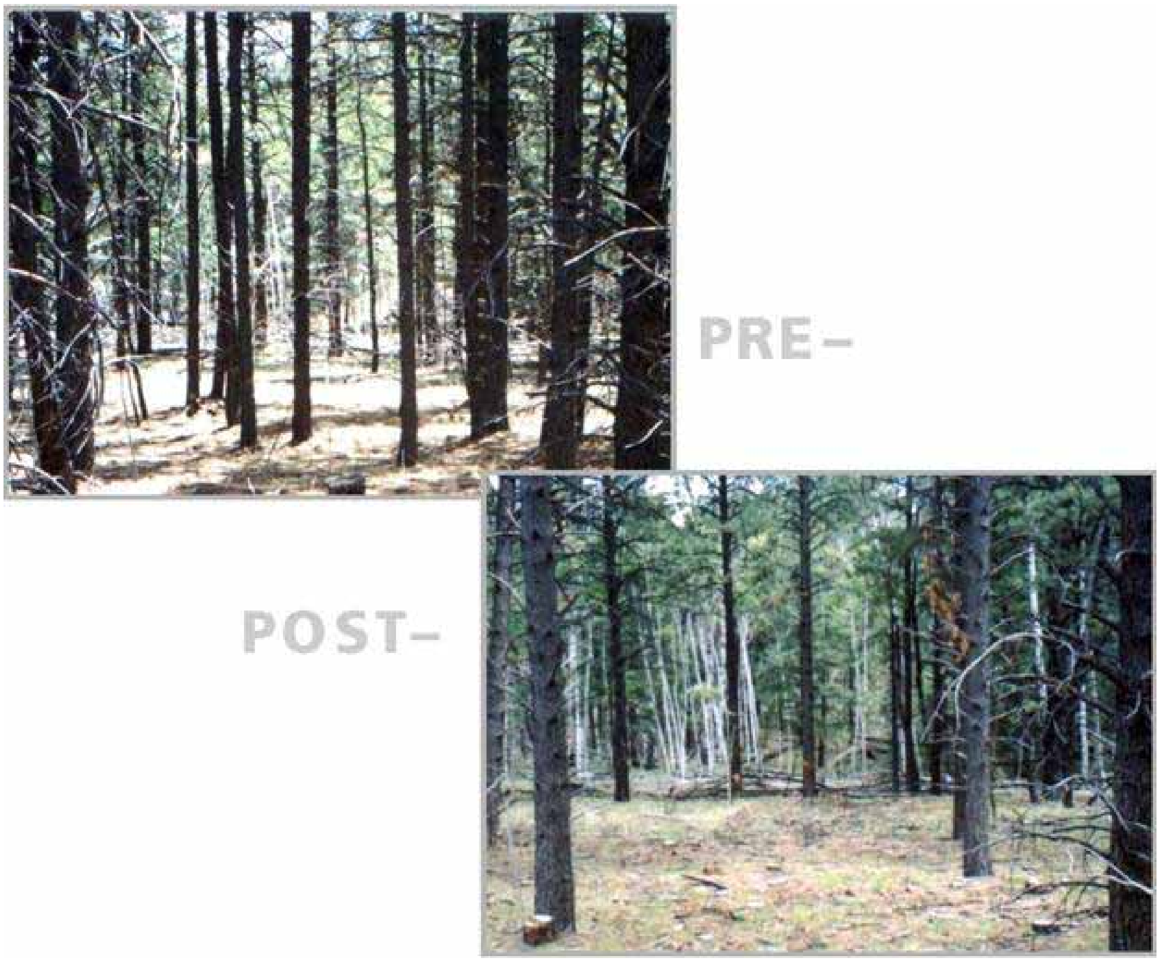
Monitoring a Fuel Reduction Treatment: Analysis of Pre- and Post-Treatment Data

A Participatory Research Project with the Pueblo of Zuni

by Martha Schumann and Clifford Waikaniwa



Forest Guild Research Center

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Introduction

The Zuni Department of Conservation formed to develop greater capacity and independence over the management of tribal lands. The tribe became interested in developing a relationship with the Forest Service to do contracting. Their goal was to build the capacity of the tribe in land management, so that ultimately they could partner with the Bureau of Indian Affairs (BIA) and the Forest Service to manage their tribal land, rather than relying on BIA foresters for management.

