COLORADO FOREST
RESTORATION INSTITUTE
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Uncompahgre Collaborative Forest Landscape Restoration Program Gambel Oak Study Summary

Introduction

Vegetation management and fuel mitigation are increasingly used to reduce fuel hazard, alter fire behavior, and restore ecosystem structure and function. In ponderosa pine (*Pinus ponderosa*) systems of western Colorado, thinning, mastication, and/or prescribed burning treatments are used to manage pine and oak species. In this system, there are conflicting management concerns around Gambel oak (*Quercus gambelii*). Because Gambel oak can grow as both a shrub and a tree in this area, Gambel oak can be a hazardous ladder fuel in ponderosa pine forested ecosystems. However, it is also important wildlife habitat and forage, especially as its young shoots are preferentially grazed by large ungulates. Although some information on understory vegetation response to Gambel oak treatments exists, much of this research was developed for the Southwestern U.S. and may not reflect the unique environmental conditions on the Uncompahgre Plateau nor the conditions of the northern extent of Gambel oak's range in Colorado. At the northern extent of Gambel oak's range on the Uncompahgre Plateau and Colorado Front Range mountains, Gambel oak often grows as a low shrub and occasionally as taller shrubs or mature trees (Figure 1), whereas in the southern extent of its range, oak only may grow as tall shrubs or large mature trees. There is evidence that Gambel oak in Colorado and Utah have more ramets available for resprouting in the roots than the same species in Arizona and New Mexico (Kaufman et al., 2016). Due to this variability, it is unclear whether information and research on Gambel oak from the southwestern U.S. applies to the northern extent of its range in Colorado. Locally relevant information on Gambel oak management is greatly needed to understand understory vegetation response to cutting and prescribed burning treatments in this species.

In 2016, the Colorado Forest Restoration Institute (CFRI), in partnership with the Uncompahgre Plateau Collaborative Forest Landscape Restoration Program and the U.S. Forest Service, set out to research how Gambel oak treatments such as cutting, mowing, and prescribed fire influence Gambel oak growth and understory vegetation, particularly for the purposes of improving wildlife habitat and browse potential, and to better inform the effectiveness of treatments in Gambel oak on the western slope of Colorado. CFRI aimed to answer the following research questions:

1) How does understory vegetation respond to mechanical treatment (mowing) of Gambel oak?

2) What is the growth response of Gambel oak following treatments in terms of density and growth of sprouts?

3) What influence does Gambel oak treatment have on other tree regeneration?

4) What is the effect of mowing treatments on ground fuel loading?

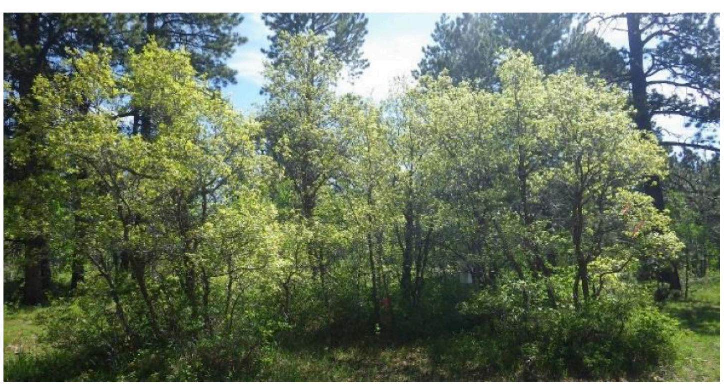

Figure 1: Photo depicting a typical Gambel oak patch surrounded by ponderosa pine in the La Fair treatment unit in the northwest portion of the Uncompahgre Plateau, CO.

