A Comparison of Visual and Quantitative Changes From Rotational Prescribed Burning in Old-Growth Stands of Southwestern Ponderosa Pine[1]

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Abstract

Two long-term prescribed fire studies were established near Flagstaff, Arizona in 1976 and 1977. One of the sites, Chimney Spring, is located on a basalt soil type and had not received any natural fires for the previous 100 years. The other site, called Limestone Flats, located on a sedimentary soil type, has a similar fire-free period but received a sanitation cut to remove the dead overstory in the early 1960s. The study was designed to test 1-, 2-, 4-, 6-, 8-, and 10-yr burning rotations in southwestern old growth ponderosa pine stands. The primary objective was to determine if a particular burning rotation would reduce and maintain the natural accumulation of fuels and reduce the stand density to a condition that would withstand a wildfire under average worst conditions. Permanent photo points were initiated at the time each study area was established, and they have been retaken periodically. Visual changes in stand structure correspond to the reduction in number of stems but don't reflect the continuation or increase in basal area per acre. The photos also show the initial reduction in large woody fuels followed by their incremental return.

Introduction

Southwestern ponderosa pine forests historically developed with the natural occurrence of frequent fire. The overstory groupings have been shown to be even- aged or even-sized. This stand structure resulted primarily from thinning by reoccurring natural fires that also stimulated the grass community and kept the accumulation of fuels in check. With the active suppression of natural and human-caused fires, the continuous accumulation of fuels and increased stand density have created a very unnatural hazardous situation in southwestern forests. Two long-term fuel reduction studies were initiated in 1976 (Chimney Spring, basalt soil type) and 1977 (Limestone Flats, sedimentary soil type) to determine if a rotational prescribed burn program would be a viable management option to reduce these hazardous conditions found in natural stands of southwestern ponderosa pine. The rotations selected reflected the fire history for the Chimney Spring area (Dieterich 1980) and included 1-, 2-, 4-, 6-, 8-, and 10-yr rotations along with a "no-burn" control.

Original fuel loadings were determined prior to the application of the burn treatments for each study area and are summarized in Sackett (1980) and Sackett and Haase (1998). Briefly, the Chimney Spring study area had a total of 22.3 tons ac^{-1} (50.0 Mg ha^{-1}) of fuel. Of this amount, 15.2 tons (34.1 Mg) were of organic material ≤1 inch (2.54 cm) in size, and the remaining 7.1 tons (15.9 Mg) was of the large woody fuel >1 inch (2.54 cm). Total fuel loading was reduced by 65 percent in the initial burn. The Limestone Flats area had a total fuel loading of 32.3 tons ac^{-1} (72.4 Mg ha^{-1}). Material less than 1 inch (2.54 cm) in diameter was 15.7 tons ac^{-1} (35.2 Mg ha^{-1}), and the larger woody fuels greater than 1 inch were 16.6 tons ac^{-1} (37.2 Mg ha^{-1}). Forty-three percent of the fuel loading was removed with the initial burn. Both areas had very similar fine fuel loadings but contrasting large fuel loadings and

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quite different consumption rates. This was most directly related to the difference in fuel moisture conditions at the time of the initial entry burns (Sackett 1980).

Various fire effects are being followed during the length of these studies. They include overstory changes in growth and mortality, understory vegetation responses, soil ammonium- and nitrate-nitrogen changes, and others. This paper was developed after evaluating the complete retake of photo points on the two study areas. The visual effectiveness of prescribed burning became obvious when comparing previously taken photos and seeing how the structure of stands can actually change with repeated prescribed fires and that this action still needs to be considered a viable management tool.

Methods

Permanent photo points were established on each of the 2.5 ac (1 ha) treatment plots at both study sites, and additional points were added when situations warranted documentation (*fig. 1*). The photo points were established from each corner looking toward the closest permanent sample point (1 to 5) and from various permanent sample points to other sample points. All trees were measured in a 0.1 ac circular plot at each of the five permanent sample points located on each treatment plot. For this paper the treatment plots that demonstrated significant visual changes were measured again in the fall of 2002, calculating the BA ac^{-1} (ft^2 ac^{-1}) of these treatment plots.

