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SageSTEP News, Winter 2015, No. 27

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Recommended Citation

SageSTEP, "SageSTEP News, Winter 2015, No. 27" (2015). *Newsletters*. 9.
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Issue 27, Winter 2015

Pros and Cons of Tree Removal by Shredding

By Jim McIver and Eva Strand

For many years now, sagebrush steppe managers have removed encroaching pinyon and juniper trees by several different means, including prescribed fire, chaining, cutting and burning, and mastication (shredding). Each practice makes its own characteristic imprint on the land, and recently shredding has received a lot of attention because practitioners believe it is one of the best practices to use for restoration of sage grouse habitat. In this article, we explore some of the principal effects shredding may have on sagebrush steppe fuel-beds, and potential fire behavior and fire severity.

Shredding is typically undertaken by machines equipped with a spinning, toothed drum mounted horizontally in front of a tractor (Fig. 1, top), or a rotating blade mounted at the end of a boom, usually attached to an excavator. In each case, the drum or the blades are used to completely shred a living tree from top to bottom, leaving a bed of woody material in the immediate vicinity of the tree (Fig. 1, bottom). This shredded material is composed of relatively fine needles, twigs, and smaller branches (< 1” diameter pieces), as well as slightly heavier woody material (1 – 3” diameter), and finally, much thicker pieces of woody material (> 3” diameter). All that is left of the tree is a shredded stump that sticks out just above the ground surface.

Shredding has been favored for many years in Utah for several reasons, including: 1) it is reasonably cost-effective; 2) the practice can be applied at almost any time of the year in most places; and 3) detailed prescriptions on residual tree density can easily be met. More recently, shredding has received attention from managers interested in restoration of sage grouse habitat, because the practice is the most efficient way to completely remove trees (both living and dead) from the landscape, without removing the sagebrush shrubs the bird need for quality habitat (see Infographic: What Sage Grouse Require). When thinking about the overall influence of shredded fuel-beds on the landscape, it is important to point out that we can anticipate both benefits and concerns in terms of potential fire behavior and fire effects in the event of a wildfire visiting a shredded site. We can expect that a shredded fuel-bed will have a beneficial effect on potential *fire behavior*, because an approaching fire will tend to drop to the ground surface (assuming the shredded area is big enough), due to the complete lack of a forest canopy. So measures of *fire intensity*, such as flame height, will tend to be much lower for a masticated fuel bed (compared to a pinyon-juniper forest), possibly even allowing firefighters to stop an advancing fire.

Figure 1. A Bull Hog™ is used for removing trees, leaving behind only a short stump and shredded material on the ground.

However, because fuels have been dropped to the ground surface by the shredding activity, other measures will likely be much higher. Specifically, *smoldering combustion* will likely be much higher in a shredded fuel-bed, because it is closely related to temperatures at the ground surface, and also to the duration of heating. As a consequence, *fire severity* – the ecosystem consequences of fire -- will also likely be much higher. As an example, when the 2009 Big Pole Wildfire burned through all of our Stansbury research plots in Utah just two years after our treatments were applied, Bruce Roundy, rangeland ecologist at Brigham Young University, found that all of his soil moisture stations were destroyed in the shredded plot, while stations deployed in the adjacent prescribed fire plot (where ground fuels had been largely removed), survived the wildfire. A year later, when he measured mortality of bunch grasses, he found a parallel pattern of higher survival in the prescribed burn plot relative to the shredded plot.

Table 1. Detailed measurements of shredded fuel-beds from three pinyon-juniper sites in Utah.

