

Pittville Fuel Treatment Effectiveness Report

Peterson Fire Complex

Lassen National Forest

June 21- June 27, 2008



Kyle Merriam
Province Ecologist
Plumas, Modoc, and Lassen National Forests
P.O. Box 11500
Quincy, CA 95971
Phone: 530 283-7777
Fax: 530 283-7716
Email: kmerriam@fs.fed.us

Executive Summary

- The Pittville Defensible Fuel Profile Zone (DFPZ) effectively reduced the intensity of the Peterson Fire Complex so that suppression efforts could focus on other portions of the fire. The Pittville DFPZ was successfully used for burn-out operations.
- Fire severity within the Pittville DFPZ was lower than in adjacent untreated areas.
- Portions of the Pittville DFPZ that were treated with both thinning and underburning prior to the Peterson Complex experienced lower fire severity as a result of the Peterson Complex than areas of the Pittville DFPZ that had been treated by thinning only.
- Distance from the DFPZ was the strongest predictor of tree mortality. Plots within the Pittville DFPZ that were further from the adjacent untreated area were more likely to survive 6 weeks post-fire.
- Animal sign was statistically similar within the Pittville DFPZ when compared with the adjacent untreated area. Although there was more grass and herbaceous cover within the Pittville DFPZ than in untreated portions of the Peterson Complex, the quick response of sprouting shrub species resulted in similar amounts of shrub cover throughout the Peterson Complex.
- Local fire managers estimated that without the Pittville DFPZ the Peterson Complex would have been at least 1,000 acres larger.

Table of Contents

Executive Summary	2
Introduction/Background	5
Fire Environment	7
Topography	7
Weather	8
Chronology of Fire.....	9
Remotely Sensed Data	9
Field Observations	12
Field Data.....	15
Results.....	16
Severity Measures.....	16
Treatment Type.....	18
Environmental Variables	20
Animal Use	21
Summary and Conclusions	22
Literature Cited.....	23
Appendix A.....	24

Figures and Tables

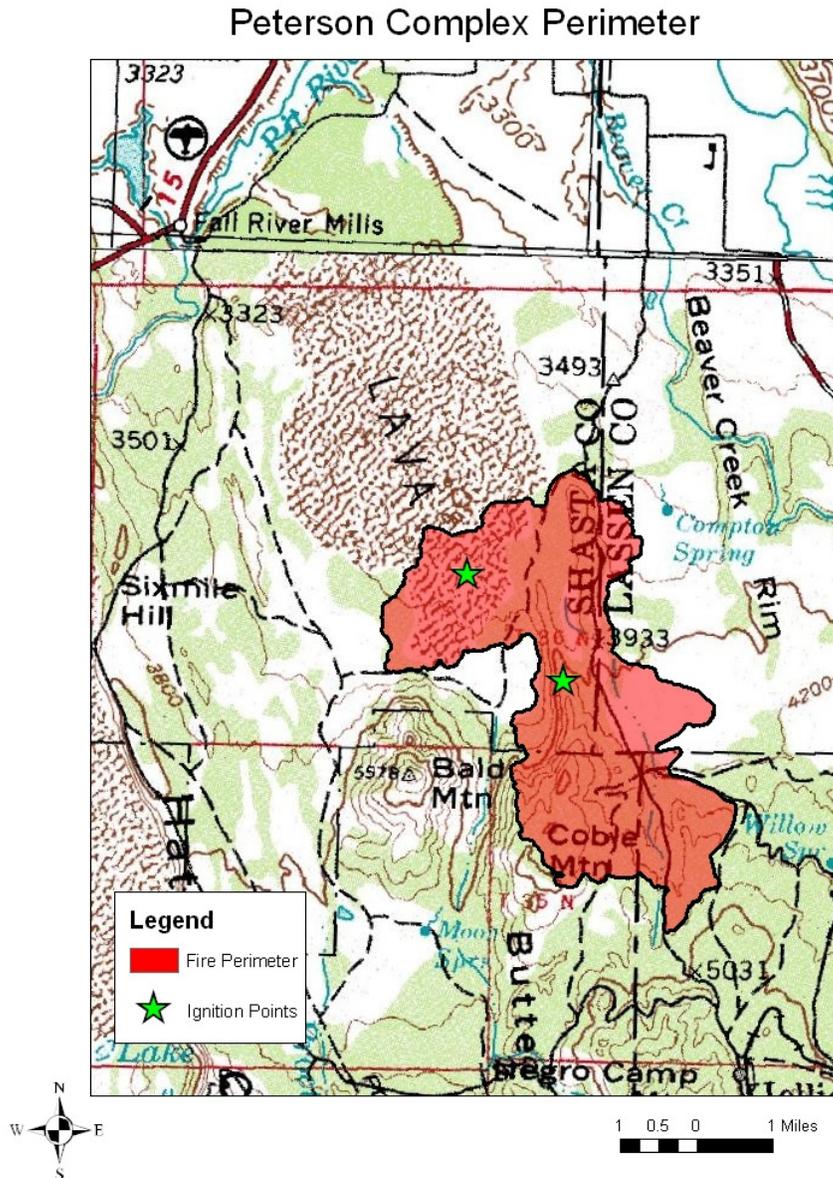
Figure 1. Peterson Complex Perimeter	5
Figure 2. Peterson Complex and Pittville DFPZ.	6
Figure 3. Thinned portion of the Pittville DFPZ.....	7
Figure 4. Shaded relief map of the Peterson Complex	7
Figure 5. Ladder Butte RAWS Data.....	8
Figure 6. Total fire size and relative growth of the Peterson Complex.	9
Figure 7. Vegetation burn severity within the Peterson Complex.....	10
Figure 8. Categories of vegetation burn severity across the Peterson Complex.....	11
Figure 9. Comparison of fire severity in treated and untreated areas	11
Figure 10. Vegetation fire severity by treatment type based on remotely sensed data.....	12
Figure 11. Photograph of Pittville DFPZ where fire severity was low.....	13
Figure 12. Photograph of the Pittville DFPZ after the Peterson Complex where fire effects were more severe.....	13
Figure 13. Fire severity in the Pittville DFPZ and adjacent untreated areas after the Peterson Complex.	14
Figure 14. Fire severity within untreated area of the Peterson Complex.....	14
Figure 15. Plot locations in relation to Peterson Complex and Pittville DFPZ.....	15
Figure 16. Fire severity in untreated areas and the Pittville DFPZ.....	17
Figure 17. Burn severity ratings in untreated areas and the Pittville DFPZ	17
Figure 18. Fire severity in untreated areas, thin and burn, and thin only units of the Pittville DFPZ.	18
Figure 19. Categorical measures of severity in untreated areas, thin and burn, and thin only units of the Pittville DFPZ.....	19
Figure 20. Severity with distance from the boundary of the Pittville DFPZ	20

Figure 21. Animal sign in the Pittville DFPZ and in the adjacent untreated area. 21
Figure 22. Grass and herb cover in the Pittville DFPZ and in the untreated area 22

