The Effects of a Low Intensity Fire on a Mixed Conifer Forest in Bryce Canyon National Park, Utah

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Abstract—Prescribed fire was used to reduce fuel loading and tree densities. Permanent vegetation and fuel loading plots were randomly established within prescribed burn units. The plots were established in 1995 and were sampled, immediately postburn (within 1 month of the fire), 1 year after the burn, and 2 years after the burn. The prescribed burns were implemented in August of 1995. Preliminary analysis of 11 plots shows fuel loading was reduced from 31.9 tons/acre to 11.4 tons/acre immediate postburn. White fir (*Abies concolor*) overstory was reduced 35 percent, poles 52 percent, and seedlings 71 percent by the second year following the burn.

Introduction

Many factors influence vegetation succession and how a fire burns across the landscape, but both are mainly affected by land use or management practices. A few other factors include: soil composition, precipitation, topography, vegetation composition and structure, live vegetation fuel moisture, fire behavior, air temperature, and relative humidity. All of these factors combine to produce varied effects on successional vegetation mosaics. "A comparison of today's landscape at Bryce Canyon National Park with the landscape shown in historic photographs indicates that a major change has occurred in the Park's vegetative mosaic" (Roberts and others 1993). "Journals from early settlers in Garfield County [Bryce Canyon area] describe open forests, where visibility was several hundred yards. These early ranchers and farmers tell of being able to take a wagon and team of horses through the forests on top of the Paunsaugunt Plateau" (Bryant 1995). What caused the change in the vegetation and landscape as described above? Land use practices and an active role in suppressing fires are the main factors that helped influence the change. Prescribed fire may be used in restoring the natural vegetative mosaic.

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Objectives

The main objectives of the project were to use prescribed fire to reduce hazardous fuel conditions and to burn the area with a low fire intensity. Specific objectives were to reduce total fuel load 20–50 percent immediate postburn, reduce white fir (*Abies concolor*) poles 10–20 percent, and white fir seedlings 20–40 percent within 2 years of the burn. Using prescribed fire may reduce fuels and vegetation densities to diminish the risk of a catastrophic wildfire. "[A park management goal]…is to restore the park ecosystem to a condition typical of pre-European settlement and prior to the establishment of fire exclusion policies" (Bryant 1994).

Study Area

Bryce Canyon National Park, in south/central Utah on the Paunsaugunt Plateau, covers 35,852 acres and ranges in elevation from 6,000 ft to 9,000 ft. Mixed conifer forests range above 8,200 ft. The prescribed burns occurred in the County Line and Yovimpa burn units in the south end of the park. General weather patterns include temperature ranges from –30 °F to 90 °F. Precipitation peaks are in January/February and July/August.

Methods

In 1995, 11 mixed conifer (*Abies concolor*/*Pinus ponderosa*) vegetation-monitoring plots were established according to the Western Region Fire Monitoring Handbook Protocols (USDI NPS 1992). All plots were randomly located within the prescribed burn units. The plots, established before a controlled burn, consist of a 20-m by 50-m area. All overstory trees (>15.1 cm diameter at breast height, d.b.h.) are recorded in the 20 m x 50 m area. Pole trees (2.51 to 15.0 cm d.b.h.) are recorded in a 10 m x 25 m area. Seedling trees (<2.5 cm d.b.h.) are recorded in a 5 m x 10 m area. Forest fuel is calculated on four, 50 ft transects. Calculations measure litter, duff, 1, 10, 100, and 1,000-hour fuels following the methodology of Brown (1974). The plots were sampled immediate postburn, 1, and 2 years after the prescribed burns.

Burn severity is determined within 1 month of the burn. It is assessed on a scale of 1 to 5 (fig. 1) and conducted in conjunction with the Brown's fuel loading transects. At each sample point (1, 5, 10 ft, and so forth), severity is evaluated in a 4 square-decimeter area. For example if litter and duff is consumed leaving white ash and all plant parts are consumed the area would be rated one (1). If the area was not burned, it would be rated five (5) for unburned. This information is then calculated to give an average burn severity.

