Fuel loading and vegetative response of mixed-conifer stands to silvicultural treatment

Glenn Mason, Terrell Baker, Jon Boren, Dawn VanLeeuwen, Sam Fernald, and Doug Cram
New Mexico State University, Las Cruces NM

Correspondence: Glenn Mason, New Mexico State University, Extension Animal Resources Department, P.O. Box 30003, MSC 3AE, Las Cruces NM 88003.
Email: gmason@nmsu.edu

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Abstract

Under the Healthy Forest Restoration Act, management agencies now have the framework established to implement broad scale fuel reduction programs. This has led to an increased use of mechanical silvicultural treatments in the wildland urban interface as well as the backcountry in many national forests. While there is an abundance of literature addressing the effects of silvicultural treatments on plant response in ponderosa pine systems of the West, there is relatively little information about mixed conifer systems. The objective of this study was to determine the effects of 3 commonly applied mechanical treatments on fuel loading and plant response in mixed conifer stands on the Lincoln National Forest, New Mexico. The 3 treatments are non-commercial thin lop and pile, non-commercial thin lop and scatter, and commercial harvest up to 61 cm DBH. We quantified surface and canopy fuel loads in treated and untreated stands to determine the effectiveness of each treatment in mitigating the danger of severe fire behavior. Vegetative response variables included species composition, herbaceous production, and shrub density. Preliminary results indicate that mechanical silvicultural treatments increase total fuel loads while the height to live crown was only decreased in commercial treatments. Vegetative response was minimal 2 years after non-commercial and 1 year after commercial treatments. Results of this research will help provide managers with the information needed to choose the treatment that best matches their objectives, whether it is reducing the risk of stand replacing wildfires or producing a more productive and diverse plant community.

Keywords: fuel loading, mixed conifer, slash prescriptions, silviculture, wildland fire

Introduction

Mechanical silvicultural treatments have been widely used in the ecological restoration of ponderosa pine (*Pinus Ponderosa*) stands and are increasingly being applied in mixed conifer forests. While it is evident that mechanical and prescribed fire treatments in ponderosa pine forests can be effective in reducing fire severity (Cram et al. 2003), it is unclear how applicable these same treatments are in mixed conifer forests (Schoennagal et al. 2004). The literature consistently shows mechanical silvicultural treatments lead to increased herbaceous and mid-story production, with the exception of an initial reduction in cover following harvest (Thysell and Carey 2001). However, most of this work was done in ponderosa pine forests of the west (Pase 1958, McConnell and Smith 1965, Clary and Ffolliot 1966, McConnell and Smith 1970, Thompson and Gartner 1971, Clary 1975, Uresk and Severson 1989). Relatively little work has been done in mixed conifer forests and has typically focused on commercial treatments (Young et al. 1967, Wallmo et al. 1972, Dyrness 1973, Patton 1976) while little attention has been given to non-commercial treatments (Metlen and Fiedler 2004) or residue treatment (Scherer et al. 2000). The objective of this study was to determine the effects of 3 commonly applied mechanical silvicultural treatments on fuel loading and plant response in mixed conifer stands on the Lincoln National Forest, New Mexico.

Study Area

Three study areas (Bailey Canyon, Cox Canyon, and Sleepy Grass Campground) were located in the Lincoln National Forest, approximately 2–10 miles from Cloudcroft, NM within the Sacramento Ranger District. Elevation ranged from 2560 to 2773 meters. Vegetation type was mixed coniferous forest composed of Douglas fir (*Psuedotsuga menziesii*) (73 %), ponderosa pine (*Pinus ponderosa*) (12 %), southwestern white pine (*Pinus strobiformus*) (7 %), white fir (*Abies concolor*) (6 %), aspen (*Populus tremuloides*) (2%) and oak species (*Quercus spp.*) (1 %). Composition was estimated by basil area (BA). The 3 study areas differed in their past treatment history and current treatments being applied. The Bailey and Sleepy areas are similar in that neither had been commercially logged in the last 60–100 years, while the Cox site was unique because it had been commercially cable logged 20–30 years ago. Current treatments on Cox and

Bailey are non-commercial harvest lop and pile and non-commercial harvest lop and scatter. Sleepy was thinned with a non-commercial lop and pile, where piles near the perimeter were burned, followed by a commercial harvest were slash was piled for removal with a target BA of 18–23 m^2/ha. Each study area also contained an untreated control.

