Bureau of Land Management
San Luis Valley
Forest Fuel Reduction Monitoring Project

Prepared for:
Bureau of Land Management
MonteVista, Colorado

Prepared by:
Joe Stevens
Colorado Natural Heritage Program
Colorado State University
Fort Collins, Colorado

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Cover photos: Plot 6 at the Crestone study site. The top photo was taken prior to treatment in 2003 and the bottom photo was taken post treatment in 2004.

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INTRODUCTION

This report describes the methods and results of monitoring conducted for the Bureau of Land Management (BLM) at forest fuel reduction project sites in the San Luis Valley, Colorado. Management of BLM lands is guided by stated Land Use and Ecosystem Restoration objectives. The BLM's stated land use objective for these projects is to reduce the fuel loads in order to reduce the risk of wildland fire to adjacent private and US Forest Service lands. The stated ecosystem restoration objectives for these projects include improvement of habitat for game/non-game species and livestock, and to restore fire's impact to the ecosystem by managing fuel loads and patterns.

The monitoring was conducted during the summers of 2003 and 2004 at sites located around the valley where BLM planned mechanical fuel reduction treatments. The project included monitoring at nine different treatment sites totaling 2,300 ha (Figure 1).

The greater San Luis Valley and all of the treatment sites are within the Southern Rocky Mountains Ecoregion (Bailey 1995). All of the sites are located in montane coniferous forests of pinyon-juniper (*Pinus edulis – Juniperus scopulorum*), Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), and limber pine (*Pinus flexilis*). The plant communities located on the treatment sites represent four different NatureServe Ecological Systems. These include *Southern Rocky Mountain Pinyon-Juniper Woodland, Rocky Mountain Gamble Oak-Mixed Montane Shrubland, Rocky Mountain Ponderosa Pine Woodland,* and *Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland* (NatureServe 2005).

The baseline monitoring began in late August of 2003 with the initial placement of permanent monitoring plots at the Nolan Gulch treatment area. Over the following two months, additional plots were placed in seven other treatment areas. These other areas include Crestone, Wolf Mountain, Zapata, South Fork, Poncha Pass, Coolbroth, and Chiquita Peak. All plots were installed prior to any fuel reduction treatments.

Treatments on the sites occurred during the late summer and winter of 2003 and the spring of 2004. Treatments were accomplished by the use of a "Hydro-Axe", which is a large wheeled excavator that has been fitted with an apparatus for mulching trees in-situ. One portion of the Crestone site was treated by hand felling and bunching of the overstory trees due to the rockiness and steepness of the site. In addition to the mulching treatments to reduce tree density and cover on the treatment sites, some of the treatment sites were seeded with various mixtures of shrub and herbaceous species.

During the summer of 2004, monitoring was resumed on six of the eight original treatment sites and initiated on one new site. The Poncha Pass and Coolbroth sites were dropped by the BLM from the project list and were not monitored in 2004. The BLM added the Trickle Mountain site to the project list and it was first monitored prior to treatment in 2004. Treatment sites monitored in 2004 include Nolan Gulch, Crestone, Wolf Mountain, Zapata, South Fork, Chiquita Peak, and Trickle Mountain. Table 1 shows the size and general characteristics of the treatment sites.

The monitoring objectives for this project were based on the BLM's land use and ecosystem restoration objectives for the treatment sites. The land use objective for the treatment sites is to reduce the density and cover of live fuels, specifically the overstory trees. The ecosystem restoration objectives for the sites are to maintain or increase the cover of herbaceous species, increase the litter cover, decrease the cover of bare ground, and increase the cover of woody shrub species.

