Changes in Understory Production Following a Wildfire in Southwestern Ponderosa Pine

BRIAN P. OSWALD AND W. WALLACE COVINGTON

Abstract

An area burned by a May, 1972, wildfire and which had been previously sampled in 1972 and 1974 was remeasured in 1980 to determine changes in understory production. The area was stratified into moderately and severely burned areas. By 1974 both herbage and forage production on the moderately burned area were approximately 3 times higher than unburned control sites and did not decline significantly by 1980. While increased herbage production on the severely burned site was similar to that of the moderately burned site in 1974, it declined to only half as much production by 1980. Furthermore, while over 95% of the total herbage production was in forage species for all 3 sampling years on the moderately burned study area, only 30 percent was forage on the severely burned study area by 1980. The decline in total production and shift to non-forage species on the severely burned study area is probably a consequence of heavy grazing which followed the burn.

Since settlement in the late 1800's forage production in southwestern ponderosa pine *(Pinus ponderosa[1])* has steadily declined. Early explorers recorded the area as open and park-like with large, widely spaced trees and an abundant understory of grasses and forbs (Cooper 1960). Today, increased tree density and heavy forest floor accumulations, brought about by fire exclusion, have greatly decreased herbaceous production (Cooper 1961a, Clary et al. 1966, and others). The heavy fuel loadings have resulted in an exponential increase in the size and severity of wildfires in southwestern ponderosa pine (Barrows[2]). Several studies suggest changes in production, forage quality, and species composition in understory vegetation for the first few years following wildfires. However, only one has examined long term wildfire effects on the understory.

Pearson et al. (1972) studied the effects of wildfire on ponderosa pine understory vegetation on basalt soils in northern Arizona. The burned area was divided into moderately burned and severely burned areas. Vegetation production on the thinned, moderately burned area increased from 729 kilograms per hectare to 861 kilograms per hectare the first year after the fire. Production on the unthinned, severely burned area increased from 59 kilograms per hectare the first year to 1146 kilograms per hectare the next year. A similar study by Beaulieu (1975) and Fitzhugh and Beaulieu[3] examined wildfire effects on ponderosa pine understory on limestone soils in northern Arizona. As in the study by Pearson et al. (1972), the area burned by the 1972 Rattle Burn wildfire was divided into moderately and severely burned areas. Production increased almost threefold 2 years after the wildfire on both areas. Beaulieu (1975) found herbage production higher on the burned areas than on the unburned areas 3 years after the same wildfire.

The only long-term study of understory response to wildfire in southwestern ponderosa pine is that of Lowe et al. (1978), who measured understory basal area for areas with basalt-derived soil which had burned 1, 3, 7, and 20 years prior to their sampling. They found that forbs increased rapidly to a maximum at year 3 followed by a rapid decline by year 7 to control levels. Grasses declined the first year, but increased to a maximum by year 7. By year 20 grasses had declined somewhat but were still over twice the control. No long-term studies of wildfire effects on understory for sedimentary sites are available.

The objective of our study was to determine the extent of changes in understory vegetation production 7 years after the Rattle Burn wildfire. The approach was to remeasure the permanent plots used in the Beaulieu (1975) and Fitzhugh and Beaulieu (unpublished) studies and to compare our data with data from 1972 and 1974.

Study Area

The Rattle Burn fire started on May 7, 1972, and burned 286 ha before containment. The burned area is 30 km southwest of Flagstaff, Coconino County, Ariz. The burn is within the Coconino National Forest, Sections 15, 16, 20, 21, 27, and 28, T19N, R5E, Gila and Salt River Base Meridian. The burn was separated into 2 areas: a severely burned portion, where a high intensity ground and crown fire consumed most of the soil organic matter and plant life, and moderately burned portion, where a ground fire killed most understory vegetation and some sapling size ponderosa pine.

A severely burned sample area (8.1 ha) and a moderately burned sample area (4.0 ha) were established in 1972 within the burned areas. An unburned South Control area (17.7 ha) was established southwest of the burn at the same time. In 1974, Fitzhugh and Beaulieu (unpublished) established a North Control area northeast of the burn.

Eighty percent of the burn area has a rolling plateau surface with a relief of 25 m or less. Slopes range from 0 to 20%, and the elevation of the area ranges from 1900 to 2060 m. Soils are predominantly sandy loams in the Soldier, Hoggs, and McVickers series over Kaibab limestone and Coconino sandstone bedrock (Beaulieu 1975).

The average daily temperature of the Rattle Burn area is approximately 6° C. The area receives approximately 49 cm of precipitation annually, most in the form of winter snow.

The overstory vegetation is predominantly ponderosa pine *(Pinus ponderosa)* with scattered white fir *(Abies concolor)*, Douglas-fir *(Pseudotsuga menziesii)*, Gambel oak *(Quercus gambelii)*, and alligator juniper *(Juniperus deppeana)*. Understory vegetation included species of *Bromus, Carex, Agropyron, Poa, Senecio, Solidago, Muhlenbergia, Lathyrus,* as well as *Pteridiun*

Authors are former graduate student and associate professor, School of Forestry, Northern Arizona University, Flagstaff 86011. Oswald is now the instructor of forest and range science, College of Ganado, Ganado, Arizona, 86505.

