RESEARCH ARTICLE

EFFECTS OF CREATING TWO FOREST STRUCTURES AND USING PRESCRIBED FIRE ON COARSE WOODY DEBRIS IN NORTHEASTERN CALIFORNIA, USA

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ABSTRACT

Little is known about the dynamics of coarse woody debris (CWD) in forests that were originally characterized by frequent, low-moderate intensity fires. We investigated effects of prescribed burning at the Blacks Mountain Experimental Forest in northeastern California following creation of two stand structure conditions: 1) high structural diversity (HiD) that included retaining large, old-growth trees while thinning smaller trees in the understory through whole-tree harvesting, and 2) low structural diversity (LoD) simulating a more traditional approach that removed overstory trees by individual tree selection while thinning the vigorous younger trees and removing the suppressed understory by whole-tree harvesting. Each of the two structures was replicated six times in a randomized block design for a total of 12 approximately 100 ha factorial plots. Each factorial plot was split and prescribed fire applied to one half of each plot. We classified CWD as either: sound or decayed. Coarse woody debris was abundant on all plots regardless of stand structure. Statistically significant differences ($\alpha = 0.05$) were found in the mass of the CWD between the burned and unburned splits across all experimental units combined for both sound and decayed material. However, when analyzed separately, the difference in the burned and unburned splits was statistically significant for LoD condition but not for HiD condition, likely due to greater heterogeneity of burn in the HiD condition. Coarse woody debris mass declined even in unburned units following treatments ($p \leq 0.1$).

Keywords: Cascade Range, coarse woody debris, dead wood, down wood, fire effects, interior ponderosa pine forest, *Pinus ponderosa,* prescribed fire, stand structure

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INTRODUCTION

The management of coarse woody debris (CWD) is an issue of importance and interest to wildlife biologists, ecologists, mycologists, foresters, fire managers, soil scientists, and land managers because CWD management can have important ecological consequences (Feller 2003). Coarse woody debris provides important habitat elements for many wildlife species, influences soil processes, provides fuel for fires, and serves other ecological functions (Maser and Trappe 1984, Harmon *et al*. 1986). Although past management practices removed CWD, today these practices often include protecting or enhancing (adding to) CWD (Thomas 2002). However, what constitutes too much or too little CWD is largely unknown in forests with annual warm season droughts that originally had fire regimes characterized by frequent, low to moderate intensity fires, such as those in northeastern California. Yet, standards are often proposed in terms of what may be good or optimum for particular wildlife species or suites of species or for soil processes without accommodation for an ecological baseline that would likely be sustainable under the local climate and fire regime (Harmon 2002, Marcot 2002).

Coarse woody debris is typically defined as dead sound and decaying logs, stumps, and coarse roots that are generally greater than 7.5 cm in diameter (Stevens 1997). However, the minimum size for CWD is not standardized and has varied depending on study objectives (Stevens 1997). Managers are often faced with the competing goals of minimizing the potential for large, high-intensity wildfires, while providing for necessary ecological elements (such as CWD) for maintenance of wildlife habitat and sustaining soil processes. For managers, this is problematic because providing for too little CWD may lead to loss of critical habitat elements, while maintaining too much may lead to unusually severe fires resulting in loss of critical habitat (Thomas 2002).

Most information describing quantities and function of coarse woody debris in the western United States is from ecosystems that have experienced relatively long periods without fires (Morgan *et al*. 2002) because of a fire regime of mostly infrequent fires (e.g., Wright *et al*. 2002) or because of fire exclusion over the last century (Skinner 2002). Little information is available from forests with a functioning frequent, low to moderate intensity fire regime for the type of forests found in the southern Cascade Range of northern California, USA (Skinner and Taylor 2006). In mixed conifer forests of northwestern Mexico that have only recently been impacted by fire-suppression activities, Stephens *et al*. (2007) found that CWD accumulations averaged <20 Mg ha^{-1}. This is considerably less than the CWD found in mixed conifer forests of the western Sierra Nevada today. For example, Knapp *et al.* (2005) found 66.2 Mg ha^{-1} to 95.8 Mg ha^{-1} of CWD in Sequoia and Kings Canyon national parks, Innes *et al.* (2006) measured 63.5 Mg ha^{-1} at Teakettle Experimental Forest, and Stephens *et al.* measured 97.5 Mg ha^{-1} at Blodgett Forest. Though no data exist describing the original character of CWD in these forests, it is likely that frequent fires originally limited the accumulations of CWD (Skinner 2002, Stephens 2004).