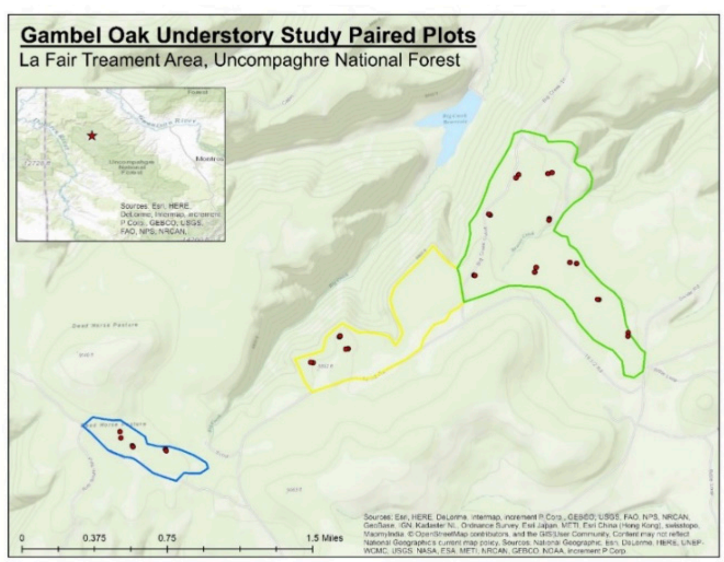

Figure 2: Map of La Fair treatment areas 1A, 1B, 1C, and paired plots (red dots) on the Uncompahgre Plateau.

Methods

CFRI implemented a paired plot study design in randomly located patches of Gambel oak within the La Fair treatment area in the northwestern part of the Uncompahgre Plateau, Colorado (Figure 2). Patches were selected that were similar in patch size and size of Gambel oak within each patch. CFRI sampled 15 paired plots, for a total of 30 plots. Each circular plot had a 3 m radius (Figure 4). Variables that were measured include regenerating and overstory stems of Gambel oak, vegetative cover, forest floor cover, and abiotic factors such as slope and aspect. In late summer 2016, the area underwent mastication treatments of Gambel oak, aspen, and small diameter ponderosa pine. Patches containing one of each paired plot were randomly mowed (Figure 3) while the other patch in each pair remained as un-mowed/control. CFRI returned to remeasure the treated and untreated plots in July 2017 for 1-year post-treatment measurements, in July 2019 for 3-year post-treatment measurements, and in July 2021 for 5-year post-treatment measurements. Measurements were taken by different observers between years, but ample care was taken to calibrate to each observer's cover estimates, so the effect of human error on percent cover estimates is marginal.

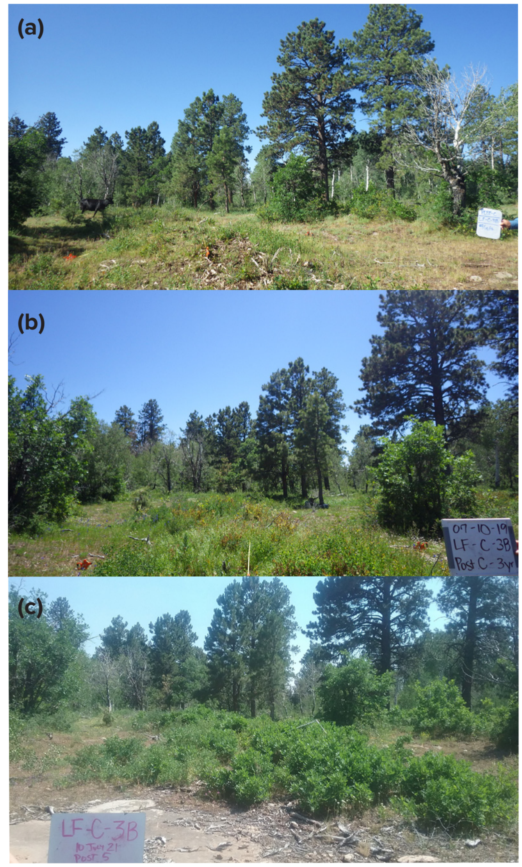

Figure 3: (a) 1-year post-treatment, (b) 3-year post-treatment, (c) and 5-year post-treatment photographs of a Gambel oak patch and plot that received mowing treatment.

