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# Effects of fuels treatments and wildfire on understory species and fuels in the ponderosa pine zone of the Colorado Front Range

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**Project Title**: Effects of fuels treatments and wildfire on understory species and fuels in the ponderosa pine zone of the Colorado Front Range

**Project Location:** Burned, treated, and unburned/untreated ponderosa pine and Douglas-fir forests of the South Platte and Pike Ranger Districts, Pike National Forest, Colorado

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**Project Overview**

The first clear indication that unnaturally dense forest conditions existed in ponderosa pine – Douglas-fir forests of the Colorado Front Range was the Buffalo Creek Fire, a large, catastrophic wildfire that burned in 1996. Ongoing research in the Front Range indicated that the Buffalo Creek Fire likely would have burned very differently under pre-settlement forest conditions; early photographs and written descriptions, as well as fire history and stand reconstruction data, all suggested that historically these forests were characterized by a matrix of low-density forests and shrubland or grassland openings that was created and maintained by a mixed-severity fire regime. As a result of the Buffalo Creek Fire and several other large and intense wildfires in the Colorado Front Range – Bobcat Gulch and Hi Meadows in 2000, and Schoonover, Snaking, and Hayman in 2002 – managers began to plan forest restoration treatments to reduce the risk of unnaturally large, stand-replacing fires, and to return ecological sustainability to the landscape through research-guided restoration actions.

Managers and others are obviously concerned about how both forest restoration treatments and intense wildfires impact the forest overstory, and these impacts are widely studied. Less studied, though, are how these disturbances impact the forest floor – in terms of both understory species composition and surface fuels that would carry a future fire. As wildfires continue to occur in the Front Range, and as forest restoration treatments continue to expand to much larger land areas, it is becoming critical for forest managers to understand how both restoration actions and wildfire influence forest understories and fuel loadings.

Our objective for this project was to conduct a holistic ecosystem evaluation of the changes in forest understory communities, fuel characteristics, and potential fire behavior that result from restoration activities and wildfires. To address this objective, we established one study area within a recently treated forest, one study area within a forest recently burned by wildfire, and three study areas within untreated, unburned reference forests. All study areas were located

within the Upper South Platte Watershed of the Pike National Forest, Colorado, USA, approximately 60 km southwest of Denver. Our treated study area was located in an area that was mechanically thinned in late 2002 and early 2003. The primary management objective was to reduce the risk of crown fires and to restore sustainable and ecologically appropriate overstory conditions by decreasing stand density, minimizing fuel ladders, and increasing canopy openings. Small canopy trees were sheared near ground-level using a boom-mounted hot saw on a tracked vehicle. Downed tree tops and limbs were crushed and further broken apart by driving over them with the tracked vehicle. In early 2003, where terrain and financial resources permitted, hand crews used chain saws to create additional openings and further reduce basal areas. The hand-cut trees were subsequently cut-to-length, piled, and burned. Our wildfire study area was located within the Hayman Fire, which burned 55,800 ha in 2002. Approximately half of the Hayman Fire area burned as a stand-replacing crown fire, much of it in a single day of extreme weather. The other half of the area burned as a mixed-severity fire, creating a mosaic of burn severities on the landscape. Our study area was situated in a transitional zone between these two fire behaviors, and therefore contained components of each. Three reference study areas were established near the treated and wildfire study areas to provide information about the untreated and unburned condition. The reference sites had not been disturbed by fire or other agents in the preceding five years.

Each study area contained fifteen 0.1-ha plots, which were stratified by aspect (north, south, and east/west) to minimize the potential effects of topography on our findings. In each plot we measured understory species composition and cover, surface fuel loading, and overstory structure. Understory data were measured in all plots in 2004, 2005, and 2006, while surface fuels and overstory data were generally only measured in one of the three years. Prefire understory, surface fuel, and overstory data collected in 1997 were also available for the Hayman Fire plots.

**Summary of Findings to Date**

*Forest restoration treatments increased exotic richness and cover, and the level of exotic invasion increased as treatment intensity increased.*

- Exotic richness was significantly greater in treated plots than in nearby reference plots for all three years of observation (2004-2006). While the number of exotics does not appear to be tapering off in the treated plots, the total number of exotic species found within a plot is generally low and suggests that exotics may not be a threat at this point in time.

