

PRESCRIBED FIRE AT BRYCE CANYON NATIONAL PARK

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Summary

Fire suppression and grazing have resulted in dramatic changes in the forests of Bryce Canyon National Park, located on the Paunsaugunt Plateau in southern Utah. Evidence of frequent fires prior to Mormon settlement indicate ponderosa pine forests in the northern portion of the park had an average fire return interval of 3.3 years. The mixed conifer forests in the southern portion of the park experienced a fire on the average of 7.5 years. The impacts of suppressing fire has resulted in high fuel loads, invasion of fire intolerant species, and the increased threat of high-intensity wildfires. The park has been conducting prescribed fires since 1990. These management-ignited fires have decreased fuel loading and resulted in mortality of overstory trees ranging from 10 to 22 percent.

Introduction

Bryce Canyon National Park is located on the eastern edge of the Paunsaugunt Plateau in southwestern Utah. Ponderosa pine (*Pinus ponderosa*) forests cover the northern half of the National Park, at elevations from 7,700 to 8,600 feet (2340 to 2620 meters). Mixed conifer forests occur at the south end of the park at elevations from 8,600 to 9,100 feet (2620 to 2775 meters) (figure 1).

Mormon settler Ebenezer Bryce (whom the area is named for) and his neighbors grazed cattle and sheep on the top of the Paunsaugunt Plateau. This grazing began in approximately 1873 (Buchanan and Tolman 1983). The plateau top provided good summer grazing for the cattle and sheep since the widely spaced trees had a good stand of perennial grass beneath them. It is thought this grazing removed much of the grasses from the understory.

Prior to intense grazing that removed the grasses from the forests floor, lightning strikes would result in frequent, low intensity fires. These burns would consume litter (dead grass, needles, and small limbs and twigs), burn dead and downed logs, kill small trees, and burn woody brush. These fires would not be hot enough to kill mature or sapling-sized ponderosa pine or Douglas fir (*Pseudotsuga menziesii*). Nor would these low-intensity fires kill mature white fir (*Abies concolor*) trees. Crown fires (when fires burn through the tops of mature forests) were unknown (Pearson et. al. 1972).

Historical Observations

When the early Mormon pioneers arrived in the area now known as Bryce Canyon National Park, the forests did not appear as they do today. Journals from those early settlers in Garfield County 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.

Early journal entries by settlers also describe the abundance of grasses both in the meadows and under the forest canopy. This abundant grass allowed large numbers of sheep and cattle to graze on the plateau starting in 1873. Grazing continued in the park until 1956 and continues to this day outside the park boundary.

Fire suppression started with the creation of the Powell National Forest in 1905. At first, there were probably few wildfires. With the removal of fine fuels (grasses) by grazing, fire could not spread along the ground for any distance. Therefore any lightning strike would probably burn only one or two trees struck. Eventually shrubs, especially greenleaf manzanita (*Arctostaphylos patula*), snowberry (*Symphoricarpos oreophilus*), and black sage (*Artemisia nova*), replaced grasses in the understory. These shrubs allowed fires to spread along the ground, but at an intensity higher than the grass fires.

The forest service established an active fire suppression policy by 1911 (Stein 1988). That fire suppression policy was continued by the creation of Bryce Canyon National Monument (subsequently changed to Bryce Canyon National Park) in 1923.

In the 1950's, park staff began to notice the forests of the park were visually changing. It was becoming more difficult to walk through the forests due to increasing dead and downed trees and the number of young trees created thickets.

Fire History Research

From 1957 to 1959, doctoral candidate Hayle Buchanan installed a number of vegetative study plots throughout the park. He also took photographs of a portion of those 266 plots (Buchanan 1960). Those plots were revisited and photographed in the late 1960's and again in 1978.

From 1978 to 1980, those vegetation plots were re-inventoried by Buchanan and Harper (1983). During the 21 year interval, several changes had occurred in the forests of Bryce Canyon. Several of those changes include the following:

1. Density of trees increased 84%.
2. The number of saplings had increased 322% [A sapling is defined as a young tree less than 10cm (4.0 inches) diameter at breast height and greater than 2.5 cm (1.0 inch) in diameter at a height 30.5 cm (1.0 foot) above the ground. Saplings may also be referred to as "pole sized trees". Any tree smaller than a sapling is referred to as a seedling.]
3. Loss of species diversity - over 14% of the vegetative species that occurred in 1957

- were no longer present.
4. Aspens (*Populus tremuloides*) were decreasing in number and range.

