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# A Descriptive Study of the Effects of Fire on Ponderosa Pine (*Pinus ponderosa*) Along the Colorado Front Range



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## Abstract

Fire suppression along the Colorado Front Range has encouraged the growth of thick tree stands and the accumulation of woody debris and other organic matter which can act as fuel for fires. With this excess of fuel, forest fires tend to be more intense than more frequent naturally occurring fires. This descriptive study investigated the effects of 5-10 year old fires on ponderosa pine (*Pinus ponderosa)*. It was found that while visibility remained relatively constant, high intensity fires increased woody debris and snag basal area, as well as decreased canopy cover and live basal area. A low intensity fire was shown to have little effect on forest structure with regard to visibility, woody debris, live basal area, and canopy remaining consistent. This study can help to further the understanding of frequent fires in ponderosa pine forests.


## Introduction

Harold Weaver (1943) found that fire suppression can be detrimental to a ponderosa pine forest. Fire is necessary to kill pines so that the forest does not become overpopulated. Frequent low intensity fires averaging every 12-25 years maintain the correct balance of a parklike forest (Wright and Bailey, 1982). Silvicultural practices have suppressed fires, thus causing an increased density of ponderosa pine and an accumulation of organic matter which acts as fuel and can create higher intensity fires (Horton and Mannan, 1988).

Snags are standing dead trees which can create homes and foraging areas for many animals (Horton and Mannan, 1988). With the creation of more snags at burn sites, we expect to find an increase in both coarse woody debris and visibility index, as well as a decrease in canopy cover and basal area.

Presently, many studies are being conducted to find both positive and negative attributes of fires. Locally, organizations such as City of Boulder Open Space and Boulder Mountain Parks are conducting prescribed burns regularly (Toll, personal communication). We hope to contribute to these present studies by further investigating the effects of fire and its ability to maintain ponderosa pine density at healthy levels.

## Methods

We selected three burns, each of which are 5-10 years old. The first, which occurred in 1989, is located off the north fork of Shanahan Ridge on City of Boulder Open Space land (The Denver Post, 1989). This high intensity wind-driven fire occurred while logging was in process (Toll, personal communication). The second fire, 6 miles northwest of Boulder on Sugarloaf Mountain, is known as the Black Tiger or Sugarloaf Fire. This was another high intensity blaze which burned 2,086 acres on July 9,1989 (The Denver Post, 1989). The third fire, Olde Stage Road Fire, is located off Olde Stage Road in northwest Boulder. This fire occurred on November 24 and 25, 1990 and the area investigated was a low intensity burn which burned 2,210 acres of ponderosa pine forest (The Denver Post, 1990).

For all three locations, we laid a 50 m transect in both a burn and control site. From a random point on this transect, we established two 50 m transects running down the south-southwest slope. The control data was collected in non-burn areas adjacent to the burn locations, in order to keep aspect, elevation, slope and soil type as similar as possible. From these transects, we obtained the data for our three different sampling methods which included:

**a. POINT-QUARTER SAMPLING:** First we chose three random points along the 50 m transect. At each of these three points, the habitat was divided into equal quadrants. From each random point on the transect, we then measured the distance to the nearest ponderosa pine tree and ponderosa pine snag (point-to-plant distance). The data for this distance will was summed for all collection locations. This method was repeated for two ponderosa pines, one live and one dead, in each quadrant at each of the three points for a total of 24 measurements per transect.

We then found the maximum crown radius of live trees by measuring the distance from the center of the tree to the tip of the outermost branch. The relative canopy coverage was calculated by dividing the canopy radius by the point-to-plant distance. Basal Diameter (BD), the diameter at 0.5 meters height, was also recorded for each tree in the quadrant. By dividing the BD by the point-to-plant distance, we found the basal area. Basal area is an estimate of ponderosa pine tree density.

**b. MEASURING VISIBILITY:** The visibility cloth is 2.5 m by 0.6 m with 10 squares. The cloth was held at 15, 30, and 45 meters from the observer who was stationed at 0 m on the transect line. The observer counted the number of squares unobstructed by live or dead ponderosa pine when the cloth was held at both 1 m and 2 m height at each of the three distances, for a total of 6 observations per transect. At each transect, the total number of unobstructed squares was then summed in order to find the visibility index.

**c. COARSE WOODY DEBRIS:** The density of coarse woody debris was found by measuring the distance intercepted by the woody debris along the transect line and then summed. Percent cover of woody debris was found by dividing this sum by 50 meters (the transect length).