Introduction/Background:

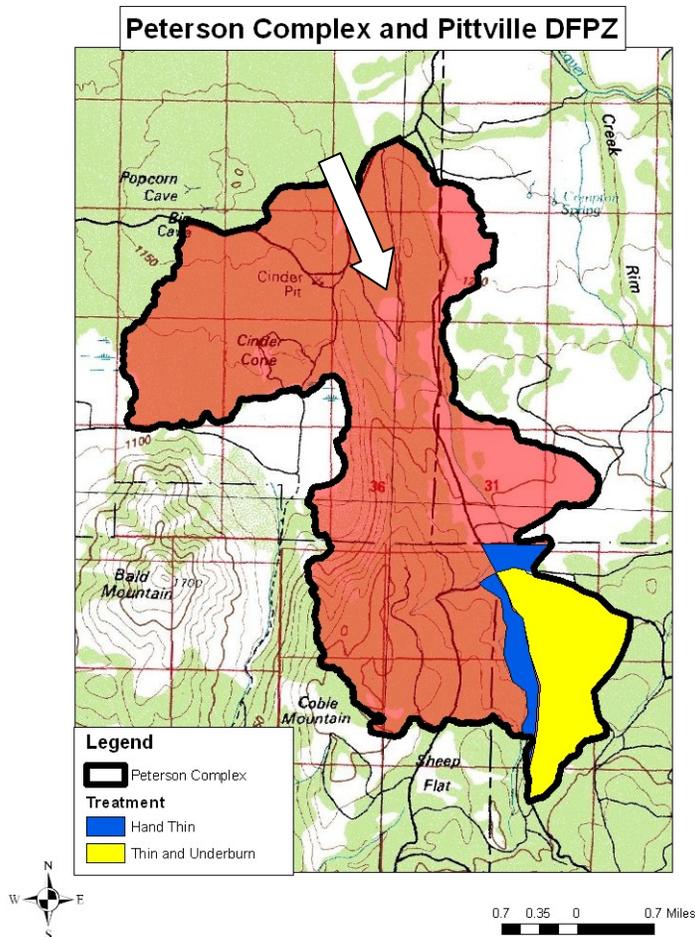
The Peterson Complex burned approximately 8,000 acres between June 21st and June 27th, 2008, including 2,500 acres on the Lassen National Forest (Figure 1). The fire began as two separate fires (the Popcorn Fire and the Peterson Fire) that were ignited by lightning near the border of Shasta and Lassen counties, approximately 10 miles southeast of Fall River Mills, California. These two separate fires merged into a single fire on June 23rd, 2008.

Figure 1. Peterson Complex Perimeter, showing ignition points for the Popcorn and Peterson fires.



Between June 23rd and 25th the Peterson Complex burned through a portion of the Pittville Defensible Fuel Profile Zone constructed during 2005 and 2006. This section of the Pittville DFPZ had undergone several different treatments, including 800 acres that were mechanically thinned and underburned and 225 acres that were chainsaw thinned only (Figure 2). The Peterson Complex burned through the Pittville DFPZ under north and northwesterly winds averaging about 5 miles per hour.

Figure 2. Peterson Complex and Pittville DFPZ. Wind direction indicated by arrow.



The thin and underburn portions of the Pittville DFPZ were constructed through a sequence of treatments that included removal of smaller, suppressed understory trees by both commercial and noncommercial thinning operations, followed by underburning of the remaining woody debris. Underburning was conducted under weather conditions that allowed low flame heights to move through the forest while retaining overstory trees (Figure 3). The hand thin portions of the Pittville DFPZ were treated by hand thinning of understory trees using chainsaws. These treatment units were not subsequently underburned after hand thinning.

Figure 3. Thinned and underburned portion of the Pittville DFPZ, prior to burning in the Peterson Complex.

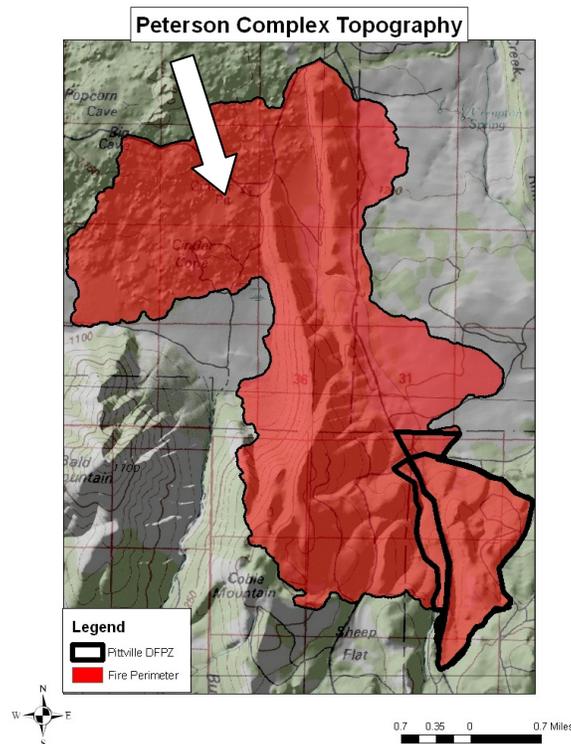


Fire Environment

Topography

The northern portion of the Peterson Complex burned through relatively flat areas on exposed volcanic substrates. The southern portions of the fire burned on steeper slopes and more varied topography near Coble Mountain (Figure 4).

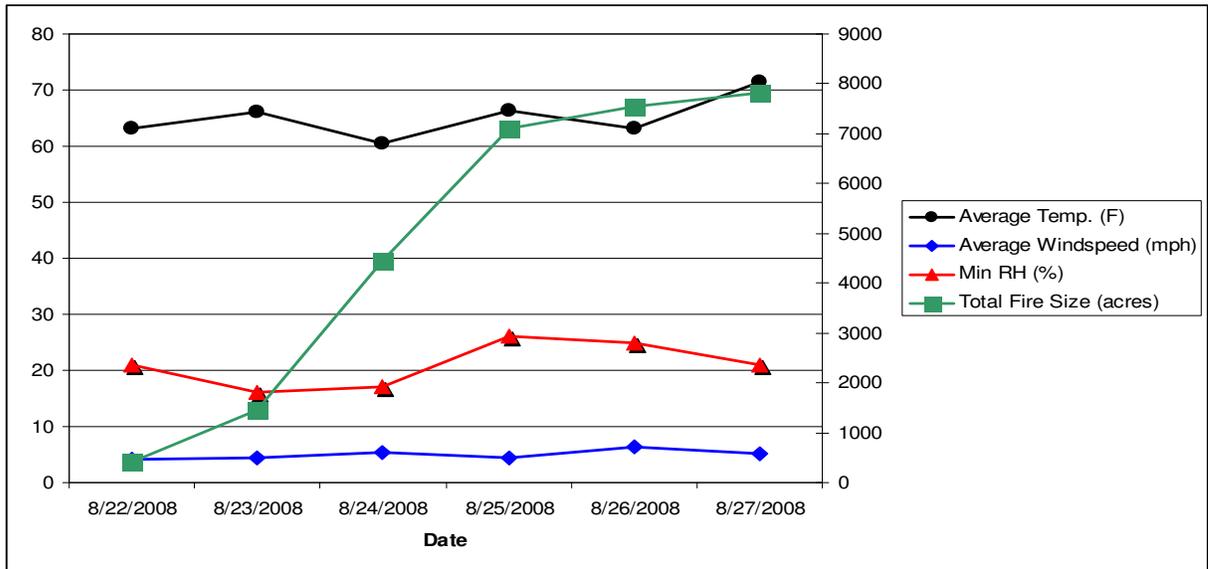
Figure 4. Shaded relief map of the Peterson Complex perimeter. Arrow indicates direction of wind and fire spread.