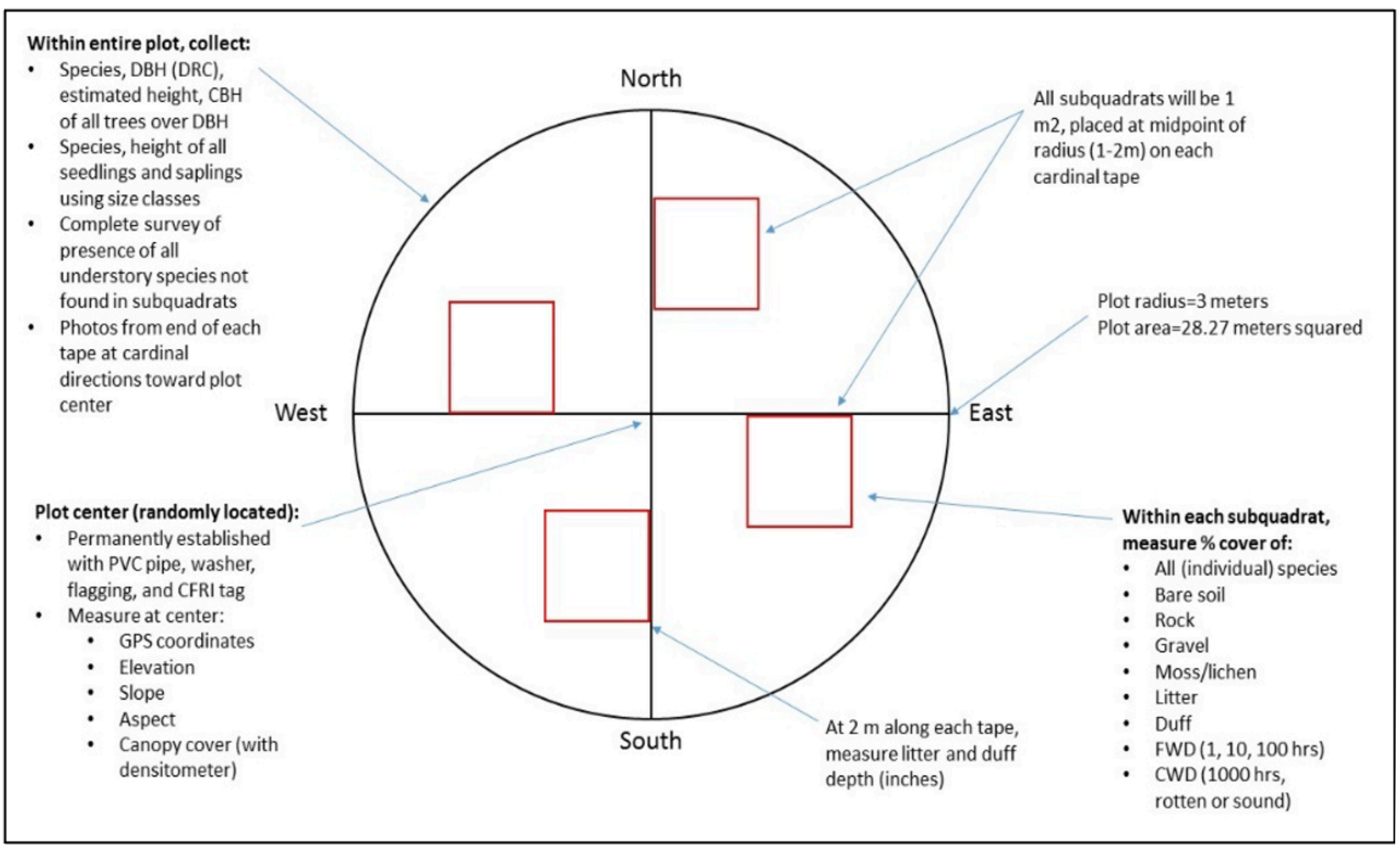

Figure 4: Plot depiction. Transects were placed along cardinal directions 3 m from a permanently established plot center. Tree species, height, DBH, CBH, tree seedlings and saplings, species and size class, and understory species presence were measured for the entire plot. Within 1 m^2 subplots centered on each transect, understory species and forest floor cover were recorded. Topographic variables, such as elevation, slope, and aspect, were measured at plot center.