The data for all three data collection methods was analyzed by a two-way analysis of variance (ANOVA).

## Results

*Woody Debris*: Our results showed a significantly greater amount of woody debris in the burn sites (13.1%) compared to the control sites (2.9%) (fig. 1). The high intensity burns of Shanahan Ridge and Sugarloaf Mountain showed a significantly greater amount of coarse woody debris (10.9% and 12.1% respectively) in comparison to the debris at the Olde Stage Fire (0.9%) (fig. 2).

*Visibility*: Our results showed no major difference between burn and control sites (fig. 3). However, Shanahan Ridge had a higher visibility index (55.8) than the other two locations (25.3 and 28.5) (fig. 4).

*Canopy cover*: Average canopy coverage was higher for the controls (28.5%) than the burns (6.8) (fig. 5). However, the Olde Stage Fire showed little variation between the control site (19.0%) and the burn site (18.5%) (fig. 6).

*Basal Area*: The data showed no significant difference in total basal area between sites (fig. 7) or locations (fig. 8). However, when total basal area was broken down into snag basal area and live basal area, a substantial difference was found. The snag basal area was higher at the burn sites (2.8%) than at the control sites (0.8%) (fig. 9). Conversely, there was a statistically higher percentage of live basal area at the control sites (5.4%) in comparison to the burn sites (1.6%) (fig.10). However, the low-intensity Olde Stage Fire exhibited a live basal area which was similar for both burn and control sites, while the other two high-intensity fires showed a higher live basal area at the control sites (fig. 11).

## Discussion

Fire suppression on the Front Range of Colorado has created a forest environment susceptible to catastrophic crown fires. Both the high intensity and low intensity fires which we investigated caused increases in woody debris. This additional woody debris can affect the spread and severity of disturbances such as fire and insect outbreaks. Woody debris can also decompose and add nutrients to the soil (Spies *et al*., 1988).

We hypothesized that the visibility index would increase at the burn sites. Although we assumed this would occur because the lower limbs of live trees would be burned, we found the visibility index remained approximately the same. We attribute the lower visibility index at burn sites to the large amount of both snag limbs and woody debris. If live trees were the only trees counted in the study, the visibility index may have shown an increase at burn sites. Contrary to the data of the Olde Stage Fire and Sugarloaf Fire, the Shanahan Ridge Fire had a markedly higher visibility index at both the burn and control sites. This is likely due to logging on Shanahan Ridge which cleared out trees and woody debris (Toll, personal communication).

Canopy coverage showed an obvious decrease at the two high intensity burns, but the Olde Stage Fire was not intense enough to create snags and thus did not decrease the canopy coverage. The high intensity crown fires of Shanahan and Sugarloaf fatally burned all trees. Due to a history of fire suppression, these fires were unusually intense in comparison to the natural fire regime. Before the fires, these areas did not exhibit the open parklike mosaic pattern of a healthy forest with frequent understory fires every 12-25 years (Wright and Bailey, 1982). The P-values for this data were not all statistically relevant. However, the aforementioned trends are pertinent. A larger sample size would increase the statistical significance of this study.

In this part of the study, we found the total basal area to be a poor indication of the difference in density between our sites or locations. Total basal area indicated that tree density was similar at all locations before the burns. Total basal area was the same between sites because this analysis does not discriminate between live and snag trees. However, when we differentiated between live and snag basal area, we found that the fires increased snag basal area and decreased live basal area. An increase in snag basal area can create homes and foraging sites for many species of animals (Horton and Mannan, 1988). Again, a discrepancy was found at the Olde Stage Fire where a similar live basal area was found at both burn and control sites. We attribute this analogous live basal area and scarcity of snags to the low intensity of the fire.

The statistical significance of our study could be improved by increasing both the area of location and the sample size, and by having annual studies. Further studies could include different types of variables such as time of year the burn occurred, moisture levels, wind severity, soil types, aspects, and elevations.

Descriptive studies, such as ours, are important to gain a general overview of biological processes. The information found in descriptive studies can be used for future applied studies. Our results underscore the ecological importance of allowing the natural course of fires to occur.