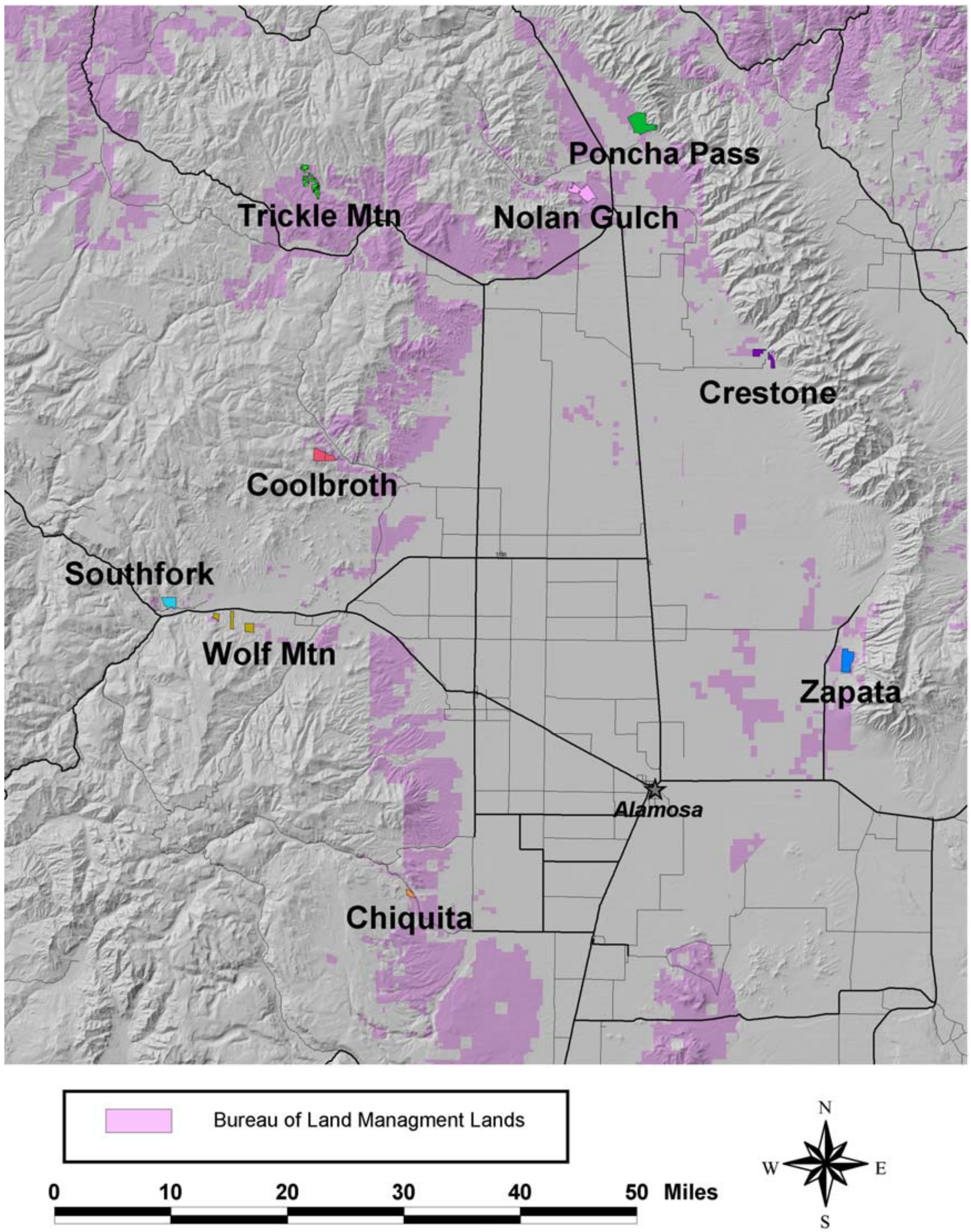


Figure 1. Location of nine study sites sampled throughout the San Luis Valley on Bureau of Land Management lands

Table 1. Characteristics of the treatment sites

Treatment Area	Average Elev. (m)	Primary Aspect	Size (ha)	Transect #'s	Dominant overstory species
Chiquita Peak	2590	North	81	28,29,30	Pinyon pine
Coolbroth*	2950	North	300	31, 32, 33,	Douglas fir
Crestone	2530	West	210	6, 7, 8, 9	Pinyon pine
Nolan Gulch	2560	East	607	2, 3, 4, 5	Pinyon pine
Poncha Pass*	2700	West	324	35, 36, 37, 38, 39	Gambel oak
South Fork**	2600	South	65	34, 45	Pinyon pine
Trickle Mountain***	2850	Varies	152	40, 41, 42, 43, 44	Ponderosa pine
Wolf Mountain	2560	Varies	283	18, 19, 20, 21, 22	Pinyon pine
Zapata	2620	West	850	10, 11, 12, 13, 14, 15, 16, 17, 23, 24, 25, 26, 27	Pinyon pine

* Transects were dropped in 2004 and monitored only in 2003
**Transect #45 added in 2004 and not monitored in 2003
*** Transects were added in 2004 and were not monitored in 2003

While this project conducted monitoring on the treatment sites for two summers, the monitoring requirements recommend monitoring prior to treatment, in the first year following treatment, and in the third and fifth years following the treatment. Additional monitoring in the third and fifth years following the treatments will need to be conducted to determine the effect of the treatments over the long-term.

METHODS

The methods used for monitoring the fuel reduction projects are presented below as the Field Methods and the Analytical methods. The monitoring study design is based on the protocols recommended by Savage (2002) with minor modifications, and utilize random placement of plots over the study area for collection of data from line transects and square quadrats. The analytical methods are based on standard descriptive statistical techniques (Elzinga et al. 1998, Zar 1999, Ott 1993).

Nomenclature for plant species names is based on the USDA PLANTS database (USDA NRCS 2004), which follows the checklist of vascular flora by Kartesz (1999). Nomenclature for plant communities is based on the International Vegetation Classification (Anderson et al. 1998, Grossman et al. 1998) and the US National Vegetation Classification (Jennings et al. 2003) approaches developed by NatureServe (NatureServe 2005).

Initial plot placement and monitoring occurred between August and October of 2003 prior to the completion of any plot treatments. Following treatment, the plots were again monitored from July to September of 2004. Plots initially located in the Poncha Pass and Coolbroth treatment areas during the summer of 2003 were not monitored in 2004 because they were dropped from the project list prior to treatment. The Trickle Mountain treatment area and an additional parcel at the South Fork site were added to the project list in 2004 and initial plot placement was completed at those sites in early August, prior to treatment of the area. For this reason, those plots have only been monitored one year.

Several transects have only been monitored in a single year. This occurred because sites were dropped from the project list after the first year of monitoring, or were added to the project list during the second year. Sites monitored in a single year (and their transect numbers) include Coolbroth Canyon (31, 32, 33), Poncha Pass (35, 36, 37, 38, 39), Trickle Mountain (40, 41, 42, 43, 44), and South Fork (45).

It was also observed that some of the plot locations had not received any treatment even though treatments had occurred throughout the remainder of the treatment site. This occurred because the randomly located transects were located within the treatment area boundary, but in an area that was not treated. The sites (and the transect numbers) monitored in the second year that did not receive treatment in the first year include Nolan Gulch (02), South Fork (44), and Wolf Mountain (21, 22).

Plot Placement and Field Methods

Permanent monitoring plots were randomly located in each of the treatment areas based on the size of the treatment area. The project monitoring plan called for a criterion of one plot per 150 acres (61 ha), resulting in placement of 40 plots over the eight treatment areas. A proportion of the 40 plots were then allocated to each treatment site based on the area of the site. Specific placement of those plots within each of the sites was accomplished in a Geographical Information System (GIS) by randomly distributing potential sample locations within each of the treatment site boundaries. The number of potential sample locations drawn on each site was equal to approximately 110% of the required number of plots. The additional potential sample locations drawn on the sites were included to provide the field crew with a sufficient number of potential sites to choose from given logistical and access considerations.

Coordinates for the randomly placed potential locations were entered into a handheld GPS unit. Upon arriving at each treatment site the field crew would select individual points at which to place a plot from the set of potential points based on distance from available access points. Placement of the plot locations remained random and was not biased because: 1) all of the potential points were randomly located within the treatment sites; 2) it is unlikely that the structure and composition of the forest is correlated with distribution of available access points; and 3) plot selections were made prior to arriving at the location and making observations of the vegetation and characteristics of the plot location.