In the spring of 2001, the Zuni Department of Conservation invited the Southwest Community Forestry Research Center (SCFRC) to partner with them on a Collaborative Forest Restoration Program (CFRP) grant. The grant provided funding to support the tribe's development of a forestry crew and to pay for fuel reduction projects on federal land. Goals of Zuni's CFRP project were aligned with those of the Program. Two goals relevant to ecological monitoring were to:

- Reduce the threat of large, high intensity wildfires
- Improve the functioning of forest ecosystems and enhance plant and wildlife biodiversity by reducing the unnaturally high density of small diameter trees The Rincon I site, located within a western portion of the Mt. Taylor District of Cibola National Forest, was the first project of their CFRP grant. The tribe and Forest Service planned to implement the project through a timber sale and pre-commercial thinning.

Developing a Monitoring Plan

The role of the Research Center in the CFRP grant was to provide training and technical assistance with monitoring the ecological effects of the treatments funded through the grant. The Research Center worked with Clifford Waikaniwa and other tribal members and staff of the Zuni Department of Natural Resources (ZDNR) to identify what monitoring indicators should be measured. The group chose to use effectiveness monitoring, which helps determine whether or not the project goals were achieved. Through this process, a multiparty assessment identified both the existing ecological condition of the proposed project area and the desired future condition. ZDNR staff and thinning crew members wanted to know whether the treatment would ecologically benefit the forest. The methods used for measuring ecological variables are described in Working Paper 4, *Community Monitoring for Restoration Projects in Southwestern Ponderosa Pine Forests*, a publication produced by the SCFRC. These methods are very similar to those found in *Handbook 4: Monitoring Ecological Effects of Collaborative Forest Restoration Program Projects* (www.fs.fed.us/r3/spf/cfrp/monitoring).

Another important question the tribe hoped to answer was whether small-diameter thinning work was economically feasible and economically beneficial to the community. ZDNR addressed these questions through reports submitted as part of their CFRP. The answers to these questions will help inform decisions about how to move from the small Rincon pilot project to larger acreages, with similar objectives and similar work involved.

The Zuni Department of Natural Resources was also interested in monitoring the effects of the treat ment on wildlife populations, but decided to approach this by monitoring indicators of wildlife habitat, rather than monitoring wildlife populations. For example, density and size of live trees, extent of canopy closure, and understory cover all provide important information about wildlife habitat (see Table 1).

Table 1. Summary of Goals and Indicators for Ecological Monitoring of the Rincon I Site

Goal	Indicator
Change fire regimes	Density and size of live trees Seedling density Extent of canopy closure Understory cover
Preserve old and large trees	Size of live trees Size of dead standing trees
Enhance native plants	Understory cover
Conserve wildlife populations and habitats	Density and size of live trees Density and size of dead standing trees Extent of canopy closure Understory cover
Conserve soil resources	Understory cover Extent of bare soil

Project Implementation

Harvesting at Rincon I began during the spring of 2003 and was completed in the spring of 2004. The project helped build the capacity of the thinning crew. Various challenges, such as an accident that totaled the hauling truck, and the fact that the forest was closed due to high fire danger, slowed the progress on completing the project.

The Rincon I unit was successfully completed and helped build the capacity of the the thinning crew and crew foreman. The crew will begin thinning their next project, the Lookout site, in the spring of 2005. Staff from the Cibola National Forest are working with the crew to train them to cut trees based on a prescription, rather than a full marking of trees to be removed.