## Works Cited

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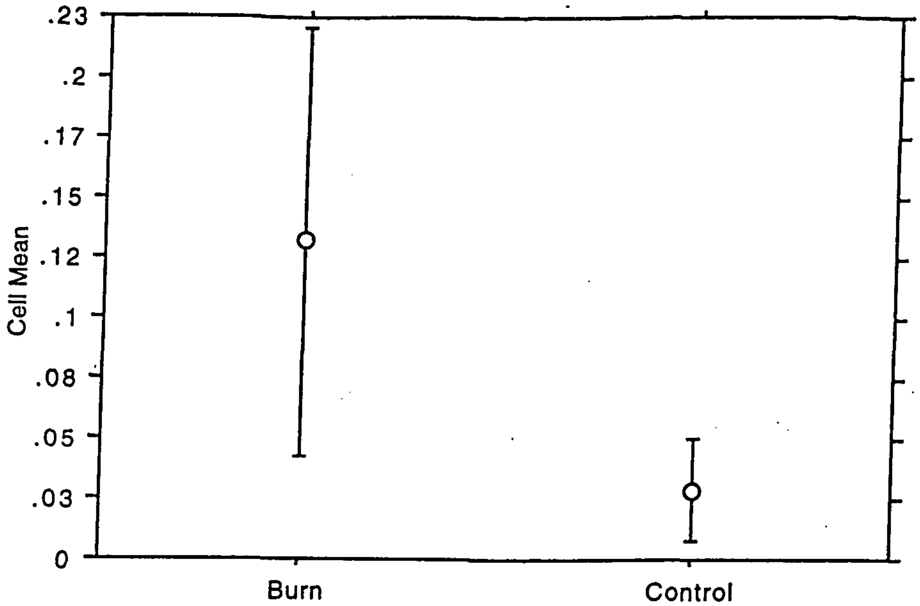
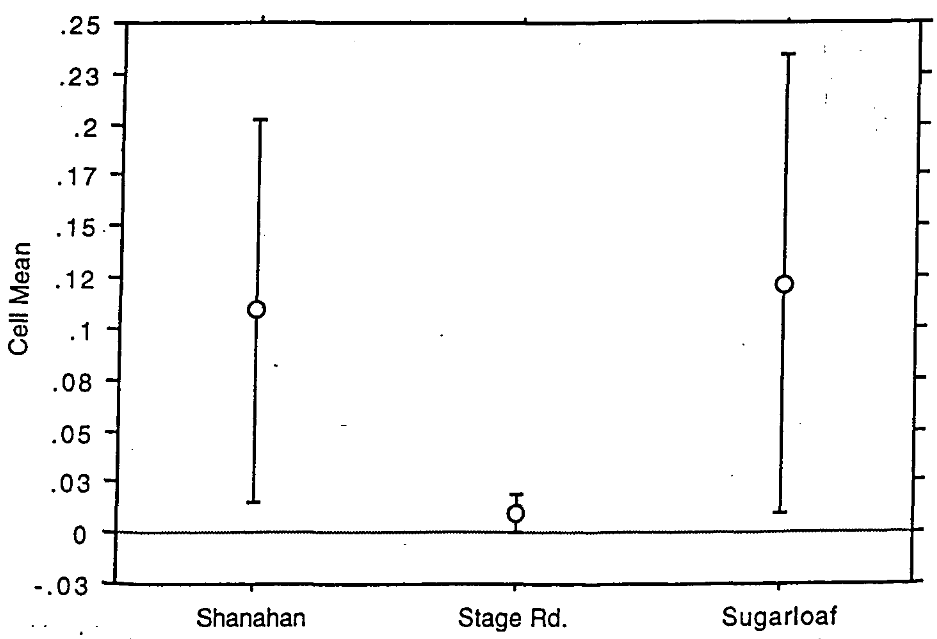
FIG. 1. Comparison of percent woody debris at burn and control sites.