Burn Severity Data					
BRCA	1 = Heavily Burned	2 = Moderately Burned	3 = Lightly Burned	4 = Scorched	5 = Unburned
Organic Substrate [Litter and Duff] (Standard Error)	19.9 % (s.e. 4.7)	4.1 % (s.e. 1.1)	7.6% (s.e. 2.2)	7.2% (s.e. 1.8)	61.2% (s.e. 7.5)
Vegetation (Standard Error)	5.5% (s.e. 5.5)	9.5% (s.e. 9.1)	4.0% (s.e. 2.5)	16.4% (s.e. 5.0)	55.5% (s.e. 11.5)
Average Severity was 3.9 Organic substrate and 3.8 Vegetation					

Figure 1—Percentage of severity categories and average severity. The data average gives a “lightly burned” severity rating.

Results

Burn severity ratings showed that 19.9 percent of the sample received a one (1) heavily burned rating, 18.9 percent received a two to four rating, and 61.2 percent receiving an unburned rating (fig. 1) creating a patchy burn with varied intensities across the landscape. The average burn severity ratings were 3.9 for organic substrate and 3.8 for vegetation for a “lightly burned” rating. Burn severity for the 11 plots was lower than expected given the mortality seen in the overstory, pole, and seedling trees especially with a significant amount receiving an unburned rating (N = 11 for this sample).

Figure 2 shows the mean total fuel load and standard error of the sample. The preburn fuel loading was 31.9 tons/acre. Fuel loading was reduced 64 percent to 11.4 tons/acre immediate postburn. Total fuels have achieved 52 percent of the pre fuel loading level to 16.5 tons/acre 2 years after the burn.

Figures 3 through 5 show the mean overstory, pole, and seedling tree densities with standard errors. White fir overstory trees had a density of 81.7 trees/acre preburn and ponderosa pine had a density of 22.8 trees/acre. Two years after the burn, overstory white fir was reduced 35 percent to 53 trees/acre and overstory ponderosa pine was reduced 16 percent to 19.1 trees/acre. White fir poles decreased 52 percent from 169.2 trees/acre to 80.9 trees/acre 2 years after the burn and ponderosa poles decreased 50 percent from 5.9 trees/acre to 2.9 trees/acre. Seedling white fir decreased 71 percent from 1,604.1 trees/acre to 463 trees/acre 2 years after the burn, while ponderosa pine seedlings decreased 40 percent from 36.8 trees/acre to 22.1 trees per acre. It is interesting to note that there were no quaking aspen (*Populous tremuloides*) seedlings preburn, but 2 years after the burn aspen was regenerating (fig. 5). At the 2-year reading, aspen seedlings were recorded at 117.7 trees/acre, but this occurred in only one plot.

Discussion

Results demonstrate that this fire produced small to medium changes to the total fuel load, overstory trees, pole trees, and seedling trees. These low intensity fires (“lightly burned”) can result in some mortality to overstory, pole, and

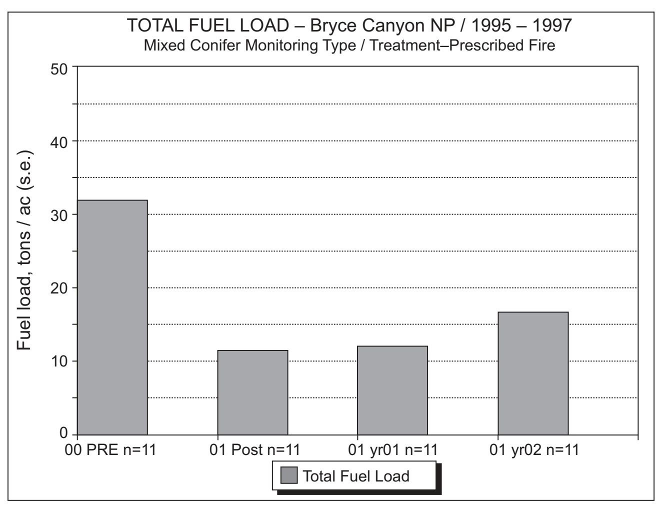

Figure 2—(USDI NPS 1999). The mean total fuel load in tons per acre before a controlled burn, immediate postburn, 1 year, and 2 years after the burn.