Monitoring Methods

Clifford Waikaniwa, the community cooperator and manager for the Zuni sawmill, identified two young people, Carlo Lonjose and Ethan Wemytewa, to assist with the collection of pre-treatment monitoring data. Over the course of 4 days during the summer of 2002, the following pre-treatment data were collected:

- Permanent photo points
- Adult tree density
- Adult tree size
- Basal area
- Density and average size of snags and fallen logs
- Tree canopy cover
- Seedling density
- Sapling density
- Understory plant cover

The site is relatively flat, with no riparian areas, and includes ponderosa pine and aspen stands. Because no treatment was planned for the aspen stands, transects were only placed in the ponderosa pine stands. However, photo points were located in the aspen. A total of 6 transects were measured, 4 300-feet long and 2 200-feet long. Square plots (30 feet by 30 feet) were established at 0, 50, 100, 150, 200 and 250 feet along each transect, for a total of 12 plots. A total a 20 photo points were recorded, 1 at the ends of each transect and 8 located in areas otherwise not sampled (see Figure 1). Photo points and transects were marked with rebar and PVC pipe and their location was recorded with a GPS system, to facilitate relocating them after treatment.

Data sheets and photographs were organized and labeled in a 3-ring binder. Two copies were made, one for the Research Center and one for Zuni Department of Conservation.

Data Analysis

Data was summarized using Microsoft Excel spreadsheets. The data analysis tool in Excel was used to generate summary statistics. More information about the data analysis methods can be found in *Handbook 6: Analyzing Monitoring Data - Data Analysis Methods for CFRP Projects*.

Results

Permanent Photo Points

Photographs taken at permanent locations within a project area over a period of years provide valuable information about how a forest has changed over time. In this case, photographs were taken prior to and after the thinning treatment. Photo points provide a visual representation of the extent of canopy cover, density and size of trees, and understory cover. Paired photographs (pre- and post-treatment) are included in the following sections when they illustrate a particular point, such as reduced tree density.

Tree Density

Density is expressed as the number of individuals per area. In this case, the number of adult trees (trees >5” dbh) per acre was calculated.

Table 2. Tree density in trees per acre by species for adult trees, saplings and seedlings.

	Tree Species	Pre-treatment 2002	Post-treatment 2004
A. Adult Trees	Ponderosa Pine	121	48
	Gambel Oak	9	9
	Aspen	2	2
	Total trees per acre	**132**	**59**
B. Saplings	Ponderosa Pine	56	0
	Gambel Oak	47	41
	Aspen	8	4
	Total trees per acre	**111**	**45**

C. Seedlings	Ponderosa Pine	18	18
	Gambel Oak	127	273
	Aspen	0	18
	Cherry	18	18
	Total trees per acre	**163**	**327**

The data show a 55% reduction in adult tree density occurred as a result of the treatment, a statistically significant change (t-test: Paired 2 Sample for Means: p=0.0006). The species composition of adult trees is shown in Table 4. Reduced tree density suggests that there is more space between tree crowns, making the forest structure more conducive to surface fires rather than crown fires. Reduced tree density may also improve habitat for some wildlife that requires more open forest structure.

The number of saplings decreased by 59%, due to the removal of all ponderosa pine saplings (Table 4). Seedlings increased by 100%, due to an increase in the number of Gambel oak and aspen stems (Table 4). In the case of Gambel oak stems, they are probably sprouts and not seedlings. Future monitoring will be helpful in determining the long-term effects of the treatment on regeneration. Opening the canopy may increase regeneration of ponderosa pine, although existing grass cover may out-compete seedlings in some areas.

Basal Area

Basal area is the cross-sectional area of a tree trunk, measured at the base of the trees (about 10 inches up the trunk from the ground surface). Basal area is expressed as the number of square feet occupied by trees in an acre (ft^2/acre). We chose to measure basal area because it is a common metric used by foresters to describe stands.

