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Comparing the Ignitability of Mulch Materials for a Firewise Landscape

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Figure 1. The eight mulches used from the upper left corner and clock wise: pine needles, bark nuggets, shredded bark, grass sod, decomposed granite (DG), garden compost, wood chips, and wheat straw.

Introduction

A Firewise landscape in Arizona may include native and non-native plants as well as a variety of mulch materials. The goal of Firewise landscaping is to prevent home ignitions by using plants and mulch to reduce the spread of fires near structures or other improvements (DeGomez et al. 2011). Appropriate plants for a particular area in Arizona vary due to the proximity to structures, the location within the landscape (such as elevation and slope), as well as temperature and moisture regimes (DeGomez and Jones 2013a).

Mulches are defined as any material used on the soil surface for a variety of reasons. The application of mulches to the landscape may improve the aesthetics, reduce soil moisture evaporation rates, improve the soil nutrient content over time, reduce weed competition, moderate soil temperatures, reduce erosion and provide cover for dust abatement (Appleton and French 1995; Rose and Smith 1996). With a wide variety of mulches available on the market, specific mulches are selected for different aesthetic and economic reasons including "eye appeal, color, size, availability, maintenance, and price" (Steward et al. 2003). Those that have been most popular in Arizona are: organic materials such as bark, wood chips, grass clippings, or compost; inorganic materials such as decomposed granite, rocks, or gravel; and finally synthetic sheet mulches or ground cloth, which are typically topped with an organic or inorganic mulch to hold them in place, protect them from ripping, and to hide them from view.

The Healthy Forest Restoration Act of 2003 was the impetus for the development of Community Wildfire

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Figure 2. Propane torch igniting the pine needles.

Protection Plans, which emphasizes fuel reduction to protect homes, properties and communities. As fuel reduction projects are being implemented across Arizona's woodlands and forests, much of the resulting debris is chipped and either spread back onto the site or taken to another location to be burned or used as wood chip mulch. Little is known about the flammability of this form of mulch, however, so an experiment was devised to test the relative ignition rate of this wood chip debris as well as seven other commercially available mulches using three different ignition sources. The objective was to determine the best mulch alternatives for Arizona's landscapes for their unique arid environments. The flammability of plants recommended for Firewise landscapes will not be addressed in this publication.

Materials and Methods

Eight common mulches were selected for evaluation of their relative ignition and flammability. (Ignition refers to the speed at which the mulch lit. Flammability refers to the height the flames reach after igniting). The mulches selected were: wood chips, shredded bark, pine needles, freshly laid grass sod, garden compost, bark nuggets, wheat straw, and decomposed granite (DG) *(Figure 1)*. Wood chips were obtained from a fuel reduction project conducted in Flagstaff, pine needles were obtained from the Centennial Forest in Coconino County, and the remaining mulches were obtained commercially. The null hypothesis assumed that all mulches were equally ignitable .

A randomized complete block design consisting of three blocks with eight 1 m² (10.8ft²) plots per block was used for randomization and replication. The edges of the plots were delineated with 10 cm (4 inch) tall landscape edging to visually separate mulches, to prevent mulch contamination, and to prevent mulch from igniting adjacent blocks. The blocks were replicated three times at three locations —Flagstaff, Prescott and Tucson—to document differences in mulch flammability at different elevations, temperature and moisture regimes. The eight cells in each block were filled with one of eight landscape mulch materials: bark nuggets, decomposed granite, garden compost, grass sod, pine needles, shredded bark, wheat straw, and wood chips. The mulches were applied within two weeks of the fall burn date at each location. Mulch depth for each sample was approximately 10cm (4in) similar to a study by Steward et al. (2003). Each of the 1 m² (10.8 ft²) plots was subdivided into 4 – ¼ m² (2.7 ft²) quadrants with a moveable aluminum 'X' during the ignition phase to test three different ignition sources.