- Exotic richness in treated areas was most significantly correlated with wood cover (i.e., slash from the restoration treatments). The number of exotics increased as the cover of wood increased, suggesting that treatment intensity is probably important in determining invasibility of treated areas.

- Within treated and reference areas, we found eight species listed as noxious weeds in Colorado: cheatgrass (*Bromus tectorum*), nodding plumeless thistle (*Carduus nutans*), white knapweed (*Centaurea diffusa*), Canadian thistle (*Cirsium arvense*), dalmatian toadflax (*Linaria dalmatica*), butter and eggs (*Linaria vulgaris*), common tansy (*Tanacetum vulgare),*

and common mullein (*Verbascum thapsus*). Of these species, only Canadian thistle and mullein were ever significantly more abundant in treated areas relative to reference areas; significant differences in Canadian thistle and mullein abundances were found in 2005 and 2006 but not in 2004.

*Forest restoration treatments did not appear to stimulate the growth of blue grama and dotted gayfeather (*Bouteloua gracilis *and* Liatris punctata*), two native understory species of interest.*

- Land managers were optimistic that forest restoration treatments would encourage the growth of blue grama and dotted gayfeather, two species important to the Pawnee montane skipper (*Hesperia leonardus montana*). Unfortunately this was not the case. The Pawnee montane skipper is a threatened butterfly indigenous to the Upper South Platte Watershed, and requires open forest conditions with blue grama and dotted gayfeather in the understory.

- The impacts of forest restoration treatments on other important native understory species are still being investigated.

*Forest restoration treatments altered forest structure by creating more open, less dense stands, but effects on surface fuels were more diverse.*

- Restoration treatments significantly reduced tree basal area, tree density, and overstory canopy cover compared to reference areas in the vicinity. Significantly greater quadratic mean diameters in forest restoration treatments compared to reference areas reflects the loss of smaller trees that could act as ladder fuels.

- Many of the fine surface fuel classes associated with fire intensity and spread showed no consistent increases or decreases with restoration treatment. Fuel loading of litter, duff, 1-hr fuels (< ¼ inch diameter), and 100-hr fuels (1 to 3 inch diameter) did not differ between forest restoration treatments and reference areas. Depth of litter, duff, and fuel beds were also similar among treated and reference plots. Furthermore, there were no differences in live surface fuel loadings (i.e., biomass of shrubs, small trees, and herbs) between treated and reference areas.

- However, restoration treatments significantly increased 10-hr fuels (¼ to 1 inch diameter) compared to untreated ponderosa pine reference stands. Sound fuels >3 inches in diameter (1000-hr fuels) were also greater following restoration treatments than in two of three reference stands.

*Preliminary FFE-FVS modeling results suggest that forest restoration treatments impacted potential short-term wildfire behavior by reducing the risk of crown fire, but did little to decrease effects of wildfire on tree mortality.*

- For all FFE-FVS modeled fire weather scenarios (low, moderate, high, and extreme fire weather conditions), potential wildfire behavior was less severe in treated versus reference areas. When fire weather conditions were low, all wildfires were predicted to be surface fires in the treated areas, but some reference areas burned as passive crown fires under this fire

weather condition. Under extreme fire weather conditions, treated areas never exhibited active crown fire, though active crown fires were predicted in reference areas.

– Despite the lessened wildfire severity in restoration treatments relative to reference areas, there was no difference in basal area mortality between treated and reference areas under low, moderate, high or extreme fire weather scenarios.

– Using stylized fuel models rather than field-measured fuel loads in the FFE-FVS modeling runs may have reduced the accuracy of fire behavior predictions. FFE-FVS generally chose stylized fire behavior models that had surface fuel loads in excess of actual fuel loads measured on the ground. This was particularly true for 1-hr fuels. This finding has implications for the reality of model outputs and further analyses are warranted.

*The Hayman Fire has had little effect on native understory plant communities.*

– We found that the 2002 Hayman Fire did not alter native plant richness from prefire levels during the first two postfire years (2003 and 2004). Native plant richness did increase significantly during 2005 and 2006, which was largely due to an increase in the number of short-lived forbs. Furthermore, we saw no effect of burn severity on native plant response — lightly burned areas contained similar numbers of native species as moderately and severely burned areas for all postfire years.