Table 3. Basal Area

	Pre-treatment	**Post-treatment**
Basal Area	2002 141.3 ft2/ac	2004 42.1 ft2/ac

The data show that a 70% reduction in basal area occurred as a result of the treatment (Table 3), a statistically significant change (t-test: 2 Sample Assuming Unequal Variances: p=0.001)., which corresponds to the reduction in tree density (Table 2).

2002

2004

Photo Pair 1: Plot R1-20

In the upper left hand corner of the photo is the branch of a large Gambel oak tree. Oak occurred in clumps throughout the unit. In the background of these photos, a clump of small diameter trees has been thinned, leaving four trees in a clump in 2004. Large stumps from historic harvesting are present in the background of both photos.

2002

2004

Photo Pair 2: Plot R1-19

The small trees adjacent to the clump of trees in the 2002 photo have been removed, eliminating ladder fuels. In addition, the 2004 photo shows that the clump of trees has been retained.

2002

2004

Photo Pair 3: Plot R1-7

Saplings present in the center of the 2002 photo were removed as part of the thinning treatment. Grass is evident in the open area in the foreground of the photos.

2002

2004

Photo Pair 4: Plot R1-16

Looking at the center of the 2004 photo, it is clear that a number of small diameter trees have been removed. On the left of the 2002 photo, there is a downed log. In 2004 this log appears to have been broken up by equipment and low levels of slash from the harvest are present.

2002

2004

Photo Pair 5: Plot R1-11

The aspen in the background of the 2002 photo are much more visible in 2004, due to a significant reduction in the number of trees. These photos illustrate the reduction in basal area that occurred as a result of the thinning. Clumps of grass are present in the foreground of both photos.

2002

2004

Photo Pair 6: Plot R1-20:

Shows reduced saplings (trees <5 inches), particularly in the left of the photos. Also, the sapling to the right of the large ponderosa pine tree in the center of the 2002 photo was removed, eliminating a ladder fuel.

