceous cover and depressed cheatgrass cover most as pretreatment tree cover increased.

Because land managers usually either decide to seed specific shredded sites, our extensive study was not able to compare vegetation responses for untreated, shredded, and shredded-seeded plots on the same site. Our results reflect comparisons made across all sites.

Perennial forb cover was low at most of our sites (< 3%), but was increased slightly by seeding (about 1.5 %). Tall and total perennial grass cover and total perennial herbaceous cover on shredded-seeded plots were not statistically different than that of shredded-not seeded plots. However, seeding increased tall and total perennial grass cover and depressed cheatgrass cover across the range of pretreatment tree cover (Figs. 5, 6). Seeded plots actually had increasingly greater perennial herbaceous cover compared to untreated plots as pretreatment tree cover increased. This is because perennial herbaceous cover decreased with untreated infilling, but increased most after shredding with greater infilling.

What this means: Shredding generally increases desirable perennial herbaceous cover on most sites, even without seeding. Sites with high tree cover and limited perennial understory cover respond well to seeding, however, which can depress dominance by weeds, such as cheatgrass.

Summary

Shredding trees makes soil water and nutrient resources available to both desirable understory plants and weeds (Fig. 7). Tree shredding maintains shrub cover and increases desirable perennial herbaceous cover, even when pretreatment tree cover is high. To best maintain shrub cover (at least 10%), trees should be shredded before tree cover exceeds about 20%. Shredding at higher tree cover still increases total perennial herbaceous cover. However, because shredding increases cheatgrass cover more as pretreatment tree cover increases, to best avoid weed dominance, sites should be shredded before tree cover exceeds 40%. If trees are shredded at higher tree cover, seeding will increase desirable cover and discourage weed dominance. Further analysis will seek to identify site characteristics associated with more or less resistance to weed dominance to better help managers plan treatments.

Figure 7. Growth of both perennial herbaceous plants and invasive weeds like cheatgrass benefit from soil water and nutrient resources made available by shredding trees. Shredding where there is high cover of perennial herbaceous plants or seeding will help discourage dominance by weeds after shredding.

References:

Cline, N. L., B. A. Roundy, F. B. Pierson, P. Kormos, and C. J. Williams. 2010. Hydrologic response to mechanical shredding in a juniper woodland. Rangeland Ecology and Management 63:467-466.

Young, K.R., B.A. Roundy, and D.L. Eggett. 2014. Tree reduction and debris from mastication of Utah juniper alter the soil climate in sagebrush steppe. In press. Forest Management and Ecology.

Roundy, B., R.F. Miller, R.J. Tausch, K. Young, A. Hulet, B. Rau, B. Jessop, J.C. Chambers, and D. Egget. 2014. Understory Cover Responses to Piñon-Juniper Treatments Across Tree Cover Gradients in the Great Basin. In review. Rangeland Ecology and Management.

Roundy, B., K. Young, N. Cline, A. Hulet, R.F. Miller, R.J. Tausch, J.C. Chambers, and B. Rau. 2014. Piñon-Juniper Reduction Increases Soil Water Availability of the Resource Growth Pool. In review. Rangeland Ecology and Management.

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Research Preview

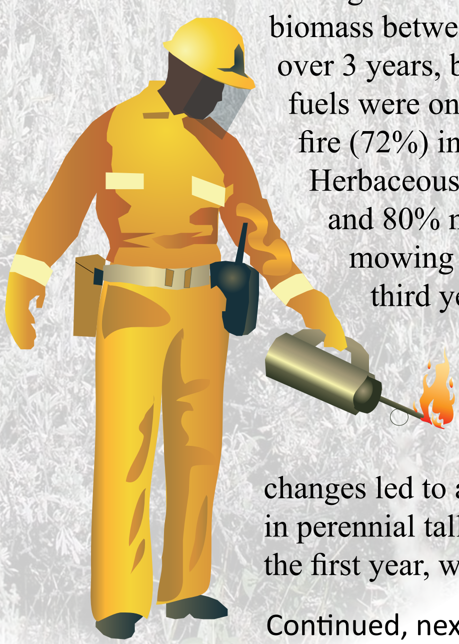
A brief glimpse at what is coming in our next issue:

Ecological Responses of Arid Wyoming Big Sagebrush Communities to Fuel Treatments

By Scott E. Shaff

Land managers across the Intermountain West are applying fuel treatments (man-made disturbances) to Wyoming sagebrush ecosystems in hopes of reducing fire potential. But if the ecosystem lacks resistance or resilience to disturbances, then cheatgrass (*Bromus tectorum*) may invade. The SageSTEP project is hoping to help land managers understand how ecosystems respond to these fuel treatments. The treatments we evaluated included prescribed fire, mechanical thinning of sagebrush by mowing, and aerial application of the herbicide tebuthiuron (Spike 20P) in order to thin sagebrush. None of the sites were seeded. The winter newsletter will have more complete information, but a preview of our results follows.