Each of the selected plot locations was navigated to by using the handheld GPS unit. Upon arrival at the plot location the actual GPS coordinates were recorded on paper field forms. Typically, the variability of the GPS signal caused the actual set of coordinates to vary slightly from the coordinates for the randomly selected plot location. Once located, the plots were permanently marked by driving a large metal timber spike into the ground and marking it with a copper tag inscribed with the plot number. The plot numbers are three digits long and represent the sequential order in which the plot was created (e.g. 001, 002, …, 045)

Line transects were laid out at the plot location by randomly selecting a bearing 90 degrees off the aspect. In this manner all transects were oriented perpendicular to the slope (i.e. slope aspect +/- 90 degrees) and had either a left or right bearing. The transect origin was then permanently marked with the metal spike and metal tag bearing the transect name and number and painted with orange paint. A wooden stake painted orange and marked with the transect number was driven into the ground within 1m of the transect origin. Using the selected transect bearing, a 100 m fiberglass tape was stretched across the hill to the 100 m mark. At this point a second orange wooden stake was driven into the ground to mark the transect end. A total of 40 plots were placed in the eight areas with this method.

The parameters collected at each transect included canopy cover and frequency of herbaceous species, canopy cover and density of tree species, canopy cover and density of shrub species, and cover of bare ground and litter. All subplots (quadrats) collected along the line transect were located on the left side of the line as seen from the transect origin. Additionally, four photos documenting the characteristics of the plots were collected from each transect.

Cover values were estimated by cover classes based on a Daubenmire six class scale (Daubenmire 1959). Cover classes used are: 1=0-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, and 6=96-100%. After data entry, the cover class data were converted to the mid point of the class and renamed “real cover”. Density values are number of individuals per unit area, and were entered as recorded. Frequency values are presence-absence per quadrat.

Herbaceous Cover: Herbaceous cover was collected from each plot using 0.25 m^2 square quadrats placed along the line transect (Savage 2002, Elzinga et al. 1998). The frame was placed at 5 meter intervals along the left side of the line transect starting at the randomly selected 3 meter mark and ending with the 88 meter mark (18 samples/transect). At each 5 meter interval from 3 meters to 88 meters, an ocular estimate was made for the cover of all herbaceous species, bare ground, rock, and litter occurring in the quadrat. Herbaceous species cover was recorded separately for grasses and forbs.

Herbaceous Frequency: The list of parameters to monitor originally included density of understory herbaceous species. Because for many species it is nearly impossible to determine what constitutes a single individual, this was determined to be unreliable and was replaced in the field by herbaceous frequency (Savage 2002, Elzinga et al. 1998). Frequency was collected using a $1.0m^2$ square nested frequency plot frame with nested divisions at 10 cm, 30 cm, 70 cm, and 1 m. The frame was placed at 5 meter intervals along the left side of the line transect starting at the randomly selected 3 meter mark and ending with the 88 meter mark (18 samples/transect). Nested frequency is a presence/absence measure. For each quadrat placed along the line, species occurring within the quadrat are noted beginning with the smallest nested area (10x10cm). Each successively larger area is then reviewed, noting only species that have not already been noted in smaller sections.

Tree and shrub cover: The cover of tree and shrub species occurring in the plots was collected from all plots using the point intercept method (Savage 2002, Elzinga et al. 1998, and others). At each one meter interval along the line transect from 1 meter to 100 meters, the point above and below the meter mark was evaluated to determine the presence of any live portion of a tree or shrub species. Where a species occurred at the meter mark, the species code and life form were recorded. Cover is directly calculated as a percent for each line from the number of points that intercept tree or shrub vegetation.

Tree and shrub density: Density of tree and shrub species was collected from each plot using square quadrats placed along the left side of the transect line (2 samples/transect). The plots measured 15 x 15 m and were placed at the 30 m and 60 m marks along the line. Within the quadrats, all individuals of tree and shrub species were counted. To be considered within the plot and counted, an individual had to be at least partially rooted in the plot. Each individual in the plot was recorded by lifeform and species. Tree species shorter than breast height were recorded as having a shrub lifeform. In the treated plots, portions of a cut tree that remained alive and healthy (*i.e.* bottom branches) were counted as a shrub of that species.

Plot photos: Visual characteristics of the plots were recorded in four digital plot photographs taken at each plot. The photos were taken from the center point of the line transect (50m mark) and were oriented toward the origin and end of the line, and to the left and right sides of the line. The photos were all taken with the same camera settings and with the camera angle parallel to land surface with a landscape orientation. Plot photos are provided on the CD-ROM disk located in the appendix to this report, and are hot-linked in the Arc-View map coverages.

Analytical Methods

Analysis of the collected data was done using standard descriptive statistical measures (e.g. mean, variance, standard deviation) to characterize the sites in each of the two years, as well as performing a paired *t*-test of the means to evaluate difference between years. Computations were completed using the statistical analysis tools in MS Excel and the analysis Add-in tool

XL-STAT. Plot parameters analyzed include density of trees and shrubs, cover of trees and shrubs, cover of grasses, forbs, bare ground and litter, and frequency of herbaceous species.

Given that an objective of the treatments was to reduce cover and density of overstory trees in the treatment areas it was necessary to determine when a difference existed between the pre treatment and post treatment data. Mean values for the density and cover parameters from 2003 and 2004 were compared and tested for significance using a Wilcoxon's signed rank test (Elzinga et al. 1998). This type of *t*-test does not require that the data be normally distributed and is a more appropriate measure for non-parametric data than analysis of variance (ANOVA) since the repeated measures are from paired (permanent) locations and since there are only two repeated values (Elzinga et al.. 1998).

Quantitatively stated, the first management objective of the project was to decrease the average cover and average density of overstory trees on the treatment sites between 2003 and 2004. The accompanying monitoring objective is to be 90% certain of detecting a 30% decrease in the average cover and density of overstory trees in the pre- and post-treatment data (2003 to 2004) with a 5% probability of making a Type I error (false change error).