Woody material in these summer dry climates decomposes slowly (Busse 1994, McColl and Powers 2003) relative to the frequency of fire that existed under pre-fire-exclusion fire regimes (Taylor 2000, Norman and Taylor 2003). Generally, median fire return intervals in forests of northeastern California varied from 5 yr to 12 yr at the stand scale before systematic fire suppression was imposed early in the twentieth century (Taylor 2000, Norman and Taylor 2003). Thus, fires would likely have occurred at least several times over the period it would have taken for woody material to decompose (e.g., Busse 1994). Even the relatively rapidly decomposing CWD in Sequoia National Park (Harmon *et al*. 1987) would likely have experienced several fires during its period of decay before disruption of the fire regime (Swetnam and Baisan 2003). Fire exclusion has likely led to increased accumulation (Parsons and DeBenedetti 1979, van Wagtendonk 1985), greater spatial continuity

(Miller and Urban 2000), and a greater abundance of CWD in advanced stages of decay (Skinner 2002, Knapp *et al*. 2005). All of these factors potentially contribute to greater fire intensity and more severe fire effects than if the historical fire regimes were still operating (van Wagtendonk 1985, Skinner and Chang 1996, Stephens 1998).

Moore *et al*. (1999) have suggested that restoration of pre-fire suppression stand conditions may be an appropriate goal to reduce the potential for unusually large, intense fires while sustaining necessary ecosystem elements and function. With the exception of the Stephens *et al*. (2007) study in northwestern Mexico, we are not aware of any existing data or estimates of pre-fire suppression CWD amounts that would help to provide restoration goals. However, it is likely that accumulations were less than that found in these forests today (Skinner 2002). Brown *et al*. (2003) developed one estimate of such a range of recommended CWD quantities for dry ponderosa pine (*Pinus ponderosa)* and Douglas-fir (*Pseudotsuga menziesii*) forests of western Montana (nomenclature follows Hickman 1993). Their recommendations are based on average CWD quantities inventoried in stands thought to be representative of stand conditions existing before the onset of fire suppression. For those forests, they recommend 11 Mg ha^{-1} to 22 Mg ha^{-1}, which turns out to be similar to the amounts found by Stephens *et al*. (2007) in northwestern Mexico.

The objective of our study was to quantify the early responses of CWD to the creation of different stand structural conditions in the Blacks Mountain Interdisciplinary Ecological Research Project (BMIERP) (Oliver 2000, Zhang *et al*. 2008). The BMIERP was designed to be a long-term (50+ yr) study of the ecological responses to creating two contrasting stand structures followed by combinations of grazing and prescribed burning. The BMIERP science team hypothesized that initially there would be little difference in CWD between structural and grazing treatments because initial stand conditions were similar before treatments and harvests targeted live trees of varying sizes. The team expected initial CWD effects to be related to whether or not treatment plots were burned. Additionally, the combinations of treatments would set the stands on very different successional trajectories and CWD differences should become more pronounced over time (Oliver 2000).

METHODS

Study Area

The study is located within the Blacks Mountain Experimental Forest (BMEF) in northeastern California, USA, about 64 km northwest of Susanville, Lassen County, at latitude 40.73º and longitude -121.15º. Blacks Mountain Experimental Forest occupies 3715 ha and is the site of the large interdisciplinary, long-term ecological research project (BMIERP) initiated in 1991 (Oliver 2000). The BMEF is in the eastern Cascade Range and has a montane Mediterranean climate characterized by warm, dry summers and cold, wet winters. Annual precipitation, which falls mostly as snow between October and April, averages about 460 mm and mean air temperatures usually range from -9 ˚C in January to 29 ˚C in July (Zhang and Ritchie 2008). The bedrock is mostly basalt. Soils are generally between 1 m and 2 m deep with mesic soil temperature regimes at lower elevations, and Andic Argizerolls with frigid soil temperature regimes at higher elevations. Elevation ranges from 1800 m to 2100 m (Dolph *et al*. 1995). Ponderosa pine site index (expected tree height) at base age 100 yr generally varies from 18 m to 24 m and averages about 22 m (Meyer 1938).