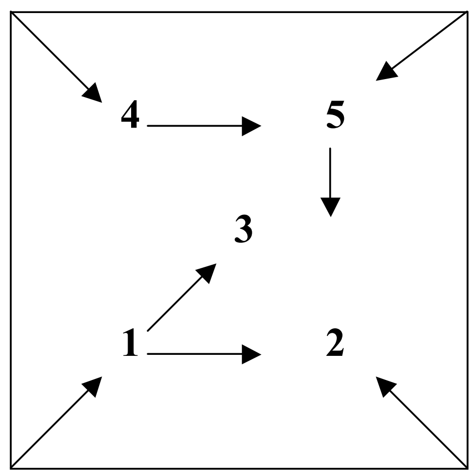

Figure 1—Diagram of possible photo point and permanent sample point orientation.

Results

The following sets of photos (*figs. 2-8*) are grouped by treatment and study site. The left-hand photo is what the photo point looked like prior to the initial burn, and the second photo is what the photo point looked like in fall 2002. Only one example is given due to the restriction of space. The stem count and basal area data are representative of the particular treatment plot represented in the photo set for that treatment and are summarized (*table 1*).

The number of times the treatments have been applied are as follows:

	Burn rotation					
	1 yr	2 yr	4 yr	6 yr	8 yr	10 yr
Chimney Spring	26	14	7	5	4	3
Limestone Flats	25	13	6	5	4	3

1 year rotation treatment

Figure 2—Top photos are taken on plot 2E1 of the Chimney Spring site, and the bottom photos are taken on plot 3A1 of the Limestone Flats research site.

2 year rotation treatment

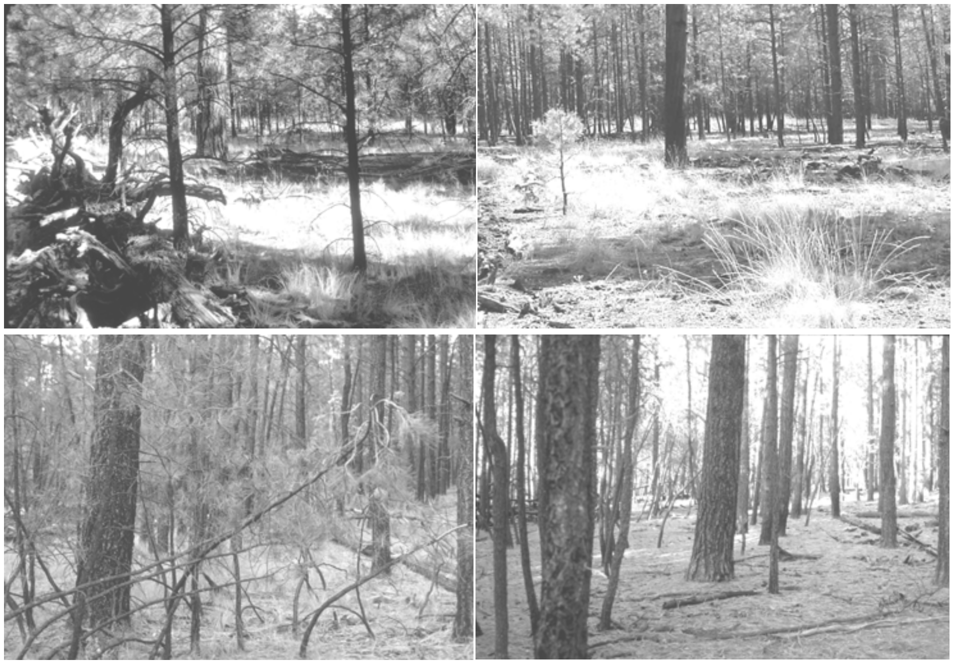

Figure 3—Top photos are taken on plot 2G2 of the Chimney Spring site and the bottom photos are taken on plot 4D2 of the Limestone Flats research site.

4 year rotation treatment

Figure 4—Top photos are of plot 1A4 of the Chimney Spring site and the bottom photos are taken on plot 4E4 of the Limestone Flats research site.

6 year rotation treatment

Figure 5—Top photos are of plot 2F6 of the Chimney Spring site and the bottom photos are taken on plot 4F6 on the Limestone Flats research site.

8 year rotation treatment

Figure 6—Top photos are taken on plot 2B8 of the Chimney Spring research site and the bottom photos are of plot 2D8 from the Limestone Flats research area.