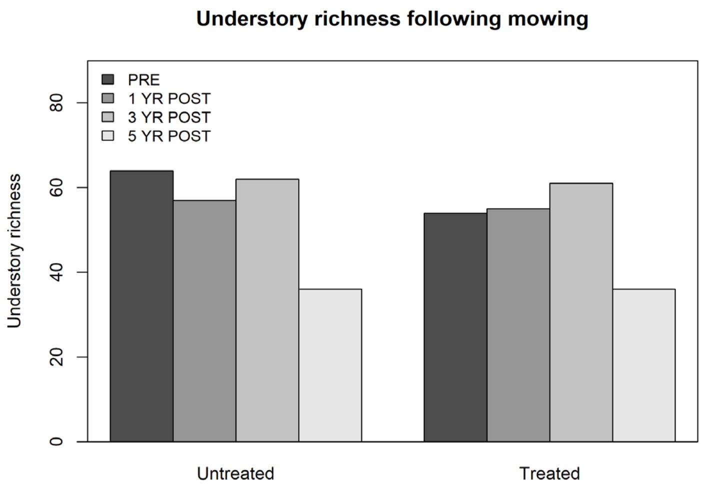

Figure 5: Bar plots depicting total understory vegetation richness in control and mowed stands.

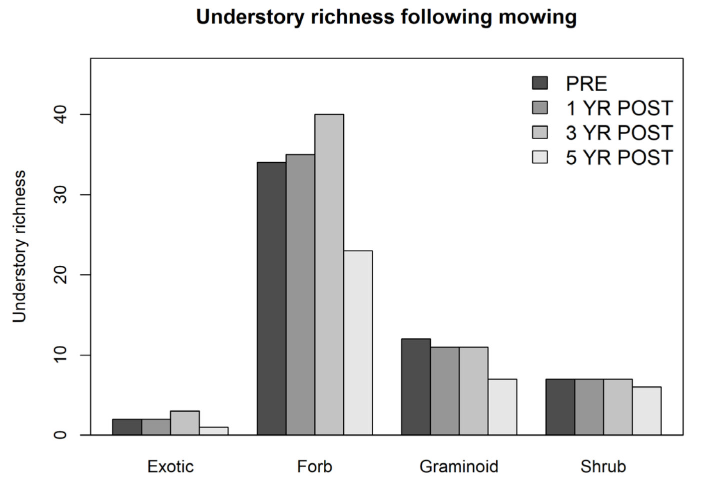

Figure 6: Bar plots depicting understory vegetation richness by functional group following mowing treatments.

Results and Discussion

Following mowing, understory vegetation saw small changes in richness and diversity and notable changes in percent cover by growth form in the first 3 years following treatment, and larger changes 5-years post-treatment. In mowed plots, richness increased from 54 to 66 total species between pre-treatment and year-3 measurements (Figure 5), most of which is accounted for by native forbs (Figure 6) but declined to 38 total species 5-years post-treatment. Richness of exotic species increased from two species (Kentucky bluegrass (*Poa pratensis*) and dandelion (*Taraxacum officionale*)) during pre-treatment and 1-year post treatment measurements, to three species (aforementioned species and Shepherd's purse (*Capsella bursa-pastoris*)) during 3-year post-treatment measurements and then declined to just one species (Kentucky bluegrass) during 5-year post-treatment measurements (Figure 7). While the richness of exotic species increased, percent cover of exotics decreased by one third in the 5-year period (Figure 8), accounted for by decreases in Kentucky bluegrass (*Poa pratensis*) and dandelion (*Taraxacum officionale*; Figure 8).