Principal tree species are ponderosa pine, Jeffrey pine (*Pinus jeffreyi*), white fir (*Abies concolor*), and incense-cedar (*Calocedrus de-*

currens) and species composition varies with elevation and aspect within the study area. The most common shrub species in the understory are greenleaf manzanita (*Arctostaphylos patula*), mahala mat (*Ceanothus prostratus*), snowbrush (*C. velutinus*), antelope bitterbrush (*Purshia tridentata*), and creeping snowberry (*Symphoricarpus mollis*).

Before treatment, the stands were multilayered and structurally diverse. An unusual feature of these stands was an average of 12.7 large, old trees, greater than 80 cm in diameter at breast height (dbh) per hectare. Most trees of this size have been removed over the years from this forest type across northeastern California. Most trees of this size at Blacks Mountain are >300 yr old (Dolph *et al*. 1995) with some, especially ponderosa pine and incense-cedar, >800 yr (C.N. Skinner, Forest Service, unpublished data).

Old-growth interior ponderosa pine forests developed under the influence of relatively frequent, mostly low-intensity fires (Agee 1993, 1994; Skinner and Taylor 2006). Fire history studies in the vicinity of BMEF show that fires were frequent (stand level fire return intervals of 5yr to 12 yr) and occurred mostly in the late summer and fall until sheep were introduced in the late 1800s followed by the initiation of organized fire suppression around 1910 (Taylor 2000, Norman and Taylor 2003).

Experimental Design

The BMIERP used a split-plot design with three blocks and four conditions (12 plots of approximately 100 ha each) that were randomly assigned. The four treatments used to create the structural conditions were: 1) un-grazed high structural diversity (HiD) that included retaining large, old-growth trees and multiple layers of thinned smaller understory trees through whole-tree harvesting, 2) the high structural diversity with cattle grazing, 3) un-grazed low structural diversity (LoD) simulating a more traditional approach that removed overstory trees by individual tree selection and thinned the vigorous younger trees and suppressed understory by whole-tree harvesting that created single-layer stands of mostly intermediate size trees, and 4) the low structural diversity with cattle grazing. Each plot was then split and randomly assigned to burned (HiD-B, LoD-B) and unburned (HiD-U, LoD-U) halves. The burned halves were intended to be periodically reburned over the course of the study (Oliver 2000, Zhang *et al*. 2008; Figure 1). The plots were measured before treatments and one year following treatments. A preliminary analysis detected no significant effect of grazing on CWD. Therefore, we combined the grazed and ungrazed plots for each structure in each plot for analysis purposes. Thus, there were 6 HiD and 6 LoD plots for comparison.

Harvest Operations

Harvesting took place over three years with one block cut each year (Hartsough 2003). Each block consisted of two HiD and two LoD structural condition plots. Trees harvested that were less than 51 cm dbh were whole-tree removed to the nearest landing for processing. In the LoD condition areas, trees larger than 51 cm dbh were directionally felled to miss selected leave trees, limbs and tops were removed and left in the forest, and boles were skidded to landings. No trees larger than 51 cm were harvested from the HiD condition areas (Hartsough 2003).

Prescribed Burns

Prescribed burns were conducted in the fall (late September through early November) following the summer dry season, one or two years after harvest. Fall was the season selected for burning because it approximated the original seasonality of fire shown in fire-scar studies for the vicinity (Taylor 2000, Norman