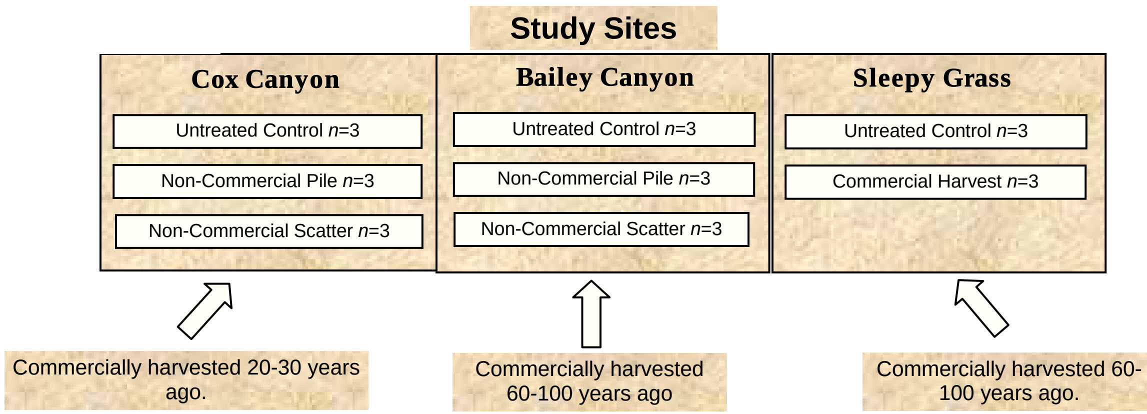

Figure 1.

Methods

Study Design

Sites were selected based on historical treatments, present treatment, area encompassed by treatment, slope, aspect, and cover type. Due to differences in these characteristics between areas we randomly selected 3 experimental units for each treatment by location combination (Figure 1). For the same reason data was analyzed separately for each treatment by location combination and trends by treatment were compared across locations.

Overstory

Two permanent 100 m transects were systematically placed perpendicular to the contour in each of the experimental units. All transects were placed at least 50 m from the stand boundary to avoid edge bias (Mueller-Dombois and Ellenberg 1974). The second transect was systematically placed 50–100 m from the first transect. Two variable radius plots were established systematically per transect at 15 m and 85 m. Basal area (m^2/ha) and tree density (stems >11.4cm/ha) were measured using a 10–factor prism (Avery and Burkhart 1994). Tree height (m) and height to live crown (m) were measured with a clinometer. Canopy cover (%) was measured at the center of each 1-m^2 herbaceous vegetation frame with a spherical densitometer (Lemmon 1957).

Midstory

Density of midstory species was measured in 20 sections of 2, 2 m x 100 m belt transects (Mueller-Dombois and Ellenberg 1974). The density of woody species was recorded as the number of stems per species by height class within each of the 20 sections. All stems under 2.54 cm DBH were put into one of 3 height classes (≤1 m, >1 m–2 m, or >2 m). The DBH of stems >2.5–11.4 cm DBH was recorded and placed into one of four height classes (≤2 m, >2–4 m, >4–6 m, and >6 m). Midstory cover was measured by species for all woody plants rooted in 30 1-m^2 frames

Herbaceous Vegetation

Cover of herbaceous vegetation was measured inside 30 1-m^2 frames using a modified Daubenmire (1959) scale along 2 transects (Cram et al. 2002). Cover was recorded for rock, soil, litter, shrubs ≤ 1 m, and shrubs 1-2 m by species for all live woody and herbaceous plants rooted within the frame. Biomass was measured separately for forbs and grass-like plants rooted inside 30 30.48 cm x 60.96 cm frames by clipping all herbaceous vegetation to ground level. All biomass samples were oven dried at 60^0C for a period of 48 hours and weighed to the nearest tenth of a gram.