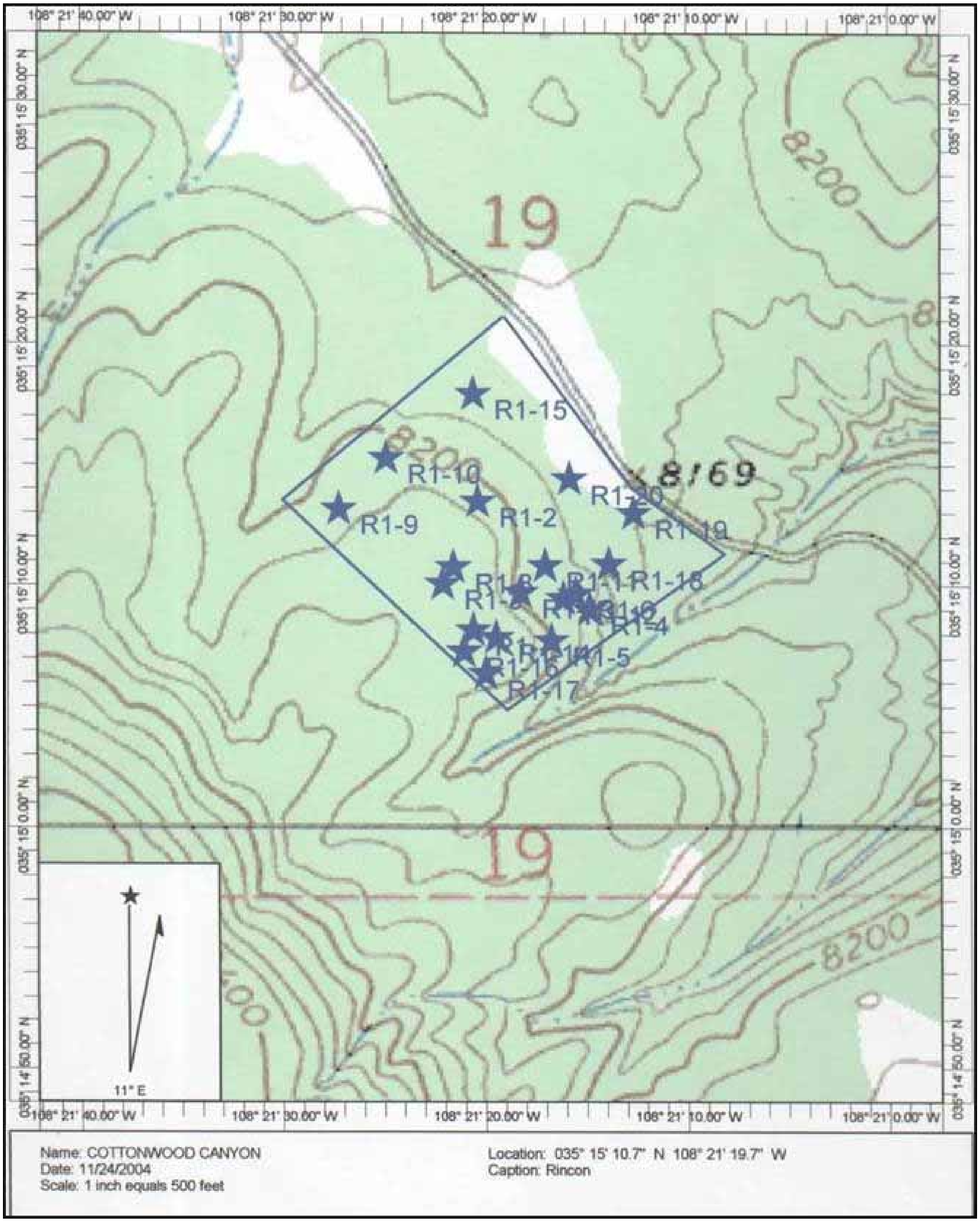

Figure 1: Map of photo points and transect locations at the Rincon Site.

Species

Transects and plots were placed in ponderosa pine stands, not aspen stands, so the following data represent the area sampled and treated, not the entire unit as defined on the map (Figure 1). Not surprisingly, ponderosa pine trees compose the majority of tree species present in the sampled area.

Table 4: Frequency tables for species of adult trees, saplings and seedlings

	Tree Species	Pre-treatment 2002	Post-treatment 2004
A. Adult Trees	Ponderosa Pine	80	32
	Gambel Oak	6	6
	Aspen	1	1
	Total	**87**	**39**
B. Saplings	Ponderosa Pine	37	0
	Gambel Oak	31	27
	Aspen	5	3
	Total	**73**	**30**
C. Seedlings	Ponderosa Pine	1	1
	Gambel Oak	7	15
	Aspen	0	1
	Cherry	1	1
	Total	**9**	**18**

Diameter

The diameter of trees was measured at breast height (referred to as “dbh”), which is approximately 4.5 feet about the ground.

Table 5: Summary statistics for the diameter of adult trees.

Diameter (inches)	Pre-treatment 2002	Post-treatment 2004
Mean	11.23”	14.46”
Minimum	5.10”	5.50”
Maximum	22.30”	22.80”

t-Test: Two-Sample Assuming Unequal Variances: P two-tail = 0.0004

The average diameter of trees increased (listed as the ‘mean’ in Table 5) as a result of removing small diameter trees, resulting in a statistically significant difference. Increased average diameter indicates that old and large trees were left on site, with a focus on removing small diameter trees. Large trees have thicker bark, making them more fire resistant and able to survive a surface fire. Large trees are also necessary for some wildlife species.