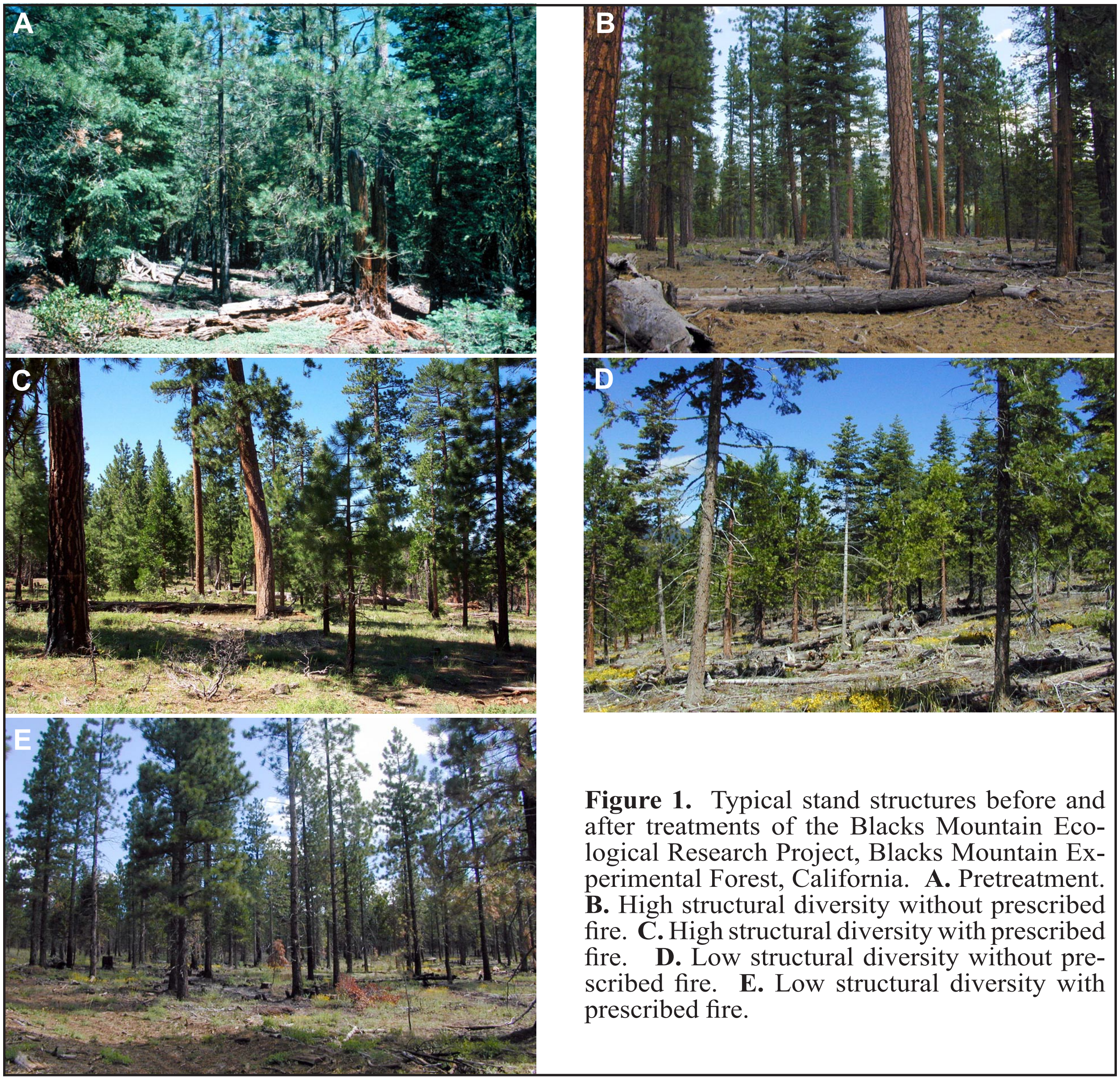

Figure 1. Typical stand structures before and after treatments of the Blacks Mountain Ecological Research Project, Blacks Mountain Experimental Forest, California. **A.** Pretreatment. **B.** High structural diversity without prescribed fire. **C.** High structural diversity with prescribed fire. **D.** Low structural diversity without prescribed fire. **E.** Low structural diversity with prescribed fire.

and Taylor 2003). Additionally, the BMIERP team thought fall burning would minimize, the post-treatment bark beetle activity that was already at high levels (Oliver 2000). One block of four condition plots was burned in each of the years 1997, 1999, and 2000. The moisture content as a percent of oven dry weight for material ≥7.62 cm in diameter range was: a) 14 % to 22 % in 1997, b) 21 % to 33 % in 1999, and c) 17 % to 32 % in 2000.

Data Collection

All data were collected from 100 m transects centered on grid points in a permanently monumented 100 m × 100 m grid in each condition plot (Oliver 2000). We collected data from 529 transects (52 900 m) and intersected a total of 14 548 woody pieces. Transects were oriented southwest to northeast. Coarse woody debris included:

- downed horizontal or suspended (not self-supporting) dead tree boles, with or without roots attached;
- fallen trees retaining green foliage if they no longer have roots attached (no living cambium) to the ground to keep them alive;
- woody pieces greater than 7.5 cm in diameter;
- uprooted (not self-supporting) stumps greater than 7.5 cm in diameter and any of their exposed dead roots greater than 7.5 cm in diameter;
- fallen, broken treetops that may be horizontal or leaning, or large fallen branches; and recently cut logs.