Examining the series of repeat Buchanan photographs clearly reveals a visual record of an open forest becoming choked with large numbers of seedlings and saplings. Photographs taken in 1978 clearly show a forest where it would be impossible to drive a wagon and a team of horses between the trees due to large numbers of young trees and shrubs.

The major changes documented by Buchanan and Harper in 1981 and the visual evidence from those photographs taken over a 21 year period resulted in a request by the park to have a fire history study prepared.

In 1983, Buchanan and Tolman completed a contract study of the fire history of Bryce Canyon National Park. The researchers examined fire-scarred (cat-faced) trees throughout the park. Wedges were removed from fire-damaged trees with a chainsaw. Wedges were examined under a dissecting microscope so that annual growth rings could be counted. By counting the number of rings between fire scars, Buchanan and Tolman conclude:

The frequency of fires was every 4 to 7 years. Each portion of the ponderosa pine and mixed conifer forests had a fire at least every decade and probably more often.

Buchanan and Tolman combined their data for both the ponderosa pine forests in the north half of the park and the mixed conifer forests, in the south end.

A second fire history study was completed by Wight in 1989. This study examined only the ponderosa pine forest near the park headquarters. Using similar techniques as Buchanan and Tolman (1983), Wight concluded that from 1700 to 1900, a fire occurred an average of every 3.3 years in the ponderosa pine forests near park headquarters. Wight also examined the period from 1900 to 1989 and calculated the fire frequency as 9.9 years.

Jenkins (1995) examined the mixed conifer forest in the south end of the park and concluded that prior to 1900, the mean fire interval was 7.5 years. After 1900 the mean fire return interval lengthened to 45 years.

These three studies clearly show that prior to Mormon settlement, fire was a regular occurrence on the Paunsaugunt Plateau. None of these fire history studies determined the season of the fire occurrences.

None of these three studies indicate whether presettlement fires were caused by lightning or were ignited by early native Americans. Indeed no method is available to determine the source of ignition of these frequent fires. Since lightning, especially associated with summer and early fall monsoonal storms, has been a frequent source of fires in this century, we can assume that nearly all fires before the arrival of the Mormon pioneers were lightning caused. However, early explorers to the southwest, including Escalante in 1776, recorded the Native Americans of the area setting fires to improve hunting and the gathering of desired plants and seeds. (see Steven Pyne's Fire in America for a discussion of fire use by Native Americans). The presettlement use of the

Paunsaugunt Plateau is poorly known and there is no evidence that Paiute Indians were responsible for any of the fires at Bryce Canyon (Buchanan and Tolman 1983).

The research started by Buchanan in 1957 has been taken over by Dr. Karl McKnight. In 1992, he re-examined the vegetative plots established by Buchanan. McKnight's preliminary data analysis (personal communication 1996) indicates the forests of Bryce Canyon National Park are continuing to change with the continuation of fire suppression. Like the 1983 Buchanan and Harper report, McKnight has documented a decrease in aspens, an increase in fuel loading, and a decrease in species diversity. Following the techniques started by Buchanan, a photograph was taken of each plot. See Figures 2 through 6 for copies of the photographs taken by Buchanan and McKnight taken over a series of years.

Ponderosa Pine Forests Without Fire

Ponderosa pine forests cover 4,293 hectares (10,603 acres) within the park boundary (Wight et al 1992). Before the re-introduction of fire, the ponderosa pine forests could be characterized by the following information collected from 20 plots installed by park staff in 1989:

- 69 overstory trees per acre (170 trees per hectare) (95% ponderosa pine)
- 91 pole sized trees per acre (224 per hectare)
- 532 seedling per acre (1292 per hectare)
- 18% overstory trees infected with "mistletoe"
- 18.5 tons/acre (41,510 kg/hectare) dead and down fuels*

*This figure is from Wight, et al. 1992. The plots installed by the park did not yield fuel loadings information.

Although these numbers appear to indicate ponderosa pine forests have not been dramatically altered (compared to a hypothetical ideal forest) by 90 years of fire suppression, there are a few facts these numbers obscure. The open forests described by the early pioneers now have a much larger number of pole sized (saplings) trees. Since many of these pole sized trees average 10.6 feet (326 cm) in height, the ability to see "through" the forest is greatly reduced. The understory is no longer composed of grasses. Instead, manzanita and antelope bitterbrush (*Purshia tridentata*) are the predominate understory plants.