Weather

Weather information was collected from the Ladder Butte RAWS station, located approximately 7 miles northeast of the Peterson Complex. Average air temperatures fluctuated between 60° and 70° between June 22nd and June 27th. Wind speed was relatively constant over the course of the fire, averaging around 5 miles per hour from the north and northwest. The lowest relative humidities of between 16-17% were observed on June 23rd and June 24th (Figure 5).

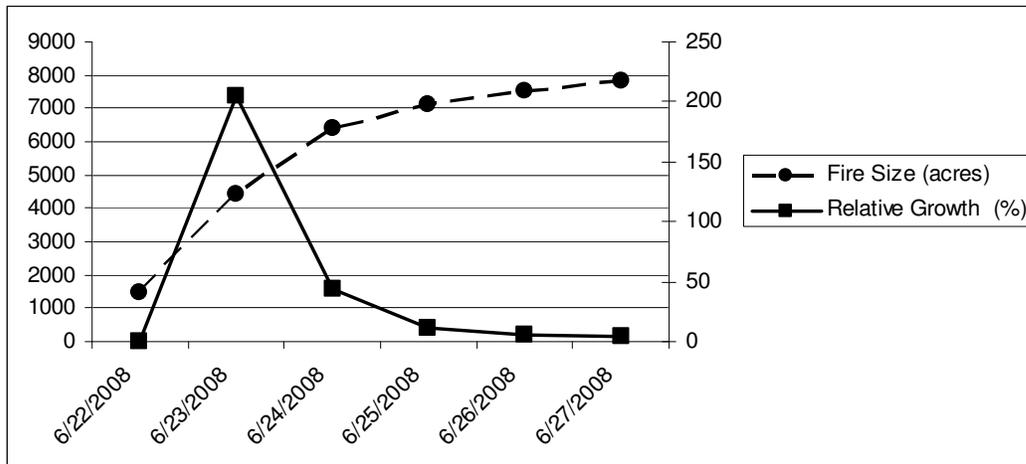
Figure 5. Ladder Butte RAWS Data for June 22- June 27, 2008. Total fire size (acres) plotted on right axis. All other variables plotted on left axis.



Chronology of Fire

The Peterson Complex started on June 21st at 1600, during an unprecedented lightning event responsible for the ignition of over 1,500 fires across California. There were two separate ignition points, burning a combined 1,454 acres by June 22nd in two separate fires. The fire made a run on June 23rd, and merged into a single fire occupying a total of 4,439 acres. On this day the fire also exhibited significant spotting behavior, including a spot fire that ignited within the Pittville DFPZ. The Southern Red Team Incident Management Team began managing the incident at 0600 on June 26th, when the fire was 7,545 acres in size. The fire reached its final size of 7,828 acres on June 27th. The growth of the Peterson Complex in acres, as well as the relative growth rate (growth in fire size/total fire size), is depicted in Figure 6.

Figure 6. Total fire size (left axis) and relative growth (right axis) of the Peterson Complex.

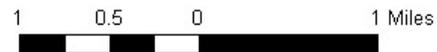
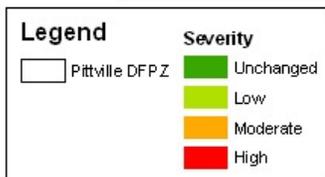
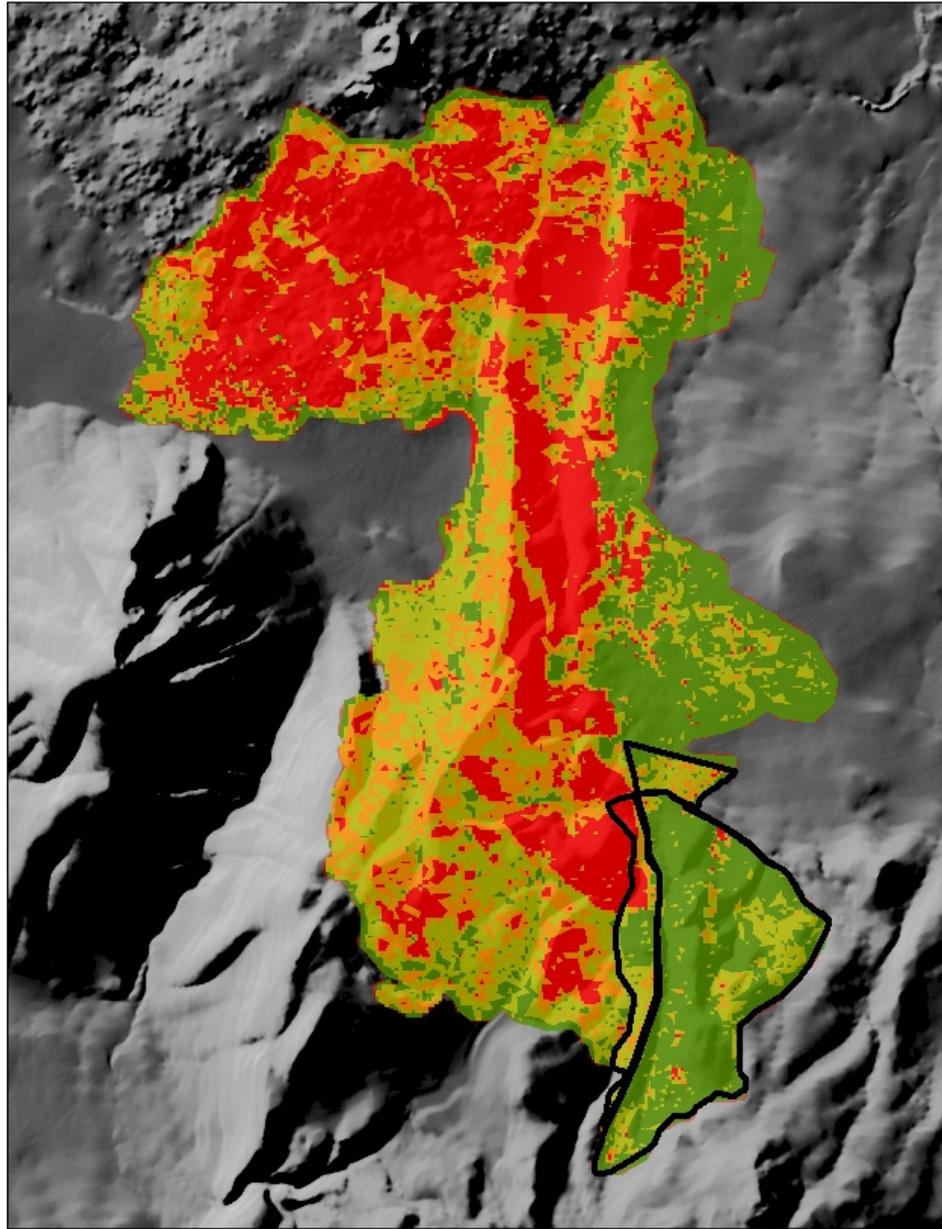