Fuel mass (kg/ha)	Sagebrush, control, no mastication	Sagebrush with masticated fuels (year 1 mean)	Sagebrush with masticated fuels (year 1 max)
Duff + Litter	250	60	60
Woody Fuel	0	10,770	19,060
Herb + Shrub	6,000	6,000	6,000

While our experience at Stansbury is consistent with expectations, it is nonetheless a one-time anecdote, and so we cannot say that the same result would be found in other treated places having experienced a similar wildfire. Fortunately, we do have detailed measurements of shredded fuel-beds from three other pinyon-juniper sites in Utah (Onaqui, Scipio, and Greenville Bench), that together can shed some light on this issue. First, when we look at shredded Phase 3 fuel-beds at our three sites (Phase 3 woodlands are dominated by trees), we note a very big difference in how much mass is on the ground surface immediately after treatment, compared to a typical treeless sagebrush steppe system (Table 1). Next, model projections of heat pulse into the soil, represented by a temperature v. time graph, show that the Phase 3 shredded fuel-bed literally cooks the soil for long periods of time (Fig. 2).

This is a problem for bunchgrasses, which typically can survive fire only if temperatures at or just below the ground surface remain for the most part below 60 ^{o}C. So as you can see from Fig. 3, shredded Phase 3 fuel-beds result in very high temperatures that last for a relatively long time, which will in turn tend to kill any bunchgrasses living in that area.

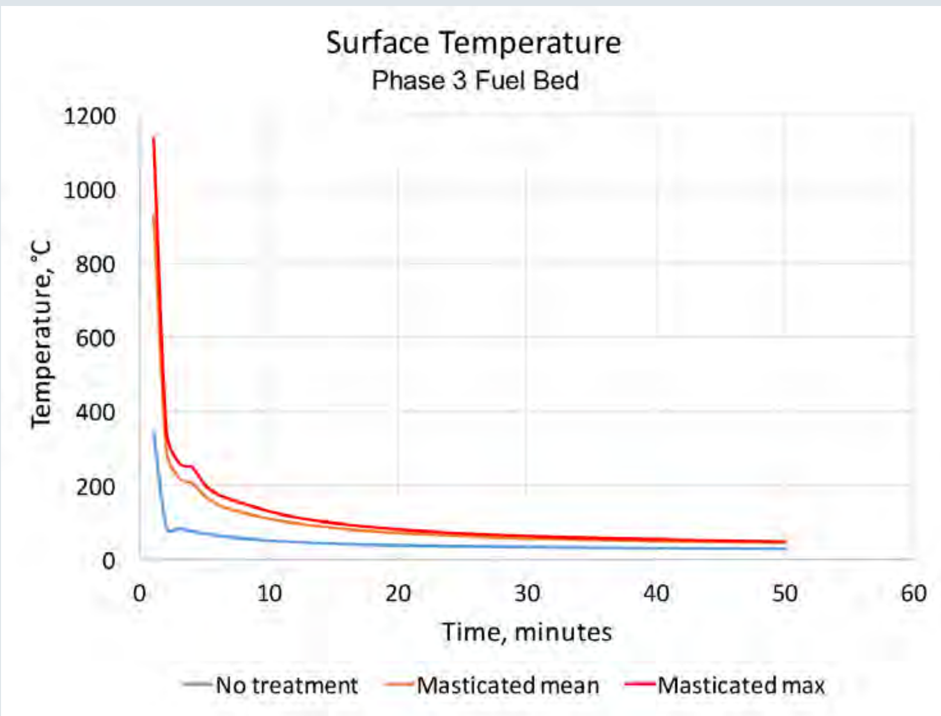

Figure 2. Model projections of heat pulse into the soil during a wildfire in an area that has tree shredding material on the ground from a Phase 3 project (treeless sagebrush steppe control plots in blue).

Fortunately however, shredded 'Phase 2' and 'Phase 1' fuel-beds are projected to have a very different effect on bunchgrasses, due to the much lower amount of biomass delivered onto the surface by the shredding activity (Fig. 4), which will result in much lower projected lethal temperatures in Phase 1 and 2 shredded areas, in the event of a wildfire (Fig. 5).

The take-home message: to allow bunchgrasses to survive a potential wildfire in a treated area, shred only under Phase 1 and 2 conditions. In this way we can get the benefit of higher quality sage grouse habitat, while at the same time decreasing the likelihood that a future wildfire will eliminate bunchgrasses, and lead to the invasion of annual grasses and the resultant site conversion.

