

# Effects of Low Intensity Prescribed Fires on Ponderosa Pine Forests in Wilderness Areas of Zion National Park, Utah

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**Abstract**—Vegetation and fuel loading plots were monitored and sampled in wilderness areas treated with prescribed fire. Changes in ponderosa pine (*Pinus ponderosa*) forest structure tree species and fuel loading are presented. Plots were randomly stratified and established in burn units in 1995. Preliminary analysis of nine plots 2 years after burning show litter was reduced 54.3 percent, duff was reduced 34.7 percent, ponderosa pine tree density in the 10.2 cm to 30.5 cm d.b.h. (diameter at breast height) size class was reduced 18 percent, and ponderosa pine tree density greater than 61.2 cm d.b.h. increased in Zion National Park.

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## Introduction

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Historically, lightning and human caused fires influenced vegetation structure. Vegetation is constantly growing and changing and fire provides a natural means of checks and balances for many landscapes. Fires reduced fuel accumulations and maintained open, grassy forest stands. However, human settlement and land use practices resulted in fewer fires and those that did ignite were quickly suppressed, whether in wilderness or not. As a result, forest structure has changed with increased fuel loads and thicker tree and shrub densities.

Fire is a natural process and a critical component in nutrient cycling and vegetation structure maintenance of many ecosystems. "Entire ecosystems can be drastically altered or maintained by periodic burning" (Kozlowski and Ahlgren 1973). Fire is a tool that can be used in restoring many forested and nonforested areas.

West and Madany (1981) cited Alter (1942) with a description from Priddy Meek's journal. This description is of the land just to the northeast of what is presently Zion National Park. In June of 1852, Priddy described the area as "...Rich soil, plenty of grass and timber... so that a team and wagon might be driven any place.... We traveled three days amongst this timber, which is of the best quality and clear of underbrush." What caused this open vegetation structure? Many studies have shown that ponderosa pine vegetation systems have evolved with fire and require it for

growth and recruitment. West and Madany (1981) researched the fire history of Zion National Park and stated that, "From the fire scar record we can safely state that any location within a ponderosa pine forest burned at least once, and more likely twice, every decade in the time before white settlement." This conclusion fits comparable descriptions from early settlers of the West and demonstrates that many fire cycles have been missed in this fire regime. Using prescribed fire in wilderness areas may help restore this scene of open forests, as well as promote nutrient cycling and vegetation structure maintenance at Zion and across the West. "The inescapable conclusion of fire effects in ponderosa pine is that the land manager responsible for these communities should be doing a lot of burning" (Saveland and Bunting 1987).

## Objectives

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Specific objectives for an initial prescribed fire treatment of ponderosa pine were: Reduce needle/litter and duff layers by 40–60 percent, and attain a 30–60 percent decrease in ponderosa pine of size class 10.2–30.5 cm diameter at breast height (d.b.h.). The objective for ponderosa pine greater than 61.2 cm d.b.h. was to maintain the density of trees. However, fires and effects can be unpredictable so mortality was required to be limited to 20 percent for fire prescription parameters.

## Study Area

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Zion National Park is located in southwestern Utah. The park covers 59,490 ha and ranges in elevation from 1,127 to 2,659 m. Temperatures vary with elevation, with lows below 0 °F in the upper elevations during winter, and exceed 100 °F at lower elevations during summer. Afternoon thunderstorms are common in July and August. Peak precipitation occurs December through March with an average of 15 inches annually at park headquarters. Ponderosa pine occurs from approximately 1,980 to 2,400 m in Zion National Park. The random plots were located in the Stave Spring, Echo Canyon, East Boundary, and Goose Creek prescribed burn units.

## Methods

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### Data Collection

Ponderosa pine vegetation monitoring plots were established according to the Western Region Fire Monitoring

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Handbook Protocols (USDI NPS 1992). Nine plots were stratified randomly within the prescribed burn units. The plots, established before a controlled burn, consist of a 20 x 50 m area. All overstory trees (>15.1 cm d.b.h.) were recorded in the 20 x 50 m area. Pole sized trees (2.51 cm–15.0 cm d.b.h.) were sampled in a 10 x 25 m section and seedling sized trees (<2.50 cm d.b.h.) were sampled in a 3 x 10 m section. Brush and herbaceous plants are also sampled in the plot but not analyzed for this poster. Forest fuel load conditions were measured on four transects. Fuel load data are calculated for litter, duff, 1, 10, 100, and 1,000-hour fuels (Brown 1974). Plots were sampled immediate postburn, 1, and 2 years after the burn to monitor the effects. Plots will be sampled at 5, 10, and 20 years after the burn or until the area has fire introduced again and the sampling starts over for a second burn event sampling all components described above. Plots in this study were burned between 1996 and 1997 during the months of September through November.

