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Guide for Quantifying Post-Treatment Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin

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Technical Note 437

University of Idaho
College of Natural Resources

Joint Fire Science Program

Sagebrush Steppe
SageSTEP
Treatment Evaluation Project

BLM

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Abstract

Invasive species and woodland encroachment have caused extensive changes in the fire regimes of sagebrush steppe over the past 150 years. Land managers and resource specialists of the Great Basin are increasingly required to implement vegetation treatments to maintain habitat, reduce fire risk and restore landscapes to a more desirable state. Often it is difficult to measure treatment effectiveness because gathering pre- and post-treatment data is time-consuming and costly. In two years of post-treatment sampling across six Great Basin states, researchers from the Sagebrush Steppe Treatment and Evaluation Project (SageSTEP) measured the vegetation response to prescribed fire, tree mastication and cutting, shrub mowing, and herbicide application. Treated plots were compared to untreated control plots. This *Guide for Quantifying Post-treatment Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* assimilates the SageSTEP post-treatment vegetation and fuels data into an assessment tool that will help users better estimate post-treatment percent cover, stem density and fuel loadings. Designed similarly to the Natural Fuels Photo Series, produced by USDA Forest Service Fire and Environmental Research Applications (FERA) team, this Guide provides the necessary landscape-level inputs required by fire behavior and fire effects models and may also be used when building custom fuelbeds. Through the use of photographs and tables with the range of values for each vegetation type, users should be able to quickly appraise sites by fuel stratum. When used in conjunction with the pre-treatment *Guide for Quantifying Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* (Stebleton and Bunting 2009), this post-treatment Guide has the capability to aid users as they predict vegetation and fuel response to the various treatment applications, assess target conditions, set management objectives for restoration projects, choose treatments to meet objectives and determine treatment effectiveness.

Acknowledgements

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Introduction

SageSTEP (Sagebrush Steppe Treatment Evaluation Project) is an interdisciplinary, long-term study to evaluate the effects of various restoration treatments in sagebrush steppe communities of the Great Basin (McIver et al. 2010). Sagebrush steppe, characterized by dry, open expanses dominated by sagebrush plant communities, is one of the most threatened vegetation types in North America (Noss et al. 1995). Loss of sagebrush steppe is often attributed to shifting fire regimes as a result of non-native grass invasion, especially cheatgrass (*Bromus tectorum*), and pinyon pine (*Pinus edulis* and *Pinus monophylla*) and juniper (*Juniperus* spp.) encroachment (Pellant 1994, Miller and Tausch 2001).

SageSTEP was funded initially by the Joint Fire Science Program with ongoing support from the National Interagency Fire Center and the Bureau of Land Management. The project involves collaboration with five universities, six federal agencies, and one non-profit organization. The objective of SageSTEP is to identify abiotic and biotic thresholds that influence the sustainability of sagebrush steppe communities and provide information to managers, ranchers, and the general public to help restore sagebrush steppe to a healthier, more diverse ecosystem.

Cheatgrass has invaded nearly 25 million acres (10 million ha) of the Great Basin (Olsen 2008). Cheatgrass is able to gain a foothold in native plant communities by providing a continuous bed of fine fuel susceptible to fire at a time when it is most harmful to native perennials (Peters and Bunting 1994) because of its ability to germinate and establish before native

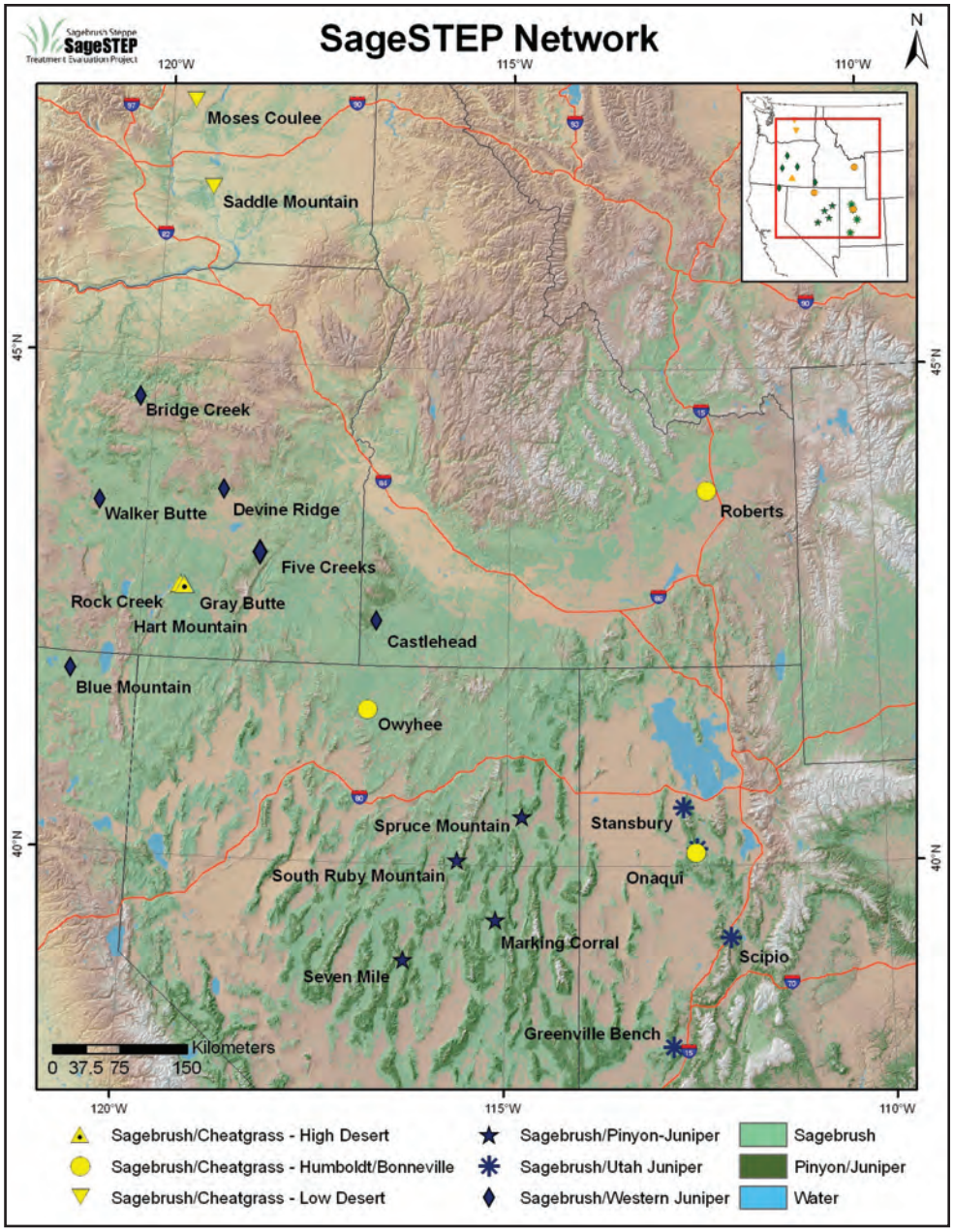

Figure 1. SageSTEP Site Map for reference with site names. Site-specific information is available at http://www.sagestep.org/locations.html.

perennial grasses (Bradford and Lauenroth 2006) and because it cures earlier in the growing season than perennials (Mutch 1967).

Cheatgrass dominance has shifted the mean fire return interval from several decades to 100+ years, in healthy Wyoming big sagebrush-dominated communities (Wright and Bailey 1982), to less than 10 years in many places (Whisenant 1990). Fire occurrence perpetuates cheatgrass expansion, quickly depletes the sagebrush seed bank, and converts native vegetation to an annual grassland (Whisenant 1990). This is the concern in the Sagebrush/Cheatgrass East and West locations (Figure 1). These will be referred to as the 'sagebrush sites' for the rest of the Guide.

Woodland encroachment by pinyon pine and juniper has caused a major shift in species assemblages and altered fire regimes of sagebrush steppe landscapes (McIver et al. 2010). The average fire return interval has shifted from 10–50 years, in healthy mountain big sagebrush-dominated communities, to more than 50 years (Miller et al. 1999, Miller and Tausch 2001). When fire does burn in these woodlands it is characterized by extreme fire behavior and results in more stand-replacing fire than in historic sagebrush communities. Native species recover slowly following high-intensity fires, allowing further invasion of exotics over large areas. This is the major concern in the Sagebrush/Pinyon-Juniper, Sagebrush/Utah Juniper, and Sagebrush/Western Juniper locations (Figure 1). These will be referred to as the 'woodland sites' for the rest of the Guide.

The *Guide for Quantifying Post-treatment Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* was created using second-year post-treatment data collected by 5 field crews in 2008, 2009, and 2010. The SageSTEP network consist of 5 regional networks with 21 total sites (18 of which were used for this guide) spanning Washington, Oregon, California, Idaho, Nevada and Utah (Figure 1). Each site was a replicated, stand-alone experiment, however because of the common sampling design, data could be aggregated for regional representation.

Why is this Guide needed?

This Guide is the only SageSTEP publication to date summarizing the post-treatment vegetation and fuels data, across all 5 regions and 18 sites, into a usable tool for managers and other land stewards. Modeled after the Natural Fuels Photo Series (Ottmar et al. 2000), it allows users to quickly access percent cover, stem density and fuel loadings by fuel stratum (Ottmar et al. 2007). This information is often time-consuming and expensive to collect on a field site. The Guide increases efficiency by giving users pictures coupled with data to make predictions based on ocular estimates and/or limited field sampling. Fuels information gathered from this Guide may be used when creating custom fuelbeds and in a variety of modeling applications for treated sites. When used in conjunction with the pre-treatment *Guide for Quantifying Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* (Stebleton and Bunting 2009), the post-treatment Guide has the capability to predict vegetation and fuel response to the various treatment applications, assess target conditions, set management objectives for restoration projects, choose the proper treatments to meet objectives and determine treatment effectiveness.

Methods

SageSTEP employed a randomized design that was implemented across all 18 sites used to create this guide, including 1140 subplots, within the Great Basin (Figure 1). At each site, subplots were established along a systematic grid with a minimum distance of 164 ft (50 m) between the center of each subplot. Sagebrush sites were at least 200 acres (80.9 ha) with 160 subplots; woodland sites ranged from 25–50 acres (10.1–20.2 ha) with 60 subplots. Each subplot was 98.4 x 108.3 ft (30 x 33 m) with 5 vegetation transects and 1 fuels transect (Figure 2). The two fuels transects, represented in Figure 2, were alternated for the three years of sampling. Transects ran parallel to the 108.3 ft (33 m) length allowing a 4.9 ft (1.5 m) buffer on either end.

A common measurement protocol was used across all sites. Refer to Table 1 for specific methods and transects used for each reported variable by fuel stratum (Ottmar et al. 2007). Descriptive variables for all subplots included: region name, site name, treatment, subplot number, sampling year, UTM coordinates at zero corner, percent slope, aspect, macrotopography (ridgetop, sideslope, terrace, or bottom), and microtopography (flat, convex, or concave).

The sagebrush sites were broken into the four descriptive Groups, identified in the pre-treatment Guide, that make up the post-treatment Sagebrush Steppe sub-guide. All subplots from the seven sites were categorized by less than or greater than 25% pre-treatment sagebrush cover and less than or greater than 25% total pre-treatment grass cover. This allows the user to more efficiently assign their field site to a group based on an ocular pre-treatment cover estimate. These groups were maintained for the post-treatment Guide to allow comparison with the pre-treatment Guide (Stebleton and Bunting 2009).

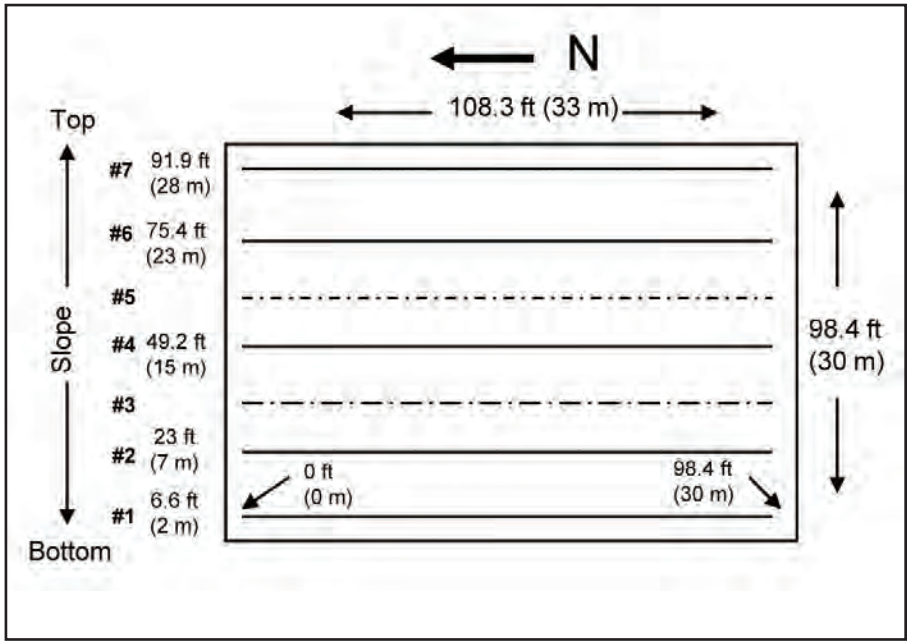

Figure 2. Subplot and transect layout. Solid lines signify vegetation transects; dotted lines denote fuels transects.

The post-treatment woodland subplots also maintained their pre-treatment designation by phases. The phases were classified by the method proposed by Miller et al. (2005): Phase 1, trees may be present on the site but the shrub and herbaceous layers are the dominant influence on ecological processes (hydrologic, nutrient, and energy cycles); Phase 2, trees are co-dominant with the shrub and herbaceous layers; and Phase 3, trees are the dominant vegetation as well as the primary layer influencing ecological processes. Three different sub-guides, Pinyon-Juniper Fuels Guide, Utah Juniper Fuels Guide, and Western Juniper Fuels Guide, were developed to capture the diversity between the different woodlands (Stebleton and Bunting 2009). Again these phases were maintained for comparison purposes in the post-treatment Guide.

Table 1. Sampling methods used for each of the reported variables by fuel stratum (Ottmar et al. 2007). Refer to Figure 2 for transect number reference.

Stratum	Variable(s)	Method	Transect(s)#
Trees	Cover	Census data and line point intercept (Bonham 1989)	1, 2, 4, 6, 7
	Density <1.6 ft (0.5 m) tall	Belt transect (Krebs 1999; Salzer 1994)	2, 4, 6
Shrubs	Cover	Line point intercept (Bonham 1989)	1, 2, 4, 6, 7
	Height	Nested circular frame (Bonham 1989)	4
	Density	Belt transect (Krebs 1989; Salzer 1994)	2, 4, 6
		Nested circular frame (Bonham 1989)	4
	Loading and bulk density	Harvest (Pechanec and Pickford 1937; Riser 1984)	NA
		Nested circular frame (Bonham 1989)	4
Nonwoody Fuels	Cover	Line point intercept (Bonham 1989)	1, 2, 4, 6, 7
	Height	19.7 in. x 19.7 in. (50 cm x 50 cm) quadrat (Bonham 1989)	3 in 2008 and 2010 ; 5 in 2009
	Loading and bulk density	Harvest (Pechanec and Pickford 1937; Riser 1984)	3 in 2008 and 2010 ; 5 in 2009
		19.7 in. x 19.7 in. (50 cm x 50 cm) quadrat (Bonham 1989)	3 in 2008 and 2010 ; 5 in 2009
Woody Fuels	10-hour loading	Planar intercept (Brown et al. 1982)	2, 4, 6
	100-hour loading	Planar intercept (Brown et al. 1982)	2, 4, 6
	1000-hour sound and rotten loading	Planar intercept (Brown et al. 1982)	1, 2, 4, 6, 7
Litter and Duff	Cover	Line point intercept (Bonham 1989)	1, 2, 4, 6, 7
	Interspace loading and bulk density	Harvest (Pechanec and Pickford 1937; Riser 1984)	3 in 2008 and 2010; 5 in 2009
		9.8 in. x 9.8 in. (25 cm x 25 cm) quadrat (Bonham 1989)	3 in 2008 and 2010 ; 5 in 2009
	Tree litter and duff depth, loading, and bulk density	Harvest (Pechanec and Pickford 1937; Riser 1984)	NA
		9.8 in. x 9.8 in. (25 cm x 25 cm) quadrat (Bonham 1989)	NA

Four treatments were implemented across the sagebrush sites: untreated control, fire, mechanical (mow), and herbicide (McIver et al. 2010). The objective for all treatments, except for the control, was to reduce sagebrush dominance. All fire treatments were conducted in the fall and implemented by agency personnel. The objective of the burn treatment was to blacken 100% of the area with a low-severity prescribed burn, however, at most sites, only 20–95% of the area was burned. The mechanical treatment involved mowing the sagebrush to a height of approximately 12 in. (30.5 cm) (Olsen 2009). The objectives were to open the sagebrush canopy and reduce sagebrush abundance by 50%. The herbicide treatment required the application of the herbicide Tebuthiuron (Spike 20P™) applied aerially in the form of pellets at a rate of 1–1.5 lbs/acre (1.1–1.7 kg/ha) (Olsen 2009). Again the objective was to reduce sagebrush abundance by 50%.

The woodland sites employed three treatments: untreated control, fire, and mechanical cutting (McIver et al. 2010). The fire treatments were conducted in the fall by agency personnel. Although the objective was to burn 100% of the study site with a low-severity prescribed burn (McIver et al. 2010), results varied depending on fuel characteristics and weather conditions (Olsen 2009). To meet research objectives, field crews returned to the subplots for follow-up burning of individual trees (Olsen 2009). The mechanical treatment involved using a chainsaw to clear-cut all trees greater than 1.6 ft (0.5 m) tall (McIver et al. 2010). Trees were left were they fell. Due to local interest, the Utah Juniper sites employed a fourth treatment, mechanical shredding using a Bull Hog™ (Olsen 2009). All trees greater than 1.6 ft (0.5 m) tall were masticated and all fuel was left on the site (Olsen 2009).

All reported measurements were converted to English units to allow for quick input into computer fire behavior and fire effects models as well as to account for manager preference. A conversion table is provided in Appendix II. Minimum, maximum and mean values are reported to allow the user to better assess their site within the range represented by a particular group or phase. Only common species are reported in this Guide. All species codes, common names and scientific names are in agreement with the USDA Plants Database (USDA NRCS 2011) and are reported in Appendix I.

Trees

Total tree canopy cover for each subplot was derived from 300 intercept points per subplot (60 points across 5 transects) using the line point intercept method (Bonham 1989). Any live branches (denoted by green foliage) of trees rooted within the subplot were counted. Trees less than 1.6 ft (0.5 m) tall were counted within a 3.3-ft (1-m) belt on either side of 3 transects giving sapling density (Table 1).

Shrubs

Total shrub canopy cover for each subplot was derived from 300 intercept points per subplot (60 points over 5 transects) using the line point intercept method (Bonham 1989; Table 1). For common shrub species, densities were derived from counts within a 3.3-ft (1-m) belt on either side of 3 transects (Table 1). The most abundant shrub species separated by height class, 2–6 in. (5–15 cm) tall or greater than 6 in. (15 cm) tall, were tallied; rare shrubs that landed within the belt were recorded but not separated by height class. Dead shrubs were tallied but not separated by species. All shrub species taller than 6 in. (15 cm) were measured at 5 sample points along transect 4 (Table 1). Height, longest diameter and perpendicular diameter were recorded within either 3.3-, 6.6-, or 9.8-ft (1-, 2-, or 3-m) radius nested circular frames.

Size of the nested plot was chosen based on the minimum requirement to measure at least 15 of each common shrub species per subplot. Shrubs must have been rooted within the nested plot to be counted. Shrubs with less than 10% live canopy cover were not recorded. A range of sizes of dominant shrub species, as identified by the site managers, were destructively sampled and separated into the different fuel classes (1-hour [includes foliage], 10-hour and 100-hour) (Stebleton and Bunting 2009). Samples were oven-dried at 58°F for 48 hours. Total shrub loading was calculated as the difference between the wet field weight and dry weight (Pechanec and Pickford 1937). Site- and species-specific regressions were developed from the destructively sampled shrubs to predict shrub loadings using height, longest diameter, perpendicular diameter and volume as covariates (Rittenhouse and Senva 1977, Stebleton and Bunting 2009). Reported R^2 values in Appendix V are the lowest R^2 obtained across the different size classes. Standing dead shrub loading was not directly measured, but was calculated by subtracting the post-treatment live loading by size class from the pre-treatment live loading by size class. Standing dead shrub loading is only reported for the sagebrush sites, in Appendix IV, because the woodland sites did not employ a herbicide treatment. Available loading, used to calculate shrub bulk density, assumed all foliage, standing dead and 1-hour fuels consumed while only 50% of the 10-hour live fuels consumed*. Shrub live and dead loadings by size class and available loadings are reported in Appendix IV.