Three ignition sources, a lit cigarette, a charcoal briquette, and a propane torch were used to test the relative ignition rate and flammability of the mulch. The ignition sources were selected to simulate various scenarios in a real-world wildfire setting. The propane torch was selected to simulate the flame front from a ground fire moving to the mulch; the charcoal briquette was selected to simulate a fire-brand (ember) being blown onto the mulch from an adjacent wind driven crown fire; and the cigarette was selected to simulate a carelessly tossed cigarette into the mulch. The center of three of the four ¼ m² (10.8 ft²) quadrants within a cell was subjected to heat from either a hand held propane torch for 15 seconds (*Figure 2*), a burned white Kingsford® self lighting charcoal briquette for 5 minutes, or a lit Montego® regular filter cigarette until the cigarette fully self consumed (Steward et al. 2003). If the mulch ignited it was allowed to burn to the edge of the ¼ m² (10.8 ft²) quadrant before it was extinguished. In the event of slow moving flames (or smoldering), any cell that did not fully consume the ¼ m²

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Figure 3. Measuring flame length in the ¼ meter cell with a metal ruler.

Table 1. Percentage of torch and briquette trials that experienced ignition when exposed to each ignition source from fall 2005 and spring 2006.

Fall 2005						
	Torch			Briquette		
Mulch Type	Tucson	Prescott	Flagstaff	Tucson	Prescott	Flagstaff
Straw	100	100	100	67	67	33
Pine Needles	100	100	100	100	100	67
Wood Chips	100	100	100	0	0	0
Pine Nuggets	100	100	100	0	0	0
Sod	100	100	100	0	0	0
Shredded Bark	100	100	100	0	0	0
Compost	100	100	100	0	0	0
DG	0	0	0	0	0	0

Spring 2006						
	Torch			Briquette		
Mulch Type	Tucson	Prescott	Flagstaff	Tucson	Prescott	Flagstaff
Straw	100	100	100	67	0	100
Pine Needles	100	100	100	67	0	67
Wood Chips	100	100	100	0	0	33
Pine Nuggets	100	100	100	33	0	33
Sod	100	33	33	0	0	0
Shredded Bark	100	67	100	0	0	0
Compost	100	67	100	0	0	0
DG	0	0	0	0	0	0

(10.8 ft²) quadrant after 25 minutes was extinguished.

To ensure that the mulch was dry prior to burning it was necessary to have 5 consecutive dry days prior to testing. Burning was conducted on November 22, 2005 and May 8, 2006 in Flagstaff; November 16, 2005 and June 1, 2006 in Prescott; and November 17, 2005 and April 24, 2006 in Tucson. During the time between burns, mulch was allowed to naturally weather in the local environment. Fresh sod was laid in the spring just prior to burning.

The period of time was measured in seconds from the ignition source application to when ignition occurred in the mulching materials (flames) and was recorded. When flames occurred immediately upon application of the ignition source, it was recorded as "0.1" seconds. The time was also recorded when flames reached the edge of the ¼ m² (10.8 ft²) quadrant, and when the mulch was extinguished. The highest flame length was measured using a metal yardstick attached to a metal rod in the center of each plot, and was recorded in inches (*Figure 3*). When flames were higher than the 91.5 cm (36 inch) ruler, estimates were recorded.

Results

Of all the materials tested, the cigarette was the only ignition source that did not cause a single ignition (data not shown). The charcoal briquette caused ignition in the pine needles and the wheat straw (*Table 1*). Pine needles were ignited by the charcoal at all three sites, with five out of six replicates ignited at the Tucson site. In Prescott pine needles were ignited at all

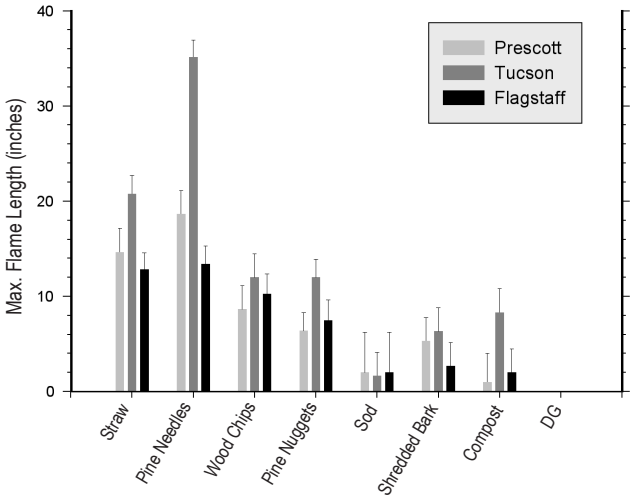

Figure 4. Average maximum flame length comparisons for each of the materials tested by study site with propane torch as ignition source. Bars represent mean flame length ± standard error of the mean.