The second management objective of the project was to increase the cover of litter and herbaceous species and decrease the cover of bare ground on the treatment sites between 2003 and 2004. The accompanying monitoring objective was to be 90% certain of detecting a 20% change in cover of herbaceous species, litter, or bare ground with a 5% probability of making a Type I error (false change error).

RESULTS

The two-year monitoring effort produced plot data for density and cover of trees and shrubs, cover of grasses, forbs, bare ground, litter and bare rock, and frequency of grass and forb species. A total of 121 species were identified across the nine treatment areas. The list of species identified in the treatment areas is included in APPENDIX A.

Over the two years of monitoring, three of the nine treatment sites were monitored in one year, whereas six of the nine sites were monitored in both years. In the sections that follow, only descriptive statistics are provided for the sites monitored in only one year. Sites monitored in both years include descriptive statistics as well as a test of the means between years.

A significant decrease in tree density was observed at all sites, with the exception of the South Fork site. At the South Fork site, the randomly selected plot location did not receive any treatment. The existing density of trees at the South Fork site is 6 trees/225m^2 (to calculate the values as average trees per ha, multiply the given value by 44.44).

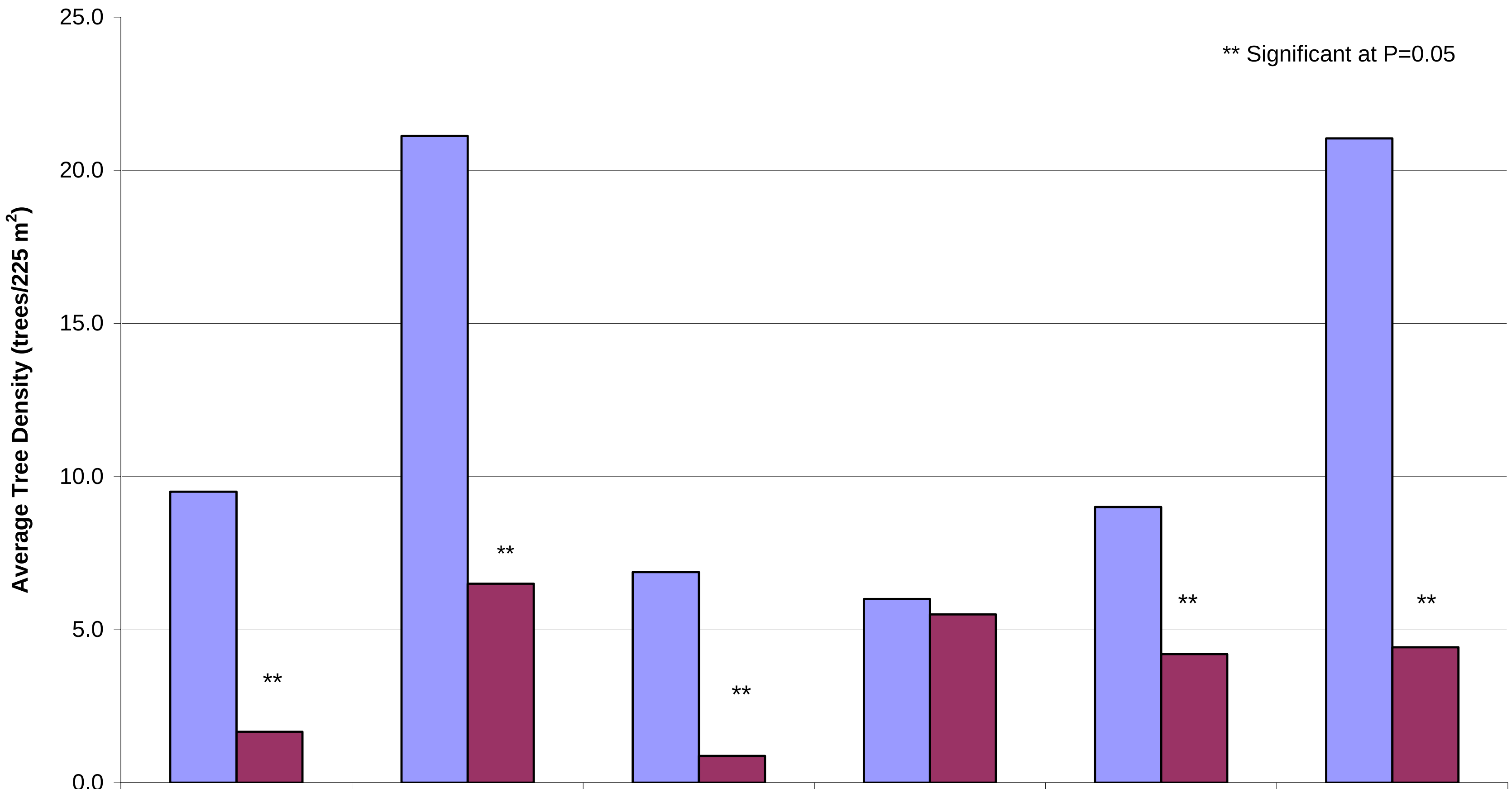
The average tree density overall decreased from 18 trees/225m^2 to 4 following treatment (78% reduction). The greatest reduction was observed at the Nolan Gulch site, which went from an average of 7 trees/225m^2 to 1 following treatment (86% reduction). The smallest reduction in tree density was observed at the Crestone site, which decreased from 21 trees/225m^2 to 6 after treatment (69% reduction). The change in tree density for each of the sites is presented in Figure 2. Descriptive statistics for overall tree density across all study sites are presented in Table 2

A significant decrease in tree cover was also observed at all sites, with the exception of the South Fork site. The average reduction of tree cover across all sites was 57%. The greatest reduction in tree cover occurred at the Chiquita site, which decreased from 29% cover to 7% after treatment (75% reduction). The lowest reduction in tree cover occurred at the Zapata site, which decreased from 43% cover to 30% after treatment (30% reduction). The change in tree cover for each of the sites is presented in Figure 3 Descriptive statistics for overall tree cover for all of the study sites are presented in Table 2 .