Nonwoody Fuels

Total perennial and annual grass and forb canopy cover for each subplot were derived from 300 intercept points per subplot (60 points over 5 transects) using the line point intercept method (Bonham 1989; Table 1). Total loadings were derived through destructive sampling along the fuels transect. All herbaceous vegetation, standing litter, and surface litter were collected from a 19.7 x 19.7 in. (50 x 50 cm) quadrat (Bonham 1989) with 15 sample points in the woodland sites and 8 sample points in the sagebrush sites. Heights of the tallest grass and forb were measured before clipping. All vegetation was removed within 2.5 in. (1 cm) of the ground and sorted as live herbaceous, standing dead herbaceous and litter. Sub-samples were oven-dried at 58°F for 48 hours. Total herbaceous loading was calculated by multiplying the percentage of dried biomass of the sub-sample by the total sample's wet weight (Pechanec and Pickford 1937). Bulk density was calculated using the total loading, assuming the available fuel is 100%, and taking the landscape average of all grass and forb heights.

*Wright, C.S. 2008. Personal Communication. Research Forester, USDA Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, Seattle, WA.

Woody Fuels

A modification of the planar intercept method (Brown et al. 1982) was used to sample down woody debris within subplots. Ten- and 100-hour fuels were tallied below 6.6 ft (2 m) along 3 transects (297 ft (90 m) total) per subplot (Table 1). A diameter for each 1000-hour fuel was measured at the point of intersection along 5 transects, 492.1 ft (150 m), per subplot and a decay class of sound or rotten was assigned to each (Brown, 1974; Table 1). Shredded fuels, in the Utah Juniper region, were categorized by size class and reported as woody fuel. One-hour fuels were not tallied. Brown's (1974) equations were used to assign loadings, by size class, for each subplot.

Litter and Duff

Interspace litter was collected from 19.7 x 19.7 in. (50 x 50 cm) quadrats (Bonham 1989) sampled at 15 sample points in the woodland sites and at 8 sample points in the sagebrush sites. Litter was collected following the clipping of all herbaceous vegetation within the 19.7 x 19.7 in. (50 x 50 cm) quadrat (Bonham 1989). Sub-samples were oven-dried at 58°F for 48 hours. Total interspace litter loading was calculated by multiplying the percentage of dried biomass of the sub-sample by the total sample's wet weight (Pechanec and Pickford 1937).

Tree litter and duff samples were collected from 6 trees, used in pre-treatment sampling, greater than 6.6 ft (2 m) in crown diameter rooted within the subplot; 2 closest to the center and 1 closest to each of the 4 corners. A 9.8 x 9.8 in. (25 x 25 cm) quadrat (Bonham 1989) was used to sample at the base of the tree, 1/3 of the canopy from the base for trees 6.6–13.1 ft (2–4 m) in crown diameter, and 2/3 of the canopy from the base for trees greater than 13.1 ft (4 m) in crown diameter. The litter and duff was separated and weighed in the field. Sub-samples were oven-dried at 58°F for 48 hours. Total loading was calculated by multiplying the percentage of dried biomass of the sub-sample by the total sample's wet weight (Pechanec and Pickford 1937). Litter and duff depths were measured from the remaining profile within the quadrat once all material was removed. The difference in the wet and dry weights combined with the depths were used to calculate the litter and duff bulk density assuming all fuel was available.

Bare ground percent cover was derived from hits along 300 intercept points per subplot (60 points over 5 transects) using the line point intercept method (Bonham 1989; Table 1). This is the only measure of fuel continuity.

Fuel Trends 2 Years Post-treatment

After compiling the data, a few trends were noted. No statistical analyses were performed on the data, these are strictly observations. Overall, fuel loading typically increased across all of the controls from pre- to post-treatment.

When the fire treatment met the objective of blackening 100% of the plot with a low-severity prescribed burn, it was very effective at reducing fuel loading. However, when this objective was not met it was not an effective treatment for fuel reduction. This can be seen in the data where there is little change in the fuel loading post-treatment. In areas where cheatgrass was present before the prescribed burn, it became a large component of the surface fuel complex post-burn.

The mechanical treatment in the sagebrush sites did not appear to affect the overall surface fuel loading. This could have been due to the height at which the shrubs were mowed or because the mowing actually stimulated growth. In the woodland sites, the mechanical treatments (removal of all trees within a subplot by either cutting or mechanical shredding) redistributed the fuels moving them from a canopy fuel to a down, dead woody surface fuel. Also, as noted by the site managers, if the whole juniper was not completely removed from the stump or the stump was not cut low enough to the ground (leaving living branches), cutting and mastication did not kill the juniper.

Finally, the herbicide treatment had varying effectiveness on the sagebrush sites. There were very few subplots where Tebuthiuron (Spike 20P™) resulted in significant top-kill. This could have been a result of poor distribution of herbicide or not enough herbicide to affect healthy shrubs.

Using the Post-treatment Fuels Guide

The *Guide for Quantifying Post-treatment Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* will help users quickly and inexpensively estimate fuel loadings on treated sites. When used in conjunction with the pre-treatment Guide (Stebleton and Bunting 2009), the post-treatment Guide has the capability to predict vegetation and fuel response to the various treatment applications, assess target conditions, set realistic management objectives for restoration projects, and determine treatment effectiveness. Designed similarly to the Natural Fuels Photo Series, produced by the USDA Forest Service Fire and Environmental Research Applications team (FERA), this Guide provides the necessary landscape-level inputs required by existing fire behavior models. Through the use of photographs and tables, with the range of values, users can quickly appraise fuels by the various fuel strata or use it to predict possible treatment outcomes. Because of the high variability of fuel distribution across individual sites, it is generally necessary to use more than one site from the post-treatment Guide to represent each particular fuel strata of a field site.

The post-treatment Guide is divided into four sub-guides (one sagebrush and three woodland guides) based on regional differences in site physiognomy and ecology: Sagebrush Steppe, Pinyon-Juniper, Utah Juniper, and Western Juniper. Sections are aggregated into groups by total pre-treatment sagebrush cover and total grass cover in the Sagebrush Steppe Guide and by pre-treatment phases (Miller et al. 2005) in the Woodland Guides (refer to Methods section for further explanation). Groups and phases are further subdivided by treatment: control, fire, mechanical (cutting, shredding and mowing), and herbicide. Two photos depict the range of canopy cover by life-form within the group or phase. Photos are arranged by increasing cover of the dominant overstory vegetation. The user notes and information at the top of photo pages give more background on specific sites sampled. Refer to Figure 1 for site names and locations. Number of subplots reported is the number of sampling units for that particular group or phase. Elevation for each photo is the elevation for that specific subplot. Elevation ranges for data are listed under general site information.

Six steps for effective use:

1. Determine your objective for using the post-treatment Guide. Most often it will be most effectively used in conjunction with the pre-treatment *Guide for Quantifying Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* (Stebleton and Bunting 2009).
2. Assess each fuel stratum individually (trees, shrubs, nonwoody fuel, woody fuel, and litter).
3. Compare the field site to the Guide group(s) or phase(s) that most closely resembles field observations. Multiple groups or phases may need to be used to capture the variability of the field site.
4. Decide where within the range of values the fuel strata of the field site fits and/or interpolate between groups or phases.
5. Some strata are not possible to estimate using photos (litter and duff depths). A combination of field sampling and observations with this Guide should be incorporated for the most accurate results.
6. Repeat these steps for each fuel stratum of interest to obtain the necessary inputs.

Author Recommendations for Guide Use

For the user to most effectively use this Guide, we recommend accounting for the assumptions and limitations listed below.

- Sampling on all sites took place from April to August (See Guide Notes in the sub-guides for more specifics). No distinction for seasonality was made in the reported variables. When comparing field sites to the photographs and reported values, be sure to account for the difference in seasonality. This is especially critical regarding the loadings of live and dead herbaceous fuels.
- Minimum and maximum values are included to capture the range of variability within groups or phases. However, in most cases, data are not normally distributed and reported means are much closer to minimum than maximum values.
- It is difficult to distinguish woody fuels, litter, and duff fuel strata in the photographs. Independent sampling or observations may be required to gain the most accurate values for these strata.
- One-hour fuels were not collected. If this information is required, the user should make this measurement.
- Shredded fuels were assigned to a size class, and loadings were calculated using Browns (1974). This method violates Brown's (1974) assumption of circular fuels, however, this was the best available method during data collection.
- Fuel bed depth, a critical input in existing fire behavior models, was not measured. It is NOT recommended to assume this value using the heights reported in the Guide. This should be measured on the site due to the sensitivity of the Rothermel surface fire spread model (Rothermel 1972) to this input.
- Treatments were implemented under the best available conditions to achieve objectives identified. Make necessary adjustments when different objectives are identified. Also, results may vary considerably when outside factors, such as weather or resource availability, significantly influence the treatment application.
- The organization and layout of this Guide is based on pre-treatment established conditions. Using this Guide in conjunction with the pre-treatment *Guide for Quantifying Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin* (Stebleton and Bunting 2009) is highly recommended.

Further Information

- Joint Fire Science Program (JFSP): http://www.firescience.gov
- Sagebrush Steppe Treatment Evaluation Project (SageSTEP): http://www.sagestep.org
- *Guide for Quantifying Fuels in the Sagebrush Steppe and Juniper Woodlands of the Great Basin*: http://www.cnr.uidaho.edu/GBFuelsGuide or http://www.sagestep.org/pdfs/SageSTEPFuelsGuide.pdf
- University of Idaho, Department of Rangeland Ecology and Management: http://www.cnr.uidaho.edu/range
- USDA Forest Service Fire and Environmental Research Applications team (FERA): http://www.fs.fed.us/pnw/fera/
- Natural Fuels Photo Series (Digital): http://depts.washington.edu/nwfire/dps/

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Sagebrush Steppe Fuels Guide: 4 Groups, 4 Treatments
User Notes

Site Notes

- Four groups with four treatments represent the SageSTEP Sagebrush/Cheatgrass East and West sites characterized by the Loamy 10–12” ecological type (NRCS 1997).
- General site information:
  - Average annual precipitation ranges between 8.5–12.8 in. (21.6–32.5 cm) averaging 11 in. (27.9 cm);
  - Slopes (0–10%), all aspects;
  - ‘Loamy’ soil texture, and soil depths >20 in. (50.8 cm) with minimal stoniness.
- Prior to cheatgrass invasion, typical fire return interval on these sites was from several decades to 100 years (Wright and Bailey 1982). Since the introduction of cheatgrass the fires have been larger, often with a return interval of less than 10 years (Whisenant 1990).
- Four treatments were employed across the region: control, fire, mechanical (mow), and herbicide.
- Rock Creek and Gray Butte are the only sites that are not within active grazing allotments. All other subplots may have been grazed prior to construction of the exclosures at the beginning of the SageSTEP project.
- Site locations and elevation range for data used in tables are as follows:
  - Group 1: **Control:** Roberts, Rock Creek, Gray Butte; 18 subplots; 4865–4961 ft (1483–1512 m)
    Fire: Roberts, Rock Creek, Gray Butte; 10 subplots; 4823–4954 ft (1470–1510 m)
    Mow: Roberts, Rock Creek, Gray Butte; 12 subplots; 4856–4951 ft (1480–1509 m)
    Herbicide: Gray Butte, Onaqui, Owyhee, Roberts; 18 subplots; 4852–5531 ft (1479–1686 m)
  - Group 2: **Control:** Gray Butte, Moses Coulee, Owyhee, Roberts, Rock Creek, Saddle Mt; 24 subplots; 906–5341 ft (276–1628 m)
    Fire: Onaqui, Roberts, Rock Creek, Saddle Mt; 21 subplots; 846–5449 ft (258–1676 m)
    Mow: Gray Butte, Moses Coulee, Onaqui, Owyhee, Roberts, Rock Creek, Saddle Mt; 34 subplots; 899–5505 ft (274–1637 m)
    Herbicide: Gray Butte, Moses Coulee, Onaqui, Owyhee, Rock Creek; 28 subplots; 899–5505 ft (524–1686 m)
  - Group 3: **Control:** Gray Butte, Owyhee, Roberts; 9 subplots; 4925–5341 ft (1501–1628 m)
    Fire: Gray Butte, Owyhee, Rock Creek; 18 subplots; 4902–5377 ft (1494–1639 m)
    Mow: Onaqui, Owyhee; 8 subplots; 5371–5505 ft (1637–1678 m)
    Herbicide: Gray Butte, Owyhee; 9 subplots; 4905–5318 ft (1495–1621 m)
  - Group 4: **Control:** Moses Coulee, Onaqui, Saddle Mt; 18 subplots; 4902–5377 ft (276–1671 m)
    Fire: Onaqui, Owyhee, Roberts, Rock Creek, Saddle Mt; 23 subplots; 846–5499 ft (258–1676 m)
    Mow: Gray Butte, Onaqui, Owyhee, Roberts, Saddle Mt; 18 subplots; 899–5505 ft (274–1678 m)
    Herbicide: Onaqui, Owyhee, Saddle Mt; 17 subplots; 879–5531 ft (268–1686 m)

Guide Notes

1. Groups are organized by **pre-treatment** total shrub and total grass cover, perennial and annual grass combined (Stebleton and Bunting 2009).
   - Group 1: Shrub cover = 0–25%; Total grass cover = 0–25%
   - Group 2: Shrub cover = 0–25%: Total grass cover = >25%
   - Group 3: Shrub cover = >25%; Total grass cover = 0–25%
   - Group 4: Shrub cover = >25%: Total grass cover = >25%
2. Treatments, abbreviations and treatment objectives:
   - Control (CO): Untreated
   - Fire (FI): Objective was to blacken 100% of the plot area with a low-severity prescribed burn (not all plots met objective).
   - Mow (MO): Sagebrush was mowed to a height of ~12-15 in. (30.5–38.1 cm) throughout the plot.
   - Herbicide (TE): Tebuthiuron (Spike 20P™) pellets were applied aerially at a rate of ~1.5 lbs/acre (1.7 kg/ha) with an objective of at least 50% sagebrush mortality (not all plots met mortality objective).
3. The caption above the photos denotes measured percent live cover by fuel stratum for that post-treatment photo. This may or may not match up with the Group it was assigned to since Group placement was based on pre-treatment conditions.
4. Sampling took place between April and August in 2008, 2009, and 2010. The date of the photo is in the lower right hand corner.
5. Percent bare ground is the only reported measure of fuel continuity.
6. Dominant graminoids: ACHY, ACTH7, BRTE, ELEL5, HECO26, LECI4, PASM, POCU3, POSE, and PSSPS
7. BRTE is the only annual grass reported with the exception of a small amount of BRAR5 found in Group 2.
8. Shrub loadings are restricted by height, longest diameter, perpendicular diameter and volume. Refer to Appendix V, ‘Sagebrush Steppe’, for sample ranges used in this study and R^2 values.
9. Minimum values presented with an asterisk (*) indicate minimum value when present. Mean value includes all subplots.
10. The designation of “NA” indicates data were not available.
11. Tables of species codes and metric conversions can be found in Appendix I and II.

Sagebrush Steppe: Group 1, Control

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: 0–25%)

Site: Hart Mountain-Rock Creek **Elevation:** 4961 ft (1512 m)

Shrubs: 17% Perennial Grass: 19% Total Grass: 20% Bare Ground: 33%

07/25/09

Site: Roberts **Elevation:** 4865 ft (1483 m)

Shrubs: 30% Perennial Grass: 13% Total Grass: 48% Bare Ground: 18%

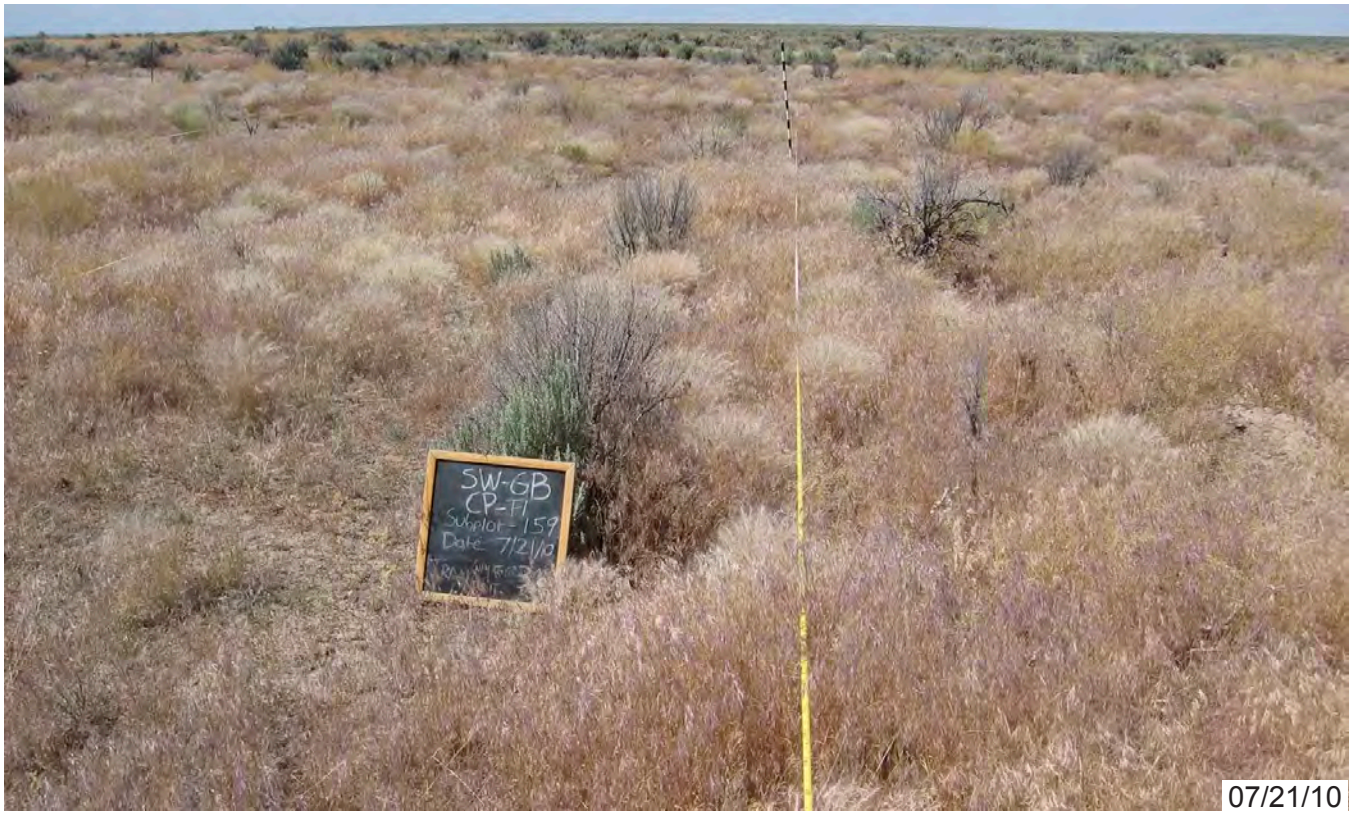
07/20/09

Sagebrush Steppe: Group 1, Fire

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: 0–25%)

Site: Hart Mountain-Gray Butte **Elevation:** 4902 ft (1494 m) **Treatment Date:** 10/2008

Shrubs: 1% Perennial Grass: 13% Total Grass: 42% Bare Ground: 32%



07/21/10

Site: Roberts **Elevation:** 4823 ft (1470 m) **Treatment Date:** 09/2007

Shrubs: 9% Perennial Grass: 23% Total Grass: 55% Bare Ground: 2%

07/07/09

Sagebrush Steppe: Group 1, Mow

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: 0–25%)

Site: Roberts **Elevation:** 4856 ft (1480 m) **Treatment Date:** 10/2007

Shrubs: 3% Perennial Grass: 8% Total Grass: 93% Bare Ground: 7%

Site: Hart Mountain-Rock Creek **Elevation:** 4856 ft (1480 m) **Treatment Date:** 09/2007

Shrubs: 9% Perennial Grass: 25% Total Grass: 30% Bare Ground: 25%

Sagebrush Steppe: Group 1, Herbicide

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: 0–25%)

Site: Hart Mountain-Gray Butte **Elevation:** 4905 ft (1495 m) **Treatment Date:** 11/2008