We used a line intersect sampling (LIS) method, a commonly used method for assessing the amount of downed woody material on a site (Warren and Olsen 1964, Van Wagner 1968, Bailey 1970, Bate *et al*. 2002). The intersect method involves measuring specific attributes of CWD pieces that are crossed by line transects established on an area (Marshall *et al*. 2000). Coarse woody debris was measured along the full length of the 100 m transect in the following way:

- Coarse woody debris pieces that intersected a vertical plane passing through transects were measured. The diameter perpendicular to the long axis of the piece at the point of intersection determined the size.
- The length of transect intercepted by each intersected piece was recorded.
- The height above ground to the top of each piece where it was intersected by the transect was recorded to the nearest 0.1 m.
- Pieces were classified as either sound (undecomposed, including charred tree remains generally equivalent to stages 1 and 2 of Maser and Trappe [1984]), or decayed (crumbly, brown cubicle rot present with structural materials, and crumbly brown cubical rot only, no structure remaining generally equivalent to stages 3, 4, and 5 of Maser and Trappe [1984]).

Data Analysis

The volume (m^3 ha^{-1}) of CWD pieces was estimated separately for sound and decayed pieces using the formulas of Brown (1974) and wood characteristics provided by van Wagtendonk *et al.* (1996, 1998). Coarse woody debris volume estimates were summed by structural condition, plot, grid point, and condition class (sound or decayed), then averaged and converted to mass (Mg ha^{-1}) before our analysis was conducted.

The data were analyzed using an ANOVA model with random effects (McCulloch and Searle 2001). The statistical model we used was:

$$\text{Response}_{ijkr} = G_{ti} + T_{tj} + G*T_{tij} + R_r + R*G_{tri} + R*T_{trj} + R*G*T_{trij} + B_{tk} + G*B_{tik} + T*B_{tjk} + G*T*B_{tijk} + R*B_{tk} + R*G*B_{trik} + R*T*B_{trjk} + R*G*T*B_{trijk} + \text{err}_{trijk},$$

where: t = 1 (before) and 2 (after), i = 1 (grazed) and 2 (ungrazed); j = 1 (high) and 2 (low) and k = 1 (burn) and 2 (no-burn); with fixed effects G = grazing, T = forest structure, and B = fire; random effects R = block (accounts for the different years of treatment and data collection); r =1 , 2, 3, and the interactions of R with the all fixed effects; and ε = residual error. The response is the mean value of CWD mass before and after treatment.

The SAS (v.9.1)[1] MIXED procedure was used to estimate the parameters. This procedure was used in order to estimate the variance components of the large amount of random effects that this model has. The variance homogeneity was tested with the Levene test (Levene 1960). The test showed a significant variance difference between before and after treatment. Therefore, the variances were assumed to be different for before and after treatment. Other groupings, such as forest structure or prescribed burn levels, were tested but the tests for variance equality were not significant at α-level = 0.05. The interactions between the fixed effects were not significant (Table 1). We will discuss significant differences at both $p \leq 0.1$ and $p \leq 0.05$.

RESULTS

Coarse woody debris was abundant on all plots regardless of stand structure (Table 2). High structural diversity and LoD conditions were not significantly different from each other either before or after treatment at $p \leq 0.05$ (Table 3). There was a significant difference between before and after CWD of the burned compared to unburned splits regardless of structural condition (Table 3). However, when analyzed separately, there was a significant difference between burned versus unburned for low stand structural diversity but not for high stand structural diversity (Table 3). Coarse woody debris mass declined following treatments even in unburned units ($p \leq 0.1$) (Table 2).

Table 1. Type 3 tests of fixed effects assuming block as a random effect for treatments at the Blacks Mountain Experimental Forest, California.