Remotely Sensed Data

Fire severity, based on vegetation, across the entire Petersen Complex was mapped using satellite imagery (Miller and Thode 2007). Severity is categorized based on basal area mortality of vegetation where high is >75% basal area mortality, moderate is between 25 and 75% mortality, low is <25% mortality, and unchanged corresponds to no mortality (Figure 7).

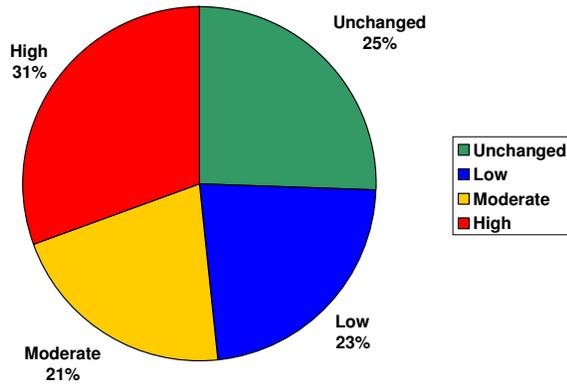
Figure 7. Vegetation burn severity within the Peterson Complex.

Petersen Complex Fire Severity



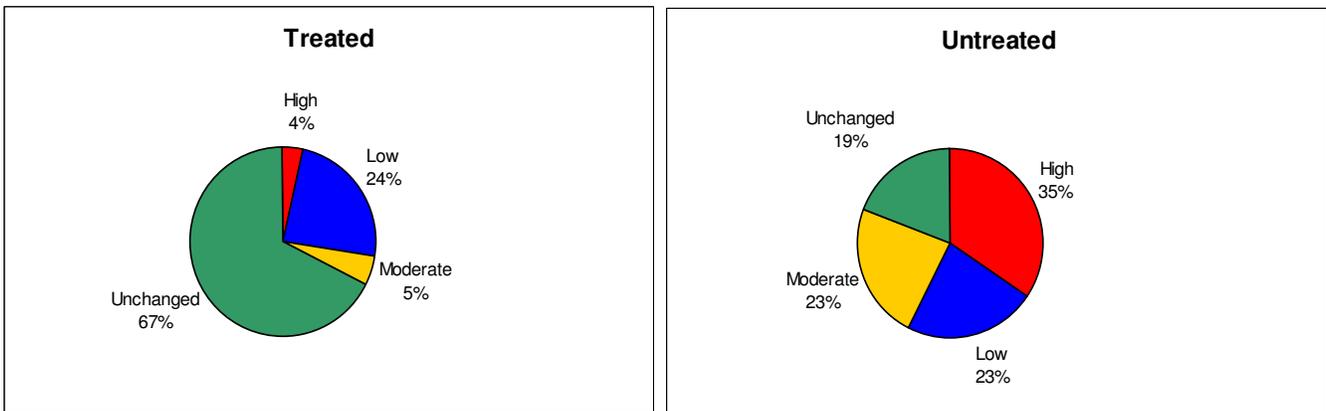
Based on the satellite imagery approximately 30% of the entire Peterson Complex area was categorized as high severity, 21% was moderate, 23% was low, and 25% was unchanged (Figure 8).

Figure 8. Categories of vegetation burn severity across the Peterson Complex.



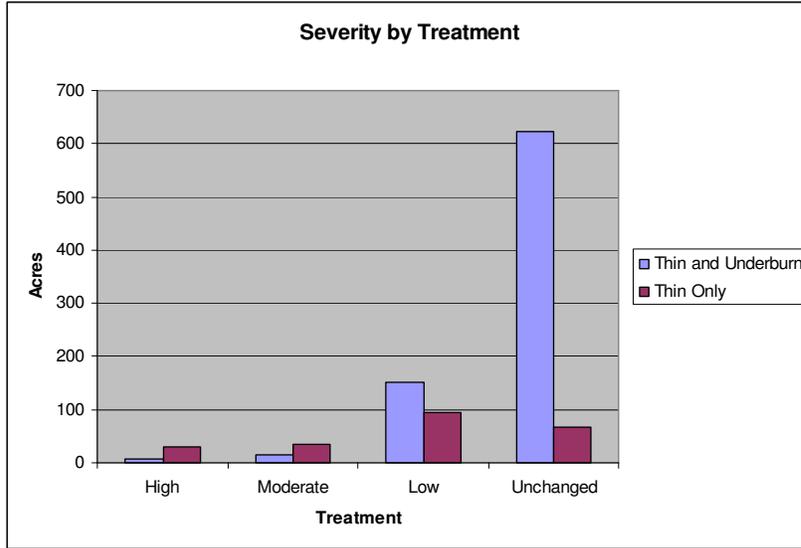
A comparison of treated and untreated areas shows that only 4% of the Pittville DFPZ experienced high severity fire effects, compared with 35% of the untreated area. Over 65% of the Pittville DFPZ was considered unchanged after the Peterson Complex, compared with only 19% of the untreated area (Figure 9).

Figure 9. Comparison of fire severity in treated and untreated areas within the Peterson Complex.



The type of treatment implemented within the Pittville DFPZ prior to the Peterson Complex also had an effect on fire severity as a result of the Peterson Complex. Areas within the Pittville DFPZ that had been treated through both thinning and underburning had more unchanged and low severity fire effects after the Peterson Complex than areas that had only been thinned but not underburned (Figure 10).

Figure 10. Vegetation fire severity by treatment type based on remotely sensed data.



Field Observations

The Hat Creek Ranger District Fire Management Officer, Debbie Mayer, observed that rates of spread and flame heights slowed significantly when the Peterson Complex entered the Pittville DFPZ. She recalls that:

“The fire behaved much as prescribed understory burn, which allowed the limited fire crews to focus suppression efforts on portions of the fire with intense fire behavior. We did not worry about the treated area for 2 days while we chased the head of the fire.”

After entering the Pittville DFPZ, spot fires from the Peterson Complex, “crept around the unit with low intensity (1 foot flame lengths) for 2-3 days.” This type of fire behavior resulted in high tree survival and low fire severity within the Pittville DFPZ (Figure 11).