– On average, nearly 80% of the native plant species found in the prefire survey were also found in the postfire surveys. The proportion of prefire species found in the postfire surveys increased slightly but non-significantly through time. The surprisingly high level of compositional similarity between prefire and postfire native communities is likely because the majority of these species exhibit regeneration strategies that promote survival or rapid re-establishment after disturbance, such as sprouting, seedbanking, and long-distance seed dispersal. For example, we found that for all species with available information on postfire sprouting potential, 72% are known to sprout after even severe fire, while only 17% of the species are not capable of sprouting after fire (mostly annuals).

*The degree of exotic invasion after wildfire was related to burn severity and time since fire*.

– The Hayman Fire's effect on exotic richness and cover was highly dependent on burn severity and time since fire. There was little effect of fire on exotic richness and cover in lightly burned areas where less than 50% of the forest overstory was killed. In contrast, fire greatly favored exotic establishment and growth in moderately and severely burned areas where 50% or more of the forest overstory was killed. In these more severely burned areas, the increase in exotic richness and cover was most profound during the last two years of the study (2005 and 2006, three to four years after fire), with little indication that exotic levels in these burned sites would return to prefire levels in the near future. However, it is important to note that even our most heavily invaded plots had relatively low values of exotic richness and cover.

- Few exotic species were widespread and abundant within the Hayman Fire. Mullein (*Verbascum thapsus*) was by far the most prevalent exotic species found over the course of this study, though its cover averaged only 0.2% and never exceeded 2% in a plot at any point in time. While mullein cover was affected by fire, it only increased significantly over prefire levels in 2005. These results suggest that the Hayman Fire did not allow mullein to gain a foothold within the fire's perimeter, though its noxious weed status suggests that it should be carefully monitored. It is noteworthy that cheatgrass (*Bromus tectorum*), a highly invasive exotic grass of particular concern to western land managers, was not found in our study area during the study. However, it was seen in nearby burned areas each year we sampled and was found in our 2007 survey (2007 measurements are not a part of this JFSP project).

- The composition of the prefire exotic community greatly influenced postfire community composition, in that over 60% of a plot's prefire exotic species were also found in the postfire surveys. Furthermore, burn severity and time since fire did not influence the proportion of prefire exotics in the postfire community. However, only 20% of a plot's postfire exotics were those species also found before fire, leaving newly-established exotic species responsible for the bulk of postfire exotic community composition. These new exotic species were most prevalent in moderately and severely burned areas.

*Exotics within the Hayman Fire do not appear to be threatening native plant communities.*

- If exotic species were deterring the establishment and growth of natives, we might expect increases in exotic cover to coincide with decreases in native richness and/or cover. However, we found that exotic cover was either positively correlated or uncorrelated with native richness and cover for all years and burn severities. These findings suggest that exotic species are not currently limiting the establishment and growth of natives. In light of the low exotic cover values observed during the course of this study, this finding is not surprising.

*A flush of ponderosa pine and Douglas-fir regeneration occurred within the Hayman Fire perimeter in late 2006 and may influence fire behavior in the long-term.*

- Hayman Fire plots were again measured in 2007 (though not for this JFSP project), and we found germinants in 52%, 37% and 0% of low, moderate, and high severity subplots ($1m^2$), respectively. These germinants, if they become established, may have an impact on long-term fire behavior, especially in lightly and moderately burned areas. However this modeling exercise has not yet been completed. We also observed many germinants in treated and reference areas throughout the Upper South Platte Watershed, though data were not collected.