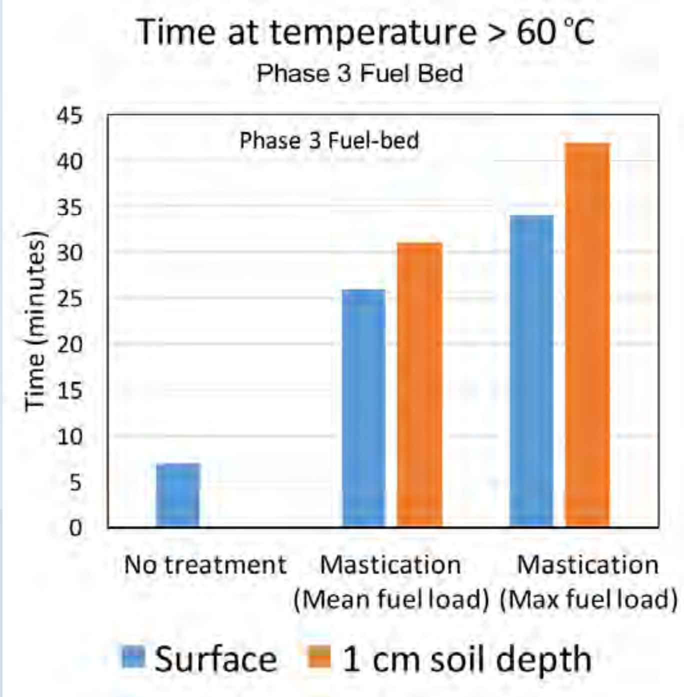

Figure 3. (Right) Time (minutes) at temperature > 60 degrees C for untreated sagebrush steppe, and for shredded fuel-beds (mean and max).

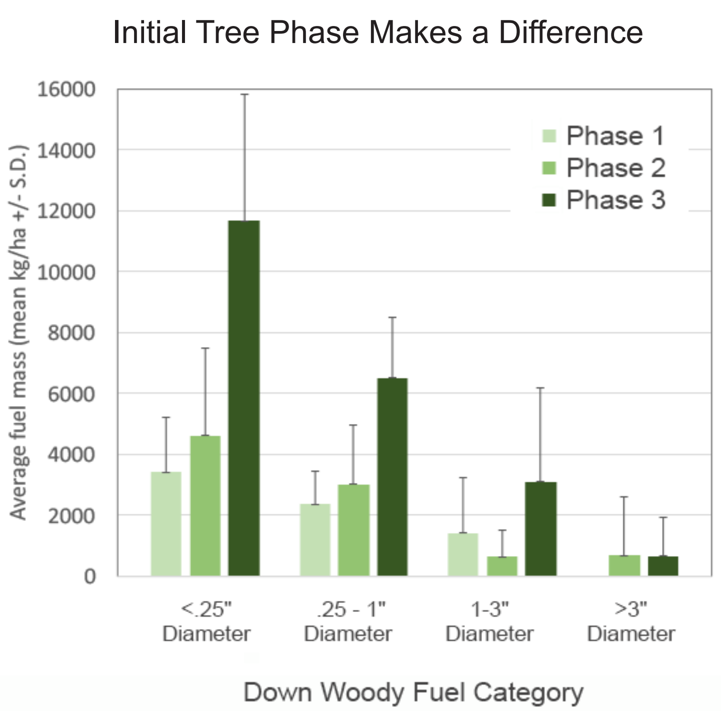

Figure 4. Average fuel mass (kg/ha +/- S.D.) in four different woody fuel categories for shredded fuelbeds that were initially in Phase 1, 2, or 3 condition.