The above data indicates that over 500 pine seedling are present per acre (1,235 seedlings per hectare). However, approximately 50 percent of the plots did not have any seedlings. We are not sure if this represents a lack of nutrient recycling, canopy closure to prevent adequate sunlight from reaching the forest floor, or competition with understory shrubs, specifically manzanita.

Mixed Conifer Forests Without Fire

The mixed conifer forests cover 10,102 acres (4,090 ha) (Wight et al 1992).

In 1995, the staff of Bryce Canyon National Park installed 11 plots following the protocols in the Western Region Fire Monitoring Handbook (1992). These plots were all located in the mixed

conifer forest in the south end of the park. Combining the data for all 11 plots results in the following information:

1. fuel load averages 22.6 tons per acre (50,710 Kg/ha)
range: 3.8 ton/acre - 54.4 tons/acre
[This is compared to Wight et al (1992) who determined the mixed conifer forest averaged between 30 and 38 tons/acre].
2. 141 overstory trees per acre (348 per hectare)
58% white fir
17% ponderosa pine
17% Douglas fir
7% limber pine (*Pinus flexilis*)
0.5% aspen
3. 200 pole sized trees per acre (494 per hectare)
84% white fir
7% limber pine
6% Douglas fir
3% ponderosa pine
1% juniper
4. 55,444 seedling per acre (137,000 per hectare)
79% white fir
20% Douglas fir
1% limber pine
1% ponderosa pine

This information indicates there has been very little recent recruitment of ponderosa pine or aspen. The lack of fire has allowed white fir to progress from a co-dominate overstory tree to a situation where eventually it may replace ponderosa pine in the south end of the park.

Prescribed Burns in Ponderosa Pine Forests

Starting in 1990, park staff began a program of management ignited prescribed fires in ponderosa pine forests in the north end of the park. Justification for fires in this developed area of the park was based on the need for fuel reduction to reduce the potential of a wildfire that could damage the historic Bryce Canyon Lodge, associated historic cabins, stores, employee housing, maintenance area, campgrounds, visitor center, and the trails and roads which receive the heaviest visitor use.

Although fuel reduction for safety and structural protection was the justification and funding source for these prescribed burns, there were many other goals, most related to ecological factors. Below are the objectives for the prescribed fires in the ponderosa pine forests:

1. Reduce total fuel load by 40 to 60 percent.
2. Reduce ladder fuels, specifically reduce brush and saplings by 40 to 60 percent.
3. Produce scorch heights from 5 to 15 feet (1.5 to 4.6 meters) to raise forest canopy.
4. Cause a 75% mortality of seedlings and saplings in the meadow-forest ecotone.
5. Cause a 60% reduction in shrub cover in the meadow-forest ecotone.

6. Reduce duff layers to less than 1 inch (2.5 centimeters) (average).

Between 1990 and 1994, over 2,900 acres (1173 hectares) were treated with fire. These fires were conducted mostly in the month of October. Fall burns offered numerous advantages in addition to meeting the prescription parameters. Fall wind patterns are generally more favorable to prevent impacts to park visitors attempting to view main park features, the erosional rock formations situated in amphitheaters on the east boundary of the park.

Fall burning also allows for adequate park staff to be available since summer crowds are decreasing. Summer monsoonal rain patterns are diminished by October and live fuel and dead/down fuels are at a level that allow for fire conditions that will achieve management goals, yet be controllable with land-based resources (hand crews and type 3 and type 6 engines). Hand ignition was used on the majority of the acres treated. One block (320 acres or 130 hectares) was burned using aerial ignition devices ("ping pong balls").

The initial cycle of management ignited fires in the ponderosa pine forest and interspersed meadow areas have been highly successfully. Fuel loads have been reduced to an average of 13.9 tons per acres (31,189 Kg/ha). This represents a reduction in dead and down fuel loadings of 25 percent. Although this is less reduction of dead and down fuels than hoped for, caution should be used since the figures used to derive this reduction came from two different sources (Wight et al 1992 verses park staff) and used two different methods to determine fuel loadings (visual estimates verses Brown's fuel inventory techniques). Large concentration of manzanita have been consumed, as have duff layers. The variety of manzanita found here in the park is killed by fire. It does not stump sprout as do other species/varieties of manzanita in the western states. Mortality of the overstory trees three years after the burns has averaged 10 percent. In the pole sized trees, an average of 22.6 percent have been killed. We can not determine the exact mortality of the seedlings due to variations in data collection techniques. Scorch height averages 5.7 feet (1.75 meters).