Immediate postburn sampling was done within 1 month of the burn and sampled burn severity, overstory tree postfire assessment, and fuel loading transects. Burn severity was assessed on a scale of one to five, and done in conjunction with the fuel loading transects. At each sample point, severity was evaluated in a 4 square decimeter area. For example, if litter and duff were consumed leaving white ash and all plant parts were consumed, the area would be rated one (1). If the area was not burned, it would be rated five (5) for unburned. The data were then averaged to give a percent for organic substrate and vegetation categories and to estimate burn severity for the area.

Overstory tree postfire assessment characterizes the amount of heat received by the trees, via sampling char height, scorch height, and percent crown scorch. Char height was measured from the ground to the maximum height on the bole of the tree. Scorch height was measured from the ground to highest point where foliar death was evident. Percent scorch was an estimate of the entire crown of the tree that was scorched.

## Prescribed Burn Conditions

The ponderosa pine fuels were classified as a timber fuel model 09 (Anderson 1982). Fuel models were used to predict fire behavior and to assess the potential to control a fire and protect resources. Plots were burned between 1,100 and 1,600 hours. Weather conditions during prescribed fires included: ambient air temperatures of 55 °F to 70 °F, relative humidity of 13–33 percent, mid-flame wind speeds of 0–18 km per hour, and 0–70 percent shade. Fire behavior observations included: flame lengths of 0.2 to 0.6 m, flame zone depths of 0.4–0.8 m, rates of spread for backing fires of 5 to 17 m per hour (m/hr), flanking fires of 5 to 15 m/hr, and head fires of 11 to 18 m/hr.

## Results

Average burn severity was 3.7 for organic substrate giving a “lightly burned” rating and 4.0 for vegetation for a “scorched” rating (fig. 1). Overstory tree postfire assessment averages for char and scorch heights were 1.4 m and 2 m, respectively. The average canopy scorch was 10.7 percent for 254 trees.

Litter was reduced 55.3 percent from 1.03 kg/m<sup>2</sup> to 0.46 kg/m<sup>2</sup> at the immediate postburn sample. Duff was reduced 34.7 percent from 4.52 kg/m<sup>2</sup> to 2.97 kg/m<sup>2</sup> immediate postburn (fig. 2). Total fuel loading was reduced 34.5 percent from 6.89 kg/m<sup>2</sup> to 4.50 kg/m<sup>2</sup> immediate postburn (fig. 3).

Ponderosa pine overstory in the 10.2–30.5 cm d.b.h. size classes was reduced 18 percent from 138.9 trees per ha to 114.4 trees per ha and trees greater than 61.2 cm increased from 1.1 to 7.8 trees per ha within 2 years after the burn (fig. 4).

## Discussion

This early analysis indicates that prescribed fire may be used to reduce fuels and small trees without mortality of large trees (figs. 5–10). These initial prescribed fires were designed to treat the areas multiple times with low to moderate fire intensities and to reduce the potential of fire starts, natural or human-caused, that occur under both extremely dry conditions and heavy fuel accumulations from years of fire suppression. Thinning was considered but due to the area being wilderness, prescribed fire was chosen. After some of the areas have been treated with prescribed fires, it is hoped that fire will be restored to occur naturally.