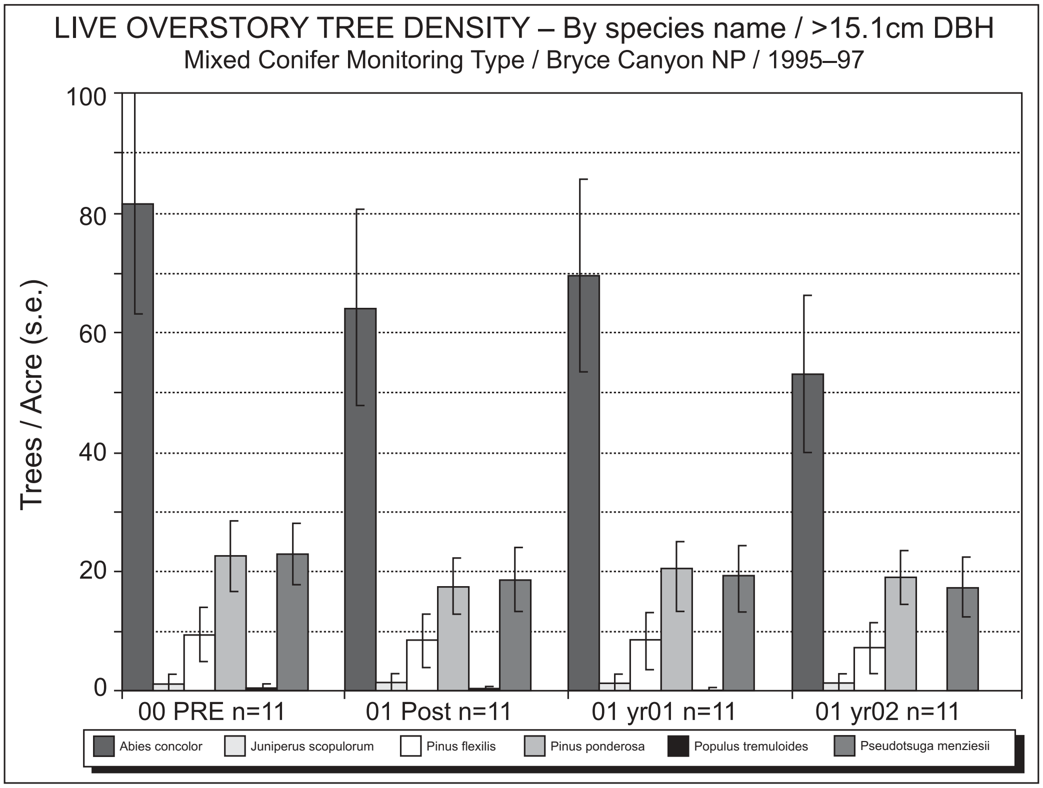

Figure 3—(USDI NPS 1999). The mean density of overstory tree species (>15.1 cm d.b.h.) before a controlled burn, immediate post, 1 year after, and 2 years after the burn.