Shrubs: 8% Perennial Grass: 15% Total Grass: 19% Bare Ground: 19%

Site: Roberts **Elevation:** 4852 ft (1479 m) **Treatment Date:** 10/2007

Shrubs: 17% Perennial Grass: 12% Total Grass: 40% Bare Ground: 32%

Sagebrush Steppe: Group 1

SHRUBS

Species	Treat-ment	Total cover (%)			Height (in.)			Density (#/acre)			Total live loading (ton/ac)			Standing dead loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRW8	CO	9*	30	18	3	54	16	1,681	7,767	4,706	0.72	4.22	1.91	NA			0.0001	0.0521	0.0113
	FI	<1*	27	11	4	33	12	23*	7,426	2,630	0.05*	3.79	1.19				0.0001*	0.0023	0.0008
	MO	2*	17	9	<1	28	16	1,272	6,972	2,930	0.11*	1.33	0.50				<0.0001*	0.0252	0.0088
	TE	2	27	15	3	50	18	1,090	6,427	3,161	0.44*	6.19	2.05	0.15*	4.31	0.84	0.0001*	0.1321	0.0241
CHVI8	CO	<1*	9	2	3	18	10	91	636	52	<0.01*	1.17	0.19	NA			<0.0001*	0.0039	0.0003
	FI	<1*	3	1	4	15	10	45*	1,045	261	0.04*	0.09	0.01				<0.0001*	0.0038	0.0004
	MO	<1	5	1	5	32	11	56*	159	15	0.01*	0.36	0.03				<0.0001*	0.0002	<0.0001
	TE	<1	7	1	1	23	10	23*	23	1	0.02*	1.79	0.16	<0.01*	0.03	<0.01	<0.0001*	0.0010	0.0001

LITTER and DUFF

	Treatment	Total cover (%)			Loading (ton/ac)		
		Min	Max	Mean	Min	Max	Mean
Interspace litter	CO	4*	17	9	0.02*	0.37	0.09
	FI	2*	9	3	0.02*	0.08	0.04
	MO	1	24	10	0.02	1.41	0.34
	TE	5	18	10	<0.01	0.59	0.06
Bare ground	CO	4	39	18	NA		
	FI	2	42	27			
	MO	2	42	16			
	TE	18	57	29			

NONWOODY FUELS

	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	4	27	14	3	32	16	3	32	17	5	30	16
Total cover: Annual grass† (%)	<1	77	23	7	69	32	<1*	84	33	<1*	34	16
Total cover: Forbs (%)	4	79	29	11	90	34	6	91	31	2	48	22
Grass height (in.)	5	12	9	6	17	10	4	15	10	4	14	9
Forb height (in.)	2*	11	3	5*	15	5	4*	9	4	1*	11	2
Live loading (lbs/ac)	44.77	393.95	129.08	17.91	174.59	86.85	17.91	398.43	135.79	4.48*	214.88	83.84
Dead loading (lbs/ac)	31.34*	94.01	39.30	31.34	35.81	16.12	8.95*	80.58	31.34	31.34*	174.59	29.51
Total loading (lbs/ac)	76.11	487.96	168.38	49.25	210.40	102.97	26.86	479.01	167.13	35.82	389.47	113.35
Bulk density (lbs/ft³)	0.0055	0.0238	0.0142	0.0034	0.0689	0.0170	0.0044	0.0305	0.016	0.0032	0.0225	0.0133

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.08	0.79	0.25	0.03	0.51	0.20	0.14	1.21	0.43	0.18	0.77	0.30
1.1–3.0 (100-hour)	0.10*	1.08	0.40	0.05*	0.84	0.20	0.15	1.53	0.59	0.05*	1.13	0.40
3.1–9.0 (1000-hour: Sound)	0.18*	1.12	0.08	0			0.09	0.09	0.01	0.09*	0.48	0.14
3.1–9.0 (1000-hour: Rotten)	0						0			0.19*	0.43	0.05
Total loading	0.36	2.99	0.73	0.08	1.35	0.40	0.38	2.83	1.03	0.51	2.81	0.89

Sagebrush Steppe: Group 2, Control

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: >25%)

Site: Hart Mountain-Rock Creek **Elevation:** 4961 ft (1512 m)

Shrubs: 17% Perennial Grass: 19% Total Grass: 19% Bare Ground: 46%

07/24/09

Site: Saddle Mountain **Elevation:** 906 ft (276 m)

Shrubs: 25% Perennial Grass: 28% Total Grass: 46% Bare Ground: 9%

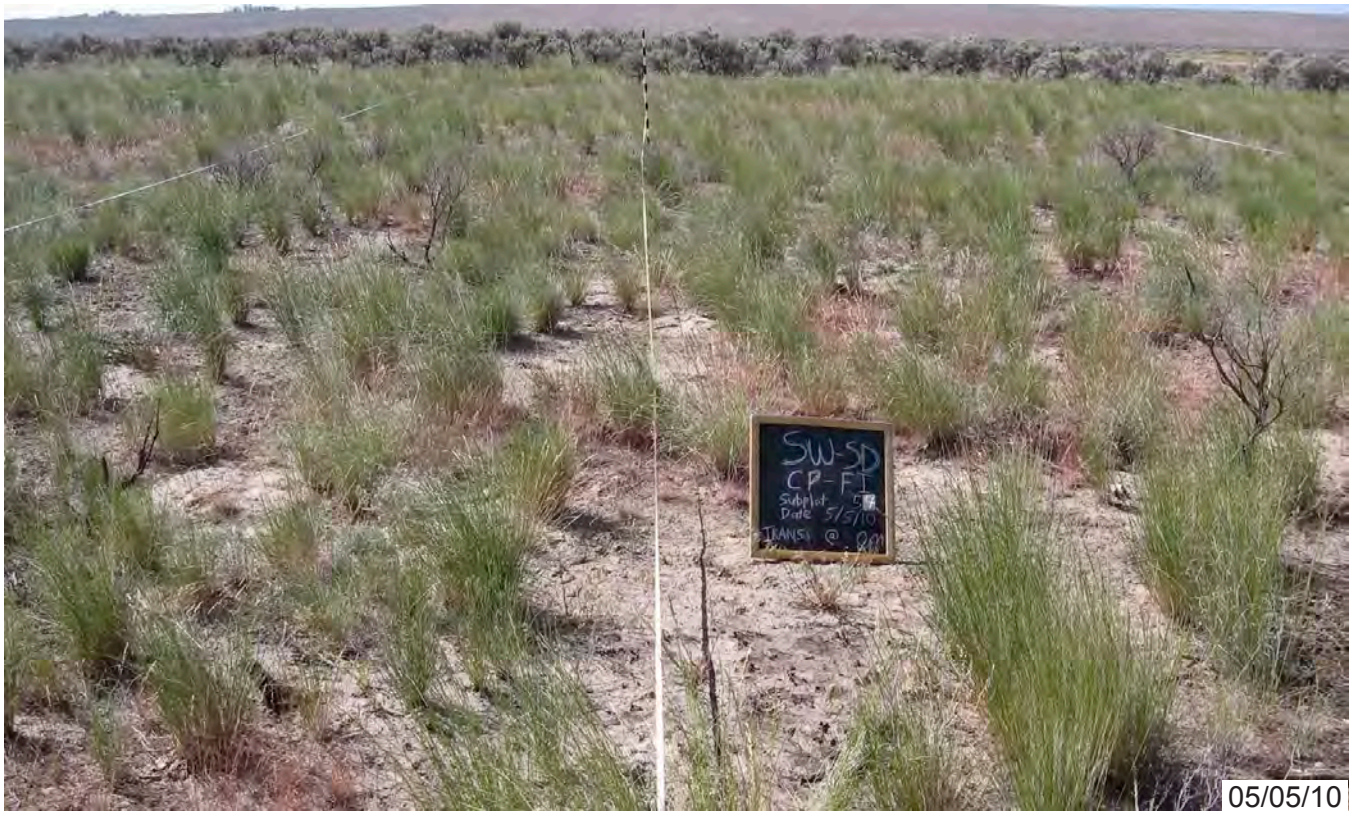
04/30/10

Sagebrush Steppe: Group 2, Fire

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: >25%)

Site: Saddle Mountain **Elevation:** 846 ft (258 m) **Treatment Date:** 09/2008

Shrubs: 0% Perennial Grass: 45% Total Grass: 50% Bare Ground: 25%



05/05/10

Site: Onaqui **Elevation:** 5499 ft (1676 m) **Treatment Date:** 09/2006

Shrubs: 2% Perennial Grass: 21% Total Grass: 21% Bare Ground: 48%

05/14/08

Sagebrush Steppe: Group 2, Mow

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: >25%)

Site: Moses Coulee **Elevation:** 1719 ft (524 m) **Treatment Date:** 02/2009

Shrubs: 9% Perennial Grass: 43% Total Grass: 55% Bare Ground: 16%

05/25/10

Site: Hart Mountain-Gray Butte **Elevation:** 4915 ft (1498 m) **Treatment Date:** 10/2008

Shrubs: 13% Perennial Grass: 8% Total Grass: 39% Bare Ground: 12%

07/11/10

Sagebrush Steppe: Group 2, Herbicide

(**Pre-treatment Cover:** Shrub: 0–25%; Total grass: >25%)

Site: Moses Coulee **Elevation:** 1719 ft (524 m) **Treatment Date:** 11/2008

Shrubs: 16% Perennial Grass: 30% Total Grass: 53% Bare Ground: 45%

05/17/10

Site: Onaqui **Elevation:** 5531 ft (1686 m) **Treatment Date:** 10/2006

Shrubs: 22% Perennial Grass: 23% Total Grass: 23% Bare Ground: 24%

06/12/08

Sagebrush Steppe: Group 2

SHRUBS

Species	Treat-ment	Total cover (%)			Height (in.)			Density (#/acre)			Total live loading (ton/ac)			Standing dead loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRW8	CO	1	25	14	4	72	24	817	6,722	2,343	0.12	4.45	1.65	NA			0.0100	0.0997	0.0237
	FI	<1*	27	7	3	57	20	45*	3,792	1,198	0.01*	3.46	0.60				0.0001*	0.0056	0.0005
	MO	<1*	24	7	5	46	15	23	4,519	1,763	0.03*	2.93	0.60				0.0014*	0.0833	0.0122
	TE	2*	20	11	6	59	25	568	3,179	1,674	0.42	5.60	1.69	0.01*	1.58	0.23	<0.0001*	0.0574	0.0175
CHVI8	CO	<1	3	<1	6	20	10	23*	658	59	<0.01*	0.01	<0.01	NA			<0.0001*	<0.0001	<0.0001
	FI	<1	1	<1	6	13	9	0			<0.01*	0.03	<0.01				<0.0001*	<0.0001	<0.0001
	MO	<1*	3	<1	3	20	11	23*	1,499	102	0.01*	0.10	0.01				0.0030*	0.0052	0.0004
	TE	<1	2	<1	7	18	11	23*	341	24	NA						NA		

LITTER and DUFF

	Treatment	Total cover (%)			Loading (ton/ac)		
		Min	Max	Mean	Min	Max	Mean
Interspace litter	CO	3*	36	13	<0.01*	0.46	0.11
	FI	<1*	12	5	<0.01*	0.13	0.04
	MO	2*	44	15	<0.01*	1.48	0.29
	TE	4	22	14	0.02	0.78	0.16
Bare ground	CO	3	53	32	NA		
	FI	10	49	25			
	MO	3*	40	22			
	TE	11	49	29			

NONWOODY FUELS

	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	7	50	25	7	45	22	3	72	29	3	44	25
Total cover: Annual grass† (%)	1*	77	14	1*	73	28	<1*	82	27	<1*	47	13
Total cover: Forbs (%)	<1*	21	7	3	67	33	1	99	14	1*	20	6
Grass height (in.)	4	15	8	4	13	9	4	15	9	4	13	8
Forb height (in.)	1*	18	4	3*	13	3	1*	17	4	1*	9	3
Live loading (lbs/ac)	4.48	546.16	130.38	89.53	886.39	271.59	13.43	420.81	161.03	22.38	1,074.41	219.01
Dead loading (lbs/ac)	4.48*	290.99	100.91	13.43*	80.58	29.84	8.95*	313.37	64.70	26.86*	492.44	144.98
Total loading (lbs/ac)	8.96	837.15	231.29	102.96	966.97	301.43	22.38	734.18	225.73	49.24	1,566.85	363.99
Bulk density (lbs/ft³)	0.0039	0.1006	0.0249	0.0124	0.0376	0.0227	0.0019	0.0787	0.0242	0.0077	0.1583	0.0376

†Species used to calculate perennial grass cover were all native, and annual grass cover includes cheatgrass and a small amount of field brome.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.09	0.98	0.31	0.06	0.69	0.17	0.04	1.10	0.42	0.11	0.95	0.32
1.1–3.0 (100-hour)	0.10	1.23	0.49	0.05*	0.30	0.11	0.05*	1.62	0.72	0.10	1.18	0.49
3.1–9.0 (1000-hour: Sound)	0.12*	0.63	0.09	0.12*	0.30	0.05	0.12*	0.29	0.06	0.15*	0.37	0.09
3.1–9.0 (1000-hour: Rotten)	0.11*	0.11	0.01	0			0.11*	0.34	0.03	0.11*	0.13	0.01
Total loading	0.42	2.95	0.90	0.23	1.43	0.42	0.32	3.35	1.23	0.47	2.63	0.91

Sagebrush Steppe: Group 3, Control

(**Pre-treatment Cover:** Shrub: >25%; Total grass: 0–25%)

Site: Hart Mountain-Gray Butte **Elevation:** 4925 ft (1501 m)

Shrubs: 16% Perennial Grass: 22% Total Grass: 27% Bare Ground: 21%

Site: Hart Mountain-Gray Butte **Elevation:** 4925 ft (1501 m)

Shrubs: 25% Perennial Grass: 12% Total Grass: 12% Bare Ground: 16%

Sagebrush Steppe: Group 3, Fire

(**Pre-treatment Cover:** Shrub: >25%; Total grass: 0–25%)

Site: Hart Mountain-Gray Butte **Elevation:** 4902 ft (1494 m) **Treatment Date:** 10/2008

Shrubs: 0% Perennial Grass: 4% Total Grass: 27% Bare Ground: 44%

07/22/10

Site: Hart Mountain-Rock Creek **Elevation:** 4954 ft (1510 m) **Treatment Date:** 09/2007

Shrubs: <1% Perennial Grass: 19% Total Grass: 29% Bare Ground: 39%

07/11/09

Sagebrush Steppe: Group 3, Mow

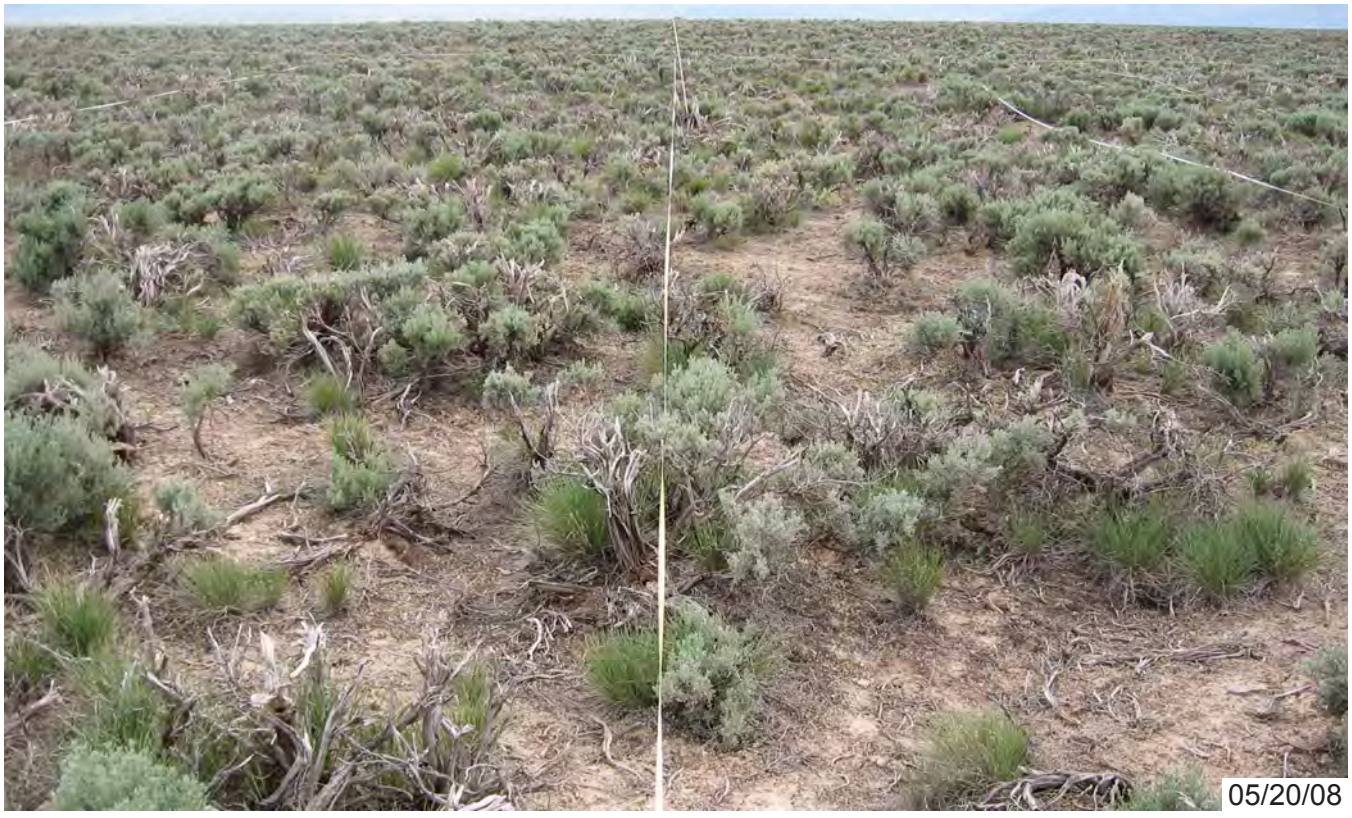
(**Pre-treatment Cover:** Shrub: >25%; Total grass: 0–25%)

Site: Onaqui **Elevation:** 5505 ft (1678 m) **Treatment Date:** 10/2006

Shrubs: 17% Perennial Grass: 11% Total Grass: 14% Bare Ground: 29%

Site: Onaqui **Elevation:** 5505 ft (1678 m) **Treatment Date:** 10/2006

Shrubs: 19% Perennial Grass: 22% Total Grass: 22% Bare Ground: 23%



Sagebrush Steppe: Group 3, Herbicide

(**Pre-treatment Cover:** Shrub: >25%; Total grass: 0–25%)

Site: Hart Mountain-Gray Butte **Elevation:** 4905 ft (1495 m) **Treatment Date:** 11/2008
Shrubs: 15% Perennial Grass: 22% Total Grass: 23% Bare Ground: 22%

07/20/10

Site: Hart Mountain-Gray Butte **Elevation:** 4905 ft (1495 m) **Treatment Date:** 11/2008
Shrubs: 21% Perennial Grass: 8% Total Grass: 10% Bare Ground: 15%

07/20/10

Sagebrush Steppe: Group 3

SHRUBS

Species	Treat-ment	Total cover (%)			Height (in.)			Density (#/acre)			Total live loading (ton/ac)			Standing dead loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRW8	CO	16*	45	34	6	78	18	1,771	13,898	8,153	0.88*	6.67	2.15	NA			0.0244*	0.3820	0.1718
	FI	<1*	58	11	6	74	18	23*	12,627	2,304	0.01*	3.80	0.62				0.0001*	0.3730	0.0602
	MO	5	15	10	5	21	11	2,316	6,359	3,822	0.45	1.31	0.93				0.0300	0.0838	0.0537
	TE	15*	35	25	6	48	21	1,794	5,859	3,919	1.97*	8.75	2.35	0.36*	8.37	2.09	0.0227*	0.2099	0.0945
CHVI8	CO	1*	1	<1	6	17	12	23*	636	81	0.07*	0.07	0.01	NA			0.0033*	0.0033	0.0004
	FI	<1*	3	1	4	15	8	23*	749	74	NA						NA		
	MO	<1*	3	1	3	14	8	0											
	TE	0			0			68*	68	10									

LITTER and DUFF

	Treatment	Total cover (%)			Loading (ton/ac)		
		Min	Max	Mean	Min	Max	Mean
Interspace litter	CO	14	22	17	<0.01	0.40	0.10
	FI	<1*	17	8	<0.01*	0.14	0.02
	MO	17	36	28	<0.01	0.04	0.02
	TE	12	21	17	<0.01	0.22	0.06
Bare ground	CO	16	39	29	NA		
	FI	15	97	51			
	MO	13	41	28			
	TE	15	58	33			