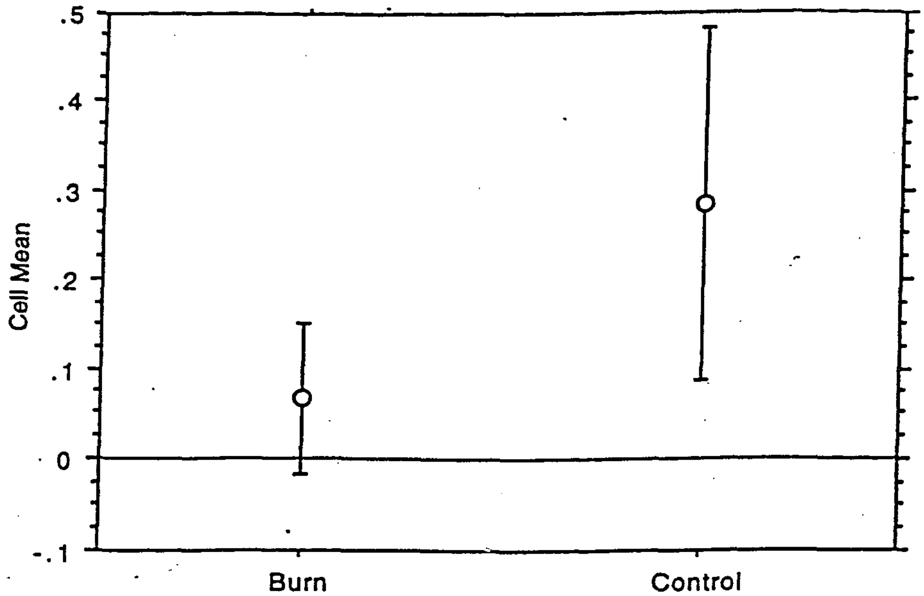

P-value 0.0136

FIG. 2. Comparison of percent woody debris at locations.



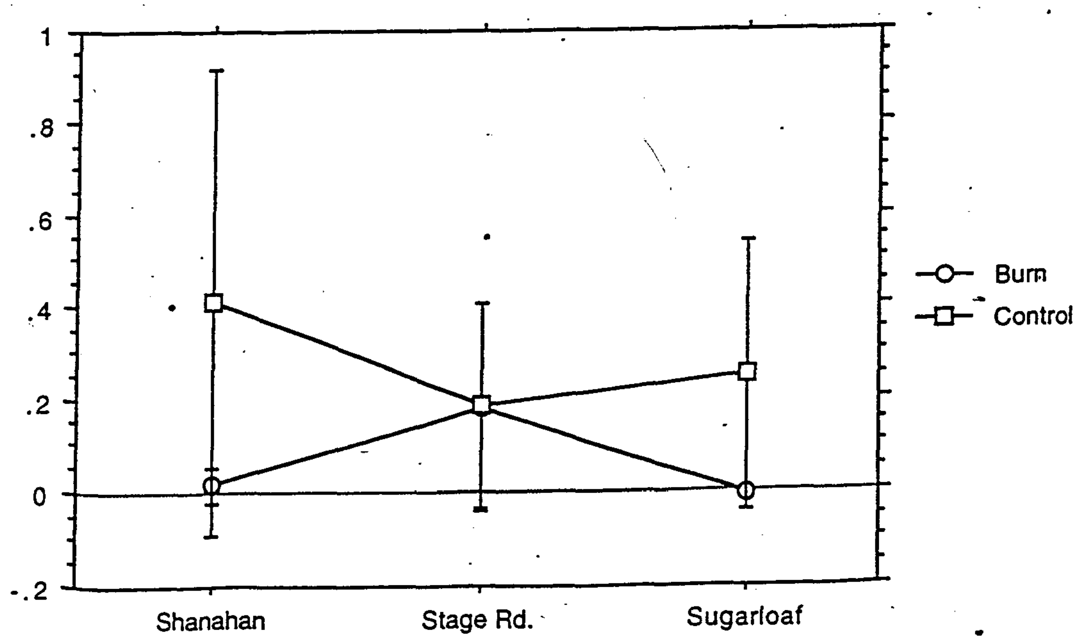

P-value 0.0413

FIG. 5. Comparison of canopy coverage at burn and control sites.