Table 2. Descriptive statistics for overall tree density and overall tree cover

Sample	N	Mean	Variance	Standard deviation	Standard-error
Overall Tree Density					
2003	54	18.2	148.1	12.1	1.6
2004	54	4.0	13.0	3.6	0.5
Overall Tree Cover					
2003	27	34.5	313.7	17.7	3.4
2004	27	21.4	217.1	14.7	2.8

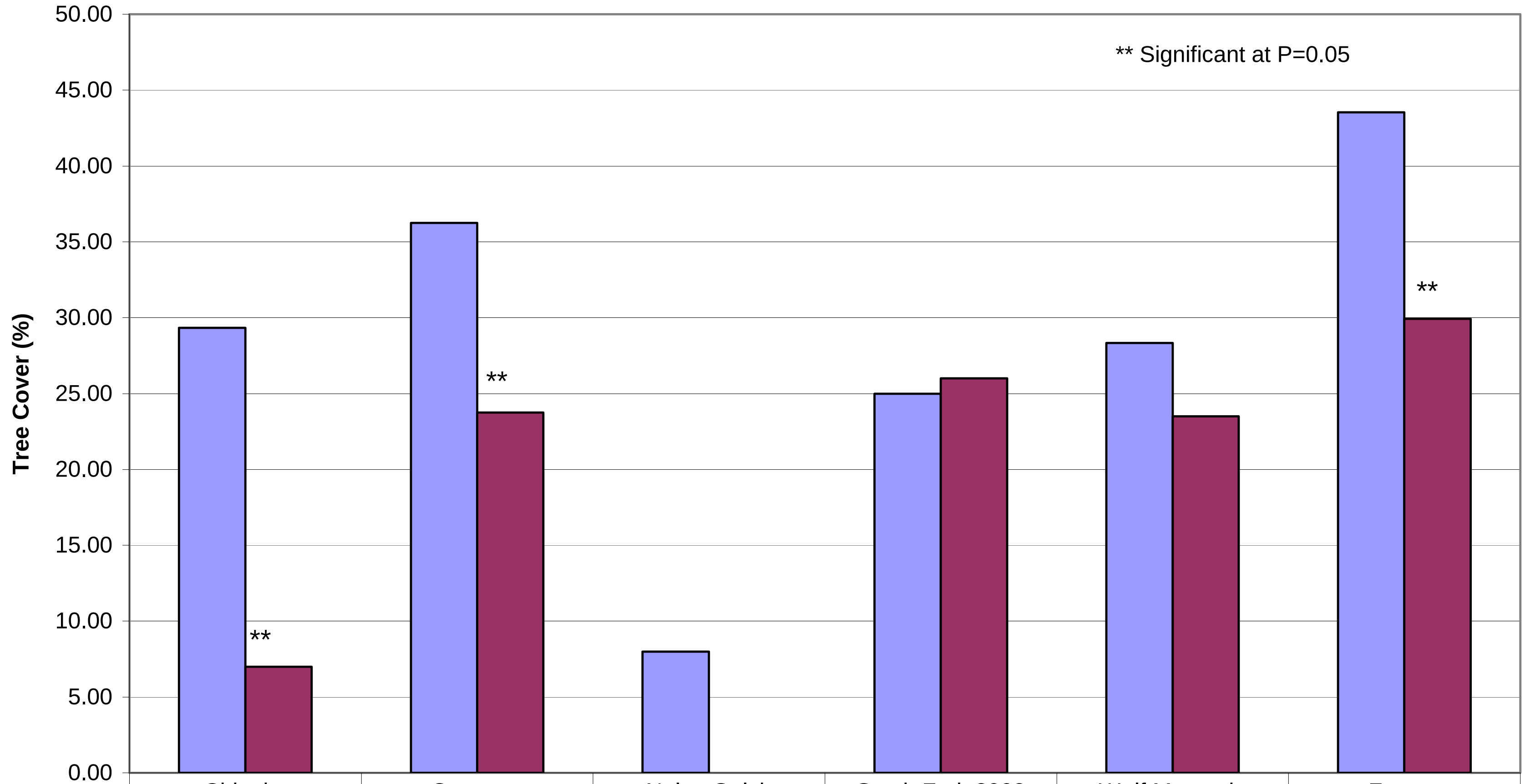
Shrub density: The overall average shrub density significantly increased following treatment ($p=0.05$). Prior to treatment the overall average density of shrubs was 4.8%. Following treatment this increased to 11.6%. Descriptive statistics for overall shrub density for all of the study sites are presented in Table 3.



	Chiquita	Crestone	Nolan Gulch	South Fork 2003	Wolf Mountain	Zapata
2003	9.5	21.1	6.9	6.0	9.0	21.0
2004	1.7	6.5	0.9	5.5	4.2	4.4

Treatment Site

Figure 2. Change in Average Tree Density, 2003 - 2004



	Chiquita	Crestone	Nolan Gulch	South Fork 2003	Wolf Mountain	Zapata
2003	29.33	36.25	8	25	28.33	43.54
2004	7	23.75	0	26	23.5	29.92

Treatment Site

Figure 3. Change in Tree Cover, 2003 - 2004

Shrub Cover: The overall average shrub cover significantly increased after treatment (p=0.05). Prior to treatment the overall average cover of shrubs was 8.1%. Following treatment this increased to 12.4%. Descriptive statistics for overall shrub cover for all of the study sites combined are presented in Table 3.

Table 3. Descriptive statistics for overall shrub density and overall shrub cover

Sample	N	Mean	Variance	Standard deviation	Standard-error
Overall Shrub Density					
2003	468	4.8	143.3	11.9	0.5
2004	468	11.6	455.7	21.3	1.0
Overall Shrub Cover					
2003	30	8.1	88.9	9.4	1.7
2004	30	12.4	116.5	10.8	2.0

Herbaceous Cover and Frequency: Total herbaceous cover consists of graminoids and forbs. Overall, the total herbaceous cover for all study sites did change significantly following treatment (p=0.05). Before treatment the average overall herbaceous cover was 8.0%, while after the treatment it was 6.6%. The average cover of all graminoids did not change significantly following the treatments (p=0.05). Average cover of forbs, overall, did change significantly following treatment (p=0.05). Prior to treatment the average cover of forbs, overall, was 2.8%, whereas following treatment it was 2.1%. The overall frequency of the dominant graminoid and forb species was low throughout the study area. Average percent frequency of graminoids did not change significantly following treatments (p=0.05). The average frequency of forb species did change significantly following treatments (p=0.05). Before treatment in 2003 the average frequency of forbs was 1.5, and in 2004 following treatment it was 1.1. Descriptive statistics for overall cover and overall frequency of herbaceous vegetation for all of the study sites combined are presented in Table 4.