Figure 11. Photograph of Pittville DFPZ where fire severity from the Peterson Complex was low.



However, portions of the Pittville DFPZ that had not been underburned prior to the Peterson Complex experienced some high and moderate severity fire effects (Figure 12). This may have resulted from higher surface fuel loading in these areas, or from topographical features that may have caused some channeling of the wind.

Figure 12. Photograph of the Pittville DFPZ after the Peterson Complex where fire effects were more severe. This portion of the DFPZ was thinned but not underburned.



In general, the Peterson Complex appeared to burn untreated areas with the greatest intensity, resulting in higher fire severity than treated areas (Figures 13 and 14).

Figure 13. Fire severity in the Pittville DFPZ and adjacent untreated areas after the Peterson Complex.

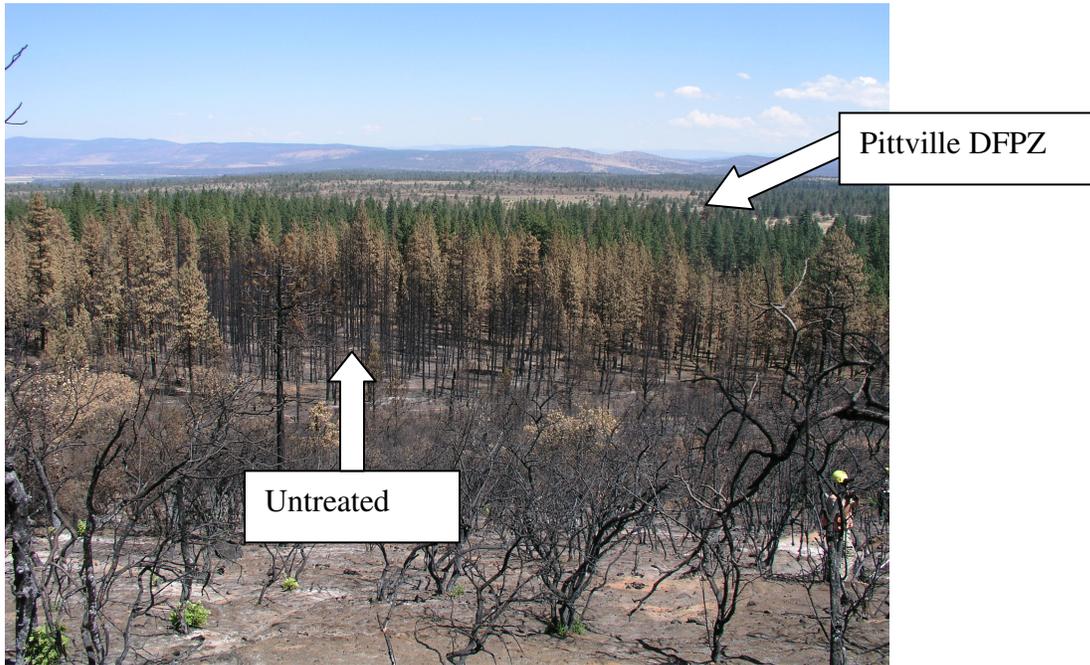


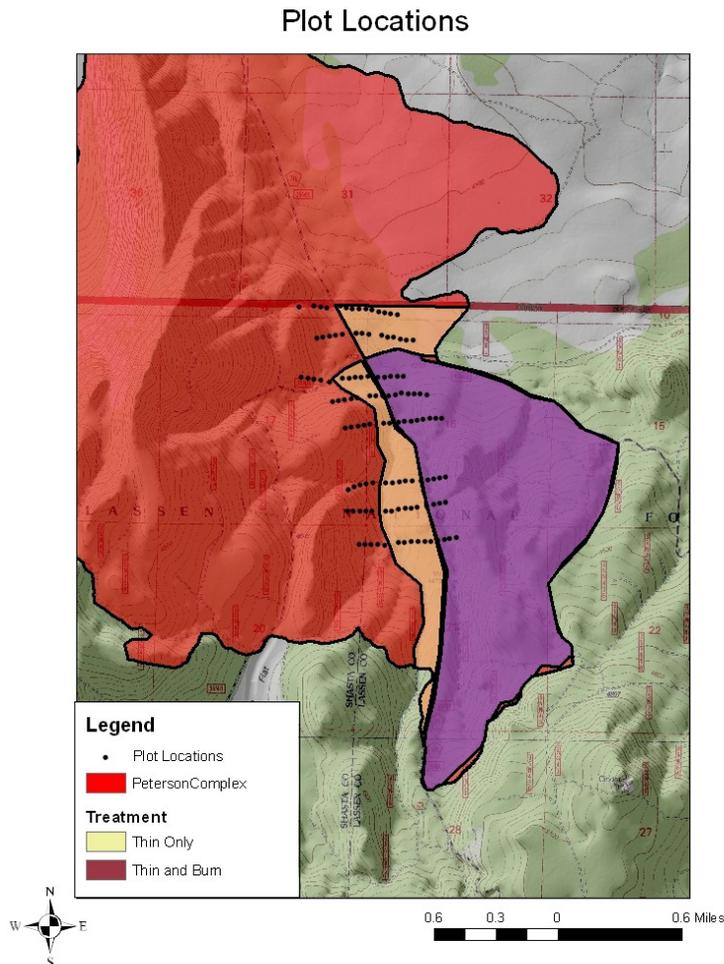
Figure 14. Fire severity within untreated area of the Peterson Complex.



Field Data

To quantitatively evaluate fire severity as a result of the Peterson Complex, we collected ground based field data between August 2nd and August 15th, 2008. Our design was intended to minimize differences in topography, vegetation, and burn conditions between the Pittville DFPZ and adjacent, untreated areas. We established eight 750-meter (m) transects oriented perpendicular to the boundary between the Pittville DFPZ and the adjacent untreated area (Figure 15). Plots were established every 50 m along each transect, for a total of 15 plots per transect and 120 plots across the entire study area. Each transect had approximately five plots located in the untreated area, five plots in the thinned only unit of the Pittville DFPZ, and five plots in the thinned and underburned portion of the Pittville DFPZ (Figure 15). The five transects in the northern portion of the Pittville DFPZ burned on June 23rd, and the three southern transects burned on June 24th.

Figure 15. Plot locations in relation to Peterson Complex perimeter and Pittville DFPZ. The four northern transects burned on June 23rd, and the three southern transects burned on June 24th.



Data were collected to quantitatively evaluate fire severity using the point-center quarter method (Cottam 1954). At each plot, the following information was recorded:

- Tree species, diameter at breast height, and tree height;
- Overstory canopy closure;
- Tree mortality;
- Scorch height and bole char height;
- Percent crown volume scorch; and
- A categorical rating of burn severity based on both soil and vegetation (USDI National Park Service 2003). See Appendix A for definitions.