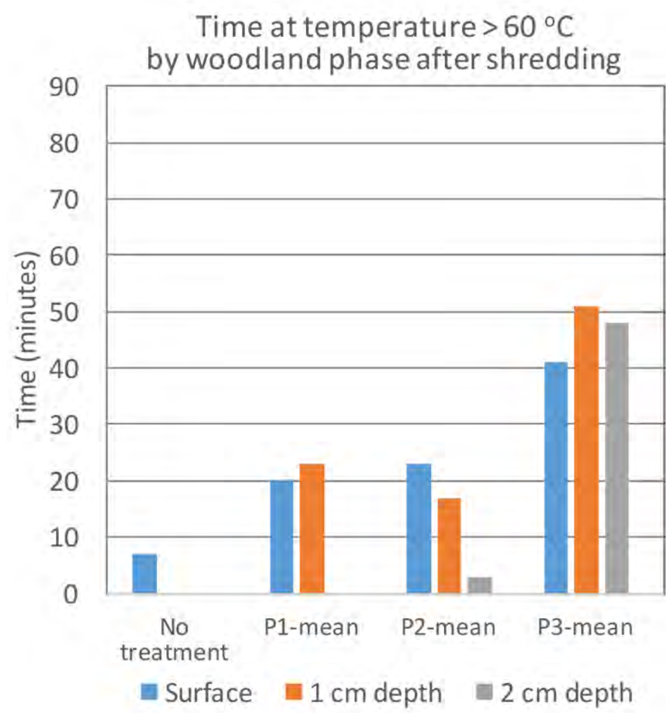

Figure 5. Average time at temperature > 60 degrees C at three depths, for untreated sagebrush steppe, and for fuel-beds shredded under Phase 1 (P1), Phase 2 (P2), or Phase 3 (P3) conditions.

Using Ecological Variables to Define Restoration Success

By Jim McIver

The Interior Department's Secretarial Order on sage grouse from November 2014, followed by the Implementation Plan of May 2015, place a clear emphasis on the habitat needs of sage grouse as one of the most important determinants of management activities on sagebrush steppe lands in the Interior West. In particular, the order lays out the need to implement restorative prescriptions within or near sage grouse strongholds that would have a high likelihood of improving sage grouse habitat, and thus stabilize or increase population size of this declining bird species. The order and the implementation plan call for the best science available to decide what these restoration prescriptions will look like, and where they will be positioned on the landscape. As a research/monitoring project, SageSTEP was designed to determine the efficacy of commonly used restoration treatments, including some (e.g. mastication) that have a high potential for being used within or near sage grouse strongholds. This article highlights some SageSTEP results on restoration of various components of sagebrush steppe ecosystems, including how treatments have affected vegetation, the fuel-bed, hydrologic function, and sagebrush-obligate passerine birds. Here we discuss an important point when it comes to restoration of sage grouse habitat: the judgement of whether or not a treatment has achieved 'restoration success' depends critically on which restoration component is being considered.

The Society of Ecological Restoration describes "restoration" as an intentional activity to initiate or accelerate the recovery of an ecosystem with respect to its health, integrity and sustainability. Typically, an ecosystem that requires restoration is degraded in some way, in consequence of human activities, natural processes, or a combination of those two. Restoration can assist the recovery of a wide variety of components and processes, including biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices. The concept of restoration has a wide definition, so it isn't surprising that the assessment of SageSTEP restoration success depends on the variables considered. To illustrate this point, let's look at how we might describe restoration success at SageSTEP sites six years after treatment, in terms of hydrological processes, vegetation, fuel beds, and biodiversity (birds and butterflies).

SageSTEP woodland work has focused on sagebrush steppe sites considered to be degraded because trees have encroached and reduced most of the original understory vegetation cover. When tree encroachment results in bare ground cover that exceeds 50 percent, both erosion and sediment transport increase exponentially, arguing for restoration in the form of tree removal (Newsletter 6). But in some plots we saw a short-term hydrological cost to our restoration treatments: one year after tree removal, there were distinct differences among rates of erosion and sediment transport between treatments (see Newsletter 14) with prescribed fire plots yielding far more sediment than masticated or cut-and-leave plots. The primary cause of increased erosion was the increase in bare ground in burned plots immediately after tree removal. Eight years later, however, herbaceous vegetation grew back into most plots such that rates of erosion and sediment transport have been greatly reduced overall, even in plots in which fire had previously removed all aboveground vegetation cover. In terms of hydrology therefore, restoration has been largely successful. Yet it is important to note that the key to restoration success hydrologically is herbaceous vegetation recovery regardless of the type: native perennial vegetation and annual vegetation like cheatgrass can both be effective at reducing rates of erosion and sediment transport.