Table 4. Descriptive statistics for overall cover and overall frequency of herbaceous vegetation

Sample	N	Mean	Variance	Standard deviation	Standard-error
Overall Herbaceous Cover (%)					
2003	486	8.0	104.5	10.2	0.5
2004	486	6.6	71.3	8.4	0.4
Overall Graminoid Cover (%)					
2003	486	5.2	67.3	8.2	0.4
2004	486	4.5	48.0	6.9	0.3
Overall Forb Cover (%)					
2003	486	2.7	40.6	6.4	0.3
2004	486	2.1	18.6	4.3	0.2
Overall Graminoid Frequency (%)					
2003	486	1.3	1.0	1.0	0.0
2004	486	1.3	1.1	1.0	0.0
Overall Forb Frequency (%)					
2003	486	1.5	2.0	1.4	0.1
2004	486	1.1	1.1	1.1	0.0

Ground cover: Total ground cover includes areas covered by litter as well as areas of bare ground and exposed rock. Overall, the average cover of bare ground and rock did not change significantly following the treatments (p=0.05). The cover of litter, overall, did significantly (p=0.05) increase from an average of 41.6% prior to the treatments to 51.5% following the treatments. Descriptive statistics for overall ground cover for all of the study sites combined are presented in Table 5.

Table 5. Descriptive statistics for overall ground cover

Sample	N	Mean	Variance	Standard deviation	Standard-error
Overall Litter Cover (%)					
2003	486	41.6	1397.8	37.4	1.7
2004	486	51.5	1484.5	38.5	1.7
Overall Rock/Bare Ground (%)					
2003	486	40.7	1204.6	34.7	1.6
2004	486	39.5	1320.2	36.3	1.6

The following sections provide site-specific overviews of the monitoring results from each of the six treatment sites that were monitored in both 2003 and 2004.

Chiquita Peak

The Chiquita Peak site is a small site (81 ha) located on the southwestern side of the San Luis Valley approximately 20 miles south of the town of Monte Vista. The site is located on a gently sloping north facing hillside. The soils are very rocky and consist largely of fine gravels. The site is dominated by the Southern Rocky Mountain Juniper Woodland Ecological System (Comer et al. 2003). Trees at this site are primarily pinyon pine (*Pinus edulis*), although some ponderosa pine (*Pinus ponderosa*) are also present in the adjacent area.

Three plots were installed at the Chiquita Peak site (plot numbers: 28, 29, and 30). The plot locations are shown in Figure 4. Representative photos from the site are shown in Figure 5.

Fuel treatment at the Chiquita Peak site significantly reduced the density and cover of trees on the site (p=0.05). Tree density on the site decreased from an average of 9.5 trees per 225m^2 to 1.6 trees per 225m^2 following treatment. Following treatment, tree cover significantly decreased from an average of 29.3% to 7.3%. Changes in tree density and tree cover are displayed in Figure 2 and Figure 3.

The dominant shrub species observed at the Chiquita site include *Juniperus scopulorum*, *Pinus edulis*, *Opuntia polyacantha*, *Ribes cereum*, and *Yucca glauca*. The average shrub density at the Chiquita Peak site did change significantly following the fuel treatments. In 2003 the average shrub density was 1.7 plants per 225m^2, whereas in 2004 it was 4.1 plants per 225m^2. The difference was significant (p=0.05). The average cover of shrubs at the Chiquita site was less than 1% in both 2003 and 2004. There was not a significant change (p=0.05) in average shrub cover following the site treatment. Descriptive statistics for shrub cover and shrub density at the Chiquita Peak site are presented in Table 6.

Table 6. Descriptive statistics for shrub density and shrub cover at the Chiquita Peak site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	42	1.7	19.9	4.5	0.7
2004	42	4.1	42.5	6.5	1.0
Shrub Cover					
2003	15	0.1	0.1	0.3	0.1
2004	15	0.1	0.4	0.6	0.2

Herbaceous cover at the Chiquita Peak site was sparse and was composed primarily of graminoid species. Dominant graminoid species observed at the site included *Achnatherum hymenoides*, *Bouteloua gracilis*, *Carex spp*., and *Muhlenbergia montana*. Average cover of graminoids changed significantly following treatment (p=0.05). Average graminoid cover in 2003 was 9% and in 2004 following treatment was 6.4%. Cover of forb species is composed primarily of *Heterotheca villosa*. Average cover of forbs changed significantly following treatment (p=0.05). Average forb cover in 2003 was 0.33%, and in 2004 following treatment was 1.3%. The overall frequency of the dominant graminoid and forb species was low at the Chiquita Peak site. Average frequency of graminoids did not change significantly following treatments (p=0.05). The average frequency of forb species did change significantly following treatments (p=0.05). Before treatment in 2003 the average frequency of forbs was 0.3, and in 2004 following treatment it was 0.5. Descriptive statistics for cover and frequency of graminoids and forbs at the Chiquita Peak site are presented in Table 7.

Table 7. Descriptive statistics for cover and frequency of herbaceous vegetation at the Chiquita Peak site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	54	9.0	138.5	11.8	1.6
2004	54	6.4	94.8	9.7	1.3
Forb Cover					
2003	54	0.3	0.9	0.9	0.1
2004	54	1.2	19.5	4.4	0.6
Graminoid Frequency					
2003	54	1.5	0.7	0.8	0.1
2004	54	1.3	1.1	1.1	0.1
Forb Frequency					
2003	54	0.3	0.3	0.5	0.1
2004	54	0.5	0.5	0.7	0.1

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the Chiquita Peak site. Average cover of litter did not change significantly following treatment (p=0.05). Average cover of litter in 2003 was 42.8%, and in 2004 following treatment was 50.1%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did not change significantly following treatment (p=0.05). Average cover of rock/bare ground in 2003 was 35.8%, and in 2004 following treatment was 37.5%. Descriptive statistics for litter cover and rock/bare ground cover at the Chiquita Peak site are presented in Table 8 below.