[1]Nomenclature follows Kearney and Peebles (1964).

[2]Barrows, Jack S. 1978. Lightning fires in southwestern forests. Final report prepared by Colorado State University for Intermountain Forest and Range Experiment Station under Cooperative Agreement 16-568-CA with Rocky Mountain Forest and Range Experiment Station, Forest Collins, Colorado.

[3]Fitzhugh, E.L., J.T. Beaulieu. 1976. Wildfire effects on plant and animal communities in Arizona ponderosa pine forests. Unpublished manuscript.

aquilinum, Gutierrezia sarothrae, Vicia americana, Lupinus hillii, and a variety of other grasses and herbaceous plants.

Two years before the fire, the area was logged. Average harvest was 6750 board feet per hectare. Skid trails were seeded at a rate of 6.7 kilograms per hectare with sheep fescue *(Festuca ovina),* orchard grass *(Dactylis glomerata),* smooth brome *(Bromus inermis),* timothy *(Phleum pratense),* and burnet *(Sanguisorba annua,* and *S. minor)* (Fitzhugh and Beaulieu, unpublished). The seeded species did not become a significant portion of the vegetal community (Beaulieu 1975).

A reduction in overstory was one effect of the wildfire. The basal area of the moderate burn changed from 30.5 m^2/ha before the fire to 23.6 m^2/ha after the fire. The severely burned area changed from 29.6 m^2/ha to 9.2 m^2/ha for the same period. No significant change has occurred in the overstory since the fire. A post-fire salvage harvest removed 1,850,000 board feet in the summer of 1972. During the summer of 1973, an area that included the southern control area was thinned. Cleanup operations with heavy equipment in the burned area continued during the summer of 1973, causing the disturbance of soil and some vegetation plots.

The area used as the South Control in 1972 and 1974 was prescribed burned in the spring of 1977. This necessitated the use of the North Control as the only control area in 1980.

The Rattle Burn area includes parts of 2 Forest Service grazing allotments and has been grazed for the past several decades.

Methods

In 1972, 30 timber inventory plots (.04 hectares) were established in each of the designated severe, moderate, and control sample areas. These plots were located along transects systematically spaced perpendicular to the long axis of the sample area. A reference point in the center of each plot was marked with a steel stake 1.3 m long. The same system was used when the second control area was established in 1974 northeast of the burn.

Four vegetation plots were established on 2 perpendicular lines intersecting each reference point. Each plot (0.89 m^2) was 7.1 m from the reference point.

The use of vegetation plots established by the Fitzhugh and Beaulieu (unpublished) and Beaulieu (1975) studies allowed direct comparison and analysis of the data from each plot of the 3 measurements. Because some plots had been damaged by road development or slash piles in 1973, only 25 plots from each sample area were used in the analysis.

On two of the vegetation plots around each timber inventory plot, the number of stems of each species was counted and recorded. For grasses, the entire bunch was treated as one stem.

In the previous studies, harvesting was excluded from the permanent plots. In this study, all vegetation in the two plots used for stem count was hand-clipped in late July and early August, preserving 2 vegetation plots for future analysis. All vegetation was clipped at ground level and separated by species. The clipped material was oven dried at 105° C for 24 hours under forced air and weighed to the nearest .01 g. Data from the 2 vegetation plots per reference point were combined and averaged.

Total herbage production by species was calculated for each of the 25 reference points per area. These data were compared by analysis of variance with the data collected by Beaulieu (1975) in 1972 and Fitzhugh and Beaulieu[3] in 1974. This analysis determined the variation as a result of the passage of time and the severity of the burn. The analysis was designed to show if significant differences resulted from passage of time, burn severity, or their interaction. Differences between treatment means were tested at .05 confidence level by the Student-Newman-Keuls multiple range test. The mean herbage and forage weights from each sample area for the 3 years we compared to determine the time-related changes in herbage and forage production.

Results and Discussion

The mean herbage production for each study area in each year is presented in Table 1. The analysis of variance showed highly significant ($p<.05$) differences in production due to severity of burn and the passage of time.

Annual precipitation variations complicate the interpretation of these data. Precipitation in the Flagstaff area for 1980 was almost 50% above the historical average. A preliminary study by Ffolliott and Clary (1974) suggests linear increases in understory production with increasing precipitation. Although production on the North Control study area was not significantly higher in 1970 than 1974, the apparent increase is suggestive of higher production in 1980.

Table 1. Mean herbage production (kg/ha) of each study area in 1972, 1974, and 1980, Rattle Burn. Means followed by the same letter are not significantly different.