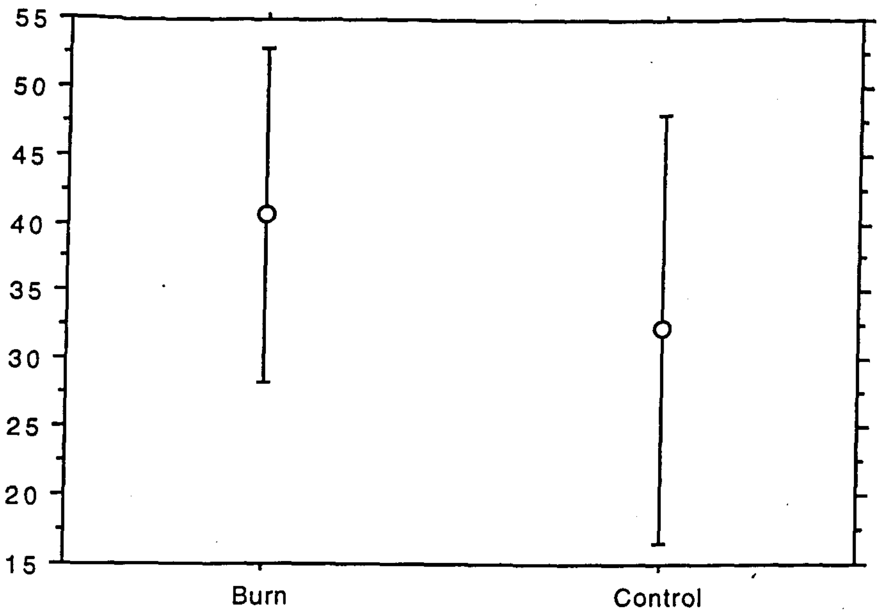

P-value: 0.0645

FIG. 6. Comparison of canopy coverage at both sites and locations.



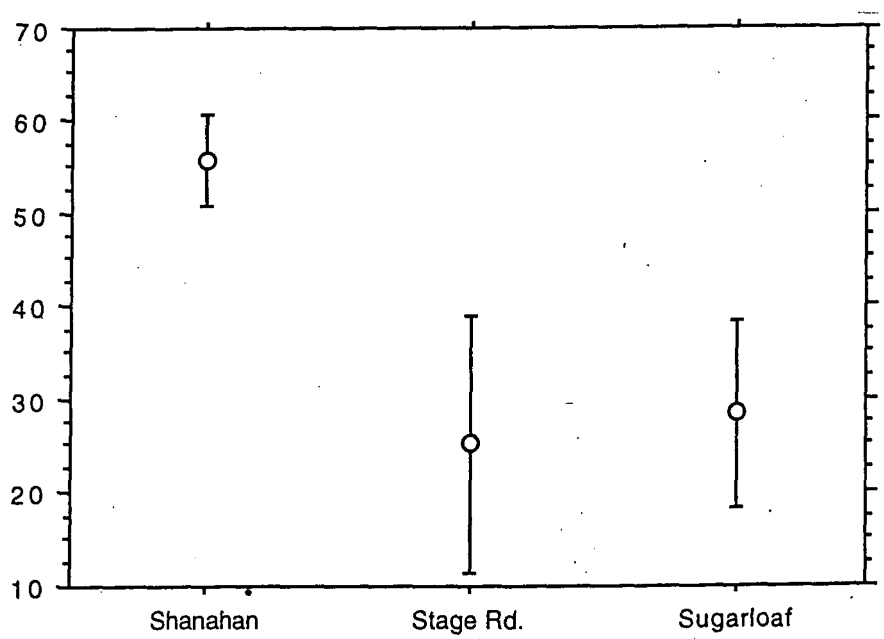

P-value: 0.3629

FIG. 3. Comparison of visibility index at burn and control sites.



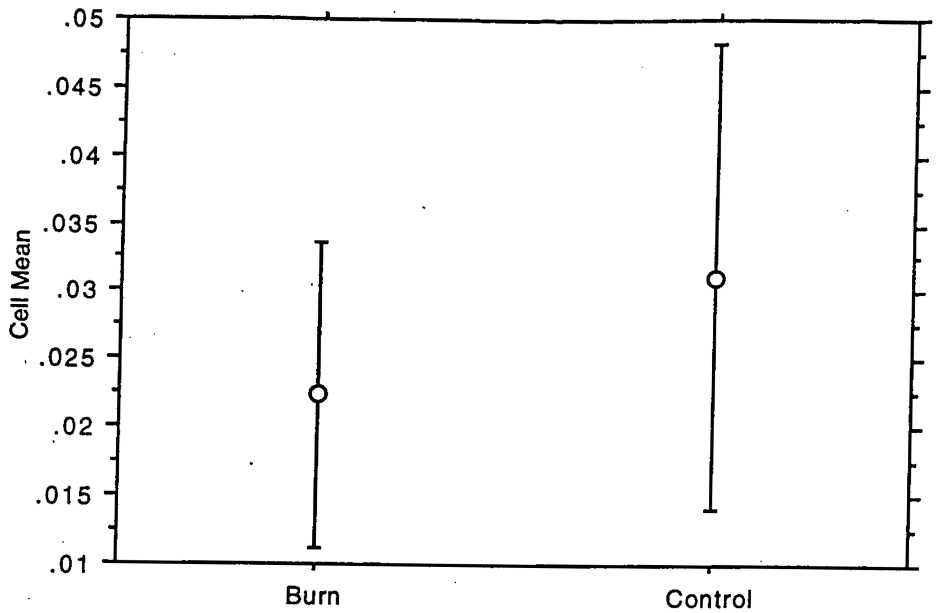

P-value 0.2039

FIG. 4. Comparison of visibility index at locations.