After mowing in 2016, percent cover of every category of growth form (graminoid, forb, shrub, and exotic) decreased during year-1 post-treatment measurements, then increased during 3-year post-treatment measurements but not to the level they were during 1-year measurements, then declined further during 5-year post-treatment measurements (Figure 8). Percent cover of forbs decreased from 3% to 2% cover in the same period. Percent cover of graminoids decreased by >50% in pre-treatment measurements compared to 1- and 3-year post-treatment measurements and decreased by >70% between pre-treatment and 5-year post-treatment measurements. This contradicts the expected trend that mechanical treatments will improve production of grasses and forbs (Kaufmann et al, 2016), but this is likely due to a dramatic increase in Gambel oak resprouting following treatment (Figure 10). Additionally, during 5-year post-treatment measurements, a decline in Diversity Indices (Table 1) illustrate that in both untreated and mowed plots there was a decline in understory species diversity, so it is likely that climatic influences account for declines in cover of graminoid and forb cover during year-5. Predictably, shrub

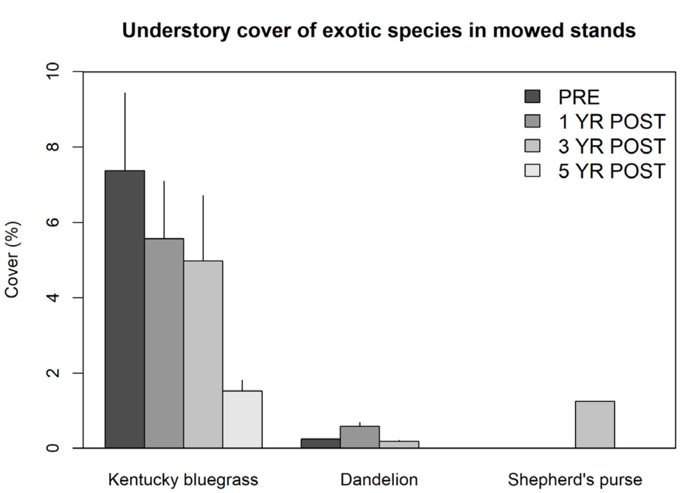

Figure 7: Bar plots depicting mean (±1 standard error of the mean) cover of individual exotic species in mowed stands of Gambel oak.

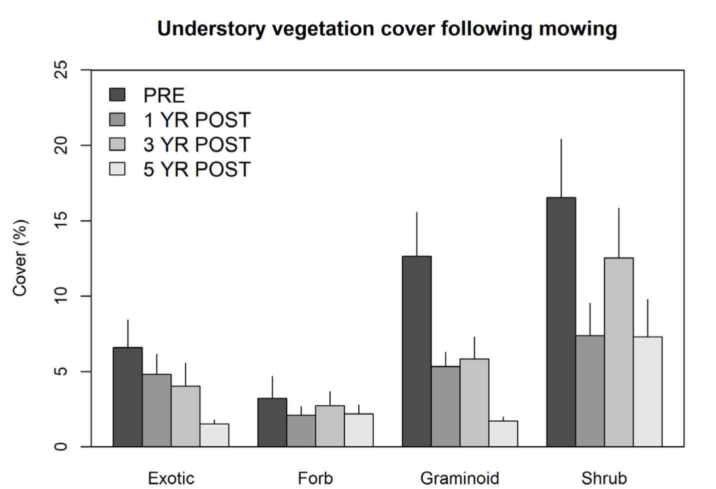

Figure 8: Bar plots depicting mean (±1 standard error of the mean) understory vegetation cover by functional group in mowed stands.