Fuels

Downed woody fuels and fine fuels were measured along 6 16 m transects. Downed and dead woody fuels were measured using the line intercept method and calculated according to Brown et al. (1982). Piled fuels were measured separately. Pile density was recorded along 2 20 m x 100 m belt transects. Pile area (m^2) and volume (m^3) was quantified by two perpendicular width measurements and a height measurement. Litter and duff depth were measured at 4 points along each transect and were quantified by weight to the nearest tenth of a gram inside 15 30.48 cm x 60.96 cm frames. Canopy bulk density (kg/m^2) was calculated using the Fire and Fuels Extension to the Forest Vegetation Simulator (Reinhardt and Crookston 2003).

Preliminary Results and Discussion

Stand characteristics for all study sites are presented in Table 1. Preliminary results from

2005 indicate that dead and down fuel loads were the highest in the non-commercial scatter (38.9 t/ha) followed by commercial (18.9 t/ha) non-commercial pile (15.6 t/ha) and the control treatments (14.5 t/ha). One hr, 10-hr, and 100-hr fuel loads were the same

Table 1. Overstory characteristics of treated and untreated stands in the Lincoln National Forest (only includes trees >11.43 cm DBH). *n*=3

Treatment	BA (m^2/ha)		Density (trees/ha)		DBH (cm)		Height (m)		HLC (m)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Sleepy Canyon										
Commercial	23.9	2.2	221.2	26.1	50.1	0.8	22.3	0.6	10.0	0.9
Control	40.7	2.4	708.7	55.1	34.3	1.4	17.0	0.6	7.4	0.9
Cox Canyon										
Non-Comm Pile	34.9	3.3	417.5	23.9	37.3	2.1	18.7	1.0	6.4	1.1
Non-Comm Scatter	30.1	3.2	457.7	32.4	33.3	0.4	16.8	0.7	6.0	0.3
Control	34.2	1.2	609.8	5.7	32.9	0.6	16.0	0.1	5.8	<0.1
Bailey Canyon										
Non-Comm Pile	24.7	2.2	306.8	23.8	37.6	1.6	17.7	0.9	7.2	0.2
Non-Comm Scatter	31.0	1.7	441.3	11.9	33.2	0.6	16.3	0.5	7.4	0.5
Control	40.0	0.8	624.5	33.7	36.2	1.6	18.1	0.4	7.4	0.2

for all treatments, however 1000-hr fuel loads were greater in all treatments except the non-commercial pile; most notable was the ~390 % increase in the scatter treatment (Fig. 2).