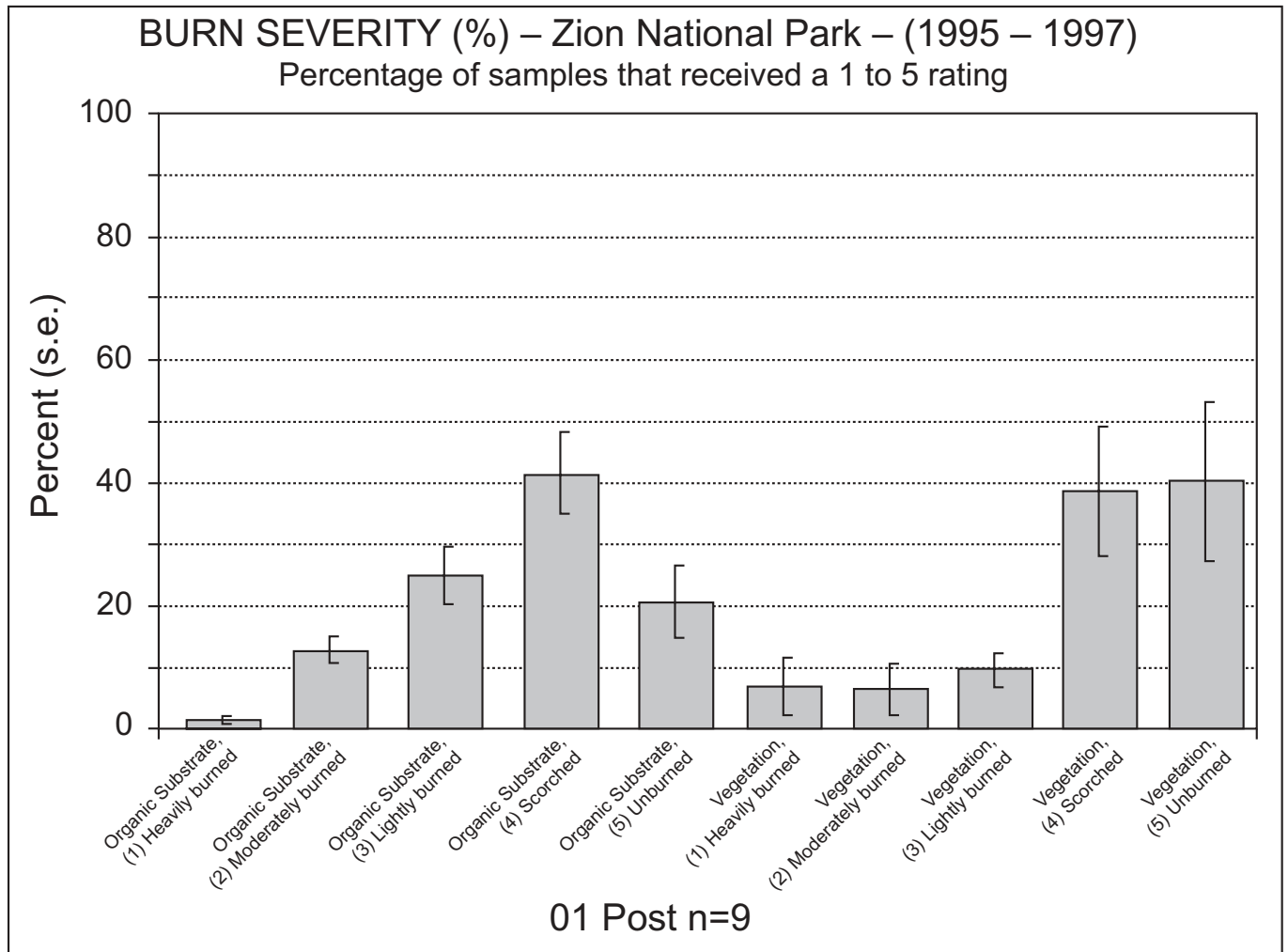
Ecosystems are complex, dynamic, and difficult to sample and analyze. With many of these environmental factors and others (soil composition, precipitation, topography, vegetation composition and structure, live vegetation fuel moisture, fire behavior, air temperature, and relative humidity), sample error needs to be discussed. It can be seen from the data that standard error varied. What may be represented here may not be what actually occurred. 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. Eight plots were needed for total fuel loading and seven plots were needed for overstory tree density to meet the 80 percent confidence level. A paired t-test was done on litter fuel loading, duff fuel loading, total fuel loading, overstory (10.2 to 30.5 cm), and overstory (61.2 cm) tree densities. The t-test showed the following values, respectively: 5.246, 2.779, 3.948, 2.204, and –1.250, showing in general a significant change from pre- to postburn conditions.