	Degrees of freedom		Sound		Decayed	
Fixed effect	**No.**	**Den.**	***F*-value**	***Pr > F* (*P*-value)**	***F*-value**	***Pr >F* (*P*-value)**
Time × grazed	2	4	012	0.8865	0.93	0.4671
Time × treat	2	4	0.26	0.7808	0.46	0.6625
Time × grazed × treat	2	4	0.41	0.6913	3.08	0.1553
Time × split	2	4	4.96	0.0825	6.14	0.0604
Time × grazed × split	2	4	0.39	0.7002	0.29	0.7600
Time × treat × split	2	4	1.44	0.3376	0.25	0.7919
Time × grazed × treat × split	2	4	0.16	0.8577	0.06	0.9453

Table 2. Mean mass estimates and standard errors (Mg ha^{-1}) of coarse woody debris for before and after treatment at the Blacks Mountain Experimental Forest, California.

	Sound			Decayed		
	Before	After		Before	After	
Label	**Estimate (SE)**	**Estimate (SE)**	**Change (%)**	**Estimate (SE)**	**Estimate (SE)**	**Change (%)**
HiD	53.5 (8.5)	29.9 (5.3)	-44.1	166.7 (50.2)	29.0 (7.8)	-82.6
LoD	61.1 (8.5)	31.4 (5.3)	-48.6	166.8 (50.2)	36.2 (7.8)	-78.3
HiD-B	55.8 (11.4)	24.0 (6.8)	-57.0	175.5 (53.8)	17.4 (.9.4)	-90.1
HiD-U	51.1 (11.4)	35.9 (6.8)	-29.7	158.0 (53.8)	40.6 (9.4)	-74.3
LoD-B	49.5 (11.4)	18.9 (6.8)	-61.8	168.5 (53.8)	20.2 (9.4)	-88.0
LoD-U	72.7 (11.4)	43.8 (6.8)	-39.8	165.1 (53.8)	52.2 (9.4)	-68.4

Table 3. Comparison between treatment levels at the Blacks Mountain Experimental Forest, California.

	Sound		**Decayed**	
	Before	**After**	**Before**	**After**
Treatments	***Pr* > *F*** **(*P*-value)**	***Pr* > *F*** **(*P*-value)**	***Pr* > *F*** **(*P*-value)**	***Pr* > *F*** **(*P*-value)**
HiD vs. LoD	0.523	0.853	1.000	0.393
Burn vs unburned	0.432	0.039**	0.723	0.025**
HiD, burn vs unburned	0.769	0.239	0.676	0.089*
LoD, burned vs unburned	0.196	0.044**	0.935	0.037**

* $P < 0.1$
** $P < 0.05$

Quantity of Coarse Woody Debris

Decayed CWD was generally two to three times the mass of sound CWD before treatments were implemented (Table 2). Across all conditions, sound CWD decreased by 46% from an average of 57.3 Mg ha^{-1} before treatment to 30.7 Mg ha^{-1} following treatments, while decayed CWD decreased by 81% from an average of 166.8 Mg ha^{-1} to 32.6 Mg ha^{-1}. Alhough there was considerable difference before treatments, the mass of sound and decayed material was similar following treatments due to the greater reduction in decayed material.

Stand Structure Treatment Effects

We found no significant difference at $p \leq 0.05$ in mass of CWD before and after treatment for sound and decayed woody materials for high diversity stand structure. However, in low diversity stand structure, post-treatment CWD was significantly different from pretreatment for sound materials but not for decayed materials (Table 3).

Prescribed Fire Effects

Significant differences were found in the mass of the CWD between the burned and unburned splits across all experimental units combined for both sound and decayed material (Table 4). However, when analyzed separately, the difference in the burned and unburned splits was statistically significant for LoD condition but not for HiD condition (Tables 1 and 4).

The prescribed fires consumed more decayed CWD than sound CWD, both absolutely and proportionately (Table 2). Sound CWD was reduced on HiD unburned plots by 30% (15.2 Mg ha^{-1}), whereas decayed CWD was reduced by 74% (117.4 Mg ha^{-1}). For HiD burned plots, sound CWD was reduced by 57% (31.8 Mg ha^{-1}), while decayed CWD was reduced by 90% (158.1 Mg ha^{-1}). Sound CWD was reduced on unburned LoD plots by 40% (28.9 Mg ha^{-1}), whereas decayed CWD on these

Table 4. Comparison of sound and decayed woody material before and after treatments in the Blacks Mountain Experimental Forest, California.