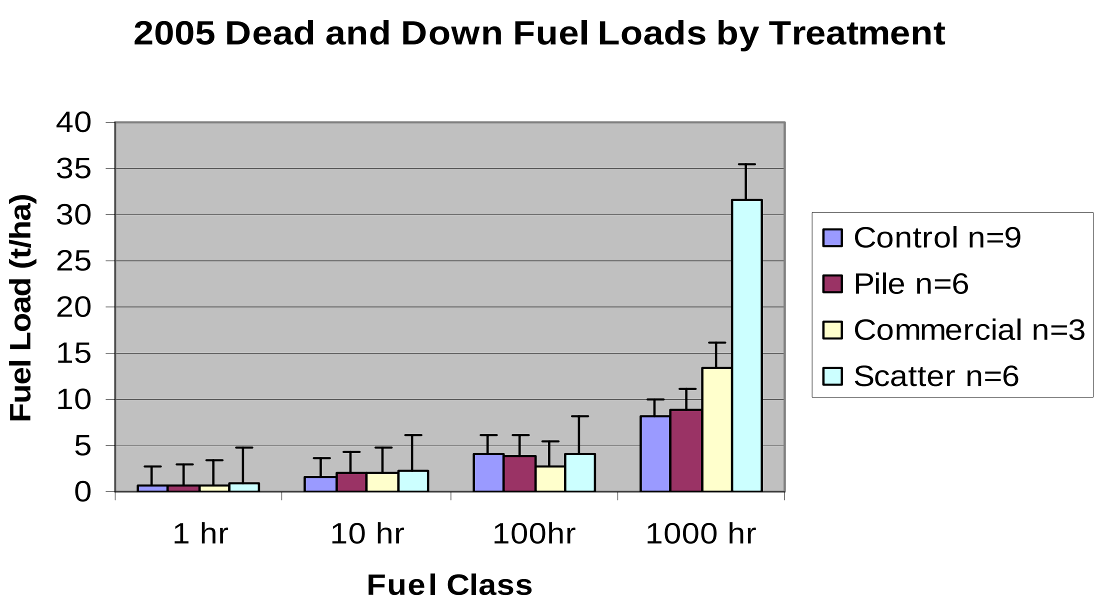

Figure 2. Fuel loads by treatment in the Lincoln national Forest 2005. Results are 1 year post harvest for the commercial treatment and 2 years post harvest for non-commercial treatments.

It is important to note that piled slash was not included in the analysis, as piles alter the distribution of fuels and are usually burned to remove slash. Average pile height, area covered and the total area occupied by pile per site are presented in Table 2.

Table 2. Pile height, area, and total area occupied in non-commercial pile treatments in the Lincoln National Forest 2005. *n*=3

Treatment	Height (m)		Average Pile Area (m^2)		Total Pile Area (m^2/ha)	
	Mean	SE	Mean	SE	Mean	SE
			Cox			
Non-Comm Pile	0.8	0.1	2.6	0.1	367.8	62.8
			Bailey			
Non-Comm Pile	1.4	0.1	4.9	0.6	533.9	75.9

Canopy fuel loads have yet to be calculated. Herbaceous ground cover showed little to no response 2 years after non-commercial and 1 year after commercial treatments while cover of soil was greater immediately following commercial treatment. Herbaceous production increased slightly in non-commercial treatments 2 years post harvest at Bailey and stayed the same or decreased at Cox sites. Herbaceous production increased slightly in commercial treatments at Sleepy sites 1 year post-harvest (Table 3). Because of the slash created during harvest, fire or other treatments such as mastication which remove or alter the composition of dead and down fuels should be used in conjunction with harvesting treatments. While slight increases in dead and down fuel loads may be mitigated by an increase in height to live crown (Table 1), this was only true in the commercial treatments. We expected greater shrub and herbaceous response however we failed to observe it. The lack of response may be partially due to the short duration of the response time, the degree of overstory removal and lack of disturbance to the forest floor in non-commercial treatments.

Table 3. Herbaceous production in treated and untreated stands in the Lincoln National Forest 2005. *n*=3

Treatment	Forb (kg/ha)		Grass (kg/ha)		Total (kg/ha)	
	Mean	SE	Mean	SE	Mean	SE
Sleepy Canyon (1 growing season post-harvest)						
Commercial	11.4	5.6	2.3	1.3	13.6	5.8
Control	4.1	0.5	2.7	0.8	6.8	1.3
Cox Canyon (2 growing seasons post-harvest)						
Non-Comm Pile	15.9	6.7	24.0	10.7	39.9	17.3
Non-Comm Scatter	20.6	6.3	31.0	4.3	51.6	5.4
Control	14.8	4.7	40.3	8.4	55.1	12.9
Bailey Canyon (2 growing seasons post-harvest)						
Non-Comm Pile	9.4	8.1	0.7	0.3	10.0	8.3
Non-Comm Scatter	6.3	4.8	14.8	14.8	21.2	19.6
Control	1.4	1.0	0.3	0.3	1.7	0.8

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