NONWOODY FUELS

	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	1	22	8	1	23	9	4	22	11	5	22	11
Total cover: Annual grass† (%)	<1*	18	3	<1*	43	8	1*	8	3	<1*	4	1
Total cover: Forbs (%)	<1*	15	3	1*	34	13	1	19	9	<1*	20	7
Grass height (in.)	4*	12	5	2*	19	6	4	7	6	3*	11	7
Forb height (in.)	1*	7	2	1*	15	5	2*	3	2	6*	10	4
Live loading (lbs/ac)	4.48	129.82	34.82	4.48	514.82	60.19	4.48	134.30	58.84	13.43	80.58	47.96
Dead loading (lbs/ac)	62.67*	102.96	28.82	4.48*	152.21	10.69	4.48*	62.67	17.91	8.95*	67.15	14.71
Total loading (lbs/ac)	67.15	232.78	63.64	8.96	667.03	70.88	8.96	196.97	76.75	22.38	147.73	62.67
Bulk density (lbs/ft³)	0.0024	0.0285	0.0081	0.0041	0.1610	0.0176	0.0035	0.0202	0.0098	0.0008	0.0191	0.0070

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.22	0.82	0.41	0.01	0.62	0.19	0.27	0.55	0.40	0.16	0.40	0.28
1.1–3.0 (100-hour)	0.10	1.58	0.67	0.10*	0.84	0.22	0.49	1.77	0.93	0.34	1.03	0.60
3.1–9.0 (1000-hour: Sound)	0.15*	0.15	0.02	0.09*	0.88	0.11	0.12*	0.36	0.13	0.12*	0.49	0.12
3.1–9.0 (1000-hour: Rotten)	0.11*	0.11	0.01	0.09*	0.49	0.08	0.16*	0.50	0.20	0.07*	0.22	0.04
Total loading	0.58	2.66	1.11	0.29	2.83	0.60	1.04	3.18	1.66	0.69	2.14	1.04

Sagebrush Steppe: Group 4, Control

(**Pre-treatment Cover:** Shrub: >25%; Total grass: >25%)

Site: Saddle Mountain **Elevation:** 906 ft (276 m)

Shrubs: 18% Perennial Grass: 7% Total Grass: 58% Bare Ground: 10%

04/30/10

Site: Moses Coulee **Elevation:** 1709 ft (521 m)

Shrubs: 22% Perennial Grass: 51% Total Grass: 70% Bare Ground: 48%

05/13/10

Sagebrush Steppe: Group 4, Fire

(**Pre-treatment Cover:** Shrub: >25%; Total grass: >25%)

Site: Hart Mountain-Rock Creek **Elevation:** 4954 ft (1510 m) **Treatment Date:** 09/2007

Shrubs: 1% Perennial Grass: 13% Total Grass: 47% Bare Ground: 16%

Site: Saddle Mountain **Elevation:** 846 ft (258 m) **Treatment Date:** 09/2008

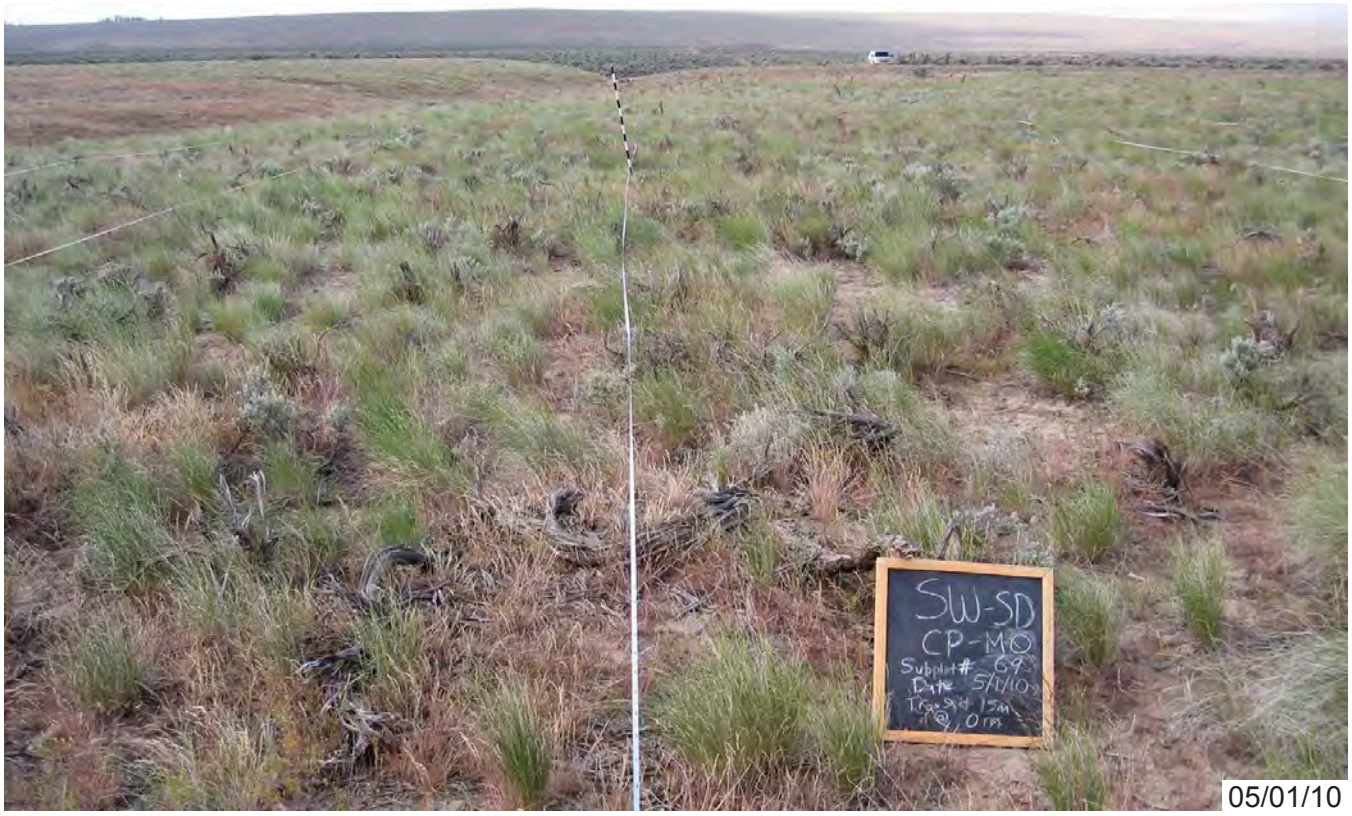
Shrubs: 4% Perennial Grass: 10% Total Grass: 57% Bare Ground: 29%

Sagebrush Steppe: Group 4, Mow

(**Pre-treatment Cover:** Shrub: >25%; Total grass: >25%)

Site: Saddle Mountain **Elevation:** 899 ft (274 m) **Treatment Date:** 11/2008

Shrubs: 6% Perennial Grass: 48% Total Grass: 47% Bare Ground: 23%



05/01/10

Site: Onaqui **Elevation:** 5505 ft (1678 m) **Treatment Date:** 10/2006

Shrubs: 14% Perennial Grass: 21% Total Grass: 22% Bare Ground: 20%

05/21/08

Sagebrush Steppe: Group 4, Herbicide

(**Pre-treatment Cover:** Shrub: >25%; Total grass: >25%)

Site: Saddle Mountain **Elevation:** 879 ft (268 m) **Treatment Date:** 11/2008
Shrubs: 1% Perennial Grass: 28% Total Grass: 29% Bare Ground: 19%

Site: Saddle Mountain **Elevation:** 879 ft (268 m) **Treatment Date:** 11/2008
Shrubs: 24% Perennial Grass: 35% Total Grass: 40% Bare Ground: 18%

Sagebrush Steppe: Group 4

SHRUBS

Species	Treat-ment	Total cover (%)			Height (in.)			Density (#/acre)			Total live loading (ton/ac)			Standing dead loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRW8	CO	15*	30	23	4	68	26	1,045	4,746	3,111	0.41*	9.58	2.94	NA			0.0002	0.0853	0.0331
	FI	<1*	24	3	4	36	18	23*	3,997	615	<0.01*	1.91	0.29				0.0001*	0.0579	0.0066
	MO	2*	29	11	3	45	13	727	6,268	2,817	0.02*	2.33	0.81				0.0003*	0.0649	0.0219
	TE	1	35	24	5	56	25	295	8,880	4,018	0.07	6.41	2.47	0.04*	2.49	0.58	0.0009	0.1696	0.0431
CHVI8	CO	<1*	5	<1	6	22	14	23*	2,339	114	NA			NA			NA		
	FI	<1*	1	<1	4	44	10	227*	227	10	0.05*	0.05	<0.01				<0.0001*	<0.0001	<0.0001
	MO	<1*	1	<1	4	16	8	45	204	25	<0.01*	<0.01	<0.01				<0.0001*	<0.0001	<0.0001
	TE	<1*	3	<1	5	30	13	23*	23	1	NA						NA		

LITTER and DUFF

	Treatment	Total cover (%)			Loading (ton/ac)		
		Min	Max	Mean	Min	Max	Mean
Interspace litter	CO	2	32	14	0.03	0.44	0.17
	FI	<1*	14	6	0.01*	0.29	0.04
	MO	2	30	17	0.02	0.88	0.23
	TE	5	22	12	0.02	0.87	0.17
Bare ground	CO	8	51	20	NA		
	FI	7	67	39			
	MO	3	36	20			
	TE	8	29	18			

NONWOODY FUELS

	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	3	56	24	9	51	18	10	66	29	9	64	32
Total cover: Annual grass† (%)	<1*	51	9	<1*	63	17	1*	63	18	<1*	5	1
Total cover: Forbs (%)	1	9	5	2	67	19	2	22	9	1*	9	3
Grass height (in.)	3*	9	5	3*	12	8	4	12	8	2*	10	4
Forb height (in.)	2*	8	6	3*	13	4	1*	8	3	1*	9	2
Live loading (lbs/ac)	17.91	590.93	132.31	8.95*	810.28	147.15	26.86	335.75	116.44	4.48*	170.11	60.39
Dead loading (lbs/ac)	8.95*	1,199.76	159.67	4.48*	58.20	5.84	4.48*	102.96	23.83	4.48*	49.24	7.90
Total loading (lbs/ac)	26.86	1,790.69	291.98	13.43	868.48	152.99	31.34	438.71	140.27	8.96	219.35	68.29
Bulk density (lbs/ft³)	0.0041	0.1046	0.0323	0.0013*	0.0417	0.0124	0.0035	0.0574	0.0153	0.0050	0.0393	0.0104

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			FI			MO			TE		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.10	0.56	0.35	0.05	0.28	0.18	0.13	1.48	0.54	0.10	0.93	0.39
1.1–3.0 (100-hour)	0.20	1.13	0.57	0.05*	1.18	0.26	0.10	1.72	0.69	0.05*	1.33	0.53
3.1–9.0 (1000-hour: Sound)	0.09*	0.78	0.19	0.15*	0.64	0.06	0.09*	0.90	0.22	0.02*	0.45	0.11
3.1–9.0 (1000-hour: Rotten)	0.22	0.82	0.06	0.07*	0.39	0.03	0.11*	1.08	0.22	0.09*	0.22	0.04
Total loading	0.61	3.29	1.17	0.32	2.49	0.53	0.43	5.18	1.67	0.26	2.93	1.07

Pinyon-Juniper Fuels Guide: 3 Phases, 3 Treatments
User Notes

Site Notes

- Three phases with three treatments represent the SageSTEP Sagebrush/Pinyon-Juniper sites characterized by the Loamy 12–14" ecological type (NRCS 1997).
- General site information:
  - Average annual precipitation ranged between 10.2–15.8 in. (25.9–40.1 cm) averaging 13.5 in. (34.3 cm);
  - Slopes 6–30%, all aspects;
  - 'Loamy' soil texture, and soil depths >20 in. (50.8 cm) with minimal stoniness.
- The amount of woodland encroachment suggests these sites have not burned since the late 1800's (Miller and Tausch 2001). With increased woodland dominance the fire regime has shifted to infrequent, high-intensity fires (Miller et al. 1999).
- Three treatments were employed across the region: control, fire and mechanical (cutting).
- All sites are in active grazing allotments, and all subplots may have been grazed prior to construction of the exclosures at the beginning of the SageSTEP project.
- Site locations, number of subplots and elevation range for data used in tables are as follows:
  - Phase I **Control:** Marking Corral, Seven Mile, South Ruby Mt; 14 subplots; 6565–7464 ft (2001–2275 m)
    Fire: Marking Corral, Seven Mile, South Ruby Mt; 13 subplots; 6575–7336 ft (2004–2236 m)
    Mechanical (Cutting): Marking Corral, Seven Mile; 7 subplots; 6677–7766 ft (2035–2367 m)
  - Phase II **Control:** Marking Corral, Seven Mile, South Ruby Mt; 16 subplots; 6565–7464 ft (2001–2275 m)
    Fire: Marking Corral, Seven Mile, South Ruby Mt; 26 subplots; 6575–7336 ft (2004–2236 m)
    Mechanical (Cutting): Marking Corral, Seven Mile; 20 subplots; 6677–7766 ft (2035–2367 m)
  - Phase III **Control:** Marking Corral, Seven Mile, South Ruby Mt; 18 subplots; 6565–7464 ft (2001–2275 m)
    Fire: Marking Corral, Seven Mile, South Ruby Mt; 16 subplots; 6575–7336 ft (2004–2236 m)
    Mechanical (Cutting): Marking Corral, Seven Mile; 7 subplots; 6677–7766 ft (2035–2367 m)

Guide Notes

1. Phases are organized by **pre-treatment** tree stand cover and understory characteristics (Stebleton and Bunting 2009).
   - Phase 1: Trees are present on the site, but the shrub and herb layer are the dominant influence on ecological processes (hydrologic, nutrient, and energy cycles).
   - Phase 2: Trees are co-dominant with shrub and herb layers. All three layers influence ecological processes.
   - Phase 3: Trees are the dominant vegetation and the primary layer influencing ecological processes.
2. Treatments, abbreviations and treatment objectives:
   - Control (CO): Untreated
   - Fire (FI): Objective was to blacken 100% of the plot area with a low-severity prescribed burn (not all plots met objective).
   - Mechanical (Cutting) (ME): All trees >1.6 ft (0.5 m) were cut at the base with a chainsaw and left on site.
3. The caption above the photos denotes measured percent live cover by fuel stratum for that post-treatment photo.
4. Sampling took place between May and July in 2008, 2009, and 2010. The date of the photo is in the lower right hand corner.
5. Percent bare ground is the only reported measure of fuel continuity.
6. Dominant graminoids: ACHY, ACNE10, ACTH7, BRTE, HECO26, POSE, and PSSPS
7. BRTE is the only annual grass reported.
8. Shrub loadings are restricted by height, long diameter, perpendicular diameter and volume. Refer to Appendix V, 'Pinyon-Juniper', for sample ranges used in this study and R^2 values.
9. Minimum values presented with an asterisk (*) indicate minimum value when present. Mean value includes all subplots.
10. The designation of "NA" indicates data were not available.
11. Tables of species codes and metric conversions can be found in Appendix I and II.

Pinyon-Juniper: Phase 1, Control

Site: South Ruby Mountain **Elevation:** 6565 ft (2001 m)
Trees: 1% Shrubs: 31% Perennial Grass: 41% Total Grass: 41% Bare Ground: 28%

08/20/10

Site: South Ruby Mountain **Elevation:** 6565 ft (2001 m)
Trees: 10% Shrubs: 10% Perennial Grass: 33% Total Grass: 38% Bare Ground: 40%

08/21/10

Pinyon-Juniper: Phase 1, Fire

Site: Marking Corral **Elevation:** 7162 ft (2183 m) **Treatment Date:** 08–09/2006
Trees: <1% Shrubs: 6% Perennial Grass: 12% Total Grass: 12% Bare Ground: 45%

06/09/08

Site: South Ruby Mountain **Elevation:** 6575 ft (2004 m) **Treatment Date:** 10/2008
Trees: 2% Shrubs: 10% Perennial Grass: 34% Total Grass: 39% Bare Ground: 23%


08/03/10

Pinyon-Juniper: Phase 1, Mechanical (Cutting)

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: 0% Shrubs: 20% Perennial Grass: 16% Total Grass: 16% Bare Ground: 25%

06/02/08

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: 1% Shrubs: 15% Perennial Grass: 11% Total Grass: 11% Bare Ground: 40%

06/03/08

Pinyon-Juniper: Phase 1

TREES

	Treatment	JUOS			CELE3			PIMO		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	1*	30	6	0			1*	4	1
	FI	1*	3	1				1*	2	<1
	ME	1*	2	1				0		
Density: <1.6 ft tall (stem/ac)	CO	0			23*	68	15	23*	45	15
	FI				23*	23	5	23*	23	2
	ME				23*	45	16	23*	23	6

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	0			0			68*	68	11	NA			NA		
	FI							0								
	ME	2*	2	<1				658*	658	94						
ARNO4	CO	0			0			0			0			0		
	FI	*1	7	1	6	31	15	45*	727	210	0.01*	0.48	0.12	0.0001*	0.0078	0.0006
	ME	4*	8	3	1	19	10	318*	1,862	522	0.17*	0.17	0.04	0.0023*	0.0026	0.0004
ARTRW8	CO	2*	20	7	6	41	17	23*	3,429	1,338	0.28*	3.43	1.98	0.0027*	0.0607	0.0166
	FI	1*	5	1	7	43	17	23*	1,385	383	0.28*	3.43	1.98	0.0001*	0.0500	0.0049
	ME	5	18	13	4	46	17	2,135	4,042	2,722	0.01	2.62	0.47	0.0162	0.0480	0.0326
CHVI8	CO	2	10	6	4	66	12	860	4,130	2,040	0.05	1.23	0.20	0.0025	0.0275	0.0060
	FI	1*	7	3	5	18	9	191	4,348	1,671	0.05*	1.23	0.20	0.0002*	0.0038	0.0013
	ME	1*	5	2	4	30	9	263	2,391	1,066	<0.01*	1.35	0.23	0.0017*	0.0030	0.0009
PUTR2	CO	1*	8	2	10	69	33	23*	295	61	0.15*	1.38	0.63	0.0012*	0.0097	0.0013
	FI	1*	2	1	7	47	15	23*	227	58	<0.01*	0.09	0.03	0.0001*	0.0009	0.0002
	ME	2*	2	1	19	29	21	91*	182	39	0.01*	0.05	0.03	0.0002*	0.0006	0.0001

Pinyon-Juniper: Phase 1

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	8	46	25	1	44	18	11	17	15
Total cover: Annual grass† (%)	5*	5	<1	1*	5	1	1*	1	<1
Total cover: Forbs (%)	11*	17	4	15*	39	15	2	16	8
Grass height (in.)	5	20	11	3	19	9	6	14	9
Forb height (in.)	2	12	7	3	15	8	3	5	4
Live loading (lbs/ac)	160.27	806.70	433.18	143.25	1,088.74	583.14	212.20	274.87	250.84
Dead loading (lbs/ac)	11.64	477.22	188.51	2.69	90.43	39.69	4.48	100.28	52.08
Total loading (lbs/ac)	171.91	1,283.92	621.69	145.94	1,179.17	622.83	216.68	375.15	302.92
Bulk density (lbs/ft³)	0.0108	0.0272	0.0197	0.0084	0.0624	0.0283	0.0084	0.0186	0.0134

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.05	0.53	0.25	0.12	0.61	0.40	0.22	0.53	0.42
1.1–3.0 (100-hour)	0.05	0.84	0.48	0.30	1.08	0.62	0.30	1.57	0.93
3.1–9.0 (1000-hour: Sound)	0.18*	1.13	0.20	0.12*	0.80	0.23	0.88*	2.56	0.89
3.1–9.0 (1000-hour: Rotten)	0			0			0		
Total loading	0.28	2.50	0.93	0.54	2.49	1.25	1.40	4.66	2.24

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			1.0	2.8	2.0	0.27	4.06	1.77	0.0999	0.9614	0.4832
	FI				<0.1	1.6	0.7	0.09	1.39	0.73	0.1373	1.3048	0.6680
	ME				1.0	2.4	1.8	0.55	6.65	2.31	0.2435	1.5483	0.5993
Tree duff	CO	NA			0.1	1.2	0.3	0.09	0.27	0.18	0.5993	0.7616	0.6805
	FI				0.2	0.2	<0.1	0.01	0.42	0.24	0.7804	0.9739	0.8771
	ME				0.1	0.2	0.1	0.06	0.58	0.23	0.3871	1.3547	0.9115
Interspace litter	CO	1*	22	5	NA			0.04	1.11	0.31	NA		
	FI	10*	37	17				0.02	0.18	0.10			
	ME	1*	18	10				0.07	0.21	0.14			
Bare ground	CO	23	52	40	NA			NA			NA		
	FI	19	69	37									
	ME	25	58	41									

Pinyon-Juniper: Phase 2, Control

Site: Marking Corral **Elevation:** 7054 ft (2150 m)
Trees: 11% Shrubs: 8% Perennial Grass: 5% Total Grass: 5% Bare Ground: 54%