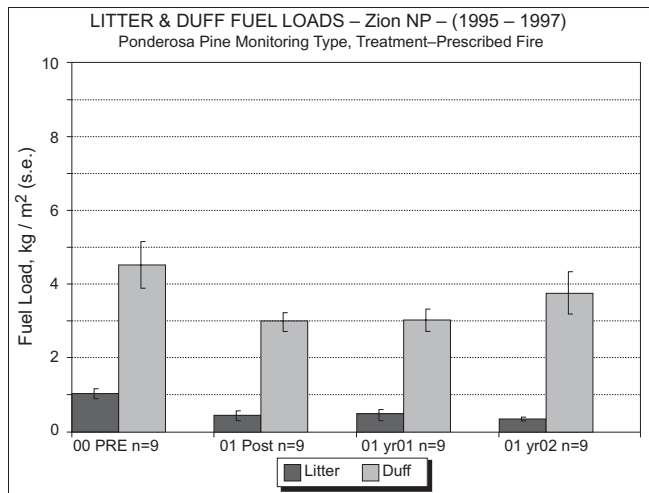
Objectives and target conditions are continually being developed and redefined from knowledge of the past and present. There are many factors that need to be considered when dealing with fire and vegetation succession. “Fire history has a decided influence on the particular successional status of vegetation and in what direction and at what rate it is changing” (West and Loope 1977). Thus, it is not surprising that prescribed fire has become a useful tool to meet a variety of management objectives (Biswell and others 1973).

## Summary

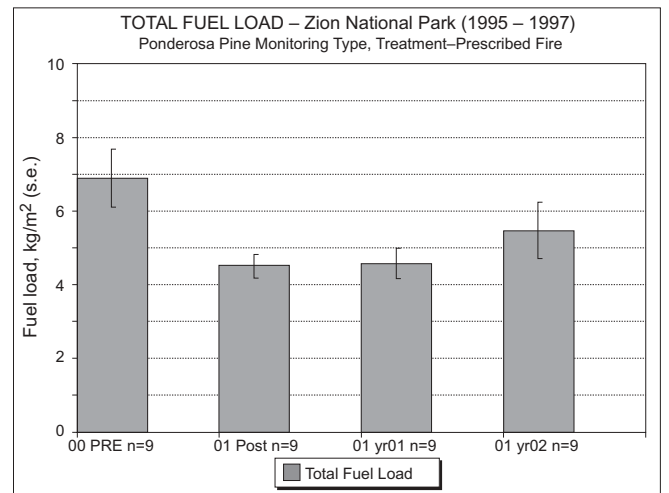
Needle/litter fuel load layer was reduced 54 percent. This meets the objective to reduce it by 40 to 60 percent. Duff fuel loading was reduced 35 percent. This is close to meeting the objective. Pole sized trees were reduced 18 percent, which is



**Figure 1**—(USDI NPS 1999). Percentage of burn severity categories on organic substrate and vegetation. 01 = the first time the area has been treated with prescribed fire, Post = sampling done within 1 month of completion of burn, and n=9 = sample size of nine plots.



**Figure 2**—(USDI NPS 1999). Litter and duff fuel loading by sample period.



**Figure 3**—(USDI NPS 1999). Total fuel load (litter, duff, and woody fuels) kg/m<sup>2</sup> from preburn sample to 2 years after the burn.