We identified six Wyoming big sagebrush locations that, within site, vary in their degree of resistance and resilience after disturbances. We examined the impacts of treatments on the dominance of major plant species and how they influenced important land health parameters. Our preliminary results show the fire and mowing treatments reduced woody biomass between 97% and 85% over 3 years, but herbaceous fuels were only reduced by fire (72%) in the first year. Herbaceous fuels produced 36 and 80% more biomass with mowing from the first to the third year. Tebuthiuron never showed significant effects on biomass. These fuel changes led to a 59% reduction in perennial tall-grass cover in the first year, which recovered in



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Initial Effects of Imazapic on Cheatgrass, Native Grasses and Forbs

By M. Lee Davis

Imazapic is a pre-emergent herbicide that is of interest to land managers and restoration ecologists facing invasions of non-native grasses, particularly after wildfires and other disturbances. These disturbances often create conditions ideal for invasions of cheatgrass. The use of imazapic may provide a window of cheatgrass suppression during which native forbs and perennial grasses are more likely to reestablish. There is a downside, however. Because imazapic is a broad spectrum pre-emergent herbicide, it may negatively affect native annual forbs and shallow-rooted perennials such as Sandberg bluegrass (*Poa secunda*). We studied the effect of imazapic on common and uncommon native forbs, cheatgrass, and Sandberg bluegrass within sagebrush ecosystems of the Great Basin.

More complete results will be reported in our winter newsletter, but initial data from the SageSTEP study (Years 1-4 post-treatment) indicate that imazapic has provided ongoing suppression of cheatgrass and of exotic forb cover in treated plots. By year 4, cheatgrass in imazapic plots had returned to pre-treatment levels (around 11%), but remained far below the percent cover observed in non-imazapic plots (around 22%). Exotic forb cover returned to pre-treatment levels by year 3 in imazapic plots (around 4%), but also remained below the percent cover observed in non-imazapic plots (around 9%). While both Sandberg bluegrass and native forbs were initially suppressed by imazapic application, by year 3 there were no differences

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Ecological Responses, cont.

following years. Cover of all remaining herbaceous groups, including cheatgrass, was not changed by fuel treatments. Fire reduced the density of perennial short grasses between 40 and 58%, decreased lichen and moss cover between 69 and 80% and increased bare ground between 21 and 34%. Reductions in cover and density resulted in more gaps among perennial plants > 2 m. Although these early observations may be considered by land managers when implementing fuel treatments, they should do so knowing that longer-term findings may provide more critical information for management decisions and for understanding ecosystem trajectories.

The longer-term effects of fuel treatments on invasive annual grasses are more problematic than the effects of treatments on woody fuels for fire control. Further, there is the potential to change species dominance of vegetation, and those potential effects could then affect species, such as the Greater Sage-grouse. There are many complexities here to consider, such as, if the benefits outweigh the negative effects of treatments. The passage of time likely will reveal the ultimate trends in cover or biomass of herbaceous growth. Meanwhile, the goal of fuel treatments in arid Wyoming sagebrush communities could shift from reducing woody fuels to creating communities of herbaceous perennials with discontinuous fuels.

Initial Effects, cont.

in the percent cover of either Sandberg bluegrass or native annual forbs between imazapic and non-imazapic subplots. Importantly, uncommon native annual forb species (for example *Plantago patagonica*, *Polemonium micranthum*, and *Gayophytum racemosum*) also showed no difference in percent cover by year 3 in imazapic vs. non-imazapic plots.

While there is an exceptional amount of within- and among-site variability in the amount of cheatgrass that has colonized plots treated with imazapic, much of this appears to be based on the amount of cheatgrass present before disturbance, and may be an effect of either seedbanks within the treated sites or local seed rain from areas surrounding the treated sites. On the whole, however, imazapic appears to provide suppression of cheatgrass and annual exotic forbs while not unduly harming either Sandberg bluegrass or native annual forbs over the longer term. The ongoing suppression of cheatgrass and other exotic annuals, combined with the weaker effect on natives, suggests imazapic might be a useful tool for opening a window of reduced competition to facilitate perennial grass success, both increasing growth of existing plants and improving establishment of new ones.

The Winter SageSTEP Newsletter will give more detail on these results while exploring several of the possible causes for variability in the effectiveness of imazapic at controlling cheatgrass after fuels treatments at our sites.

Graphic images courtesty of Kim Kraeer, Lucy Van Essen-Fishman, and IAN Image library.

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