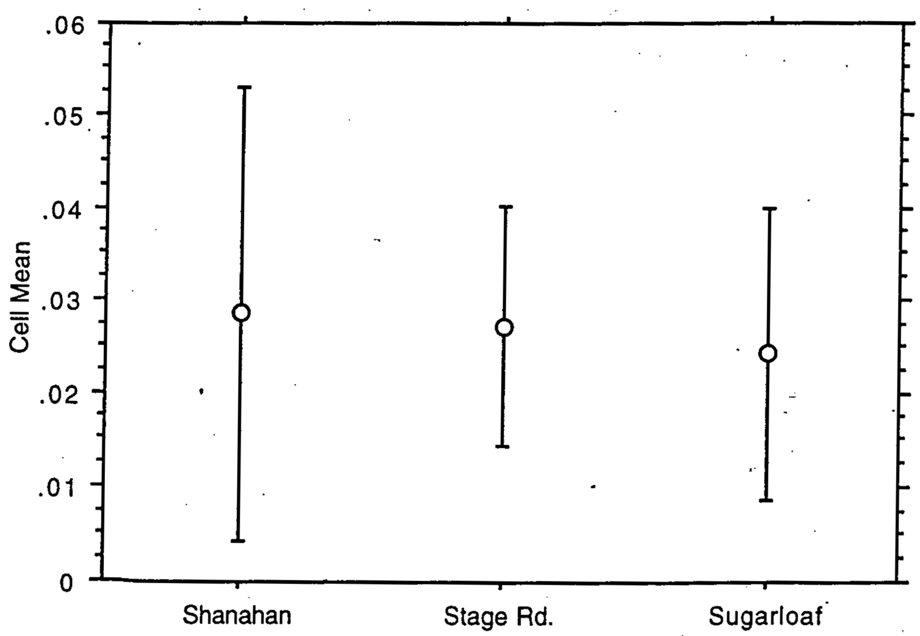

P-value: 0.0099

FIG. 7. Comparison of total basal area at burn and control sites.



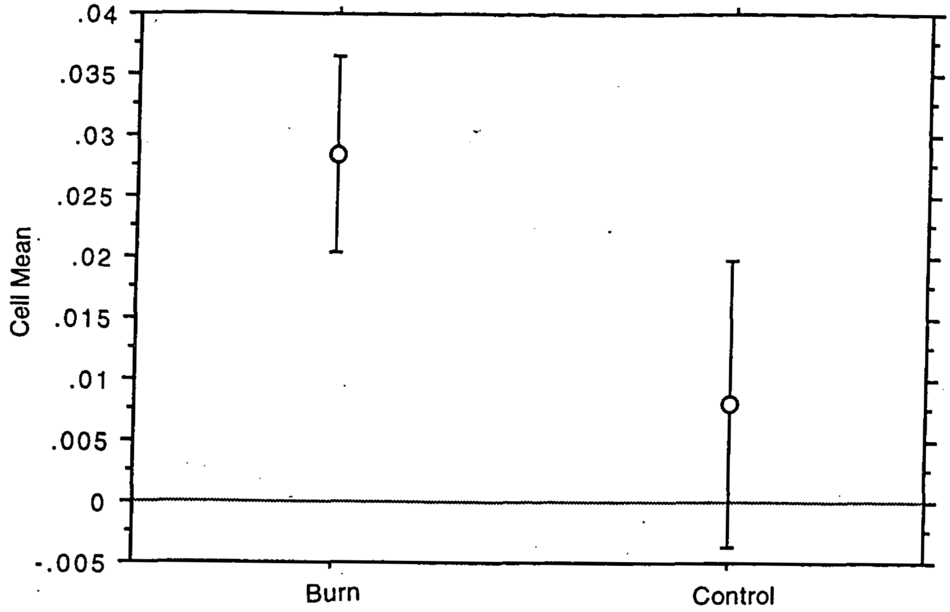

P-value: 0.4203

FIG. 8. Comparison of total basal areas at locations.