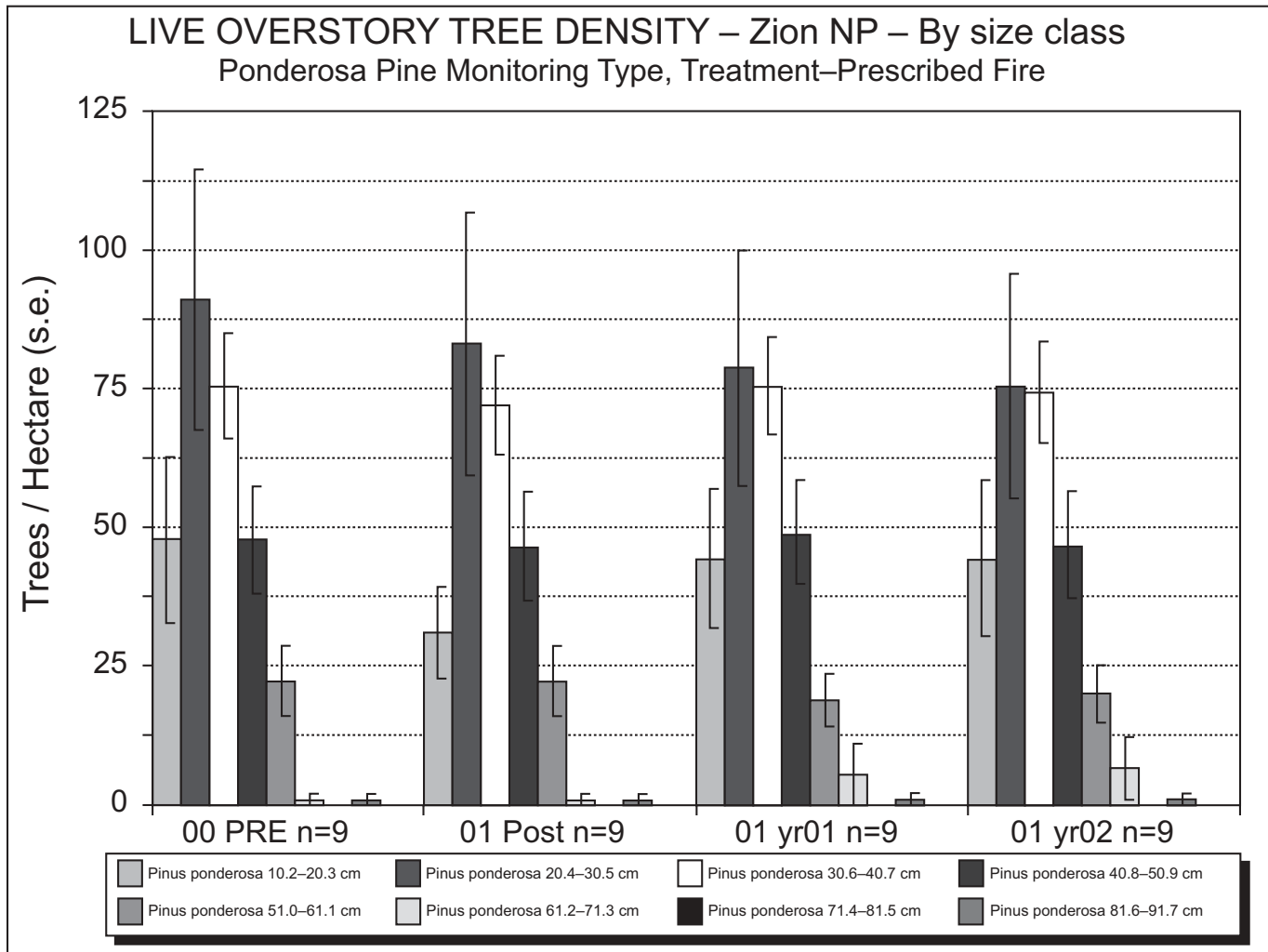


Figure 4—(USDI NPS 1999). Ponderosa pine overstory trees per ha divided into size classes by sample period.



Figure 5—Preburn Echo Canyon photograph of ponderosa pine forest at Zion National Park.



Figure 6—Postburn Echo Canyon picture, same view as figure 5. Smaller trees have been reduced a little toward target objective.



**Figure 7**—Same view from figure 5, 1 year after the burn. Brush has generally decreased.



**Figure 9**—Postburn picture, same view as figure 8.



**Figure 8**—Preburn Goose Creek picture of ponderosa pine forest at Zion National Park.



**Figure 10**—One year after the burn, same view as figure 8. Understory has been opened up.

well below the objective of attaining a 30 to 60 percent decrease in this size class. These results provide some evidence that prescribed burning can be an important step in restoring some vegetation structure described in the past (figs. 5–10). Continued burning and monitoring may help restore the natural range of variability in these vegetation communities to a self-sustaining state. “One of the primary and unique missions of the National Park Service is to perpetuate natural ecosystems in a state approximating the pristine” (Stone 1965; Houston 1971).

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