Prescribed Fire in Mixed Conifer Forest

Based on the vegetative and fire history evidence, in 1995 the park staff conducted two prescribed fires in the mixed conifer forests at the south end of Bryce Canyon National Park.

The spring of 1995 was exceptionally wet and cool. Live fuel moistures had remained higher than normal. In mid-July, white fir had a live fuel moisture of over 200 percent. These elevated live fuel moistures suggested that an understory burn could be accomplished in summer months without experiencing a crown fire.

Objectives for the mixed conifer forest burns were as follows:

1. Reduce dead and down fuels by 30%.
2. Kill a minimum of 50% of white fir seedlings.
3. Kill a minimum of 20% white fir pole sized trees
4. Kill no more than 10% of overstory ponderosa pines.
5. Kill no more than 20% of overstory Douglas firs.
6. Reduce manzanita by 25%.
7. Create canopy openings for aspen regeneration.

In July 1995, a 77 acre (31 hectares) block was burned. A portion (roughly 25 acres or 10 hectares) was ignited at night. In late August, a 530 acre (214 hectare) block was burned in the south end of the park. Both of these burn blocks were ignited by drip torches. The larger area was ignited over a six day period, predominately from 0700 to 1400 hours. In both burns small crown fires occurred. In the smaller County Line burn, an area of approximately one acre (0.5 hectare) crowned. In the larger (Yovimpa) burn, a crown fire consumed approximately three acres (1.2 hectare). Lack of continuous fuels or changes in slope were the reasons the crowns fires stopped.

The 11 plots were re-examined within two months after the burn was conducted. The results of the prescribed fires in the mixed conifer forests are as follows:

Overstory tree mortality	22%
Pole mortality	36%
Seedling mortality	76%
Scorch height on overstory trees	11.8 feet (3.6 meters)
Char height on overstory trees	5.9 feet (1.8 meters)

Fuel loading information was not collected in this post burn inventory due to time limitations. Current plans call for additional data collection to occur in 1996.

Plans For Future Years

In the ponderosa pine area, there are still several blocks of forest identified as needing treatment with prescribed fire to reduce fuel loads, reduce pole-size trees and shrubs, and decrease the ladder fuels. The blocks burned in 1990 through 1992 should be reburned in the next year or two. This interval is longer than the 3.3 year average documented by Wight (1989). However, this five or six year rotation does fall within the normal range of fire returns in ponderosa pine. Actual completion of these prescribed fires depends on weather (if prescription parameters can be met), funding, staffing, and political realities.

Post fire inventory indicates that some of the goals of the reintroduction of fire in the mixed conifer forest have been achieved by the 1995 prescribed burns. However, with the mortality in the overstory and pole-size trees, a substantial fuel load of standing dead trees has been created. We plan to again burn these two blocks in seven to ten years to attempt to mimic the 7.5 year fire return interval documented by Jenkins.

Some prescribed fire specialists have suggested a second burn in the mixed conifer after two or three years. However, it takes several years for the scorched needles to fall from the pines and firs. If a second fire was started before these aerial fuels fall, a high intensity fire may occur.

The six years of prescribed fire were accomplished with very limited staff and funding. Although the park received FIREPRO funds for fuel reduction, these dollars covered only a small portion of the actual cost of conducting these burns. Time has been volunteered by park staff and additional funds have been made available by the superintendent to fund the cost of out-of-park staff to assist us.

Staff to conduct the burns came from a variety of sources. Dixie National Forest and Cedar City Bureau of Land Management have been very helpful in providing both staff and equipment as has Zion National Park. In 1995, a newly created five person module of prescribed fire specialists helped the park conduct the burns in the mixed conifer. The park's Fire Management Officer, John Morlock and former Chief Ranger Charlie Peterson have been the driving force in gathering adequate staff, funding, and support to conduct the prescribed fires over the last four years.

The use of logging, fire wood removals and manual vegetative thinning may solve some of the symptoms (i.e. reduction of fuel loading) of the unhealthy forest. But only fire can produce the results needed to restore forest health. This includes nutrient recycling, seed bed preparation, etc.

The Resources Management staff strongly believes restoration of fire in the ecosystem is the most important project this park can accomplish. Support from park management and adequate funding/staffing are essential. An expanded effort of education of the staff, park neighbors, and general public is very important to ensuring fires become a regular component of the ecosystem.

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