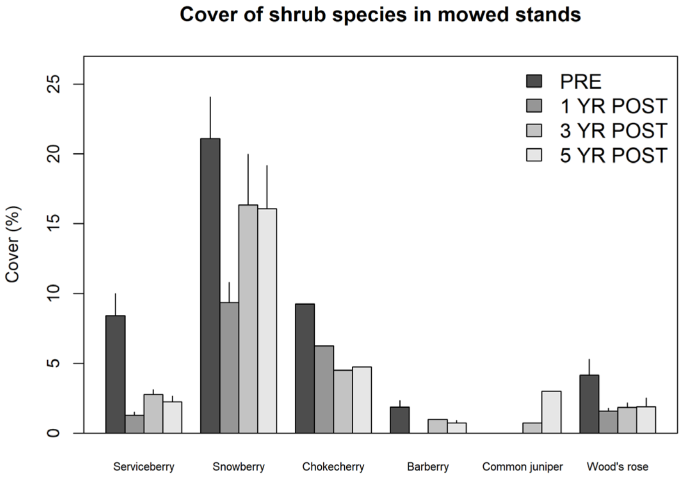

Figure 9: Bar plots depicting mean (±1 standard error of the mean) of the cover of shrub species by functional group. Gambel oak is omitted from this summary, as it is included in its own figure (Figure 10).

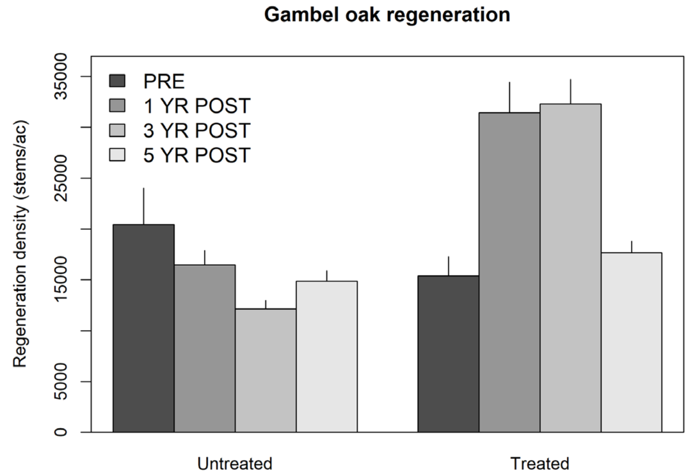

Figure 10: Bar plots depicting mean (±1 standard error of the mean) Gambel oak regeneration density in control and mowed plots pre- and post-treatment.

cover decreased drastically the first year after mowing, with percent cover reduced by >50%. By 3-years post-treatment, shrub cover had increased to 75% of the pre-treatment value but declined back to <50% of the pre-treatment values 5-years following mowing (Figure 8). This large increase 3-years post-treatment was largely due to the quick regrowth of snowberry (*Symphoricarpos rotundifolia*; Figure 9). In 2017, snowberry cover was half of what it had been before mowing, and by 2019 cover of snowberry regained 75% of the pre-treatment value (Figure 9). Serviceberry (*Amelanchier alnifolia*), barberry (*Mahonia repens*), and Wood's rose (*Rosa woodsii*) grew back but more slowly. Chokecherry (*Prunus virginiana*) cover decreased through 3-years post-mowing, then slightly increased 5-years post-mowing. Additionally, one new shrub species - common juniper (*Juniperus communis*) - established in mowed plots where it had not been observed before 2017 (Figure 9). Diversity Indices fluctuated between years in un-mowed plots and slightly but steadily increased in mowed plots except in year-5 measurements when both Indices saw a decline in species diversity; again, this is likely due to a climatic influence such as drought. On average, these plots have very high diversity values (Table 1).