	Sound	**Decayed**
Comparison	***Pr* > *F*** **(*P*-value)**	***Pr* > *F*** **(*P*-value)**
All combined	0.024**	0.041**
Unburned	0.085*	0.072*
Prescribe burned	0.032**	0.032**
High diversity	0.078*	0.053*
Low diversity	0.041**	0.061*
HiD burned	0.074*	0.044**
LoD burned	0.082*	0.053*
HiD unburned	0.313	0.098*
LoD unburned	0.094*	0.107

* $P < 0.1$
** $P < 0.05$

plots was reduced by 68 % (112.9 m^3 ha^{-1}). For burned LoD plots, sound CWD was reduced by 62 % (30.6 Mg ha^{-1}), while decayed CWD was reduced by 88 % (148.3 Mg ha^{-1}).

DISCUSSION

The amount of CWD in the untreated Blacks Mountain stands greatly exceeded the 11 Mg ha^{-1} to 22 Mg ha^{-1} of CWD recommended by Brown *et al*. (2003) and found by Stephens *et al*. (2007) in mixed conifer forests of northwestern Mexico. In total, the amount of CWD in untreated condition also exceeded the amounts reported by Knapp *et al*. (2005), Stephens and Moghaddas (2005), and Innes *et al*. (2006) for mixed conifer forests on the westside of the Sierra Nevada. Further, both HiD and LoD stands still either met or exceeded the recommended amounts after treatment even with prescribed fire.

The creation of the contrasting HiD and LoD stand structures did not lead to significant differences in quantities of CWD. As expected, the only differences between CWD conditions were found to be between the burned and unburned splits. Interestingly, harvesting alone resulted in significant reductions of CWD. This was likely due to the breaking up of larger material, especially decayed CWD, by harvesting machines as they moved about the experimental units (Weatherspoon 1983, Torgersen 2002).

Fire consumed more (both absolutely and proportionately) decayed than sound CWD (Table 2). This is consistent with observations of others in the southern Cascade Range (Skinner 2002) and the Sierra Nevada (Knapp *et al*. 2005, Stephens and Moghaddas 2005). It is likely that the difference in amount of sound and decayed CWD consumed by fire (Table 2) can be attributed to differences in the structure of the two types of material, which contributes to greater flammability of the decayed CWD (Martin *et al*. 1974, Kauffman and Martin 1989), as well as the decayed material being easier for harvesting machines to break down.

It is interesting that there was a significant difference in sound CWD in LoD stands between burned and unburned splits, but not in sound CWD in HiD stands (Table 3). We believe this is due to a greater heterogeneity of fuel consumption in the HiD stands. In order to conduct the burns within prescribed weather and fuel moisture conditions, most burning occurred after the first rain of the fall season. The LoD stands were quite open and the fuels appear to have dried and burned more uniformly following the rains than the fuels in the HiD stands. Additionally, a component of each HiD stand was that 10 % to 15 % of the area was left in dense, unthinned patches of up to 0.8 ha (Oliver 2000). Many of these thickets did not dry sufficiently to burn and contributed to high variability in consumption of CWD in the HiD stands. Thus, even though the difference between burned and unburned HiD stands was not statistically significant, likely due to burn heterogeneity, there was a 57 % reduction in the total mass of sound CWD in the HiD burned stands (Table 2).

The mean mass of CWD for the various combinations of stand structure and fire (Table 2) are consistent with the results of other studies (Tinker and Knight 2000, Brown *et al*. 2003, Feller 2003, Knapp *et al*. 2005). These amounts of CWD are generally within or exceed levels recommended for small mammals and for maintaining soil productivity (Brown *et al*. 2003). Additionally, the results of the Cone Fire that burned into several of our treatment units under relatively severe conditions in mid-September 2002 suggest that the amount of CWD remaining after thinning and prescribed fire in either the LoD or HiD stand structures did not adversely affect fire behavior (Ritchie *et al*. 2007, Symons *et al*. 2008). Thus, from a fire hazard perspective, there seems little need to further reduce CWD.

Restoration goals that include large amounts of decayed, coarse woody debris do not appear to be appropriate for these dry pine forests of northeastern California. Prescribed fire reduced the amount of CWD regardless of stand structure and CWD condition class. Additionally, coarse woody debris in more advanced stages of decay was more readily consumed than were sound materials. These results, and those of others (Knapp *et al*. 2005, Stephens and Moghaddas 2005), suggest that most CWD under a pre-fire suppression fire regime in this summer dry climate was unlikely to progress through the various stages of decay to become fully decomposed before fire would likely have consumed it (Skinner 2002).

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