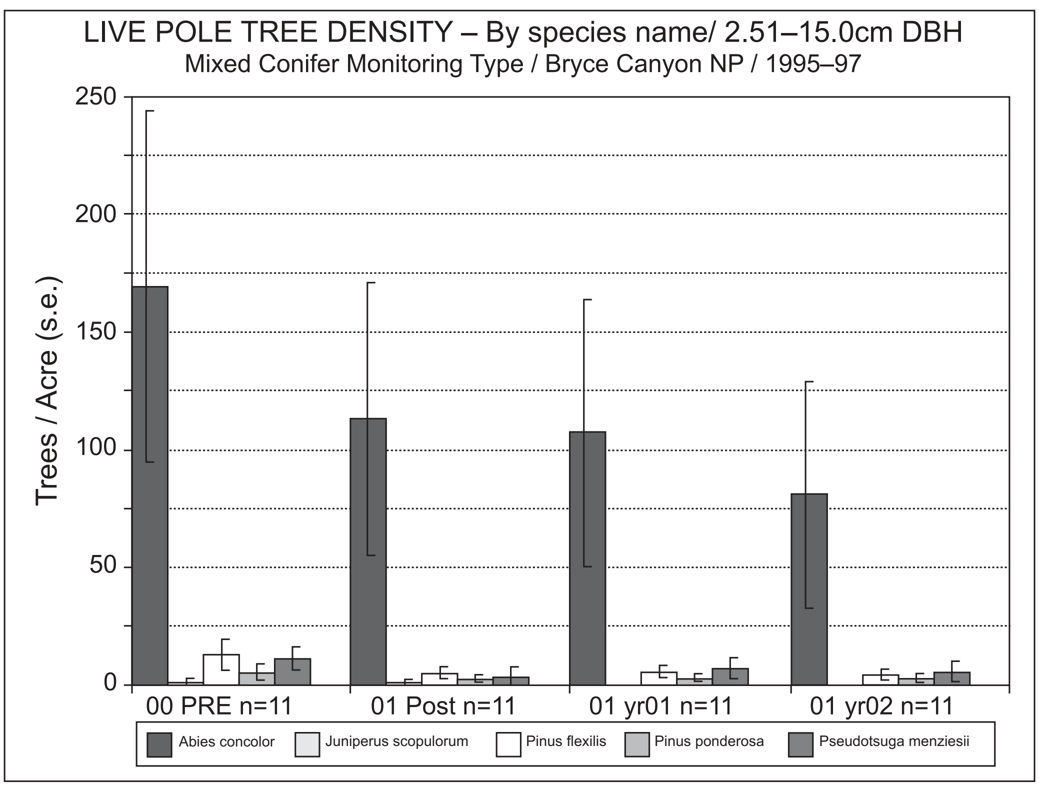

Figure 4—(USDI NPS 1999). The mean density of pole sized trees (2.51–15.0 cm d.b.h.) before a controlled burn, immediately post, 1 year after, and 2 years after the burn.

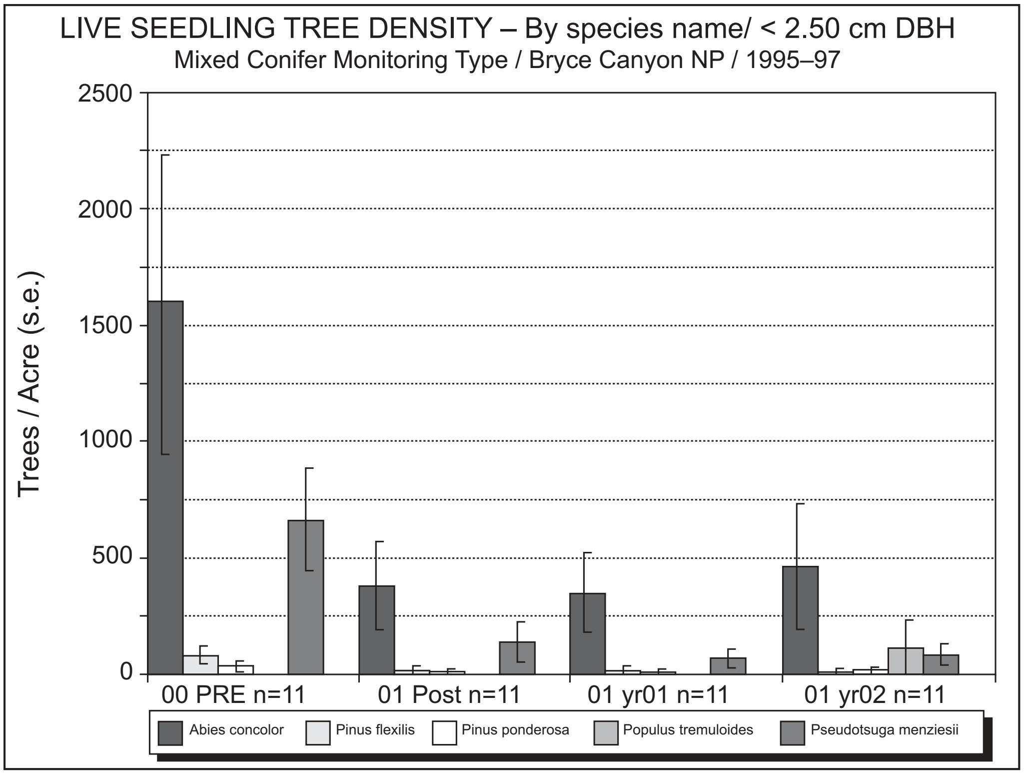

Figure 5—(USDI NPS 1999). The mean density of seedling sized trees (<2.50 cm d.b.h.) before a controlled burn, immediate post, 1 year after, and 2 years after the burn.

seedling-sized trees. Monitoring shows changes in preburn and postburn forest fuel conditions (fuel loading) and overstory, pole, and seedling trees densities. "In mixed conifer forests where white fir dominates the understory due to years of fire suppression, prescribed low-intensity surface fires will kill large numbers of white fir" (FEIS 1996). " This reduces the hazard of white fir providing a fuel ladder to ignite the crown of overstory trees and also restores tree species composition closer to that of pristine conditions" (FEIS 1996).