In un-mowed plots, there was a small and steady decrease in density of Gambel oak in 1- and 3- year measurements, with a slight increase in 5-year measurements, while treated plots had a large increase in regeneration density between 1- and 3-year post-treatment measurements, and dropped dramatically during 5-year post-treatment measurements

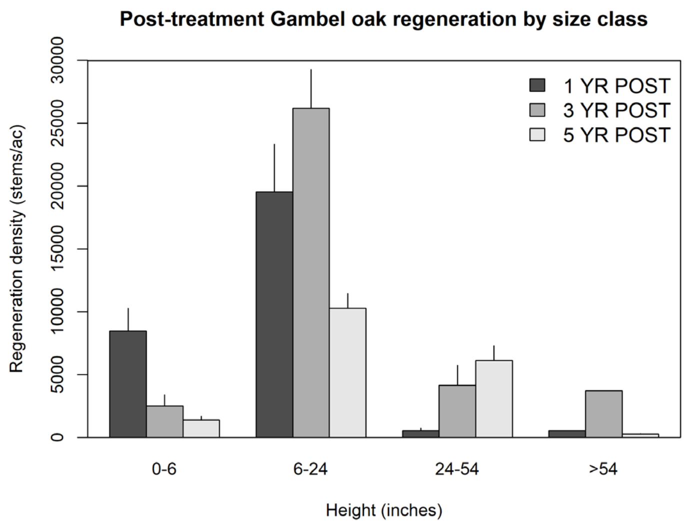

Figure 11: Bar plots depicting mean (±1 standard error of the mean) Gambel oak regeneration density by size class in mowed plots.

(Figure 10). One- and 3-years after mowing, Gambel oak regeneration density more than doubled. This drastic increase in Gambel oak sprouts suggests that mowing might be counter-productive if removing Gambel oak is the goal, at least in the short term. However, there was a dramatic drop in Gambel oak regeneration 5-years post-treatment, indicating that this sprouting species may have leveled off in resprouting following disturbance, or have begun a self-selection process. Longer term monitoring will yield more information on regeneration trends. Predictably, the regenerating stems were taller on average in 3-years

	Untreated				Treated			
	Pre	1-yr post	3-yr post	5-yr post	Pre	1-yr post	3-yr post	5-yr post
Shannon	3.8025	3.7296	3.8591	3.1276	3.6627	3.7582	3.8815	3.1882
Simpson	0.9708	0.9694	0.9740	0.9381	0.9669	0.9718	0.9746	0.9462

Table 1: Results for Shannon's and Simpson's Diversity Index in control and mowed plots pre- and post-treatment. Shannon's Diversity Index values range from 0-4, where 4 indicates a high level of species richness and evenness. Simpson's Diversity Index values range from 0- 1, where 1 indicates the highest level of species richness and evenness.

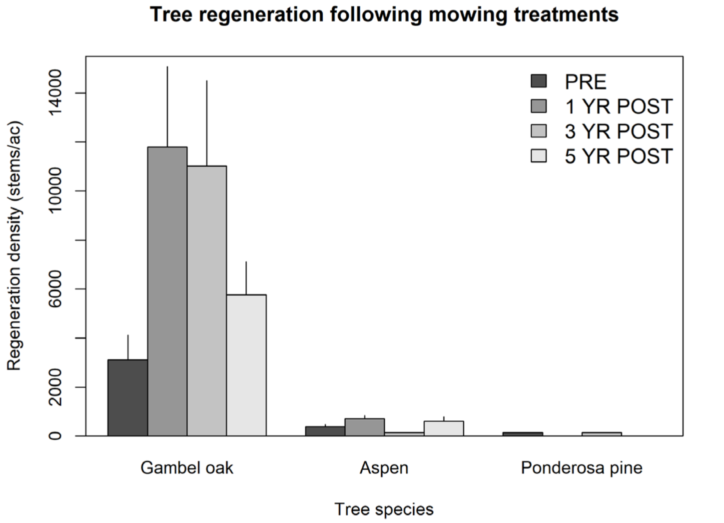

Figure 12: Bar plots depicting mean (±1 standard error of the mean) tree regeneration density in mowed plots pre- and post-treatment.