Site: South Ruby Mountain **Elevation:** 6565 ft (2001 m)
Trees: 12% Shrubs: 8% Perennial Grass: 26% Total Grass: 26% Bare Ground: 51%

Pinyon-Juniper: Phase 2, Fire

Site: Marking Corral **Elevation:** 7162 ft (2183 m) **Treatment Date:** 08–09/2006
Trees: 1% Shrubs: 2% Perennial Grass: 5% Total Grass: 5% Bare Ground: 65%

06/10/08

Site: Marking Corral **Elevation:** 7162 ft (2183 m) **Treatment Date:** 08–09/2006
Trees: 4% Shrubs: 4% Perennial Grass: 9% Total Grass: 9% Bare Ground: 42%

06/03/08

Pinyon-Juniper: Phase 2, Mechanical (Cutting)

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: 0% Shrubs: 10% Perennial Grass: 9% Total Grass: 9% Bare Ground: 22%

05/29/08

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: <1% Shrubs: 5% Perennial Grass: 11% Total Grass: 12% Bare Ground: 39%

05/28/08

Pinyon-Juniper: Phase 2

TREES

	Treatment	JUOS			CELE3			PIMO		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	5*	44	14	0			2*	24	8
	FI	1*	14	2				1*	12	1
	ME	1*	1	<1	2*	4	<1	1*	1	<1
Density: <1.6 ft tall (stem/ac)	CO	0			23*	318	91	23*	91	27
	FI				23*	250	22	23*	91	7
	ME				23*	182	31	23*	159	22

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	2*	7	1	6	45	13	23*	68	10	0.02*	0.90	0.23	0.0080*	0.0151	0.0014
	FI	0			0			0			0			0		
	ME	1*	2	<1	4	20	12	159*	704	60	0.45*	0.46	0.45	0.0147*	0.0196	0.0017
ARNO4	CO	1*	2	<1	7	14	11	23*	68	10	NA			NA		
	FI	1*	3	1	4	27	12	23*	2,271	372	<0.01*	1.13	0.14	0.0022*	0.0192	0.0015
	ME	2*	12	1	6	15	9	23*	2,907	176	NA			NA		
ARTRW8	CO	1*	19	6	6	43	16	159*	3,089	1,468	0.02*	1.87	0.81	0.0003*	0.0262	0.0119
	FI	1*	10	1	6	37	15	23*	1,113	184	0.01*	2.11	0.36	0.0001*	0.0415	0.0025
	ME	5*	20	11	6	48	17	1,158*	3,792	2,181	0.51*	4.50	2.06	0.0087*	0.0806	0.0296
CHVI8	CO	1	6	2	<1	23	9	48	3,043	998	<0.01	0.14	0.02	0.0001	0.0066	0.0013
	FI	1*	5	1	2	22	8	48	1,882	485	<0.01*	0.04	0.01	0.0001*	0.0025	0.0006
	ME	1*	3	1	1	21	9	48	3,913	778	<0.01*	0.17	0.02	0.0004*	0.0066	0.0008
PUTR2	CO	3*	8	1	7	93	28	23*	386	67	0.05*	1.34	0.36	0.0013*	0.0091	0.0010
	FI	1*	2	<1	7	49	18	23*	1,812	36	0.01*	0.25	0.09	0.0009*	0.0040	0.0006
	ME	1*	4	1	7	35	21	68*	386	70	0.01*	0.18	0.08	0.0003*	0.0020	0.0003

Pinyon-Juniper: Phase 2

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	1	30	10	1*	44	9	3	19	10
Total cover: Annual grass† (%)	1*	1	<1	2*	2	<1	1*	1	<1
Total cover: Forbs (%)	2*	15	4	5*	42	14	2*	17	6
Grass height (in.)	4	13	7	2	15	7	4	11	8
Forb height (in.)	1	9	4	2	7	4	2	6	4
Live loading (lbs/ac)	25.96	461.10	185.93	38.50	1,452.24	325.53	29.99	296.36	170.37
Dead loading (lbs/ac)	7.16*	71.63	38.44	2.69	140.57	38.67	2.69*	102.96	28.65
Total loading (lbs/ac)	33.12	532.73	224.37	41.19	1,592.81	364.20	32.68	399.32	199.02
Bulk density (lbs/ft³)	0.0032	0.0168	0.0111	0.0050	0.1011	0.0280	0.0057	0.0193	0.0114

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.07	0.44	0.28	0.13	0.51	0.31	0.31	1.98	0.71
1.1–3.0 (100-hour)	0.15*	0.84	0.34	0.10	1.48	0.67	0.25	3.00	1.56
3.1–9.0 (1000-hour: Sound)	0.15*	1.66	0.28	0.09*	0.83	0.22	0.21	10.17	3.27
3.1–9.0 (1000-hour: Rotten)	0			0			0.35*	0.35	0.02
Total loading	0.37	2.94	0.90	0.32	2.82	1.20	1.12	15.50	5.56

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			1.3	2.3	1.8	2.01	18.62	6.89	0.7117	4.4138	2.0119
	FI				0.2	1.8	0.6	0.26	5.62	2.15	0.3621	3.9021	1.8203
	ME				0.9	2.6	1.7	1.63	9.44	4.25	0.4870	3.3025	1.3905
Tree duff	CO	NA			0.1	0.6	0.2	0.17	10.58	1.89	0.7554	11.3872	2.9178
	FI				<0.1	0.4	0.1	0.09*	1.71	0.61	0.4994*	4.9319	2.0519
	ME				<0.01	0.6	0.1	0.06*	1.20	0.66	0.8865*	3.3462	2.0810
Interspace litter	CO	1*	33	10	NA			0.02	0.30	0.11	NA		
	FI	5	41	22				<0.01	0.21	0.06			
	ME	1*	26	12				<0.01	0.31	0.10			
Bare ground	CO	33	63	48	NA			NA			NA		
	FI	18	82	44									
	ME	22	65	42									

Pinyon-Juniper: Phase 3, Control

Site: Marking Corral **Elevation:** 7054 ft (2150 m)
Trees: 25% Shrubs: 2% Perennial Grass: 4% Total Grass: 4% Bare Ground: 42%

05/21/08

Site: Marking Corral **Elevation:** 7054 ft (2150 m)
Trees: 43% Shrubs: 2% Perennial Grass: 2% Total Grass: 2% Bare Ground: 32%

05/21/08

Pinyon-Juniper: Phase 3, Fire

Site: Marking Corral **Elevation:** 7162 ft (2183 m) **Treatment Date:** 08–09/2006
Trees: 4% Shrubs: <1% Perennial Grass: 7% Total Grass: 8% Bare Ground: 52%

06/09/08

Site: South Ruby Mountain **Elevation:** 6575 ft (2004 m) **Treatment Date:** 10/2008
Trees: 10% Shrubs: 1% Perennial Grass: 24% Total Grass: 24% Bare Ground: 27%

08/03/10

Pinyon-Juniper: Phase 3, Mechanical (Cutting)

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: 0% Shrubs: 1% Perennial Grass: 5% Total Grass: 5% Bare Ground: 25%

05/29/08

Site: Marking Corral **Elevation:** 7247 ft (2209 m) **Treatment Date:** 09/2006
Trees: 0% Shrubs: 8% Perennial Grass: 8% Total Grass: 9% Bare Ground: 22%

05/29/08

Pinyon-Juniper: Phase 3

TREES

	Treatment	JUOS			CELE3			PIMO		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	6	56	26	1*	4	<1	2*	40	18
	FI	1*	12	5	0			1*	12	4
	ME	3*	19	3	6*	18	3	2*	5	1
Density: <1.6 ft tall (stem/ac)	CO	0			23*	454	107	23*	114	34
	FI				23*	159	47	23*	45	14
	ME	91*	91	13	23*	182	58	23*	114	55

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	0			0			0			0			0		
	FI															
	ME	1*	3	1	4	19	11	227*	931	263	0.02*	0.13	0.06	0.0008*	0.0060	0.0014
ARNO4	CO	2*	2	<1	6	24	11	23*	295	51	<0.01*	<0.01	<0.01	0.0001*	0.0001	<0.0001
	FI	1*	2	<1	3	23	10	45*	749	111	0.14*	0.14	0.07	0.0039*	0.0039	0.0004
	ME	0			8	13	10	45*	68	16	0			0		
ARTRW8	CO	1*	5	1	6	39	17	159*	1,725	411	0.06*	0.84	0.26	0.0008*	0.0106	0.0022
	FI	1*	1	<1	6	30	11	23*	363	87	0.01*	0.16	0.07	<0.0001*	0.0057	0.0011
	ME	1	10	5	5	33	14	454	1,408	951	0.06	2.31	0.73	0.0025	0.0496	0.0141
CHVI8	CO	1*	2	<1	6	17	10	24	1,087	360	<0.01*	0.02	<0.01	0.0001*	0.0009	0.0001
	FI	1*	1	<1	6	9	7	24	119	56	<0.01*	<0.01	<0.01	0.0001*	0.0001	<0.0001
	ME	1*	1	<1	7	16	11	24	72	40	<0.01*	<0.01	<0.01	<0.0001*	0.0001	<0.0001
PUTR2	CO	1*	3	1	6	39	19	23*	409	95	0.04*	0.36	0.16	0.0006*	0.0057	0.0011
	FI	1*	3	<1	6	33	16	23*	204	33	<0.01*	0.19	0.07	0.0001*	0.0031	0.0006
	ME	1*	1	<1	20	20	20	23*	23	3	0.02*	0.02	0.02	0.0003*	0.0003	<0.0001

Pinyon-Juniper: Phase 3

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	1*	19	6	2*	24	7	3	9	5
Total cover: Annual grass† (%)	3*	3	<1	1*	2	<1	1*	1	<1
Total cover: Forbs (%)	1*	12	1	1*	22	5	2	19	9
Grass height (in.)	3	14	6	4*	11	6	5	8	7
Forb height (in.)	1*	6	3	1	13	6	3	8	5
Live loading (lbs/ac)	71.60	59.99	33.96	14.33*	477.22	132.85	47.45	203.24	109.23
Dead loading (lbs/ac)	2.69*	25.96	5.15	2.69*	326.80	39.51	11.64*	11.64	2.87
Total loading (lbs/ac)	74.29	85.95	39.11	17.02	804.02	172.36	59.09	214.88	112.10
Bulk density (lbs/ft³)	0.0018	0.0091	0.0042	0.0024*	0.0365	0.0105	0.0027	0.0175	0.0081

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.11	1.69	0.44	0.11	1.24	0.47	0.43	1.49	0.79
1.1–3.0 (100-hour)	0.05	1.82	0.49	0.34	1.72	0.94	1.08	2.07	1.71
3.1–9.0 (1000-hour: Sound)	0.12*	9.39	1.12	0.21*	7.40	1.97	2.34	7.55	4.91
3.1–9.0 (1000-hour: Rotten)	0			0			0.16*	0.16	0.02
Total loading	0.28	12.90	2.05	0.66	10.36	3.38	4.01	11.27	7.43

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			0.8	2.0	1.6	3.39	18.68	8.36	1.5483	5.2316	2.7500
	FI				0.5	2.4	0.8	0.69	11.11	5.00	1.8042	5.6187	3.4170
	ME				1.4	2.3	1.7	4.25	11.79	8.14	4.5670	3.9580	2.7319
Tree duff	CO	NA			0.1	0.6	0.2	0.31*	7.76	2.54	1.4921*	7.7538	3.8623
	FI				<0.1	0.8	0.1	0.02	9.03	1.87	0.2123	9.0710	4.5414
	ME				<0.1	0.5	0.1	0.64	3.05	1.71	2.9716	5.1192	3.8810
Interspace litter	CO	2*	57	14	NA			0.02*	0.30	0.11	NA		
	FI	16*	61	24				<0.01*	0.21	0.06			
	ME	1*	27	11				<0.01*	0.31	0.10			
Bare ground	CO	17	77	51	NA			NA			NA		
	FI	12	80	38									
	ME	22	55	40									

Utah Juniper Fuels Guide: 3 Phases, 4 Treatments
User Notes

Site Notes

- Three phases with four treatments represent the SageSTEP Sagebrush/Utah Juniper sites characterized by the Loamy 12–14” ecological type (NRCS 1997).
- General site information:
  - Average annual precipitation ranges between 12.7–17.5 in. (32.3–44.5 cm) averaging 14.9 in. (37.8 cm);
  - Slopes 3–33%, all aspects;
  - ‘Loamy’ soil texture, and soil depths >20 in. (50.8 cm) with minimal stoniness.
- The amount of woodland encroachment suggests these sites have not burned since the late 1800’s (Miller and Tausch 2001). With increased woodland dominance the fire regime has shifted to infrequent, high-intensity fires (Miller et al. 1999).
- Four treatments were employed across the region: control, fire, mechanical (cutting) and mechanical shredding.
- Onaqui is the only site with an active grazing allotment, which may have been grazed prior to construction of the exclosures at the beginning of the SageSTEP project.
- Site locations, number of subplots and elevation range for data used in tables are as follows:
  - Phase I
    Control: Greenville, Onaqui, Scipio, Stansbury; 19 subplots; 5617–5919 ft (1712–1804 m)
    Mechanical Shredding: Greenville, Onaqui, Scipio, Stansbury; 15 subplots; 5558–6024 ft (1704–1768 m)
    Fire: Greenville, Onaqui, Scipio, Stansbury; 19 subplots; 5591–5801 ft (1694–1836 m)
    Mechanical (Cutting): Greenville, Onaqui, Scipio, Stansbury; 12 subplots; 5696–5856 ft (1736–1785 m)
  - Phase II
    Control: Greenville, Onaqui, Scipio, Stansbury; 23 subplots; 5617–5919 ft (1712–1804 m)
    Mechanical Shredding: Greenville, Onaqui, Scipio, Stansbury; 22 subplots; 5558–6024 ft (1704–1768 m)
    Fire: Greenville, Onaqui, Scipio, Stansbury; 23 subplots; 5591–5801 ft (1694–1836 m)
    Mechanical (Cutting): Greenville, Onaqui, Scipio, Stansbury; 22 subplots; 5696–5856 ft (1736–1785 m)
  - Phase III
    Control: Greenville, Onaqui, Scipio, Stansbury; 20 subplots; 5617–5919 ft (1712–1804 m)
    Mechanical Shredding: Greenville, Onaqui, Scipio, Stansbury; 19 subplots; 5558–6024 ft (1704–1768 m)
    Fire: Greenville, Onaqui, Scipio, Stansbury; 15 subplots; 5591–5801 ft (1694–1836 m)
    Mechanical (Cutting): Greenville, Onaqui, Scipio, Stansbury; 27 subplots; 5696–5856 ft (1736–1785 m)

Guide Notes

1. Phases are organized by **pre-treatment** tree stand cover and understory characteristics (Stebleton and Bunting 2009).
   - Phase 1: Trees are present on the site, but the shrub and herb layer are the dominant influence on ecological processes (hydrologic, nutrient, and energy cycles).
   - Phase 2: Trees are co-dominant with shrub and herb layers. All three layers influence ecological processes.
   - Phase 3: Trees are the dominant vegetation and the primary layer influencing ecological processes.
2. Treatments, abbreviations and treatment objectives:
   - Control (CO): Untreated
   - Mechanical Shredding (BM): All trees in each plot were masticated and the mulch was left on-site.
   - Fire (FI): Objective was to blacken 100% of the plot area with a low-severity prescribed burn (not all plots met objective).
   - Mechanical (Cutting) (ME): All trees >1.6 ft (0.5 m) were cut at the base with a chainsaw and left on site.
3. The caption above the photos denotes measured percent live cover by fuel stratum for that photo.
4. Sampling took place between May and early August in 2008, 2009, and 2010. The date of the photo is in the lower right hand corner.
5. Percent bare ground is the only reported measure of fuel continuity.
6. Dominant graminoids: ACHY, ELEL5, HECO26, PLJA, POSE, PSSPS
7. BRTE is the only annual grass reported.
8. Shrub loadings are restricted by height, long diameter, perpendicular diameter and volume. Refer to Appendix V, 'Utah Juniper', for sample ranges used in this study and R^2 values.
9. Minimum values presented with an asterisk (*) indicate minimum value when present. Mean value includes all subplots.
10. The designation of "NA" indicates data were not available.
11. Tables of species codes and metric conversions can be found in Appendix I and II.

Utah Juniper: Phase 1, Control

Site: Onaqui **Elevation:** 5617 ft (1712 m)

Trees: 4% Shrubs: 7% Perennial Grass: 24% Total Grass: 24% Bare Ground: 30%

05/14/08

Site: Scipio **Elevation:** 5751 ft (1753 m)

Trees: 7% Shrubs: 21% Perennial Grass: 17% Total Grass: 29% Bare Ground: 19%

07/16/09

Utah Juniper: Phase 1, Mechanical Shredding

Site: Onaqui **Elevation:** 5591 ft (1704 m) **Treatment Date:** 11/2006
Trees: 0% Shrubs: 3% Perennial Grass: 32% Total Grass: 32% Bare Ground: 18%

05/28/08

Site: Greenville Bench **Elevation:** 5801 ft (1768 m) **Treatment Date:** 11/2007
Trees: 1% Shrubs: 14% Perennial Grass: 40% Total Grass: 40% Bare Ground: 26%

07/20/09

Utah Juniper: Phase 1, Fire

Site: Stansbury **Elevation:** 5741 ft (1750 m) **Treatment Date:** 09/2007
Trees: 0% Shrubs: <1% Perennial Grass: 1% Total Grass: 91% Bare Ground: 6%

Site: Greenville Bench **Elevation:** 6024 ft (1836 m) **Treatment Date:** 10/2007
Trees: 0% Shrubs: 7% Perennial Grass: 21% Total Grass: 22% Bare Ground: 30%

Utah Juniper: Phase 1, Mechanical (Cutting)

Site: Scipio **Elevation:** 5741 ft (1750 m) **Treatment Date:** 11/2007

Trees: 1% Shrubs: 12% Perennial Grass: 23% Total Grass: 30% Bare Ground: 34%

07/08/09

Site: Stansbury **Elevation:** 5738 ft (1749 m) **Treatment Date:** 10/2007

Trees: 1% Shrubs: 28% Perennial Grass: 48% Total Grass: 90% Bare Ground: 4%

06/24/09

Utah Juniper: Phase 1

TREES

	Treatment	JUOS			PIED		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	1	22	7	<1*	7	1
	BM	<1*	1	<1	<1*	1	<1
	FI	1*	3	<1	1*	1	<1
	ME	<1*	1	<1	<1*	1	<1
Density: <1.6 ft tall (stem/ac)	CO	23*	136	24	23*	68	6
	BM	23*	91	23	23*	23	5
	FI	0			23*	45	5
	ME	23*	91	21	23*	91	14

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRV	CO	<1*	30	6	6	47	23	1,711*	2,748	2,071	2.71*	6.10	3.52	0.0183*	0.0617	0.0104
	BM	<1*	2	<1	8	26	17	23*	318	104	0.18*	0.21	0.19	<0.0001*	0.0034	0.0003
	FI	0			0			0			0			0		
	ME	<1*	20	2	7	45	17				2.26*	2.26	2.26	0.0330*	0.0330	0.0027
ARTRW8	CO	6*	22	10	6	55	19	1,181*	4,178	1,649	0.77*	5.90	2.67	0.0118*	0.0564	0.0246
	BM	3*	13	5	6	51	18	91*	3,475	1,619	0.14*	2.71	1.04	0.0050*	0.0356	0.0138
	FI	<1*	4	1	6	33	16	23*	1,067	336	0.02*	0.34	0.10	<0.0001*	0.0049	0.0006
	ME	1*	31	13	6	52	22	1,408	4,156	2,589	0.57*	7.68	3.29	0.0003*	0.0032	0.0002
CHVI8	CO	<1*	9	1	6	27	11	24*	2,826	681	<0.01*	0.11	0.01	0.0010*	0.0124	0.0010
	BM	<1*	6	1	6	18	10	24*	4,782	599	<0.01*	0.31	0.03	0.0010*	0.0124	0.0010
	FI	<1*	5	1	6	17	11	24*	3,043	637	<0.01*	0.20	0.04	0.0001*	0.0079	0.0012
	ME	<1*	13	3	6	18	10	167	7,609	2,534	0.18*	0.55	0.12	0.0057*	0.0233	0.0029
PUTR2	CO	9*	18	4	10	78	39	295*	636	110	0.40*	2.50	1.14	0.0052*	0.0137	0.0020
	BM	9*	21	4	8	82	33	159*	1,226	575	0.97*	8.26	3.72	0.0123*	0.0470	0.0068
	FI	<1*	<1	<1	6	7	7	45*	250	100	0.01*	0.03	0.01	<0.0001	0.0003	0.0001
	ME	<1*	8	1	24	59	40	227*	227	19	0.67*	0.67	0.67	0.0048*	0.0048	0.0004