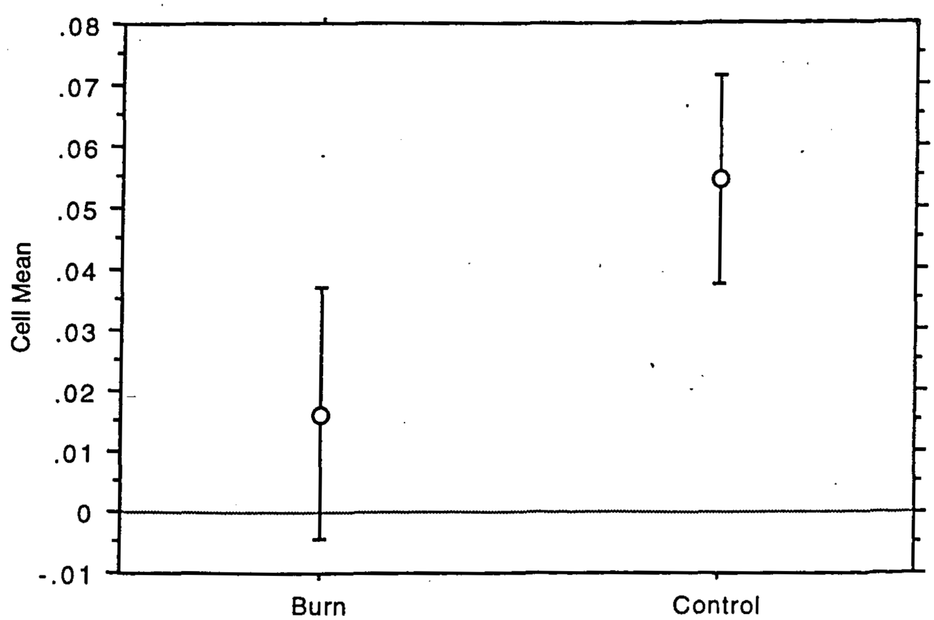

P-value: 0.9419

FIG. 9. Comparison of snag basal area at burn and control sites.



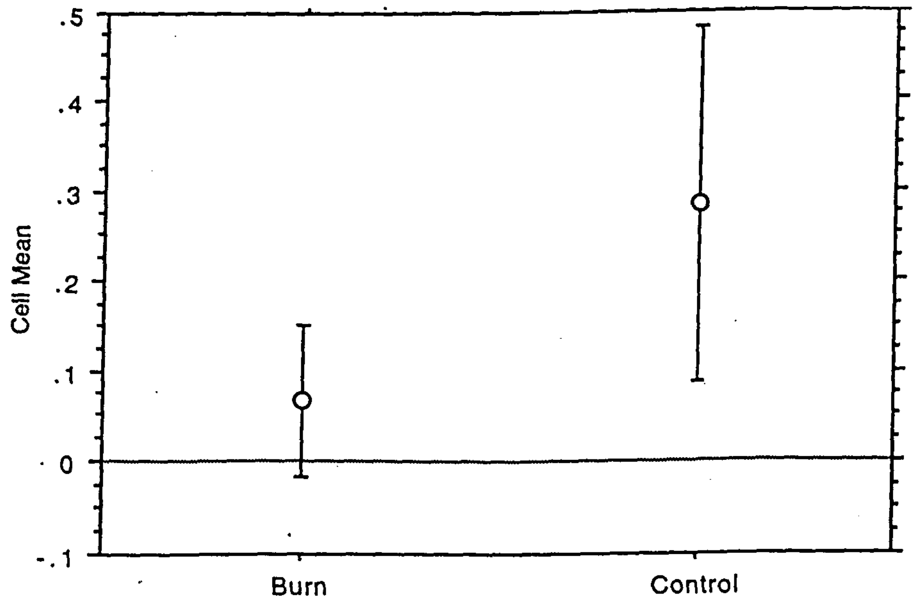

P-value: 0.0279

FIG. 10. Comparison of live basal area at burn and control sites.