Remnant populations of quaking aspen were scattered throughout the mixed conifer forests and it was hoped that through using prescribed fire, the aspen would be stimulated and regenerate in openings created by the fire. The results demonstrate that this may be occurring but, it is too early to report any significance of aspen regeneration.

In 1995 Jenkins examined the mixed conifer forest near the south end of the park and concluded that the mean fire return interval was 7.5 prior to the 1900s. "Studies concluded that the accumulation of woody vegetation and down and dead woody fuels have increased significantly in the present century" in Bryce Canyon National Park (Jenkins 1995).

Ecosystems are complex and dynamic. It is difficult to accurately sample them without error. Figure 3 demonstrates this point. Overstory white fir trees were reduced from 81.7 trees/acre preburn to 64.0 trees/acre postburn. However, at the 1 year reading there were 69.5 trees/acre. This is due to the difficulty in accurately determining if the tree is dead or alive immediate postburn due to scorching of the tree canopy. Observers introduce error regardless of their knowledge, experience, and expertise on the job. Due to many variables in observing and recording data, it is difficult to accurately sample without some error.

Minimum plot calculations were done using an 80 percent confidence level with an R value of 25. Eleven plots were necessary for total fuel load to meet the 80 percent confidence level. Overstory trees required six plots, poles 35 plots, and seedlings needed 44 plots to meet 80 percent confidence. It is important to remember that the sample size must be large enough to infer that the result has occurred across the entire landscape, when evaluating the data.

Conclusion

The results indicate that ("lightly burned") low intensity prescribed burns will create small to medium changes creating openings in the forest. These results meet the project and program objectives at Bryce Canyon. Total fuel loading was reduced a little over half. Overstory, pole, and seedling densities were reduced with moderate changes. With all of the factors that influence vegetation succession and fire severity in the environment, a mosaic of patterns and intensities from fire can be expected. Fire behavior and intensity can vary from burn to burn, and will vary across the landscape producing different effects. These changes move the forest vegetation structure toward a less crowded forest where future prescribed or natural fires will function in maintaining an open vegetation mosaic. This is an example of what prescribed fire can do in this vegetation type. “Prescribed fires can be used as a means of reducing hazardous fuel loads and reestablishing pre-settlement fire regimes” (Jenkins 1995).

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References

Brown, J.K. 1974. Handbook for inventorying downed material. USDA Forest Service. Intermountain Forest and Range Experiment Station. Gen. Tech. Report INT-16. Ogden, UT.

Bryant, R.M. 1994. Draft environmental assessment for fire management plan, Bryce Canyon National Park, Utah. On file at: Bryce Canyon National Park.

Bryant, R.M. 1995. Prescribed fire at Bryce Canyon National Park. On file at: Bryce Canyon National Park.

Buchanan, H. 1960. The Plant Ecology of Bryce Canyon National Park. Ph.D. Dissertation, University of Utah, Salt Lake City, UT.

Fire Effects Information System [Online] 1996, September. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer). Available: www.fs.fed.us/database/feis/ [1998, March 12] White fir (*Abies concolor*) section.

Jenkins, M.J. 1995. Fire History Determination in the Mixed Conifer/Aspen Community of Bryce Canyon National Park. Project UW #5/34080: 2.

Roberts, D.W., M.J. Jenkins, D.W. Wight. 1993. Historical Vegetation, Fuel Loads, and Integrated Resource Information System for Bryce Canyon National Park. Final Report USDI Contract No. 88–264: 249.

USDI National Park Service. 1992. Western Region Fire Monitoring Handbook. Western Region Office, San Francisco, CA.

USDI National Park Service. 1999. NPS National Fire Monitoring Handbook [FMH 3.10.1.3 Fire Monitoring Handbook Software]. (Data Analysis and Graphic productions) National Interagency Fire Center, Boise, ID.