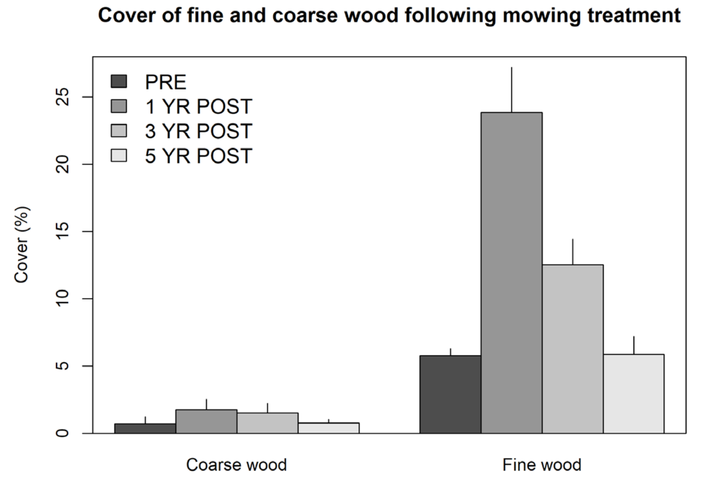

Figure 13: Bar plots depicting mean (±1 standard error of the mean) coarse and fine wood cover pre- and post-mowing treatments.

post-treatment than they were 1-year following mowing (Figures 11 & 14). On average, 3720 stems per acre were already surpassing a height of 54 inches 3-years following mowing.

Along with the large increase in Gambel oak sprouts, mowed plots saw only a slight increase in aspen 5-years post-treatment, and while only one ponderosa pine seedling was observed in pre-treatment measurements, only a single ponderosa pine seedling was observed 3-years post-treatment (Figure 12). It is possible that the same seedling was missed in the 1-year post-treatment visit, or possibly it died between visits and another seedling sprouted before 3-year post-treatment measurements; no ponderosa pine seedlings were observed in 5-year post-treatment measurements.

Mowing treatment caused a slight increase in coarse woody debris and a large increase in fine woody debris initially following treatment (Figure 13). Three-years post-treatment, percent cover of fine wood decreased by nearly half from immediate post-treatment values and declined to nearly pre-treatment values 5-years post treatment. Some of the fine wood probably had begun decomposing, or they may have been covered by leaf litter or shrub foliage and so were underestimated in visual estimates of cover.

Future actions: Prescribed burning is planned for this treatment area, pending appropriate conditions. This will provide more information on the combined effects of mechanical thinning and prescribed burning for the management of Gambel oak. At the time of writing there is no funding available to remeasure these plots, but continued long-term monitoring would enhance understanding of Gambel oak regeneration and understory recovery dynamics.

Figure 14: Photos illustrating a) Gambel oak regeneration representative of size class 0-6" tall; b) Gambel oak regeneration representative of size class 6-24" tall; c) Gambel oak regeneration representative of size class 6-24" tall and with many stems regenerating from a mowed stump.

Acknowledgements:

Colorado State University acknowledges, with respect, that the land the university is on today is the traditional and ancestral homelands of the Arapaho, Cheyenne, and Ute Nations and peoples. This was also a site of trade, gathering, and healing for numerous other Native tribes. Additionally, the Uncompahgre Plateau and surrounding landscapes are the traditional and ancestral homelands of the Tebeguache (Uncompahgre) Ute people. We recognize the Indigenous peoples as original stewards of this land and all the relatives within it. As these words of acknowledgment are spoken and heard, the ties Nations have to their traditional homelands are renewed and reaffirmed. CSU is founded as a land-grant institution, and we accept that our mission must encompass access to education and inclusion. And, significantly, that our founding came at a dire cost to Native Nations and peoples whose land this University was built upon. This acknowledgment is the education and inclusion we must practice in recognizing our institutional history, responsibility, and commitment.

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Works Cited

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