trials in the fall, but none ignited in the spring. In Flagstaff, two out of three trials ignited in both fall and spring. Wheat straw had inconsistent ignition results with the briquette: two starts at the Prescott study site and four starts at both the Flagstaff and Tucson study sites. All materials experienced ignition when the propane torch was applied, except for decomposed granite. In most cases, however, flames were not sustained when the torch was removed. Most of the pine needles and wheat straw plots had flames that rapidly burned the entire quadrant. Smoldering occurred for up to 25 minutes in all the mulches except the decomposed granite and sod with both the torch and briquette. When the entire quadrant was not consumed during ignition the common pattern observed was for the material to smolder either when the flames subsided when ignited by the torch or when the briquette was removed after the five minute period. In the case of the briquette, smoldering was often promoted when it was removed and oxygen was permitted to reach the hot spot created by the briquette.

A statistical analysis determined that the pine needles and the wheat straw ignited the fastest when a propane torch was applied. No difference was found for the ignitability of mulches between the three locations[1].

Maximum flame lengths ranged from 2.5 to 100 cm (1 to 40 inches) (*Figure 4*). Pine needles and wheat straw had the greatest flame length, with wheat straw varying widely between sites. All other materials averaged less than 28 cm (11 inches) at each of the three sites.

Discussion

Ignition Source —The lit cigarette was ineffective at igniting any of the mulches in both the spring and fall. The results obtained were directly opposite of what was found by Steward et al. (2003), which may be explained by their use of three lit cigarettes per trial as compared with our single lit cigarette per trial. The charcoal briquette did not ignite any of the mulches during the first 5 minutes of application, however once the briquette was removed ignition occurred and/or smoldering continued in most mulches for the maximum 25 minute period. This can probably be attributed to the availability of air allowed to circulate over the "hot spot" once the briquette was removed, enabling some of the smoldering embers to burst into flame. The propane torch was very effective at initiating flames but with many of the mulches the flames were not sustained to the edges of the ¼ m² (10.8 ft²) quadrant.

Mulch type—As expected, the organic mulches with the greatest amount of air space between the particles had the greatest ability to ignite and burn to the edge of the ¼ m² (10.8 ft²) quadrant. The wheat straw and the pine needles were the most flammable followed by the woodchips and bark nuggets. Similar results were obtained by Steward et al. (2003), with oat straw and pine needles having the fastest ignition rates. The compost and shredded bark mostly smoldered; they initially ignited but did not carry a sustained flame. Foliage of the sod in direct contact with the propane torch or the briquette burned but smoldering and flames were not sustained in the live material once the ignition source was removed. As expected, the decomposed granite did not ignite or smolder, though debris that had collected on the surface such as windblown leaves did burn.

Conclusions

Inorganic mulches such as decomposed granite, gravel or rocks offer superior fire-proofing as landscape mulches and should be used when mulch is needed that directly abuts flammable structural materials such as siding or decking. We would also recommend, however, that any windblown debris that has collected on the rocks be regularly removed as to prevent small debris fires from igniting structures.

Green, closely mowed sod will provide excellent fire-proofing in the landscape. We would caution however that sod allowed to grow tall (> 10 cm/4 inches) and become dry would have a similar relative flammability as the pine needles and wheat straw. With this in mind we recommend keeping sod several feet away from flammable structural materials.

Dense, finely ground/screened materials such as the garden compost and the shredded bark proved to have excellent fire-proofing characteristics. These materials could possibly smolder over many days and may eventually cause other

[1]A two-way ANOVA was run on time to ignition using only data from propane torch ignitions. No statistically significant difference was found for site (df = 2, $F = 0.70$, $P = 0.50$) or the interaction of site and material (df = 12, $F = 0.66$, $P = 0.78$), but a significant difference was found due to type of mulch material (df = 6, $F = 4.66$, $P = 0.001$).

materials to ignite but it appeared to the authors that it would be an unusual occurrence. Again, as with sod, we recommend keeping a border of several feet between these mulches and any flammable structures or other improvements.

The wood chips and bark nuggets were less desirable in their fire-proofing characteristics. However, they do have a place in the landscape. We recommend that these materials be used outside Zone 1 of the property. (Zone 1 is defined as an area 4.6–9.2 m (15–30 feet) around the structure [DeGomez and Jones 2013b]). Because of the high amount of air space between these particles they could eventually spread fire to other flammable materials (structures and plants) over time.

The wheat straw and pine needles were the least desirable in their fire-proofing characteristics. We recommend that these materials be used well outside Zone 1 of the property.

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