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Comments: Patterns of Aspen (Populus tremuloides) regeneration following the Spring 2016 Prescribed Fire in the Hunter Creek Valley, Pitkin County, CO
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Overview:
The goal of this project was to test if the May 2016 prescribed fire in the Hunter Creek Valley stimulated aspen (Populus tremuloides) regeneration. To evaluate the ecological outcomes of the fire for the aspen cover type, I measured aspen forest characteristics in 200m2 plots in burned (treatment plots) and unburned (control plots) sites. Overall the prescribed fire increased aspen regeneration considerably. Specifically, in the burned area, the density of new aspen stems increased from an average of approximately 200 stems per acre in August 2015 to an average of >2,000 stems per acre in August 2016. Young aspen stem density did not change notably in the unburned plots from 2015 to 2016. The regeneration response of aspen to the prescribed fire was generally related to the severity of the fire, with high-severity fire resulting in more aspen regeneration.
Background:
The May 2016 prescribed fire in the Hunter Creek Valley adjacent to Aspen, CO had multiple objectives, however, the influence on the aspen forest type has wide ranging implications for conservation and adjacent communities. More specifically, because aspen forests are relative hotspots of biodiversity in the Rocky Mountains (Chong et al. 2001, Kuhn et al. 2011) they are a critical forest type for restoring or maintaining biodiversity in the region. In the context of adjacent communities, aspen forests can help protect communities from wildfire by decreasing the likelihood of wildfire ignition (Jones and DeByle 1985), and generally reducing fire spread potential and extreme fire behavior (Brown and Simmerman 1986, Smith et al. 1993). In moderate fire weather conditions, the relatively high fuel moisture levels of aspen forests mean that they may act as fire breaks (Debyle et al. 1987). In addition to the ecological and wildfire protection importance of aspen, they are also valued for their beauty and consequently their contributions to the tourism-based economy in the region.
Given the broad importance of the aspen forest type, the rapid decline of aspen forests across much of the Colorado Rockies in the early 2000s was of significant concern. Severe drought and high temperatures in the early 2000s have been identified as the primary reason for the sudden decline of aspen in the region (Worrall et al. 2013). Nonetheless, because aspen is a fire-adapted species, fire exclusion practices of the 20th century undoubtedly contributed to its overall decline and likely exacerbated the impacts of the drought by shifting landscape dominance to older, more drought-susceptible stands. Canopy mortality resulting from the early 2000s drought initiated new aspen regeneration in some areas, although at much lower densities than in post-fire sites.
Because aspen regenerates vigorously through "suckering" from existing roots following fire events (Romme et al. 1995), fire has the potential to reestablish aspen forests impacted by decline in the early 2000s. Fire initiates aspen suckering by killing overstory trees which stops the production of hormones that inhibit new aspen suckers and initiates the production of hormones that promote suckering (Bartos 2001). Consequently, prescribed fire is a potential prescription to restore aspen landscapes. However, it is not clear that prescribed fire will result

in the strong suckering response that is typical for aspen because of damage to aspen root structures from the early 2000s drought, which might limit sucking response to fire (Worrall et al. 2010). Whereas there is limited information on how pre-fire drought-caused mortality might influence post-fire regeneration, one study in the region did look at aspen suckering response to timber harvest to test for an influence of pre-harvest drought impacts on suckering response. In this study, Shepperd et al. (2015) found that post-treatment aspen sucker density was contingent on pre-treatment overstory mortality. Specifically, sucker densities following canopy removal were lower in stands with more pre-treatment overstory dieback and mortality. This suggests that prescribed fire in drought-impacted stands might not result in high aspen sucker densities.
In addition to uncertainty about the response of aspen regeneration following fire, because of herbivory by

unnaturally large populations of ungulates, primarily elk, it is not certain that new aspen suckers will recruit to form a new forest canopy (Baker et al. 1997). Larger fires (e.g. >10,000 acres) that create abundant suckering across large areas have been found to increase the likelihood of aspen recruitment to the forest canopy following fires by spreading out and diminish the overall impact of herbivory (Smith et al. 2011). In contrast, high-severity fires, even through they often result in abundant aspen suckers, can increase ungulate impacts on aspen because such fires often reduce shrub and herbaceous cover and concentrate browse on aspen (Bailey and Withal 2002, Bates et al. 2006). Overall the influences of drought damage to root structures and herbivory mean that there is uncertainty regarding the ability of prescribed fire to restore aspen forests.