NONWOODY FUELS

	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	12	51	24	16	55	33	1	37	14	11	48	23
Total cover: Annual grass† (%)	<1*	41	10	<1*	52	12	<1*	90	34	<1*	42	10
Total cover: Forbs (%)	<1	24	9	1	15	6	6	54	21	1*	17	7
Grass height (in.)	5	13	9	6	18	13	5	20	12	5	13	10
Forb height (in.)	2	8	4	1	8	4	1	14	7	2	7	4
Live loading (lbs/ac)	48.35	590.92	221.15	88.64	686.73	396.85	85.95	1,740.54	679.30	67.15	597.19	211.15
Dead loading (lbs/ac)	0.01	0.16	0.05	9.85*	212.20	71.21	13.43*	13.43	1.21	4.48	119.08	52.99
Total loading (lbs/ac)	48.36	591.08	221.20	98.49	898.93	468.06	99.38	1,753.97	680.51	71.63	716.27	264.14
Bulk density (lbs/ft³)	0.0023	0.0282	0.0140	0.0084	0.0239	0.0166	0.0042	0.0321	0.0174	0.0049	0.0198	0.0116

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.09	0.45	0.29	0.13	0.76	0.36	0.01	0.58	0.15	0.17	0.69	0.39
1.1–3.0 (100-hour)	0.10	1.48	0.58	0.15	2.85	0.84	0.10*	1.43	0.28	0.20	2.31	0.93
3.1–9.0 (1000-hour: Sound)	0.09*	2.33	0.23	0.05*	1.16	0.11	0.12*	0.99	0.16	0.15*	2.96	1.12
3.1–9.0 (1000-hour: Rotten)	0.07*	0.27	0.03	0.13*	1.16	0.11	0			0		
Total loading	0.35	4.53	1.13	0.46	3.31	1.42	0.23	3.00	0.59	0.52	5.96	2.44

Utah Juniper: Phase 1

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			0.4	2.0	1.1	0.22	6.88	2.01	0.3371	2.2412	0.9440
	BM				0.6	1.8	1.0	0.69	3.94	2.19	0.5681	2.0290	1.2493
	FI				0.1*	0.5	0.2	0.06*	1.39	0.36	0.3871*	1.6232	0.5145
	ME				0.6	1.5	1.1	0.38	4.92	2.34	0.3746	1.9166	1.0920
Tree duff	CO	NA			0			0			0		
	BM												
	FI												
	ME												
Interspace litter	CO	6	26	15	NA			<0.01	0.11	0.03	NA		
	BM	4	25	13				0.01*	0.04	0.02			
	FI	1*	32	12				<0.01*	0.04	<0.01			
	ME	4	24	14				<0.01	0.04	0.02			
Bare ground	CO	7	50	26	NA			NA			NA		
	BM	5	41	25									
	FI	2	53	24									
	ME	4	47	28									

Utah Juniper: Phase 2

TREES

	Treatment	JUOS			PIED		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	3	30	14	1*	16	3
	BM	<1*	1	<1	<1*	1	<1
	FI	1*	4	<1	<1*	3	<1
	ME	<1*	3	1	<1*	<1	<1
Density: <1.6 ft tall (stem/ac)	CO	23*	91	17	23*	136	15
	BM	23*	136	38	23*	91	11
	FI	23*	45	5	23*	45	4
	ME	23*	318	61	23*	23	3

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRV	CO	11*	20	3	7	49	23	1,635*	2,112	356	0.44*	5.85	1.67	0.0089*	0.0597	0.0050
	BM	1*	8	1	7	36	22	45*	568	63	0.23*	1.75	0.84	0.0020*	0.0164	0.0018
	FI	<1*	<1	<1	0			23*	23	1	0			0		
	ME	1*	4	1	10	43	24	68*	613	49	0.04*	0.73	0.34	0.0005*	0.0060	0.0006
ARTRW8	CO	1*	24	6	6	52	20	522*	2,067	940	0.20*	5.99	1.65	0.0047*	0.0565	0.0155
	BM	1*	12	5	6	46	17	409*	3,452	1,048	0.02*	4.94	1.43	0.0002*	0.0464	0.0133
	FI	<1*	5	1	5	51	18	23*	1,204	283	0.01*	1.02	0.25	<0.0001*	0.0163	0.0029
	ME	1*	21	8	6	57	20	272*	3,407	1,695	0.22*	4.21	1.83	0.0018*	0.0498	0.0205
CHVI8	CO	<1*	7	1	1	20	10	24*	2,391	666	<0.01*	0.30	0.02	0.0003*	0.0054	0.0005
	BM	<1*	6	1	6	20	9	24*	6,087	717	0.01*	0.30	0.02	<0.0001*	0.0092	0.0004
	FI	<1*	6	1	6	18	10	24*	2,826	823	0.01*	0.15	0.03	0.0002*	0.0051	0.0009
	ME	1*	9	2	4	20	11	24*	1,0435	1,526	0.12*	0.40	0.06	0.0037*	0.0131	0.0012
PUTR2	CO	3*	8	1	7	71	33	136*	363	52	0.03*	0.69	0.18	0.0003*	0.0045	0.0003
	BM	4*	19	2	9	86	35	91*	386	55	0.05*	4.92	1.98	0.0003*	0.0151	0.0024
	FI	0			7	12	9	45*	159	19	0			0		
	ME	2*	3	<1	16	71	39	23*	136	19	0.07*	1.20	0.50	0.0009*	0.0060	0.0004

Utah Juniper: Phase 2

NONWOODY FUELS

	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	1	42	18	13	52	30	4	49	18	9	55	25
Total cover: Annual grass† (%)	1*	33	6	<1*	47	11	<1*	73	16	<1*	50	17
Total cover: Forbs (%)	<1	28	9	1	16	6	1	36	16	<1	27	9
Grass height (in.)	3	11	7	5	17	11	3	17	9	6	17	11
Forb height (in.)	1	10	3	1	6	3	2	11	5	2	8	5
Live loading (lbs/ac)	2.69	554.22	138.82	59.09	1,055.61	414.59	18.80	1,084.26	337.66	39.40	725.23	319.23
Dead loading (lbs/ac)	4.48	273.97	81.10	19.70*	162.95	62.84	9.85*	9.85	0.82	2.69	232.79	59.69
Total loading (lbs/ac)	7.17	828.19	219.92	78.79	1,218.56	477.43	28.65	1,094.11	338.48	42.09	958.02	378.92
Bulk density (lbs/ft³)	0.0024	0.0227	0.0108	0.0060	0.0484	0.0198	0.0016	0.0280	0.0130	0.0026	0.0274	0.0147

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.04	0.47	0.29	0.12	0.96	0.50	0.02	0.56	0.27	0.10	1.26	0.59
1.1–3.0 (100-hour)	0.15	1.48	0.58	0.15	2.76	1.04	0.05*	1.62	0.54	0.64	5.46	2.20
3.1–9.0 (1000-hour: Sound)	0.07*	1.05	0.10	0.15*	2.49	0.45	0.09*	0.99	0.29	0.09	6.10	2.37
3.1–9.0 (1000-hour: Rotten)	0.13*	0.13	0.01	0.07*	1.05	0.09	0.09*	0.09	<0.01	0.07*	0.69	0.03
Total loading	0.39	3.13	0.98	0.49	7.26	2.08	0.25	3.26	1.10	0.90	13.51	5.19

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			1.6	5.4	3.5	1.76	8.55	5.33	1.0800	4.1828	2.1261
	BM				0.4	1.9	1.1	1.15	14.29	3.81	0.7741	6.0619	1.9475
	FI				0.2*	1.6	0.5	0.15*	6.17	1.84	0.5431*	3.2151	1.5360
	ME				0.7	1.6	1.2	0.45	8.81	4.65	0.2060	3.7395	2.2023
Tree duff	CO	NA			<0.1	0.1	<0.1	0.29*	1.24	0.07	4.0080*	4.0080	0.1743
	BM				0			0			0		
	FI												
	ME												
Interspace litter	CO	5	25	13	NA			<0.01	0.10	0.03	NA		
	BM	3	25	12				<0.01*	0.12	0.02			
	FI	2	26	15				<0.01*	0.02	<0.01			
	ME	2	17	10				<0.01	0.04	0.01			
Bare ground	CO	7	53	34	NA			NA			NA		
	BM	2	47	25									
	FI	6	57	33									
	ME	2	43	23									

Utah Juniper: Phase 2, Control

Site: Onaqui **Elevation:** 5617 ft (1712 m)

Trees: 6% Shrubs: 5% Perennial Grass: 14% Total Grass: 14% Bare Ground: 38%

05/14/08

Site: Stansbury **Elevation:** 5738 ft (1749 m)

Trees: 19% Shrubs: 3% Perennial Grass: 25% Total Grass: 58% Bare Ground: 14%

06/24/09

Utah Juniper: Phase 2, Mechanical Shredding

Site: Onaqui **Elevation:** 5591 ft (1704 m) **Treatment Date:** 11/2006
Trees: 1% Shrubs: 11% Perennial Grass: 26% Total Grass: 32% Bare Ground: 26%

05/26/08

Site: Scipio **Elevation:** 5558 ft (1694 m) **Treatment Date:** 11/2007
Trees: 0% Shrubs: 7% Perennial Grass: 38% Total Grass: 42% Bare Ground: 36%

06/15/09

Utah Juniper: Phase 2, Fire

Site: Stansbury **Elevation:** 5741 ft (1750 m) **Treatment Date:** 09/2007
Trees: 0% Shrubs: <1% Perennial Grass: 49% Total Grass: 91% Bare Ground: 6%

Site: Scipio **Elevation:** 5715 ft (1742 m) **Treatment Date:** 10/2007
Trees: 0% Shrubs: 2% Perennial Grass: 22% Total Grass: 23% Bare Ground: 20%

Utah Juniper: Phase 2, Mechanical (Cutting)

Site: Greenville Bench **Elevation:** 5856 ft (1785 m) **Treatment Date:** 11/2007
Trees: 0% Shrubs: 15% Perennial Grass: 19% Total Grass: 20% Bare Ground: 29%

07/22/09

Site: Stansbury **Elevation:** 5738 ft (1749 m) **Treatment Date:** 10/2007
Trees: 1% Shrubs: 4% Perennial Grass: 55% Total Grass: 96% Bare Ground: 4%

06/22/09

Utah Juniper: Phase 3, Control

Site: Greenville Bench **Elevation:** 5919 ft (1804 m)
Trees: 17% Shrubs: 5% Perennial Grass: 1% Total Grass: 1% Bare Ground: 60%

07/27/09

Site: Scipio **Elevation:** 5751 ft (1753 m)
Trees: 38% Shrubs: 1% Perennial Grass: 3% Total Grass: 4% Bare Ground: 54%

07/16/09

Utah Juniper: Phase 3, Mechanical Shredding

Site: Onaqui **Elevation:** 5591 ft (1704 m) **Treatment Date:** 11/2006
Trees: 0% Shrubs: 0% Perennial Grass: 4% Total Grass: 5% Bare Ground: 33%

05/27/08

Site: Stansbury **Elevation:** 5699 ft (1737 m) **Treatment Date:** 10/2007
Trees: <1% Shrubs: 7% Perennial Grass: 53% Total Grass: 84% Bare Ground: 5%

05/27/09

Utah Juniper: Phase 3, Fire

Site: Stansbury **Elevation:** 5741 ft (1750 m) **Treatment Date:** 09/2007
Trees: 0% Shrubs: 0% Perennial Grass: 32% Total Grass: 65% Bare Ground: 14%

Site: Greenville Bench **Elevation:** 6024 ft (1836 m) **Treatment Date:** 10/2007
Trees: 20% Shrubs: 4% Perennial Grass: 4% Total Grass: 4% Bare Ground: 31%

Utah Juniper: Phase 3, Mechanical (Cutting)

Site: Greenville Bench **Elevation:** 5856 ft (1785 m) **Treatment Date:** 11/2007
Trees: 1% Shrubs: 1% Perennial Grass: 5% Total Grass: 6% Bare Ground: 36%

Site: Stansbury **Elevation:** 5738 ft (1749 m) **Treatment Date:** 10/2007
Trees: 1% Shrubs: 13% Perennial Grass: 54% Total Grass: 79% Bare Ground: 5%

Utah Juniper: Phase 3

TREES

	Treatment	JUOS			PIED		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	5	49	26	1*	30	7
	BM	<1*	2	<1	<1*	<1	<1
	FI	<1*	6	2	5	15	2
	ME	<1*	1	<1	<1*	<1	<1
Density: <1.6 ft tall (stem/ac)	CO	23*	68	25	23*	91	18
	BM	23*	91	24	45*	45	4
	FI	23*	45	8	0		
	ME	23*	341	78	23*	90	20

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARTRV	CO	2*	5	1	6	35	16	250*	909	154	0.01*	0.45	0.23	0.0003*	0.0107	0.0014
	BM	1*	6	1	10	37	22	136*	682	119	0.06*	1.02	0.38	0.0009*	0.0124	0.0017
	FI	0			0			0			0			0		
	ME	2*	8	2	6	57	23	182*	1,431	273	0.27*	1.26	0.55	0.0023*	0.0160	0.0031
ARTRW8	CO	<1*	6	2	6	41	16	114*	681	670	0.01*	1.68	0.45	0.0014*	0.0476	0.0071
	BM	<1*	6	2	7	37	15	23*	1,408	411	0.08*	1.32	0.38	0.0007*	0.0175	0.0038
	FI	<1*	3	1	6	43	15	45*	454	102	0.02*	0.38	0.15	0.0003*	0.0073	0.0023
	ME	<1	10	1	6	39	16	23*	3,293	249	0.01	1.80	0.31	0.0003	0.0244	0.0019
CHVI8	CO	<1*	2	<1	5	20	8	24*	1,344	247	<0.01*	1.14	<0.01	0.0001*	0.0001	<0.0001
	BM	<1*	1	<1	6	34	11	24*	538	124	<0.01*	0.03	<0.01	<0.0001*	0.0011	0.0001
	FI	<1*	1	<1	7	20	11	24*	215	151	<0.01*	0.01	<0.01	<0.0001*	0.0002	<0.0001
	ME	<1*	3	<1	6	23	12	24*	2,609	515	<0.01*	0.31	<0.01	<0.0001*	0.0136	0.0004
PUTR2	CO	1*	6	1	18	24	22	45*	114	8	0.04*	0.06	0.04	0.0009*	0.0009	0.0005
	BM	1*	5	1	10	55	20	23*	114	24	0.02*	0.24	0.12	0.0004*	0.0036	0.0005
	FI	0			0			45*	45	6	0			0		
	ME	<1*	15	2	9	126	41	23*	636	103	0.01*	2.46	0.01	0.0001*	0.0128	0.0015

NONWOODY FUELS

	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	0	27	9	3	53	22	3	46	15	5	60	28
Total cover: Annual grass† (%)	<1*	23	4	<1*	54	17	<1*	49	14	<1*	54	21
Total cover: Forbs (%)	1	21	7	2	15	6	5	42	19	3	31	10
Grass height (in.)	3	10	6	2	17	10	3	19	8	1	19	8
Forb height (in.)	1	5	3	1	11	4	1	17	6	<1	17	4
Live loading (lbs/ac)	2.69	340.85	72.95	33.13	882.81	351.72	51.93	1,152.30	309.06	25.96	1,195.28	272.86
Dead loading (lbs/ac)	2.69	160.27	25.58	4.48*	185.34	23.08	0			4.48	124.45	35.68
Total loading (lbs/ac)	5.38	501.12	98.53	37.61	1,068.15	374.80	51.93	1,152.30	309.06	30.44	1,319.73	308.54
Bulk density (lbs/ft³)	0.0014	0.0190	0.0073	0.0044	0.1178	0.0200	0.0037	0.0514	0.0121	0.0056	0.0313	0.0134

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)											
	CO			BM			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.09	0.71	0.29	0.12	1.24	0.63	0.10	0.83	0.48	0.20	2.72	0.97
1.1–3.0 (100-hour)	0.05	1.97	0.55	0.34	2.51	1.16	0.15	1.92	0.81	0.20	7.82	2.14
3.1–9.0 (1000-hour: Sound)	0.12*	3.99	0.61	0.09*	6.49	1.42	0.07*	1.00	0.38	0.07*	13.39	4.11
3.1–9.0 (1000-hour: Rotten)	0.09*	0.09	<0.01	0.11*	0.81	0.15	0.09*	0.29	0.02	0.07*	1.20	0.10
Total loading	0.35	6.76	1.46	0.66	11.05	3.36	0.41	4.04	1.69	0.54	25.13	7.32

Utah Juniper: Phase 3

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			0.7	2.1	1.3	4.77	12.54	8.59	2.2038	5.1629	3.6749
	BM				0.7	1.7	1.1	2.82	7.29	5.63	2.1913	4.2702	2.9720
	FI				0.1	1.4	0.7	0.15	11.80	4.95	1.0800	6.8797	3.6006
	ME				0.6	2.2	1.3	2.21	15.26	7.27	1.1050	4.7009	3.6221
Tree duff	CO	NA			0			0			0		
	BM												
	FI												
	ME												
Interspace litter	CO	4	20	12	NA			<0.01	0.05	0.01	NA		
	BM	2	19	12				<0.01	0.04	0.01			
	FI	2	31	17				<0.01	0.03	<0.01			
	ME	2	20	10				<0.01	0.07	0.02			
Bare ground	CO	13	60	38	NA			NA			NA		
	BM	4	46	26									
	FI	7	52	27									
	ME	1	43	22									

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Western Juniper Fuels Guide: 3 Phases, 3 Treatments
User Notes

Site Notes

- Three phases with three treatments represent the SageSTEP Sagebrush/Western Juniper sites characterized by the Loamy 12–14” ecological type (NRCS 1997).
- General site information:
  - Average annual precipitation ranges between 10.2–19.4 in. (25.9–49.3 cm) averaging 14.4 in. (36.6 cm);
  - Slopes 0–41%, all aspects,
  - ‘Loamy’ soil texture, and soil depths >20 in. (50.8 cm) with minimal stoniness.
- The historical fire return interval on these sites was 10–50+ years with low- to moderate-severity fires (Miller and Rose 1999, Miller et al. 1999). The amount of woodland encroachment suggests that these sites have not burned since the late 1800’s (Miller and Tausch 2001). With increased woodland dominance the fire regime has shifted to infrequent, high-intensity fires (Miller et al. 1999).
- Three treatments were employed across the region: control, fire and mechanical (cutting).
- Bridge Creek is the only site without an active grazing allotment and has not been grazed. All other subplots may have been grazed prior to construction of the exclosures at the beginning of the SageSTEP project.
- Site locations, number of subplots and elevation range for data used in tables are as follows:
  - Phase I
    Control: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 12 subplots; 4616–5020 ft (871–1530 m)
    Fire: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 13 subplots; 2943–4967 ft (897–1514 m)
    Mechanical (Cutting): Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 12 subplots; 2838–5180 ft (865–1579 m)
  - Phase II
    Control: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 23 subplots; 2858–5020 ft (1407–1530 m)
    Fire: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 30 subplots; 2943–4967 ft (897–1514 m)
    Mechanical (Cutting): Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 23 subplots; 2838–5180 ft (865–1579 m)
  - Phase III
    Control: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 28 subplots; 2858–5020 ft (1407–1530 m)
    Fire: Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 18 subplots; 2943–4967 ft (897–1514 m)
    Mechanical (Cutting): Blue Mt, Bridge Creek, Devine Ridge, Walker Butte; 23 subplots; 2838–5180 ft (865–1579 m)

Guide Notes

1. Phases are organized by **pre-treatment** tree stand cover and understory characteristics (Stebleton and Bunting 2009).
   - Phase 1: Trees are present on the site, but the shrub and herb layer are the dominant influence on ecological processes (hydrologic, nutrient, and energy cycles).
   - Phase 2: Trees are co-dominant with shrub and herb layers. All three layers influence ecological processes.
   - Phase 3: Trees are the dominant vegetation and the primary layer influencing ecological processes.
2. Treatments, abbreviations and treatment objectives:
   - Control (CO): Untreated
   - Fire (FI): Objective was to blacken 100% of the plot area with a low-severity prescribed burn (not all plots met objective).
   - Mechanical (Cutting) (ME): All trees >1.6 ft (0.5 m) were cut at the base with a chainsaw and left on site.
3. The caption above the photos denotes measured percent live cover by fuel stratum for that photo.
4. Sampling took place between May and early August in 2008, 2009, and 2010. The date of the photo is in the lower right hand corner.
5. Percent bare ground is the only reported measure of fuel continuity.
6. Dominant graminoids: ACHY, ACNE10, ACTH7, BRTE, HECO26, POSE, and PSSPS
7. BRTE is the only annual grass reported.
8. Shrub loadings are restricted by height, long diameter, perpendicular diameter and volume. Refer to Appendix V, 'Western Juniper', for sample ranges used in this study and R^2 values.
9. Minimum values presented with an asterisk (*) indicate minimum value when present. Mean value includes all subplots.
10. The designation of "NA" indicates data were not available.
11. Tables of species codes and metric conversions can be found in Appendix I and II.