Table 8. Descriptive statistics for litter and rock/bare soil cover at the Chiquita Peak site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	54	42.815	1593.1	39.9	5.4
2004	54	50.130	1811.1	42.6	5.8
Rock/Bare Ground Cover					
2003	54	35.833	981.2	31.3	4.3
2004	54	37.481	1337.9	36.6	5.0

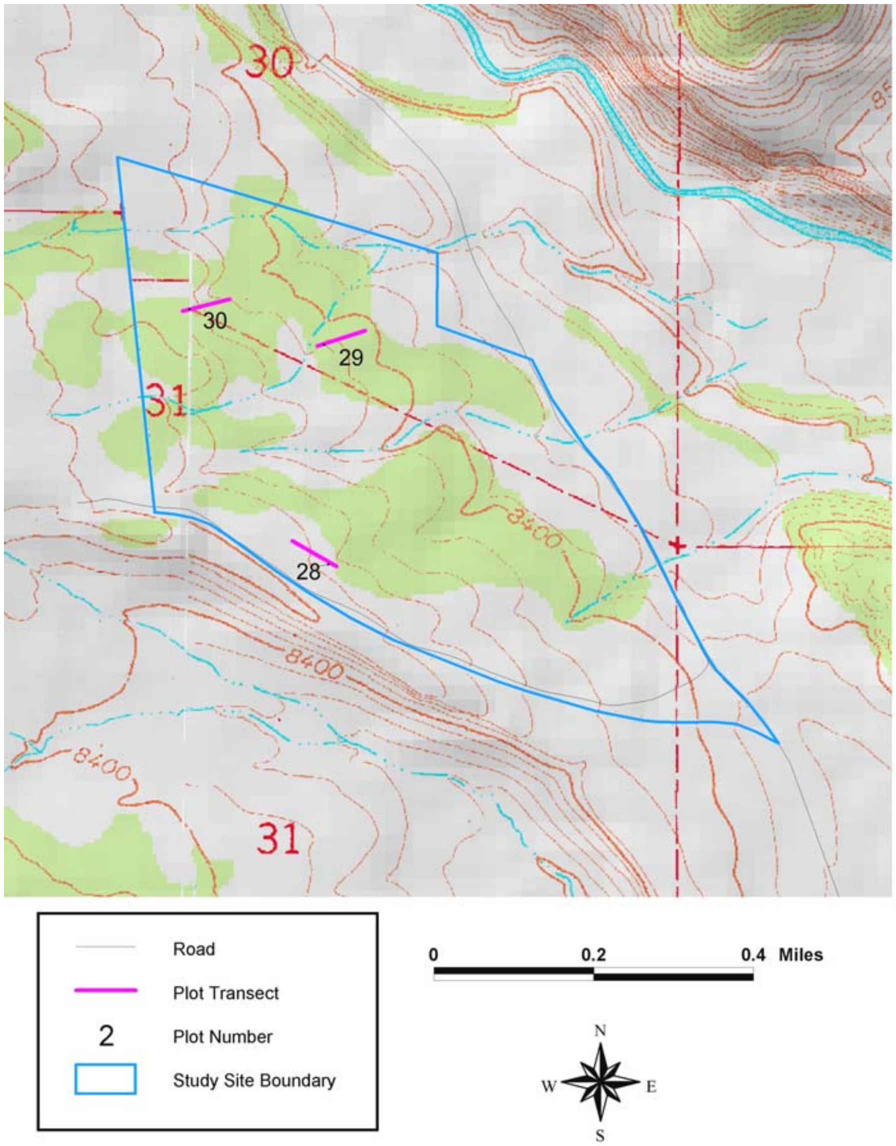


Figure 4. Three transects were sampled at the Chiquita Peak study site

Figure 5. 2003 (left) and 2004 (right) photos from plot 28 at the Chiquita Peak study site

Crestone

The Crestone site is a moderate sized site (210 ha) located on the eastern side of the San Luis Valley approximately 40 miles northeast of the town of Alamosa and adjacent to the Town of Crestone. The site consists of two separate treatment areas located on the upslope and downslope sides of the town. The lower site is located on a gently sloping west facing hillside. Soils at this area are sandy with exposed pockets of large cobbles and small boulders. Vegetation is dominated by the Southern Rocky Mountain Pinyon-Juniper Woodland Ecological System (Comer et al. 2003). Trees at this site are primarily pinyon pine (*Pinus edulis*), although some Rocky Mountain juniper (*Juniperus scopulorum*) are also present.

Four plots were installed at the Crestone site (plot numbers: 6, 7, 8, and 9). The plot locations are shown in Figure 6. Representative photos from the site are shown in Figure 7.

Fuel treatment at the Crestone site significantly reduced the density and cover of trees on the site. Tree Density on the site decreased from 21 trees per $225m^2$ to 6.5 trees per $225m^2$ following treatment. Following treatment, tree cover significantly decreased from 36.3% to 23.8%. Changes in tree density and tree cover are displayed in Figure 2 and Figure 3.

The dominant shrub species observed at the Crestone site include *Cercocarpus montanus, Chrysothamnus viscidiflorus, Eriogonum effusum, Eriogonum jamesii, Ericameria nauseosus, Opuntia polyacantha*, *Rhus trilobata, Ribes cereum*, and *Yucca glauca*. The average shrub density at the Crestone site changed significantly following the fuel treatments. In 2003 the average shrub density was 7.9 plants per $225m^2$, whereas in 2004 it was 17.3 plants per $225m^2$. The difference was significant (p=0.05). The average cover of shrubs at the Crestone site was less than 2% in both 2003 and 2004. In 2003 the average shrub cover was 1.2%, whereas in 2004 it was 0.9%. The change in shrub cover following site treatment was not significant (p=0.05). Descriptive statistics for shrub density and shrub cover at the Crestone site are presented in Table 9.