At each plot location slope and aspect were recorded. Shrub, grass, and herb cover were estimated in 10% cover classes within a 2m radius circle established at plot center. We searched the plot circle for any evidence of animals, including scat and burrows. Plot locations were recorded with GPS, and distance to the nearest boundary between the Pittville DFPZ and the untreated area was calculated in GIS. Photos were taken facing north from plot center.

Statistical Analysis

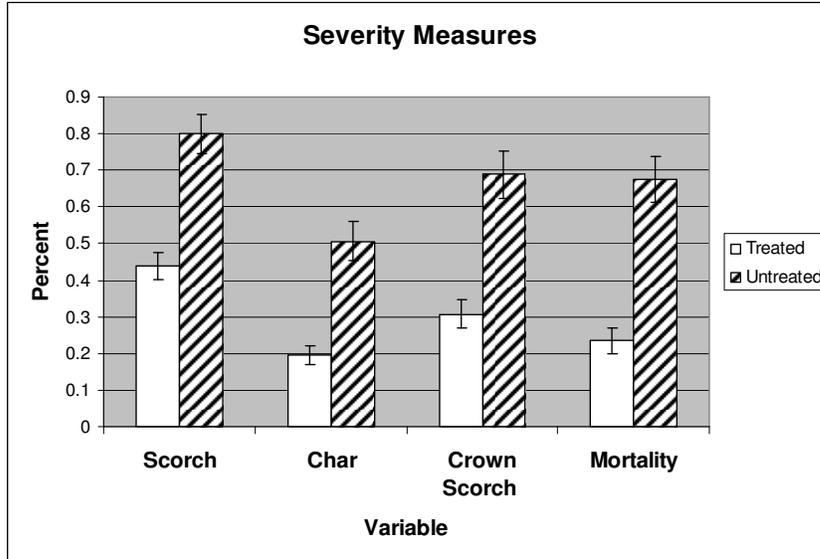
All analyses were completed in SAS (SAS 2006). Percent crown scorch, percent char height, percent mortality and percent scorch height were arc-sine square root transformed to improve normality. Differences in these variables as a result of treatment type were evaluated using ANOVA. Post-hoc tests of pair-wise differences were conducted using the Bonferroni approach. Differences in categorical variables between treatment types, including the NPS severity rating and the presence or absence of animal sign, were analyzed with chi-square tests. Relationships between char height, scorch height, and crown scorch and distance from the DFPZ boundary were evaluated with linear regression. Percent mortality was based on an evaluation of the four nearest trees per plot, and was therefore limited to 5 possible values (0, 25, 50, 75 and 100%). Therefore mortality data was analyzed using a general linear model. Exploratory analyses to determine which explanatory variables may have influenced tree mortality and animal sign were conducted using the AIC criterion (Burnham and Anderson 1998). We then used a general linear model (for mortality) and logistic regression (for animal sign) to compare the relative importance of each predictor variable selected through AIC.

Results

Severity Measures

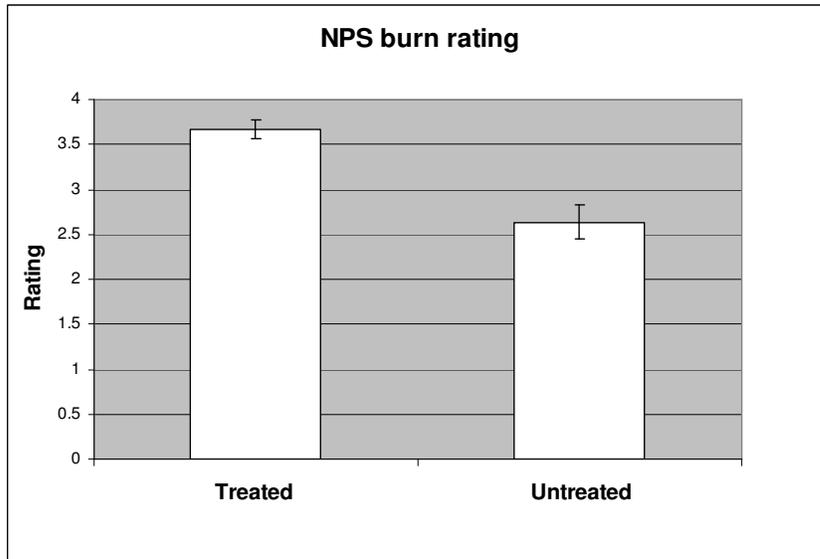
The severity measures we evaluated were char height and scorch height, percent char height and percent scorch height (as a percent of tree height), percent crown scorch, and percent mortality. Since absolute char and scorch heights were strongly correlated with percent char and percent scorch height (adjusted $R^2=0.79$ and 0.65 respectively), we report the relative measures here to allow for simpler graphical presentation. We found that percent char, percent scorch, percent crown scorch and percent mortality were all significantly lower within the Pittville DFPZ than in the adjacent untreated area (Figure 16).

Figure 16. Percent char and scorch height, percent crown scorch, and percent mortality were significantly higher in untreated areas than within the Pittville DFPZ, (df=1,118, $p<0.001$, except for scorch height where $p=0.008$).



The categorical burn severity rating based on both vegetation and soil was also significantly less severe within the Pittville DFPZ than within the adjacent untreated area (Figure 17). According to this rating system, lower values indicate higher severity (Appendix A).

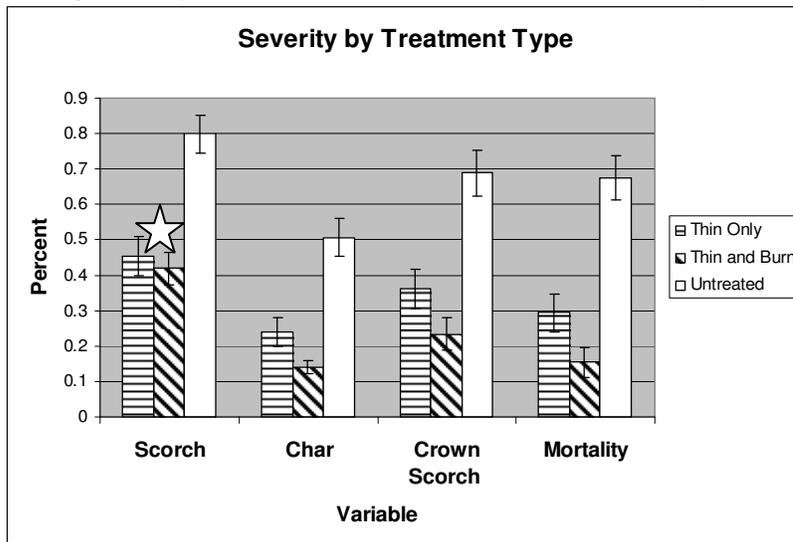
Figure 17. There were significantly higher burn severity ratings (indicated by a lower score) in untreated areas burned during the Peterson Complex than in the Pittville DFPZ (df=4, chi-square=26.32, $p<0.001$).