Resampling:

In the late summer of 2015, prior to the May 2016 prescribed fire, I established 60,10 x 20m (200m2) plots in the aspen cover type on the south-facing slopes of the Hunter Creek Valley. Because the exact boundary of the prescribed fire was not known in 2015, I established plots randomly across the landscape with the expectation that some would burn and serve as treatment plots and others would not be within the burn perimeter and could serve as control plots. Plots were not permanently marked and instead plot corner locations were recorded using a GPS and relocated using their recorded location. I relocated and resampled all 60 plots in August 2016. Of the 60 plots established in 2015, 21 burned in the prescribed fire (Figure 1). The fire killed all small aspen stems (i.e. <2m tall and <3cm diameter at breast height) within burned plots, but overstory aspen mortality was highly variable in burned plots and ranged from 0 to 100% of overstory trees that were killed by the fire. Although an equal division in the number of treatment and control plots would have been ideal, having 21 of the original plots burn provides a solid basis to investigate the influence of the prescribed fire on patterns of aspen regeneration.

Did the prescribed fire increase aspen suckers?

The prescribed fire in Hunter Creek notably increased the density of aspen regeneration within the burn area. The abundant new aspen regeneration (hereafter referred to as "suckers" based on the likelihood that the new regeneration is a result of resprouting, also called "suckering," in contrast to establishment via seed) that is evident when walking through the burn area is also

supported by measured sucker densities within established plots. Within plots that burned (n=21), the average density of aspen suckers increased from 190 suckers per acre in 2015 to 2,384 suckers per acre in 2016. Based on the relatively small increase in the density of aspen suckers (65 suckers per acre) in control plots (n=39) from 2015 to 2016, it is clear that the

increase in aspen sucker density in the burned plots is a result of the influence of the fire and not other potential drivers such as the anomalously wet spring and early summer of 2015.

Although the prescribed fire generally increased aspen regeneration, aspen sucker density is clearly variable within the burn perimeter and this variability is also evident from plot data. Within resampled plots in August 2016, aspen sucker density ranged from no post-fire suckers to >14,000 suckers per acre. Whereas there are no clear statistical relationships between potential influences on patterns of aspen sucker density and actual sucker density, the relationship with fire severity is conspicuous (Figure 2). Specifically, the endpoints of the fire severity spectrum created striking contrasts in patterns of aspen regeneration. Three sites that burned but had little to no aspen canopy tree mortality associated with the fire, had no or few new suckers following the fire. These three burned sites actually declined in aspen regeneration density as a result of sucker mortality from the low-severity fire combined with no new regeneration. On the opposite end of the fire severity spectrum are two plots where 100% of the overstory aspen were killed by the fire. These two plots had the highest density of post-fire aspen suckers with >12,000 suckers per acre. To be clear, outside of the sites with extremely low and high canopy mortality associated with the fire, patterns of regeneration did not follow linear or predictable relationships associated with canopy mortality (Figure 2). Nonetheless, fire severity was the only interpretable influence on post-fire patterns of aspen sucker density. Surprisingly, there was no relationship between pre-fire overstory mortality from the early 2000s and post-fire sucker density (Figure 3). It is possible that there is an interactive influence of pre-fire mortality and fire- related mortality on patterns of suckering, but the limited number of burned plots (n=21) constrained the potential for a statistical test of interactions and no qualitative relationships are evident.

The general abundant aspen regeneration resulting from the prescribed fire generally restored burned areas and should facilitate aspen recruitment to the forest canopy. Whereas there was considerable aspen regeneration in these sites prior to the prescribed fire, likely in response to canopy mortality early in the 2000s, the prescribed fire converted many of the burned stands back to dense, single-cohort, post-fire stands that likely dominated the landscape prior to the early 2000s drought. At this time it is not clear what influence the extent of the fire (approximately 900 acres) and abundance of post-fire suckers will be on the impacts of herbivory over the next few years. No herbivory was recorded in August 2016, however, in Hunter Creek, elk are perhaps more likely to use the site as a transition site between winter and summer ranges and therefore impacts would be unlikely in the late spring and summer months and would not have been evident at the time of sampling in August 2016.

Figure 1. Map the the study area and sampled forest plots.

Figure 2. Aspen sucker density following the 2016 prescribed fire (y-axis) in relation to the percent of the canopy basal area killed by the 2016 prescribed fire.

Figure 3. Aspen sucker density following the 2016 prescribed fire (y-axis) in relation to the percent of the canopy basal area killed by the early 2000s drought.