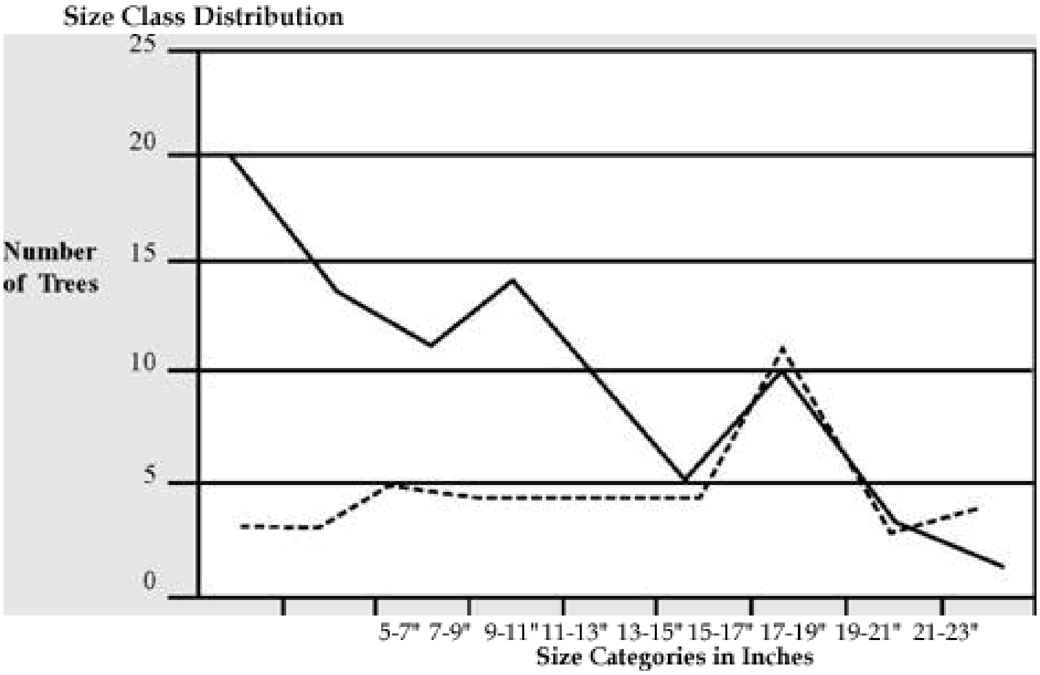

Figure 2: Distribution of trees across size classes.

In assessing the future structure of a forest stand, it is useful to look at the distribution of trees across size classes, that is, how many trees there are for each size category. In many ponderosa pine forests, there is an abundance of trees in the middle size classes (for example, 7 to 13 inches in diameter). A ponderosa pine forest with a natural range of variability would have more trees in large size/age classes, a so-called all-age forest. The data from Rincon show that the number of trees in smaller size classes (5 to 15 inches) was greatly reduced after thinning, with no trees greater than 15 inches cut (Figure 2). Over time, these trees should increase in diameter, and new regeneration should occur. Future monitoring will be necessary to determine the long-term effects of treatments on the distribution of trees across size classes.

Snags

Sampling measured only three snags in 2002 and the same three snags in 2004, with an average diameter of 7.9 inches. This data shows that snags were not removed during the treatment, which is positive, since the data also suggests that few snags are present on the site (an average of 4.5 snags per acre). Snags are important for wildlife habitat, particularly cavity nesting birds. Future management at the site should preserve snags.

Downed Logs

Downed logs with a diameter greater than 5 inches were measured in the plots. When it was possible to determine, the diameter of a log was measured 4.5 feet from the base of the log. When it was not possible, the diameter in the middle of the log was measured. If only a portion of a log was in the plot, the entire length of the log was measured. Logs in varying degrees of decay were measured. These trees were not re-measured in 2004; their presence was simply confirmed by referring to the 2002 data sheets. However, downed logs that were recently harvested and left on the site were measured. The number of logs per acre increased from 83 to 90.

Table 6. Summary statistics for the length and diameter of downed logs.