Treatment Type

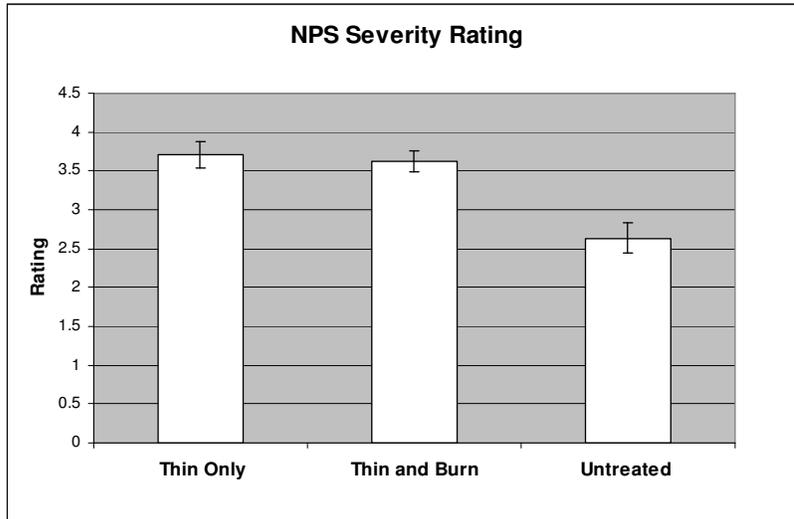
Areas that were thinned and underburned within the Pittville DFPZ prior to the Peterson Complex had significantly lower percent char height, percent crown scorch and percent mortality as a result of the Peterson Complex than areas of the Pittville DFPZ that had been thinned only (Figure 18). Percent scorch height did not differ significantly between thin only and thin and burn treatments within the Pittville DFPZ.

Figure 18. All severity measures were significantly higher in untreated areas than in the Pittville DFPZ after the Peterson Complex. All measures except percent scorch height (indicated by a star) were significantly lower in thin and burn units than in thin only units within the Pittville DFPZ.



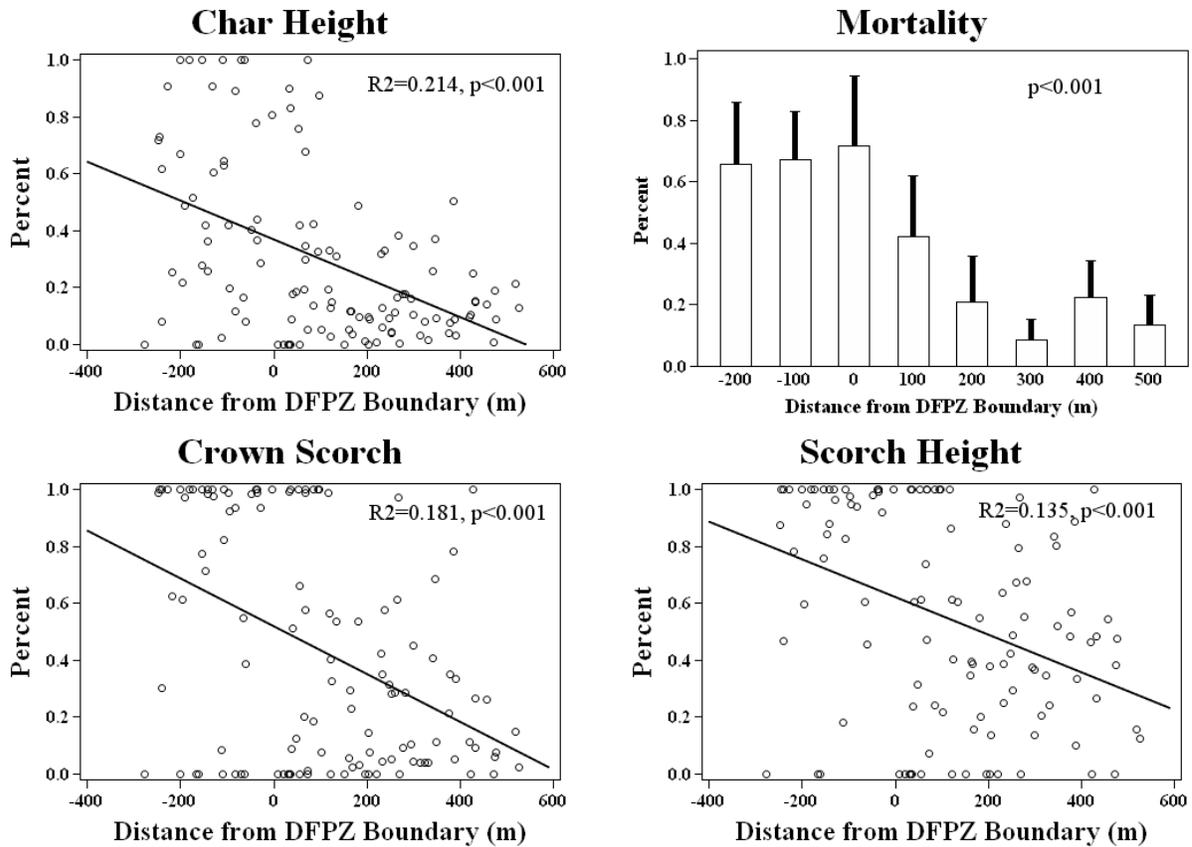
The categorical severity ratings were lower (more severe) in untreated areas than within the Pittville DFPZ, but did not significantly differ between thin and underburn and thin only units (Figure 19).

Figure 19. Categorical measures of severity were significantly higher (indicated by lower values) in untreated areas than in the Pittville DFPZ after the Peterson Complex. However there was no difference in severity between thin and burn units and thin only units within the Pittville DFPZ.



All four severity measures (percent char height, percent scorch height, percent crown scorch, and percent mortality) declined significantly with distance from the border between the Pittville DFPZ and the adjacent untreated area (Figure 20).

Figure 20. All measures of severity declined significantly with distance from the boundary of the Pittville DFPZ and the adjacent untreated area (boundary is at zero, negative values are in the untreated area, positive values are in the Pittville DFPZ). Mortality was evaluated by general linear model, other variables with linear regression.



Environmental Variables

To evaluate the effect of other factors that may have influenced fire severity as a result of the Peterson Complex, we used a general linear model to evaluate slope, aspect, burn day, vegetation type, and distance from the Pittville DFPZ boundary with the adjacent, untreated area. We choose to focus on mortality for this analysis since this variable is of greatest interest for forest restoration efforts. We found that of all variables evaluated, distance from the DFPZ boundary was the most significant predictor of tree mortality (Table 1; Figure 20). Slope and aspect also improved the predictability of the model, while vegetation type and burn day did not. However, lack of sufficient data precluded analysis of a number of variables that are known to influence fire behavior such as site specific fuel loading. Inclusion of these data likely would have improved the predictability of our model.