Western Juniper: Phase 1, Control

Site: Walker Butte **Elevation:** 4616 ft (1407 m)

Trees: 4% Shrubs: 2% Perennial Grass: 27% Total Grass: 27% Bare Ground: 40%

Site: Devine Ridge **Elevation:** 4980 ft (1518 m)

Trees: 11% Shrubs: 8% Perennial Grass: 15% Total Grass: 15% Bare Ground: 39%

Western Juniper: Phase 1, Fire

Site: Blue Mountain **Elevation:** 4918 ft (1499 m) **Treatment Date:** 09/2007
Trees: 0% Shrubs: 3% Perennial Grass: 42% Total Grass: 52% Bare Ground: 14%

Site: Devine Ridge **Elevation:** 4967 ft (1514 m) **Treatment Date:** 09/2007
Trees: 4% Shrubs: 2% Perennial Grass: 12% Total Grass: 24% Bare Ground: 34%

Western Juniper: Phase 1, Mechanical (Cutting)

Site: Bridge Creek **Elevation:** 2835 ft (864 m) **Treatment Date:** 10/2006
Trees: 0% Shrubs: 4% Perennial Grass: 34% Total Grass: 37% Bare Ground: 10%

Site: Walker Butte **Elevation:** 4656 ft (1419 m) **Treatment Date:** 10/2006
Trees: 0% Shrubs: 10% Perennial Grass: 29% Total Grass: 31% Bare Ground: 34%

Western Juniper: Phase 1

TREES

	Treatment	JUOC			CELE3		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	2	32	9	23*	204	47
	FI	<1*	10	1	23*	68	2
	ME	<1*	2	<1	23*	409	48
Density: <1.6 ft tall (stem/ac)	CO	<1	13	<1	23*	68	3
	FI	0			0		
	ME	0			23*	23	1

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	<1*	8	1	7	24	12	23*	2,453	111	NA			NA		
	FI	0			0			0								
	ME	<1*	5	<1	7	25	13	45*	45	2						
ARTRV	CO	<1	12	2	2	54	13	114*	2,112	506	0.02	1.24	0.36	0.0001	0.0199	0.0035
	FI	<1*	5	<1	7	50	23	23*	363	50	0.01*	0.42	0.11	0.0001*	0.0067	0.0006
	ME	<1*	24	7	6	59	22	136*	2,725	894	0.02*	5.40	1.18	0.0008*	0.0602	0.0120
CHVI8	CO	<1*	4	1	6	31	11	114*	909	84	<0.01*	0.04	<0.01	0.0001*	0.0078	0.0009
	FI	1*	8	1	6	25	14	182*	1,295	83	0.01*	0.17	0.02	0.0003*	0.0054	0.0009
	ME	<1*	6	1	4	41	12	136*	1,499	140	<0.01*	0.02	<0.01	0.0002*	0.0164	0.0023
PUTR2	CO	1*	10	2	7	83	32	23*	999	191	0.21*	0.98	0.13	0.0008*	0.0108	0.0010
	FI	<1*	2	<1	6	42	16	23*	318	30	0.01*	0.33	0.04	0.0002*	0.0069	0.0004
	ME	<1*	12	2	5	93	38	23*	522	94	0.02*	2.70	0.49	0.0041*	0.0237	0.0016

Western Juniper: Phase 1

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	14	45	26	10	42	23	16	53	33
Total cover: Annual grass† (%)	1*	15	1	1*	18	5	1*	5	1
Total cover: Forbs (%)	1	16	5	3	45	20	2	24	9
Grass height (in.)	5	19	11	5	18	9	5	19	10
Forb height (in.)	2*	8	5	1	20	8	2	11	5
Live loading (lbs/ac)	95.80*	835.35	314.77	346.50	1,890.96	785.27	121.77	773.58	422.33
Dead loading (lbs/ac)	40.29*	468.26	178.10	9.85	332.17	82.19	9.85	296.36	110.40
Total loading (lbs/ac)	136.09	1,303.61	492.87	356.35	2,223.13	867.46	131.62	1,069.94	532.73
Bulk density (lbs/ft³)	0.0079*	0.0384	0.0205	0.0119	0.1572	0.0339	0.0103	0.0357	0.0226

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.08	0.52	0.31	0.02	0.36	0.14	0.07	0.91	0.40
1.1–3.0 (100-hour)	0.05	1.23	0.44	0.05	1.82	0.40	0.05	1.82	0.79
3.1–9.0 (1000-hour: Sound)	0.12*	1.54	0.13	0.12	1.39	0.15	0.12	4.36	1.20
3.1–9.0 (1000-hour: Rotten)	0.09*	0.09	<0.01	0			0		
Total loading	0.34	3.38	0.89	0.19	3.57	0.69	0.24	7.09	2.39

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			0.2	1.5	0.6	0.06	2.23	0.53	0.0250	1.3048	0.5131
	FI				<0.1	0.5	0.1	<0.01*	0.34	0.08	0.0437*	0.6805	0.2711
	ME				0.1	1.0	0.5	0.01	1.36	0.43	0.1498	1.4796	0.5215
Tree duff	CO	NA			0.1	2.8	1.1	0.06	3.85	1.33	0.0437	2.5659	0.7906
	FI				0.1	1.3	0.1	0.04	2.76	0.62	0.0312	1.5545	0.6389
	ME				0.5	3.2	1.3	0.22	4.23	1.50	0.1498	1.4796	0.5806
Interspace litter	CO	7	30	16	NA			0.01	0.59	0.24	NA		
	FI	5	32	17				0.01	0.39	0.12			
	ME	5	31	16				<0.01	0.66	0.22			
Bare ground	CO	5	56	26	NA			NA			NA		
	FI	5	56	34									
	ME	5	42	22									

Western Juniper: Phase 2, Control

Site: Walker Butte **Elevation:** 4616 ft (1407 m)

Trees: 7% Shrubs: 3% Perennial Grass: 14% Total Grass: 14% Bare Ground: 45%

Site: Bridge Creek **Elevation:** 2858 ft (871 m)

Trees: 25% Shrubs: 1% Perennial Grass: 30% Total Grass: 31% Bare Ground: 11%

Western Juniper: Phase 2, Fire

Site: Bridge Creek **Elevation:** 2943 ft (897 m) **Treatment Date:** 10/2006
Trees: 0% Shrubs: 2% Perennial Grass: 11% Total Grass: 39% Bare Ground: 25%

06/07/08

Site: Devine Ridge **Elevation:** 4967 ft (1514 m) **Treatment Date:** 09/2007
Trees: 8% Shrubs: 2% Perennial Grass: 12% Total Grass: 21% Bare Ground: 40%


07/29/09

Western Juniper: Phase 2, Mechanical (Cutting)

Site: Bridge Creek; **Elevation:** 2838 ft (865 m); **Treatment Date:** 10/2006

Trees: 0% Shrubs: 1% Perennial Grass: 33% Total Grass: 36% Bare Ground: 13%

Site: Blue Mountain; **Elevation:** 5108 ft (1557 m); **Treatment Date:** 10/2007

Trees: 0% Shrubs: 15% Perennial Grass: 28% Total Grass: 31% Bare Ground: 29%

Western Juniper: Phase 2

TREES

	Treatment	JUOC			CELE3		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	6	41	22	23*	568	77
	FI	1*	8	1	23*	23	1
	ME	<1*	1	<1	23*	545	94
Density: <1.6 ft tall (stem/ac)	CO	1*	11	<1	23*	23	1
	FI	0			0		
	ME	3*	15	1	23*	91	11

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	<1*	1	<1	6	14	9	88*	204	11	NA			NA		
	FI	0			0			0								
	ME	1*	1	<1	8	91	32	23*	23	1						
ARTRV	CO	<1*	10	3	6	49	24	45*	1,317	496	0.08*	1.27	0.32	0.0001*	0.0135	0.0034
	FI	1*	2	<1	6	16	9	45*	500	79	<0.01*	0.24	0.12	0.0006*	0.0052	0.0009
	ME	1*	15	5	8	91	37	159*	2,453	878	0.02*	2.97	0.63	0.0006*	0.0315	0.0075
CHVI8	CO	<1*	2	<1	3	26	11	23	1,136	328	<0.01*	0.04	<0.01	<0.0001*	0.0050	0.0003
	FI	<1*	6	1	3	23	11	23*	224	50	0.01*	0.15	0.08	<0.0001*	0.0052	0.0009
	ME	<1*	4	<1	6	82	23	23*	1,067	321	<0.01*	0.03	<0.01	0.0001*	0.0127	0.0007
PUTR2	CO	1*	14	4	1	47	17	0			0.06*	2.08	0.42	0.0007*	0.0215	0.0030
	FI	<1*	1	<1	8	91	26				0.02*	0.06	0.01	0.0004*	0.0019	0.0002
	ME	<1*	17	5	6	94	34				0.26*	1.83	0.44	0.0035*	0.0193	0.0029

Western Juniper: Phase 2

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	5	39	22	8	46	21	14	43	30
Total cover: Annual grass† (%)	1*	2	<1	4*	28	7	1*	10	2
Total cover: Forbs (%)	1	15	6	6	42	20	3	21	9
Grass height (in.)	5	14	9	4	15	9	5	20	10
Forb height (in.)	1	11	5	2	18	8	2	13	6
Live loading (lbs/ac)	47.45	625.84	201.55	171.91	1,552.52	713.44	147.73	923.99	351.99
Dead loading (lbs/ac)	14.33	253.38	90.08	9.85	131.62	53.67	17.01	494.23	94.05
Total loading (lbs/ac)	61.78	879.22	291.63	181.76	1,684.14	767.11	164.74	1,418.22	446.04
Bulk density (lbs/ft³)	0.0038	0.0249	0.0134	0.0047	0.0794	0.0301	0.0072	0.0348	0.0175

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.06	0.74	0.39	0.08	0.51	0.20	0.11	0.98	0.54
1.1–3.0 (100-hour)	0.10	2.16	0.65	0.10	1.62	0.55	0.34	3.20	1.79
3.1–9.0 (1000-hour: Sound)	0.12*	3.52	0.21	0.19*	4.33	0.88	0.21	11.14	3.94
3.1–9.0 (1000-hour: Rotten)	0.11	5.14	0.19	0			0.07*	0.07	<0.01
Total loading	0.39	11.56	1.44	0.37	6.46	1.63	0.73	15.39	6.28

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			<1	1	1	0.22	3.38	1.14	0.3808	2.5871	1.1429
	FI				<1	<1	<1	<0.01*	0.38	0.09	0.0562*	3.4087	0.7526
	ME				<1	1	<1	0.06	6.56	1.03	0.2123	2.8905	1.0029
Tree duff	CO	NA			<1	3	1	0.67	7.95	3.95	0.4058	5.0630	2.0710
	FI				<1	1	<1	0.07	0.95	0.47	0.2997	4.3201	1.2727
	ME				1	2	1	0.30	6.36	3.05	0.2872	4.2390	1.7437
Interspace litter	CO	9	30	18	NA			0.01	0.62	0.21	NA		
	FI	7	24	14				0.01	0.17	0.08			
	ME	10	34	19				0.01	0.48	0.17			
Bare ground	CO	9	52	26	NA			NA			NA		
	FI	14	67	37									
	ME	9	44	19									

Western Juniper: Phase 3, Control

Site: Devine Ridge **Elevation:** 4980 ft (1518 m)
Trees: 44% Shrubs: 3% Perennial Grass: 20% Total Grass: 20% Bare Ground: 9%

Site: Devine Ridge **Elevation:** 4980 ft (1518 m)
Trees: 48% Shrubs: 3% Perennial Grass: 13% Total Grass: 15% Bare Ground: 32%

Western Juniper: Phase 3, Fire

Site: Bridge Creek **Elevation:** 2943 ft (897 m) **Treatment Date:** 10/2006
Trees: 0% Shrubs: 0% Perennial Grass: 21% Total Grass: 24% Bare Ground: 38%

06/06/08

Site: Blue Mountain **Elevation:** 4918 ft (1499 m) **Treatment Date:** 09/2007
Trees: 7% Shrubs: 7% Perennial Grass: 20% Total Grass: 21% Bare Ground: 23%

07/11/09

Western Juniper: Phase 3, Mechanical (Cutting)

Site: Bridge Creek **Elevation:** 2838 ft (865 m) **Treatment Date:** 10/2006
Trees: <1% Shrubs: 2% Perennial Grass: 18% Total Grass: 18% Bare Ground: 40%

Site: Walker Butte **Elevation:** 4656 ft (1419 m) **Treatment Date:** 10/2006
Trees: 2% Shrubs: 9% Perennial Grass: 32% Total Grass: 37% Bare Ground: 21%

Western Juniper: Phase 3

TREES

	Treatment	JUOC			CELE3		
		Min	Max	Mean	Min	Max	Mean
Total cover (%)	CO	10	48	30	23*	68	19
	FI	<1*	9	2	23*	23	5
	ME	<1*	2	1	23*	204	96
Density: <1.6 ft tall (stem/ac)	CO	0			0		
	FI						
	ME	<1*	13	3	45*	954	93

SHRUBS

Species	Treatment	Total cover (%)			Height (in.)			Density (#/acre)			Total loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
ARAR8	CO	1*	1	<1	9	17	13	45*	114	13	NA			NA		
	FI	0			0			0								
	ME	1*	1	<1	9	70	33									
ARTRV	CO	1*	7	2	6	71	24	23	977	291	0.01*	0.29	0.12	0.0002*	0.0060	0.0021
	FI	<1*	3	1	6	76	22	45*	545	115	<0.01*	0.29	0.14	0.0001*	0.0044	0.0015
	ME	<1*	3	1	9	70	35	23*	545	163	0.02*	0.08	0.04	0.0003*	0.0019	0.0006
CHVI8	CO	<1*	<1	<1	6	76	17	45*	500	138	NA			NA		
	FI	<1*	2	<1	6	70	21	23*	658	87	<0.01*	0.02	<0.01	0.0001*	0.0044	0.0015
	ME	<1*	6	1	6	70	21	23*	817	161	<0.01*	<0.01	<0.01	<0.0001*	0.0008	0.0001
PUTR2	CO	1*	7	2	6	76	18	0			0.23*	0.79	0.25	0.0032*	0.0085	0.0014
	FI	<1*	6	1	6	70	25				0.02*	0.97	0.27	0.0002*	0.0162	0.0032
	ME	<1*	14	3	6	70	23				0.39*	2.31	0.48	0.0045*	0.0230	0.0029

Western Juniper: Phase 3

NONWOODY FUELS

	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Total cover: Perennial grass† (%)	12	38	18	4	33	16	16	55	28
Total cover: Annual grass† (%)	1*	2	1	1	20	6	1*	15	5
Total cover: Forbs (%)	1*	18	4	3	44	21	3	17	11
Grass height (in.)	5	11	7	6	14	9	4	15	9
Forb height (in.)	1	11	4	3	15	8	2	11	6
Live loading (lbs/ac)	20.14	188.92	102.44	214.88	819.24	484.17	138.78	530.04	284.72
Dead loading (lbs/ac)	14.33	229.21	76.63	4.48	217.57	62.95	7.16	207.72	47.38
Total loading (lbs/ac)	34.47	418.13	179.07	219.36	1,036.81	547.12	145.94	737.76	332.10
Bulk density (lbs/ft³)	0.0049	0.0279	0.0112	0.0091	0.0255	0.0190	0.0095	0.0231	0.0144

†Species used to calculate perennial grass cover were all native, and cheatgrass was the only annual grass.

WOODY FUELS

Diameter (in.)	Loading (ton/ac)								
	CO			FI			ME		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
0.26–1.0 (10-hour)	0.16	0.60	0.37	0.04	0.59	0.26	0.12	2.48	0.92
1.1–3.0 (100-hour)	0.10*	0.84	0.43	0.05*	3.69	0.75	0.89	5.95	2.71
3.1–9.0 (1000-hour: Sound)	0.18*	1.97	0.40	0.21*	9.45	2.00	1.97	10.91	7.18
3.1–9.0 (1000-hour: Rotten)	0.93*	0.93	0.08	0			0		
Total loading	1.37	4.34	1.28	0.3	13.73	3.01	2.98	19.34	10.81

LITTER and DUFF

	Treatment	Total cover (%)			Depth (in.)			Loading (ton/ac)			Bulk density (lbs/ft³)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tree litter	CO	NA			1	1	<1	0.35	2.16	1.06	0.7055	3.7707	1.4619
	FI				1	1	<1	0.03	3.04	0.86	0.2247	4.8196	1.6345
	ME				1	1	<1	0.19	4.02	1.73	0.8990	3.9393	2.1538
Tree duff	CO	NA			1	2	1	3.50	9.59	5.99	1.5920	5.3689	3.1558
	FI				1	1	<1	0.03	7.91	1.76	0.4245	11.4808	2.9700
	ME				1	2	1	1.97	13.15	6.28	2.2724	5.3252	3.4071
Interspace litter	CO	10	42	24	NA			0.03	1.20	0.28	NA		
	FI	4	39	22				0.02	0.52	0.19			
	ME	9	31	22				<0.01	0.73	0.17			
Bare ground	CO	9	49	25	NA			NA			NA		
	FI	9	65	32									
	ME	3	40	15									

Appendix I: Species Index

Stratum	Code*	Scientific Name	Common Name
Trees	CELE3	*Cercocarpus ledifolius*	curl-leaf mountain mahogany
	JUOC	*Juniperus occidentalis*	western juniper
	JUOS	*Juniperus osteosperma*	little Utah juniper
	PIED	*Pinus edulis*	twoneedle pinyon pine
	PIMO	*Pinus monophylla*	singleleaf pinyon pine
Shrubs	ARAR8	*Artemisia arbuscula*	little sagebrush
	ARNO4	*Artemisia nova*	black sagebrush
	ARTRV	*Artemisia tridentata (vaseyana)*	mountain big sagebrush
	ARTRW8	*Artemisia tridentata (wyomingensis)*	Wyoming big sagebrush
	CHVI8	*Chrysothamnus viscidiflorus*	yellow rabbitbrush
	PUTR2	*Purshia tridentata*	antelope bitterbrush
Graminoids	ACHY	*Achnatherum hymenoides*	Indian ricegrass
	ACNE10	*Achnatherum nevadense*	Nevada needlegrass
	ACTH7	*Achnatherum thurberianum*	Thurber's needlegrass
	BRAR5	*Bromus arvensis*	field brome
	BRTE	*Bromus tectorum*	cheatgrass
	ELEL5	*Elymus elymoides*	squirreltail
	FEID	*Festuca idahoensis*	Idaho fescue
	HECO26	*Hesperostipa comata*	needle and thread
	LECI4	*Leymus cinereus*	basin wildrye
	PASM	*Pascopyrum smithii*	western wheatgrass
	PLJA	*Pleuraphis jamesii*	James' galleta
	POCU3	*Poa cusickii*	Cusick's bluegrass
	POSE	*Poa secunda*	Sandberg bluegrass
	PSSPS	*Pseudoroegneria spicata spicata*	bluebunch wheatgrass

*USDA NRCS 2011

Appendix II: Conversion Table

Reported Unit	Conversions
1 ac	0.4050 ha; 4046.8560 m^2
1 in.	2.5400 cm
1 ft	0.3048 m
1 lb	0.0005 ton; 0.4520 kg
1 ton	907.2000 kg
1 lb/ac	0.0005 ton/ac; 0.0001 kg/m^2; 1.1200 kg/ha
1 ton/ac	0.2242 kg/m^2; 2241.7023 kg/ha
1 lb/ft^3	16.0000 kg/m^3

Appendix III: Glossary of Terms

Available fuel loading: Fuel that could be readily consumed at any given time. Highly dependent of fuel moisture, particle size and arrangement (Miller 2001).

Biomass: All vegetation on the site (Miller 2001).

Bulk density: Weight of biomass per unit volume; loading/fuel depth (Brown 1982).

Common species: Species that have the highest abundance on the site.

Community: An assemblage of plants, animals, bacteria and fungi that live in an environment, interact with one another, forming a distinctive living system within its own composition, structure, environmental relations, development and function (Whittaker 1975). It is the biotic component of the ecosystem and has no implicit definition of spatial extent or boundaries (Kimmins 1987).

Dominant species: Species that exerts ecological influence over other species on the site.

Duff: The fermentation and humus layers of the forest floor. Needles, leaves, and other castoff vegetation are no longer distinguishable due to decomposition (Brown 1974).

Ecosystem: The community and non-living environment functioning together as an ecological system (Odum 1971). No implicit definition of spatial extent or boundaries (Kimmins 1987).