	Pre-treatment Length (feet) 2002	Post-treatment Length (feet) 2004	Pre-treatment Diameter (inches) 2002	Post-treatment Diameter (inches) 2004
Mean	15.64ft	15.38ft	9.04”	9.02”
Standard Error	1.52	1.42	0.52	0.49
Count	55.00	60.00	55.00	60.00
Logs per acre	83.33	90.90		

The data for downed logs shows little change in the number, length, or diameter of logs. Due to the location of the unit directly adjacent to the road, and a market for logs by the Zuni Sawmill, the majority of logs that were cut were removed. From a fuels and fire hazard perspective, the removal of logs is positive. However, downed wood also plays an important role in nutrient cycling, water storage, and wildlife habitat. Given that the density of downed wood seemed adequate (84 trees per acre prior to treatment), there was no clear need to leave harvested logs on the ground at the site to serve these functions.

Canopy Cover

Overhead canopy can be measured by the amount of shade that the canopies of trees create on the ground. Canopy cover is expressed as a percent of the sky covered or of the ground shaded. Canopy cover was measured using a siting tube (as described in Working Paper 4), taking 25 measurement along a 100-foot transect.

Table 7. Percent canopy cover.

	Pre-treatment	Post-treatment
Canopy Cover	**2002** 56 %	**2004** 32 %

The data shows that a 43% reduction in canopy cover occurred as a result of the treatment. Reduced canopy cover suggests that there is more space between tree crowns, thereby reducing the ability of a crown fire to spread. Reduced canopy cover will also allow more light to reach the ground, potentially increasing ground cover, and may also positively impact wildlife habitat.

Ground Cover

Using a small plot method (Working Paper 4), 6 plots were located on each transect, for a total of 36 plots sampled. In each plot, we estimated the amount of ground cover that was shaded by plants growing near the ground surface. Plant cover included grasses and forbs. Forbs are non-woody, broad-leafed plants, such as Indian paintbrush. Understory cover provided by shrubs was also measured. Plant cover was estimated in percentages, using the following categories: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100%. The use of categories helps reduce the bias introduced by different people making measurements, but does not eliminate this factor.

Table 8. Percent ground cover (* denotes a statistically significant difference).

Percent Cover	Pre-treatment 2002	Post-treatement 2004	% Change	T-test Paired 2 Sample for Means
Grass	6.4%	12.5%	95% increase	0.002*
Forbs	2.9%	4.6%	58% increase	0.166
Shrubs	2.5%	2.5%	no change	n/a
Litter	78.6%	67.4%	14% decrease	0.009*
Bare Ground & Rock	11.6%	10.9%	6% decrease	0.791

Data show that plant cover (grass and forbs) increased after treatment, corresponding with a small decrease in the amount of bare ground and rock. The increase in grass cover was statistically significant (p=0.002). The amount of litter also decreased, probably due to the use of equipment on the site, a difference that is statistically significant (p=0.009). Because control data was not collected, we can not say with confidence that the increase in plant cover was due to the treatment, since it could be due, in part, to climatic changes such as increased moisture. Long-term monitoring, however, will help determine whether plant cover continues to increase, which would be the desired effect of the treatment, regardless of climatic variation.

Conclusion

Monitoring data from the Rincon site shows that project goals, as listed in Table 1, have been met. Several factors support the goal of changing the fire regime. There was a 55% percent reduction in tree density and a 70% reduction in basal area, with a focus on removing small diameter trees. Canopy closure was reduced by 43%, and understory cover, particularly grass, increased. The goal of preserving old and large trees was met. Average size of adult trees increased from 11.2 to 14.5 inches, since the majority of trees removed were small. In addition, the few snags measured on the site were not removed during harvesting. These snags are important for wildlife habitat, as are other attributes that were enhanced, such as increased ground cover. Soil resources were conserved; harvesting did not significantly change the percent of bare ground measured. The process of monitoring the Rincon site, as well as the data that support the treatment goals were accomplished, speak to the increased capacity of the Zuni Department of Natural Resources to successfully implement forest restoration projects.