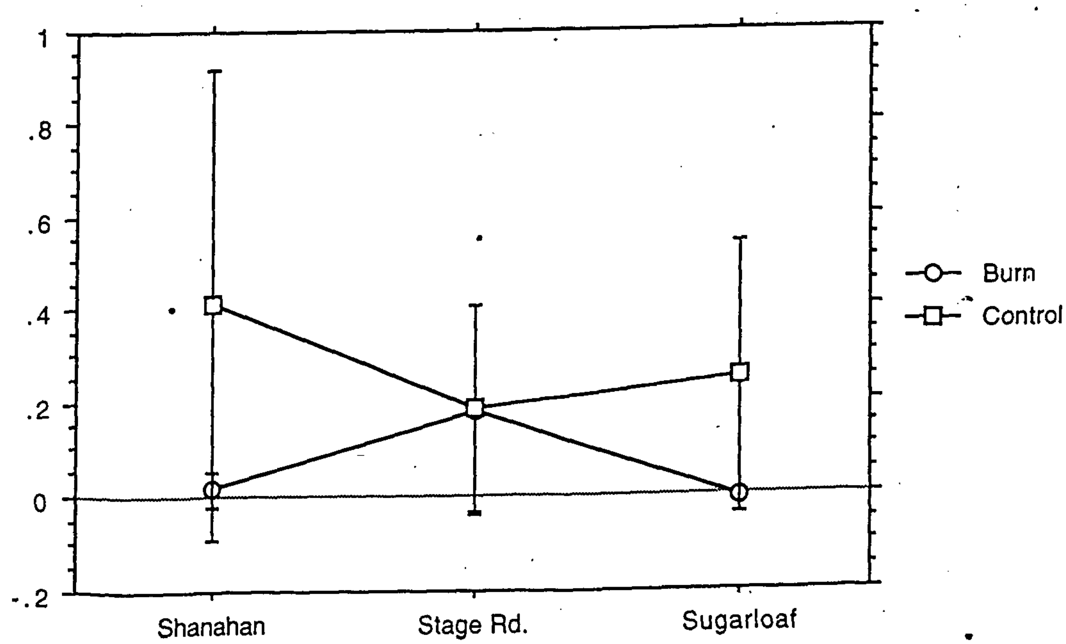

P-value: 0.0004

FIG. 5. Comparison of canopy coverage at burn and control sites.



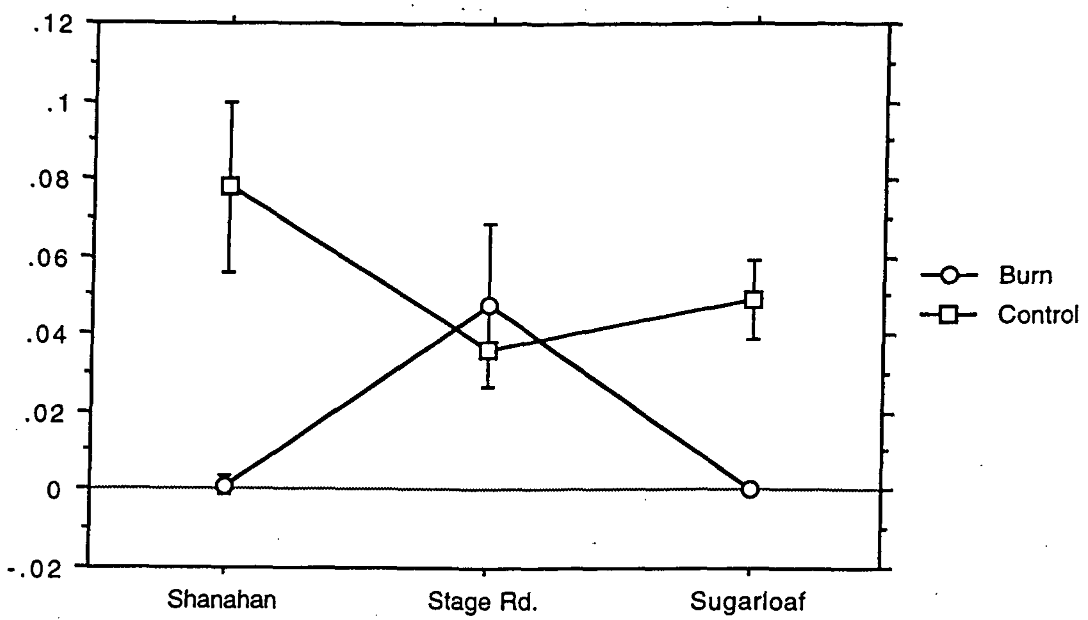

P-value: 0.0645

FIG. 6. Comparison of canopy coverage at both sites and locations.




P-value: 0.3629

FIG. 11. Comparison of live basal area at both sites and locations.




P-value: 0.0015