Fire behavior model: A computer model that uses a set of physically based mathematical equations to predict certain aspects of fire behavior. Inputs include fuel characteristics and environmental conditions for a particular site (Rothermel 1972).

Fire regime: A general description of the role fire plays in an ecosystem. It can be described by characteristics of the disturbance (type, frequency, predictability, extent, magnitude, synergism or timing), a summary of the ecological effects on the dominant or potential vegetation of the ecosystems, or the fire severity on dominant vegetation (Agee 1993).

Fire return interval: The number of years between two successive fire events at a specific site or an area of a specified size (Agee 1993).

Fuel: Live and dead biomass that contribute to wildland fire (Davis 1959). Often defined by loading, depth, height, and bulk density.

Fuelbed: Measured or averaged physical characteristics of reactively uniform unit on the landscape that represents a distinct fire environment (Riccardi et al. 2001).

Fuelbed depth: Depth of surface fuel available to the flaming front (Miller 2001).

Fuel continuity: Relates to the proximity of individual fuel particles as well as different fuel strata. It affects fire spread, ignition rates and area and how much consumption takes place (Miller 2001).

Fuel loading: Weight of fuel per unit area (Brown 1982).

Fuel strata: A horizontal layer of fuel having approximately the same composition throughout; parallel layers arranged one on top of another. Identified in this Guide as trees, shrubs, nonwoody fuel, woody fuels, litter and duff (Ottmar et al. 2007, Sandberg et al. 2001).

Litter: The surface layer of the site consisting of freshly fallen leaves, needles, twigs, bark and fruits (Brown 1974).

Time lag: The length of time it takes a fuel particle to reach 63 percent equilibrium moisture content with the environment at standard conditions of 80º F and 20 percent relative humidity (Schroeder and Buck 1970).

1-hour fuel: Fuel particles with 0–0.24 in. (0–0.6 cm) diameter; fuel size class distinction (Brown 1974). One-hour refers to the timelag.

10-hour fuel: Fuel particles with 0.25–0.99 in. (0.6–2.5 cm) diameter; fuel size class distinction (Brown 1974). Ten-hour refers to the timelag.

100-hour fuel: Fuel particles with 1.00–2.99 in. (2.5–7.6 cm) diameter; fuel size class distinction (Brown 1974). Hundred-hour refers to the timelag.

1000-hour fuel: Fuel particles with greater than 3.00 in. (7.6 cm) diameter; fuel size class distinction (Brown 1974). Thousand-hour refers to the timelag.

Appendix IV: Shrub Loadings by Size Class

Size class loadings were calculated from site- and species-specific linear regressions developed from harvest sampling (Pechanec and Pickford 1937, Riser 1984). Various combinations of shrub height, longest diameter, perpendicular diameter and volume were used as predictor variables in the regressions. One-hour loading includes foliage and 1-hour fuels from the shrub canopy. The available loading assumes 100% of the 1-hour and 50% of the 10-hour fuels will consume in the flaming front*.

*Wright, C.S. 2008. Personal Communication. Research Forester, USDA Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, Seattle, WA.

LIVE LOADING AT SAGEBRUSH STEPPE SITES

Live Loading		Group 1								Group 2							
		ARTRW8				CHVI8				ARTRW8				CHVI8			
		CO	FI	MO	TE	CO	FI	MO	TE	CO	FI	MO	TE	CO	FI	MO	TE
1-hour (ton/ac)	Min	0.37	0.03*	0.04*	0.24	<0.01*	0.04*	0.01*	0.02*	0.29	<0.01*	0.02*	0.19	0.01*	<0.01*	0.01*	
	Max	3.11	2.47	0.77	4.60	1.17	0.08	0.36	1.79	2.58	1.86	1.81	1.81	0.01	0.03	0.09	NA
	Mean	1.08	0.78	0.30	1.28	0.19	0.01	0.03	0.16	0.91	0.34	0.38	0.63	<0.01	<0.01	0.01	
10-hour (ton/ac)	Min	0.39	0.02	0.05	0.19	0.01*	0.01*			0.20*	<0.01*	0.01*	0.16			0.01*	
	Max	1.72	1.61	0.54	2.57	0.01	0.01	0		1.71	1.45	1.15	2.22	0		0.02	NA
	Mean	0.79	0.49	0.25	0.76	<0.01	<0.01			0.60	0.25	0.25	0.71			<0.01	
Available (ton/ac)	Min	0.60	0.04	0.08*	0.33	<0.01*	0.04	0.01*	0.02*	0.43*	0.01*	0.02*	0.53	0.01*	<0.01*	0.01	
	Max	3.96	3.27	1.04	5.21	1.17	0.08	0.36	1.79	2.95	2.58	2.32	2.93	0.01	0.03	0.10	NA
	Mean	1.47	1.03	0.42	1.85	0.19	0.01	0.03	0.16	1.21	0.46	0.50	1.11	<0.01	<0.01	0.01	
		Group 3								Group 4							
1-hour (ton/ac)	Min	0.47	<0.01*	0.44	0.72*	0.07*				0.18	<0.01*	0.01*	0.03		0.05*	<0.01*	
	Max	11.10	12.72	1.30	7.20	0.07	NA			3.38	1.70	1.75	6.32	NA	0.05	<0.01	NA
	Mean	4.82	1.76	0.92	2.87	0.01				1.18	0.22	0.34	1.39		<0.01	<0.01	
10-hour (ton/ac)	Min	0.04	<0.01*	0.02*	0.35*	<0.01*				0.17	<0.01*	<0.01*	0.03				
	Max	1.23	0.94	0.74	1.49	<0.01	NA			4.29	0.76	0.97	3.33	NA	0		NA
	Mean	0.70	0.18	0.27	0.87	<0.01				1.26	0.12	0.42	1.05				
Available (ton/ac)	Min	0.75	<0.01*	0.67	1.20*	0.07*				0.27	<0.01*	0.01*	0.80		0.05*	<0.01*	
	Max	11.54	13.19	1.30	7.87	0.07	NA			5.52	1.80	2.23	7.98	NA	0.05	<0.01	NA
	Mean	5.17	1.85	1.06	3.36	0.01				1.81	0.28	0.75	2.32		<0.01	<0.01	

DEAD LOADING AT SAGEBRUSH STEPPE SITES

Dead Loading		Group 1								Group 2							
		ARTRW8				CHVI8				ARTRW8				CHVI8			
		CO	FI	MO	TE	CO	FI	MO	TE	CO	FI	MO	TE	CO	FI	MO	TE
1-hour (ton/ac)	Min	NA			0.01*	NA			<0.01*	NA			0.01*	NA			
	Max				2.36				0.03				0.51				
	Mean				0.27				<0.01				0.08				
10-hour (ton/ac)	Min				0.06*								0.11				
	Max				1.46				0				2.22				
	Mean				0.30								0.71				
Available (ton/ac)	Min				0.05*				<0.01*				0.02*				
	Max				3.09				0.03				0.82				
	Mean				0.42				<0.01				0.13				
		Group 3								Group 4							
1-hour (ton/ac)	Min	NA			<0.01*	NA				NA			0.01*	NA			
	Max				3.32								0.98				
	Mean				0.49								0.28				
10-hour (ton/ac)	Min				0.06*								0.01*				
	Max				0.32								0.88				
	Mean				0.09								0.26				
Available (ton/ac)	Min				0.03*								0.01*				
	Max				0.16								1.42				
	Mean				0.06								0.44				

LIVE LOADING AT PINYON-JUNIPER SITES

Phase	Live Loading		ARAR8			ARNO4			ARTRW8			CHVI8			PUTR2		
			CO	FI	ME	CO	FI	ME	CO	FI	ME	CO	FI	ME	CO	FI	ME
1	1-hour (ton/ac)	Min	0			0	<0.01*	0.06*	0.09	0.09	<0.01	0.05*	0.05	<0.01*	0.06	0.06	<0.01
		Max					0.17	0.06	1.01	1.01	0.89	1.15	1.15	0.07	0.43	0.43	0.04
		Mean					0.04	0.01	0.64	0.64	0.16	0.18	0.18	0.02	0.21	0.21	0.01
	10-hour (ton/ac)	Min	0			0	<0.01	0.06*	0.06	0.06	<0.01	0.02*	0.02	<0.01*	0.05	0.05	<0.01
		Max					0.14	0.06	1.05	1.05	0.91	0.04	0.04	0.01	0.52	0.52	0.04
		Mean					0.04	0.01	0.45	0.45	0.14	0.01	0.01	<0.01	0.24	0.24	0.01
	Available (ton/ac)	Min	0			0	<0.01*	0.09*	0.12	0.12	<0.01	0.05*	0.05	<0.01*	0.08	0.08	<0.01
		Max					0.24	0.09	1.53	1.53	1.35	1.15	1.15	0.07	0.69	0.69	0.05
		Mean					0.06	0.02	0.86	0.86	0.23	0.18	0.18	0.02	0.33	0.33	0.02
2	1-hour (ton/ac)	Min	0.01	0	0.27*	0	<0.01*	0	0.01	<0.01	0.20	<0.01*	<0.01	<0.01	0.02	<0.01	<0.01
		Max	0.24		0.28		0.37		0.47	0.72	1.47	0.12	0.04	0.07	0.46	0.09	0.06
		Mean	0.13		0.27		0.05		0.25	0.09	0.65	0.02	0.01	0.02	0.13	0.03	0.03
	10-hour (ton/ac)	Min	0.01	0	0.19*	0	<0.01*	0	0.01	<0.01	0.10	<0.01*	<0.01	<0.01	0.02	<0.01	<0.01
		Max	0.16		0.19		0.41		0.48	0.80	1.09	0.06	0.01	0.04	0.53	0.09	0.06
		Mean	0.10		0.19		0.05		1.18	0.80	0.48	0.01	<0.01	0.01	0.14	0.03	0.02
	Available (ton/ac)	Min	0.20	0	0.36*	0	<0.01*	0	0.01	<0.01	0.25	<0.01*	<0.01	<0.01	0.03	<0.01	<0.01
		Max	0.32		0.37		0.57		0.66	1.11	1.86	0.12	0.04	0.13	0.73	0.14	0.09
		Mean	0.18		0.37		0.08		0.35	0.13	0.89	0.02	0.01	0.02	0.20	0.04	0.04
3	1-hour (ton/ac)	Min	0		0.01	0	0.05*	0	0.01	<0.01	0.06	<0.01	0		0.02	<0.01	0.01
		Max			0.10		0.05		0.22	0.06	0.81	0.01			0.15	0.09	0.01
		Mean			0.04		0.05		0.08	0.05	0.26	<0.01			0.06	0.03	0.01
	10-hour (ton/ac)	Min	0		0.01	0	0.05*	0	<0.01	<0.01	0.01	<0.01	0		0.01	0.01	0.01
		Max			0.04		0.05		0.17	0.07	0.82	0.02			0.12	0.07	0.01
		Mean			0.02		0.03		0.04	0.02	0.20	<0.01			0.05	0.03	0.01
	Available (ton/ac)	Min	0		0.02	0	0.08*	0	0.01	<0.01	0.06	<0.01	0		0.03	<0.01	0.01
		Max			0.12		0.08		0.29	0.10	1.22	0.02			0.21	0.12	0.01
		Mean			0.05		0.04		0.10	0.04	0.36	<0.01			0.09	0.05	0.01

LIVE LOADING AT UTAH JUNIPER SITES

Phase	Live Loading		ARTRV				ARTRW8				CHVI8				PUTR2			
			CO	BM	FI	ME	CO	BM	FI	ME	CO	BM	FI	ME	CO	BM	FI	ME
1	1-hour (ton/ac)	Min	0.58	0.05	0	0.68	0.21	0.06	<0.01	0.20	<0.01	0.02*	<0.01*	0.09*	0.13	0.36*	0	0.22
		Max	1.79	0.06		0.68	1.73	0.79	0.13	2.06	0.06	0.21	0.18	0.38	0.70	2.31		0.22
		Mean	1.10	0.05		0.68	0.77	0.38	0.02	0.90	<0.01	0.02	0.03	0.07	0.34	1.21		0.22
	10-hour (ton/ac)	Min	0.31	0.06	0	0.74	0.27	0.08	<0.01	0.18	0				0.15	0.38*	0	0.26
		Max	2.02	0.06		0.74	1.97	1.00	0.13	2.47					0.93	3.04		0.26
		Mean	1.19	0.06		0.74	0.86	0.44	0.03	1.13					0.43	1.45		0.26
	Available (ton/ac)	Min	0.73	0.08	0	1.05	0.34	0.11	<0.01	0.09	<0.01*	0.02*	<0.01*	0.09*	0.20	0.55*	0	0.35
		Max	2.80	0.09		1.05	2.71	1.29	0.19	3.22	0.06	0.21	0.18	0.38	1.16	3.83		0.35
		Mean	1.70	0.08		1.05	1.20	0.60	0.04	1.46	<0.01	0.02	0.03	0.07	0.56	1.93		0.35
2	1-hour (ton/ac)	Min	0.22	0.06	0	0.01	0.06	<0.01	<0.01	0.03	<0.01*	<0.01*	<0.01*	0.08*	0.01*	<0.01	0	0.03
		Max	1.64	0.45		0.19	1.65	0.97	0.40	1.35	0.08	0.13	0.10	0.24	0.23	1.12		0.34
		Mean	0.67	0.21		0.09	0.48	0.32	0.08	0.64	0.01	0.01	0.02	0.04	0.06	0.47		0.15
	10-hour (ton/ac)	Min	0.20	0.07	0	0.01	0.08	0.01	<0.01	0.03	0				<0.01*	<0.01	0	0.03
		Max	1.84	0.52		0.20	2.14	1.17	0.39	1.53					0.28	1.68		0.44
		Mean	0.65	0.25		0.10	0.62	0.42	0.09	0.73					0.07	0.68		0.19
	Available (ton/ac)	Min	0.32	0.09	0	0.02	0.10	0.01	<0.01	0.04	<0.01*	<0.01*	0.01*	0.08*	<0.01	0.01	0	0.04
		Max	2.55	0.71		0.29	2.72	1.55	0.60	0.03	0.09	0.13	0.10	0.24	0.37	1.96		0.56
		Mean	1.00	0.33		0.14	0.79	0.53	0.13	1.01	0.01	0.01	0.02	0.04	0.15	0.81		0.24
3	1-hour (ton/ac)	Min	0.01	0.05	0	0.06	0.02	<0.01*	0.01*	0.01*	<0.01*	<0.01*	<0.01*	<0.01*	0.02	0.01	0	<0.01*
		Max	0.19	0.29		0.40	0.86	0.38	0.12	0.51	<0.01	0.02	<0.01	0.26	0.02	0.07		0.63
		Mean	0.11	0.13		0.20	0.19	0.08	0.06	0.09	<0.01	<0.01	<0.01	0.02	0.02	0.04		0.27
	10-hour (ton/ac)	Min	<0.01	0.05	0	0.09*	0.01	<0.01*	<0.01*	0.01*	0				0.02	0.01	0	0.03
		Max	0.17	0.33		0.40	0.49	0.28	0.09	0.62					0.02	0.09		0.85
		Mean	0.10	0.14		0.19	0.19	0.09	0.06	0.09					0.02	0.04		0.35
	Available (ton/ac)	Min	0.01	0.07	0	0.06	0.03	<0.01*	0.01*	0.01*	<0.01*	<0.01*	<0.01*	<0.01*	0.03	0.01	0	<0.01*
		Max	0.28	0.45		0.60	1.05	0.52	0.17	0.82	<0.01	0.02	0.01	0.26	0.03	0.11		1.02
		Mean	0.16	0.20		0.30	0.29	0.14	0.09	0.15	<0.01	<0.01	<0.01	0.02	0.03	0.06		0.45

LIVE LOADING AT WESTERN JUNIPER SITES

Phase	Live Loading		ARAR8			ARTRV			CHVI8			PUTR2		
			CO	FI	ME	CO	FI	ME	CO	FI	ME	CO	FI	ME
1	1-hour (ton/ac)	Min	NA			<0.01*	<0.01*	0.01	<0.01*	0.01*	<0.01*	0.09	0.01*	0.11*
		Max				0.69	0.18	2.58	0.13	0.17	0.02	0.41	0.19	1.13
		Mean				0.18	0.05	0.60	0.02	0.03	<0.01	0.06	0.03	0.21
	10-hour (ton/ac)	Min				<0.01	<0.01*	0.01	<0.01*	<0.01*	<0.01*	0.14	<0.01*	0.07*
		Max				0.51	0.18	2.02	0.07	0.02	0.20	0.67	0.14	2.20
		Mean				0.15	0.05	0.47	0.01	<0.01	0.01	0.08	0.02	0.38
	Available (ton/ac)	Min				<0.01	<0.01*	0.02	<0.01*	0.01*	<0.01*	0.16	<0.01*	0.15
		Max				0.94	6.27	3.59	0.17	0.17	0.35	0.75	0.26	2.23
		Mean				0.26	0.07	0.83	0.02	0.03	0.06	0.10	0.04	0.40
2	1-hour (ton/ac)	Min	NA			<0.01*	0.01	0.01	<0.01*	<0.01*	<0.01*	0.02*	0.01*	0.12*
		Max				0.63	0.10	1.49	0.06	0.08	0.25	0.79	0.04	0.84
		Mean				0.16	0.05	0.34	0.01	0.02	0.02	0.17	0.01	0.19
	10-hour (ton/ac)	Min				<0.01*	<0.01	0.01	0.01*	<0.01*	0.01*	0.04*	<0.01*	<0.01*
		Max				0.48	0.10	1.14	0.02	<0.01	0.09	2.10	0.01	1.27
		Mean				0.13	0.05	0.26	<0.01	<0.01	0.01	0.31	<0.01	0.29
	Available (ton/ac)	Min				<0.01*	0.01	0.02	<0.01*	<0.01*	<0.01*	0.04*	<0.01*	<0.01*
		Max				0.87	0.15	2.06	0.07	0.08	0.30	1.84	0.05	1.33
		Mean				0.23	0.08	0.47	0.01	0.02	0.02	0.35	0.01	0.34
3	1-hour (ton/ac)	Min	NA			<0.01	<0.01	0.01	0	<0.01*	<0.01*	0.23*	0.01*	0.30*
		Max				0.12	0.15	0.06		0.02	0.01	0.79	0.44	1.07
		Mean				0.05	0.08	0.02		<0.01	<0.01	0.25	0.12	0.22
	10-hour (ton/ac)	Min				<0.01	<0.01	0.01	0	0	0.01*	0.09*	0.01*	0.20
		Max				0.12	0.12	0.04			0.01	0.37	0.76	1.36
		Mean				0.05	0.06	0.02			<0.01	0.11	0.21	0.28
	Available (ton/ac)	Min				0.01	<0.01	0.01	0	<0.01	<0.01*	0.19*	0.01*	0.28
		Max				0.19	0.21	0.08		0.02	0.01	0.62	0.79	1.75
		Mean				0.08	0.11	0.03		<0.01	<0.01	0.19	0.23	0.36

Appendix V: Shrub Sample Ranges

Sample ranges used to predict shrub loadings. R^2 values are the lowest calculated values from all developed regressions.

SAGEBRUSH STEPPE

	Height (in.)	Longest Diameter (in.)	Perpendicular Diameter (in.)	Volume (in^3)	R^2
ARTRW8	8–57	7–75	3–57	61–125138	0.80
CHVI8	10–28	9–48	5–42	332–18686	0.67

PINYON-JUNIPER

	Height (in.)	Longest Diameter (in.)	Perpendicular Diameter (in.)	Volume (in^3)	R^2
ARAR8	4–19	9–34	7–31	164–9731	0.90
ARNO4	3–24	2–55	2–35	5–19593	0.78
ARTRV	6–39	6–49	4–17	82–50995	0.93
ARTRW8	2–55	3–63	2–51	9–75889	0.79
CHVI8	4–51	5–73	4–31	62–61476	0.81
PUTR2	5–75	4–146	4–91	38–516631	0.90

UTAH JUNIPER

	Height (in.)	Longest Diameter (in.)	Perpendicular Diameter (in.)	Volume (in^3)	R^2
ARTRV	6–64	8–78	8–45	215–96153	0.84
ARTRW8	6–52	6–72	4–61	111–88538	0.86
CHVI8	7–24	7–31	7–22	229–6460	0.74
PUTR2	6–79	13–149	7–138	305–762917	0.97

WESTERN JUNIPER

	Height (in.)	Longest Diameter (in.)	Perpendicular Diameter (in.)	Volume (in^3)	R^2
ARAR8	6–17	7–32	2–24	66–5870	0.84
ARTRV	8–51	7–66	6–62	194–104745	0.68
CHVI8	7–29	4–38	2–33	43–14747	0.62
PUTR2	7–89	10–119	5–101	268–556134	0.94