10 year rotation treatment

Figure 7—Top photos are of plot 1B10 of the Chimney Spring research site and the bottom photos are from plot 5D10 of the Limestone Flats research site.

Controls

Figure 8—Top photos are of control plot 2CC on the Chimney Spring research site and the bottom photos are of plot 5CC of the Limestone Flats research site.

***Table 1**—Changes in number of trees per acre and basal area (BA=ft^2 acre^{-1}) of specific treatment plots of both study areas. Chimney Spring study area was initially sampled in 1976 and Limestone Flats study area in 1977. Selected plots of both areas were then sampled in 2002.*

	Chimney Spring			**Limestone Flats**		
Treatment sample period	**Stems ac^{-1}**	**Plot ID**	**BA ac^{-1}**	**Stems ac^{-1}**	**Plot ID**	**BA ac^{-1}**
1 year rotation		2E1			3A1	
Initial	2,808		171.8	2,132		131.7
2002	674		202.3	350		164.1
2 year rotation		2G2			4D2	
Initial	1,658		153.0	2,056		149.4
2002	664		166.1	754		186.8
4 year rotation		1A4			4E4	
Initial	1,168		160.7	2,700		152.7
2002	282		164.8	668		188.7
6 year rotation		2F6			4F6	
Initial	2,636		171.7	1,826		103.3
2002	682		181.9	314		106.7
8 year rotation		2B8			2D8	
Initial	2,334		157.8	2,298		121.9
2002	574		167.3	560		142.9
10 year rotation		1B10			5D10	
Initial	2,708		166.8	1,848		146.4
2002	282		159.0	696		172.5
Control		2CC			5CC	
Initial	2,434		175.8	2,584		119.5
2002	1,356		197.6	1,830		218.0

Discussion

The number of trees per acre and BA information (*table 1*) is based on the plots corresponding to the photos and cannot be interpreted as treatment averages, but similar visual and quantitative responses were found on the other treatment replications. Prescribed burning affects many aspects of a ponderosa pine ecosystem, but most are not as easily assessed as what these photos show (Harrington 1991, Sackett and Haase 1998). The greatest prescribed burning effect seen in the photos, both visually and quantitatively, is a decreased number of trees per acre. The reduced tree numbers appear significant for the reported treatment plots both visually and quantitatively. The smaller size classes were the most affected, as seen in the photos where the sapling thickets were greatly reduced. This reduction was achieved with subsequent applications of prescribed fire. Once the initial fuels were reduced, fire was applied more aggressively, altering the stand more significantly. Another important response that was contrary to the reduced number of trees per acre was the general increase of basal area on most of these treatment plots. This would suggest that the larger trees can continue to put on annual increments with the removal of competing smaller trees and with improved soil moisture conditions (Clary and Ffolliott 1969, Harrington 1991).

Another obvious result was the removal of large woody material. Fire managers have had to work with the requirement made by wildlife managers that to conserve this fuel size class for small mammals and other users. As the prescribed fire thins these stands, the amount removed is restored with newer, sounder material. Although not easily seen in the photo sets shown, large woody material is being added to the system on a regular basis. A portion of mature yellow pines were killed by the initial prescribed burns because of the heavy fuel loadings around the bases of these trees, and they will all eventually fall, adding to the coarse woody debris component of the ecosystem. Tops of pole size and larger trees are often struck by lightning and, as seen in the photos of the controls (*fig. 8*), demonstrate that these large fuels are being added to the system and not being removed. Also seen in these same photos is the breakdown of the large woody component overtime, but even in this condition the fuel still remains a concern for the fire manager.

Stand structural changes are evident in these photos that support the use of prescribed burning, if the objective is to reduce natural fuel loadings and remove the small thickets typically found in stands of southwestern ponderosa pine represented here. Crown base heights are also raised, as seen in the photos, reducing the stands' crown fire potential. This is achieved by removing the lower branches of the pole size trees through scorching and the removal of ladder fuels. It is evident that prescribed burning alone is not sufficient to return existing uncut stands into stands that would significantly reduce the probability of uncharacteristic catastrophic fires. Mechanical thinning either before or after the removal of natural fuels by prescribed burning may be needed to address the issue of making stands safe from catastrophic wildfire in a more timely manner.

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