But a manager looking at invading cheatgrass from the perspective of other ecosystem variables may have a harder time seeing invading annual grass as a success.

The key to restoration success *hydrologically* is herbaceous vegetation recovery, regardless of the type. Native perennial vegetation and annual vegetation like cheatgrass are both effective at reducing rates of erosion and sediment transport.

> The standard for success from a *vegetation/fuels* point of view is higher. Cheatgrass cover means that fine fuels are more continuous and better able to carry fire over the landscape. More exotic vegetation also means that native biodiversity will generally be lower, taking the systems further away from a healthy condition.

For instance, if we look at restoration success from a vegetation/fuels point-of-view for the same woodland experiment, we come to a somewhat different conclusion. In terms of vegetation and fuels, the intent of tree removal is to create conditions under which native perennial vegetation will recover to a greater relative extent than cheatgrass. While we've seen substantial herbaceous vegetation recovery at every woodland site six years after tree removal, the balance between cheatgrass and native perennial vegetation cover varies markedly among sites (Newsletter 23). At the Onaqui site, for example, vegetation response after tree removal was desirable for all active treatments, with native perennial bunchgrasses dominating. On the other hand, at Scipio, while bunchgrass recovery has been good, cheatgrass cover has increased substantially on treated plots, particularly those that were burned. The standard for success from a vegetation/fuels point of view is higher than it is for hydrological processes, because not all vegetation is equal – higher cheatgrass cover generally means that fine fuels will be more continuous and thus better able to carry fire over the landscape. More exotic vegetation also means that native biodiversity, including both plants and insects that depend on native vegetation (Butterflies: Newsletter 20), will generally be lower as well, taking the systems further away from a healthy condition.

Finally, for sage-obligate birds like sage grouse and Brewer's sparrow, the standard required to judge restoration success is even higher, as these kinds of birds need particular structural elements for high-quality habitat (Newsletter 18). For instance, when tree cover exceeds about five percent of the landscape, sage-obligate birds begin to avoid these areas because trees offer convenient perches for avian predators. (Infographic, right). Even if trees are killed by prescribed fire, tree skeletons remain for a considerable time after burning, reducing the habitat quality of the landscape for sage-obligate birds. The only way to create high quality habitat for sage-obligate birds in the short term is to remove or masticate trees adjacent to high quality sagebrush steppe habitat in which the birds already live.

For the eventual recovery of *sage-obligate bird populations*, the standard for success is higher, and different. Trees in encroached areas must be entirely removed, and restoration treatments have to occur where the birds can find them to use them.

It is therefore not sufficient to just recover native herbaceous vegetation – the manager must also remove all tree structure from the landscape, conduct restoration activities adjacent to high quality habitat, and then wait a few years to see if the birds move in.

These results emphasize the need to conduct restoration activities with specific objectives in mind. If the objective is to reduce rates of hillslope erosion, then removing the influence of trees by any means will, under most conditions, release herbaceous vegetation, and eventually lead to a more acceptable hydrological condition. If the objective is to recover native biodiversity, mechanical treatments will tend to be more successful than prescribed burning, and will achieve better success in places that are cooler and wetter, and have lower cover of cheatgrass prior to treatment. If the objective is the recovery of sage-obligate bird populations, only treatments that remove trees entirely will likely be successful, and even then, only when these treatments are positioned correctly on the landscape. Clearly, it won't be easy to build additional high quality habitat for sage grouse in the Great Basin, but SageSTEP work suggests that it can be done, if restorative prescriptions are designed with the biology of sage-obligate species in mind.

Funded by:

U.S. Department of the Interior Bureau of Land Management

National Interagency Fire Center, Boise, Idaho

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SageSTEP is a collaborative effort:

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