	Treatment			
	Moderately burned	Severely burned	Control[2]	Control[3]
1972	157^{x}	201^{x}	208^{x}	—
1974	$672^{a,y}$	$668^{a,y}$	$275^{b,x}$	$139^{b,x}$
1980	$682^{a,y}$	$341^{b,x}$	—	$295^{b,x}$

[a,b]Significant ($p<.05$) differences between severity of burn (rows).
[x,y]Significant ($p<.05$) differences over passage of time (columns).
[1]Production figures, especially in 1980, greatly affected by heavy grazing of area.
[2]Study area was prescribed burned in 1977.
[3]Study area plots were not established until 1974.

Production on the moderately burned study area was significantly higher in 1974 and 1980 than in 1972, but no significant changes occurred between 1974 and 1980. The production on the moderately burned study area was also significantly greater than the control in 1974 or 1980. The herbage production on the moderately burned study area appears to be leveling off, and might be close to, or may have attained, maximum production for the study area for the existing overstory density.

Although production was not significantly different between the moderately and severely burned study areas in 1974, the production on the severe burn was significantly lower than the moderate burn by 1980.

While forage species accounted for over 95% of the total herbage production on the moderate burn for all 3 years of sampling, forage production on the severe burn was only 63% of total herbage production in 1974 and slightly over 30% in 1972 and 1980 (Table 2). The preponderance of two non-forage species, bracken *(Pteridium aquilinum)* and snakeweed *(Gutierrezia sarothrae),* on the severely burned study area explains most of this difference.

As in all studies of fire effects on understory vegetation, caution must be exercised in attributing changes to direct effects of burning. Although burning affects plants directly through mortality and injury, understory vegetation on burned areas is also altered by greater grazing and browsing pressure caused by fire-induced enhancement in nutritional value of both forage and browse (Handley 1969). Such increases in nutritional value following burning in southwestern ponderosa pine have been demonstrated by Pearson et al. (1972); increases in elk use on burned areas over nearby unburned areas has been documented by Lowe et al. (1978). In fact, elk use peaked at year 7 in the Lowe et al. study. Since our

Table 2. Mean production (kg/ha) on the moderately burned and severely burned areas, 1972, 1974, and 1980, Rattle Burn.

	Moderately burned		Severely burned	
	Herbage	Forage	Herbage	Forage
1972	157	154	201	62
1974	672	651	668	424
1980	682	653	341	107

measurements were taken during the ninth growing season after burning and our area is utilized not only by elk but also cattle and deer, the impact of grazing and browsing pressure on the understory of our burned areas could be substantial.

Conclusions

Striking understory changes have occurred in the 9 growing seasons since the Rattle Burn. There has been a significant decline in herbage production on the severely burned study area since 1974, with a striking decline in forage production. This phenomenon was caused by increases in snakeweed and bracken on the severely burned site, apparently related in part to heavy grazing. Thus, caution must be used in interpreting production changes following burning where grazing is important.

Production on the moderately burned study area did not decline in either herbage or forage production during the same period. Production of both forage and herbage has remained approximately 4 times the first post-burn season's production. However, given the wide variation in ponderosa pine understory response reported in the literature, any attempt to generalize about wildfire effects on herbage or forage production for other areas and other wildfire conditions is ill-advised.

Literature Cited

Barrows, Jack S. 1978. Lightning fires in southwestern forests. Unpublished final report, Rocky Mountain Forest and Range Exp. Sta. USDA Forest Service.

Beaulieu, J.T. 1975. Effects of fire on understory plant populations in a northern Arizona ponderosa pine forest. M.S. Thesis. Northern Arizona Univ.

Clary, W.P., P.F. Ffolliott, A.D. Zander. 1966. Differences in herbage-timber relationships between thinned and unthinned ponderosa pine stands. USDA Forest Serv. Rocky Mountain Forest and Range Exp. Sta. Note RM-60.

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecol. Monogr. 30:129-164.

Cooper, C.F. 1961. The ecology of fire. Sci. Am. 204:150-160.

Ffolliott, Peter F., and Warren P. Clary. 1974. Predicting herbage production from forest growth in Arizona ponderosa pine. Prog. Agr. Ariz. 26:3-5.

Fitzhugh, E.L., and J.T. Beaulieu. 1976. Wildfire effects on plant and animal communities in Arizona ponderosa pine forests. Unpublished Manuscript.

Handley, C.O. 1969. Fire and mammals. Proc. Tall Timber Fire Ecol. Conf. 9:151-159.

Kearney, Thomas H., and Robert H. Peebles. 1964. Arizona Flora. Univ. California Press, Berkeley.

Lowe, Philip O., Peter F. Ffolliott, John H. Dieterich, and David R. Patton. 1978. Determining potential wildfire benefits from wildfire in Arizona ponderosa pine forests. USDA Forest Serv. Rocky Mountain Forest and Range Exp. Sta. General Tech. Rep. RM-52.

Pearson, H.A., J.R. Davis, G.H. Schubert. 1972. Effects of wildfire on timber and forage production in Arizona. J. Range. 25:250-253.