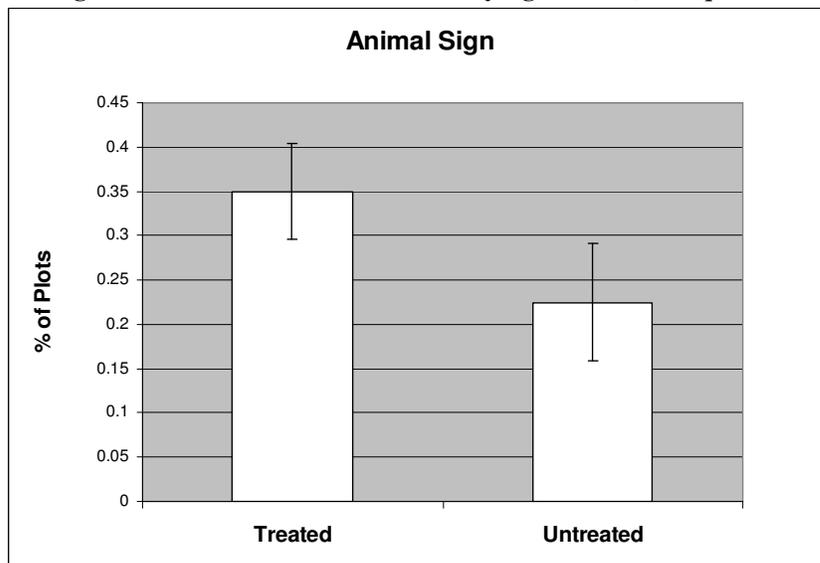
Table 1. General linear model results for factors that influenced tree mortality. Distance from the DFPZ was the most significant variable evaluated.

Variable	DF	Wald Chi-Square	P
Distance from DFPZ	1	33.69	<0.0001
Slope	1	13.60	0.0002
Aspect	1	3.54	0.0600

Animal Use

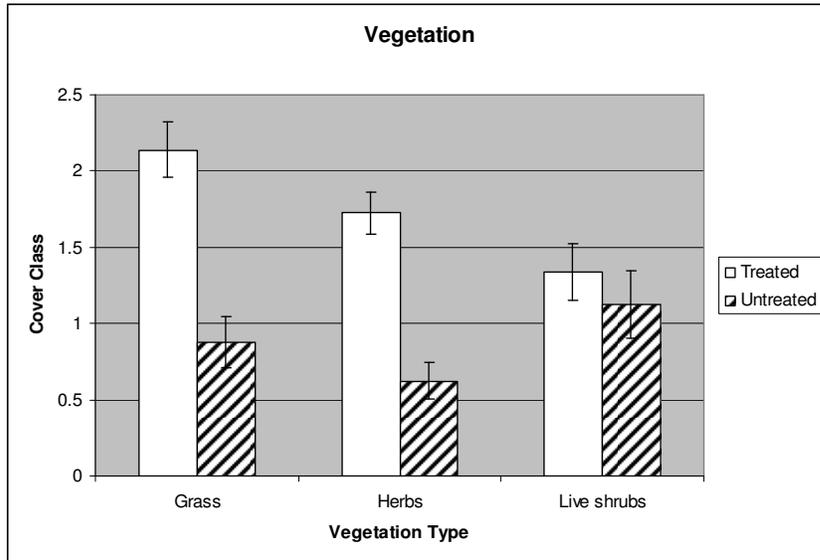
There tended to be more animal sign in the Pittville DFPZ than in adjacent untreated areas, but this difference was not statistically significant (Figure 21).

Figure 21. Animal sign tended to be greater in the Pittville DFPZ than in the untreated area, although this difference was not statistically significant (Chi-square=1.95, df=1, p=0.16).



Animal sign was most strongly related to grass cover and vegetation type (df=5, chi square=17.9, p<0.001). Vegetation type was similar within the Pittville DFPZ and adjacent untreated areas, which may explain why animal sign was also similar in these two areas. However, both grass and herb cover was significantly higher in the Pittville DFPZ compared to the adjacent untreated area, while the cover of live shrubs did not differ between the Pittville DFPZ and untreated areas (Figure 22). This was likely a result of shrub species which resprouted almost immediately after the fire.

Figure 22. Grass and herb cover were significantly higher in the Pittville DFPZ than in the untreated area burned during the Peterson Complex. However, live shrub cover did not differ between treated and untreated areas, probably as a result of sprouting shrub species found throughout the Peterson Complex.



Summary and Conclusions.

The Peterson Complex burned with a range of severities. Although some of the variation in severity across the entire fire perimeter may have been due to variations in vegetation, weather, and topography, the Pittville DFPZ effectively reduced fire intensity so that suppression efforts could focus on other portions of the fire. Satellite imagery and field data indicated that fire severity within the Pittville DFPZ was lower than in adjacent untreated areas. These data also show that thinning combined with underburning was a more effective treatment for reducing fire intensity than thinning alone. Distance from the boundary between the Pittville DFPZ and the adjacent untreated area was the most important variable determining tree mortality. Trees that were further from the untreated area were more likely to survive. Ritchie et al. (2007) also found that thinning and burning treatments resulted in lower fire severity after a wildfire than thinning treatments alone, and that tree mortality decreased with distance from the boundary between the treated and untreated area.

Animal sign was statistically similar within the Pittville DFPZ and the adjacent untreated area. Although there was more grass and herbaceous cover within the Pittville DFPZ than in untreated portions of the Peterson Complex, the quick response of sprouting shrub species resulted in similar amounts of shrub cover throughout the burned area. Other studies have shown that many species of wildlife do well after fires because it stimulates the production of important forage species, particularly understory shrubs, herbs, and grasses (Smith 2000).

Literature Cited

- Cottam, G. and JT Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* **37**: 451–460.
- Miller, Jay D. and Andrea E. Thode. 2007. Quantifying burn severity in a heterogeneous landscape with a relative version of the delta Normalized Burn Ratio (dNBR). *Remote Sensing of Environment* **109(1)**: 66-80.
- Martin W. Ritchie, Carl N. Skinner, Todd A. Hamilton. 2007. Probability of tree survival after wildfire in an interior pine forest of northern California: Effects of thinning and prescribed fire. *Forest Ecology and Management* **247** (2007) 200–208
- SAS Statistical Software. 2006. SAS Institute Inc., Cary, NC, USA.
- Smith, Jane Kapler, ed. 2000. Wildland fire in ecosystems: effects of fire on fauna. Gen. Tech. Rep. RMRS-GTR-42-vol. 1. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p.
- USDI National Park Service. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center. 274p.

Appendix A.

Definitions of categorical rating of burn severity from the Fire Monitoring Handbook (USDI National Park Service 2003).

	Heavily Burned (1)	Moderately Burned (2)	Lightly Burned (3)	Scorched (4)	Unburned (5)
Substrate (S)	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas inorganic preburn	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged	not burned
Vegetation (V)	all plant parts consumed, leaving some or no major stems/trunks; any left are deeply charred none present preburn	foliage, twigs, and small stems consumed; some branches still present	foliage and smaller twigs partially to completely consumed; branches mostly intact	foliage scorched and attached to supporting twigs	not burned