**Deliverables Crosswalk Table**

| Deliverable Type | Deliverable details | Comments | Status |
|---|---|---|---|
| Annual reports | Prepared for JFSP in 2005, 2006, 2007 | | Done |
| Invited Oral Presentation | Fornwalt, P.J., and M.R. Kaufmann. 2006. Short-term effects of fire and postfire rehabilitation on the forest understory: a case study from the Colorado Front Range. Front Range Fuels Treatment Partnership Implementer's Meeting. Denver, CO. | This project was funded by The National Commission on Science for Sustainable Forestry, but utilized data collected with JFSP dollars. | Done |
| Invited Oral Presentation | Fornwalt, P.J., and M.R. Kaufmann. 2006. Short-term effects of fire and postfire rehabilitation on understory vegetation. NCSSF Symposium on Forest Disturbance, Management, and Biodiversity. Denver, CO. | This project was funded by The National Commission on Science for Sustainable Forestry, but utilized data collected with JFSP dollars. | Done |
| Invited Oral Presentation | Fornwalt, P.J. 2006. Exotic plants, restoration, and fire in ponderosa pine forests of the Colorado Front Range. Third International Fire Ecology & Management Congress. San Diego, CA. | | Done |
| Invited Oral Presentation | Fornwalt, P.J. 2007. Exotic plants and fire in Colorado. Colorado Wildfire and Mitigation Conference. Pueblo, CO. 2-hr presentation. | | Done |
| Invited Oral Presentation | Fornwalt, P.J. 2007. Ashes to Asters: understory plants are alive and well after the 2002 Hayman Fire. Manitou Experimental Forest Open House. Woodland Park, CO. | | Done |

| Deliverable Type | Deliverable details | Comments | Status |
|---|---|---|---|
| Poster | Fornwalt, P.J., and M.R. Kaufmann. 2006. The effects of fire, postfire rehabilitation, and thinning on understory plant communities in ponderosa pine/ Douglas-fir forests. Manitou Experimental Forest Open House. Woodland Park, CO. | | Done |
| Poster | Fornwalt, P.J., W.H. Romme, and M.R. Kaufmann. 2007. Exotic plant response to wildfire severity and time since fire in a Colorado ponderosa pine – Douglas-fir forest. 92nd Annual Meeting of the Ecological Society of America. San Jose, CA. | | Done |
| Refereed Publication | Fornwalt, P.J., and M.R. Kaufmann. In review. Short-term effects of fire and postfire rehabilitation on understory vegetation in the Colorado Front Range. Submitted to Fire Ecology. | This project was funded by The National Commission on Science for Sustainable Forestry, but utilized data collected with JFSP dollars. | In review; anticipated publish date of 2008 |
| Refereed Publication | Fornwalt, P.J. and M.R. Kaufmann. In preparation. Exotic plant response to wildfire severity and time since fire in a Colorado ponderosa pine – Douglas-fir forest. To be submitted to Biological Invasions. | | In preparation; anticipated publish date of 2008 |
| Refereed Publication | Fornwalt, P.J., A.L. Lezberg and M.R. Kaufmann. In preparation. Effects of forest restoration treatments on fuel loading and potential wildfire behavior in a montane Colorado forest. To be submitted to Restoration Ecology. | | In preparation; anticipated publish date of 2008 |

| Deliverable Type | Deliverable details | Comments | Status |
|---|---|---|---|
| Refereed Publication | Fornwalt, P.J. and M.R. Kaufmann. In preparation. Prefire understory plant composition strongly influences postfire plant regeneration after a mixed severity wildfire. To be submitted to International Journal of Wildland Fire. | | In preparation; anticipated publish date of 2008 |
| Refereed Publication | Fornwalt, P.J. and M.R. Kaufmann. In planning. Short-term changes in overstory stand structure, surface fuel loading, and wildfire potential after a Colorado mixed severity wildfire. To be submitted to International Journal of Wildland Fire. | | In planning; anticipated publish date of 2009 |
| Tours/ Site Visits | Dennis, C., M.R. Kaufmann and P.J. Fornwalt. 2007. The Hayman Fire: five years of recovery. Sponsored by The Nature Conservancy. | | Done |
| Workshop | Fornwalt, P.J., and M.R. Kaufmann. 2006. Short-term effects of fire and postfire rehabilitation on understory vegetation. NFF-NCSSF Applications Workshop. Seattle, WA. | This project was funded by The National Commission on Science for Sustainable Forestry, but utilized data collected with JFSP dollars. | Done |
| Workshop | Rocca, M. Evaluating fuels treatments using fire behavior modeling. 2006. Manager's Workshop on Restoration of Ponderosa Pine Ecosystems. Sponsored by the Colorado Forest Restoration Institute. Deckers, CO. | Monique Rocca's presentation utilized data collected with JFSP dollars. | Done |