Table 9. Descriptive statistics for shrub density and shrub cover at the Crestone site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	56	7.8	311.5	17.7	2.4
2004	56	17.3	846.6	29.1	3.9
Shrub Cover					
2003	36	1.2	9.4	3.1	0.5
2004	36	1.0	3.8	2.0	0.3

Herbaceous cover at the Crestone site is sparse and is composed primarily of graminoid species. Dominant graminoid species observed at the site include *Bouteloua gracilis* and *Hesperostipa comata*. Average cover of graminoids did not significantly change following treatment (p=0.05). Cover of forb species is composed primarily of *Chenopodium leptophyllum* and *Chenopodium fremontii*. Average cover of forbs did change significantly following treatment (p=0.05). Average forb cover in 2003 was 5.6%, and in 2004 following treatment was 0.5%. The overall frequency of the dominant graminoid and forb species was low at the Crestone site. The average frequency of graminoids did not change significantly following treatments (p=0.05). The average frequency of forb species did change significantly following treatments (p=0.05). Before treatment in 2003 the average frequency of forbs was 1.4, and in 2004 following treatment it was 0.5. Descriptive statistics for the cover and frequency of graminoids and forbs at the Crestone site are presented in Table 10.

Table 10. Descriptive statistics for cover and frequency of herbaceous vegetation at the Crestone site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	72	2.5	28.9	5.4	0.6
2004	72	2.2	24.6	5.0	0.6
Forb Cover					
2003	72	5.6	174.2	13.2	1.5
2004	72	0.5	1.0	1.0	0.1
Graminoid Frequency					
2003	72	0.9	0.6	0.8	0.1
2004	72	0.9	0.8	1.0	0.1
Forb Frequency					
2003	72	1.4	1.5	1.2	0.1
2004	72	0.5	0.8	1.0	0.1

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the Crestone site. Average cover of litter did change significantly following treatment (p=0.05). Average cover of litter in 2003 was 35.5%, and in 2004 following treatment was 46.7%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did not change significantly following treatment (p=0.05). Average cover of rock/bare ground in 2003 was 52.4%, and in 2004 following treatment was 46.0%. Descriptive statistics for litter cover and rock.bare soil cover at the Crestone site are presented in Table 11.

Table 11. Descriptive statistics for litter and rock/bare soil cover at the Crestone site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	72	35.5	1192.6	34.5	4.1
2004	72	46.7	1468.6	38.3	4.5
Rock/Bare Soil Cover					
2003	72	52.4	1276.2	35.7	4.2
2004	72	45.9	1430.6	37.8	4.5

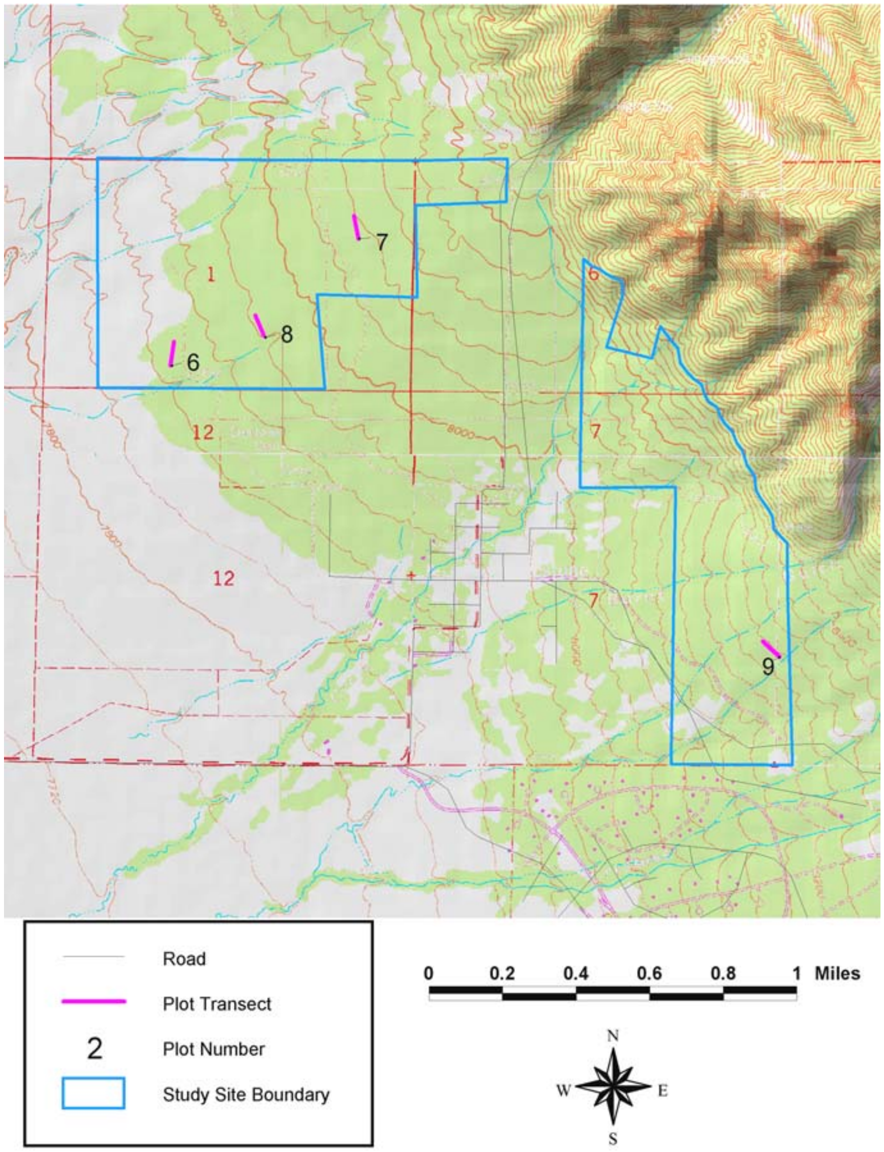


Figure 6. Four transects were sampled at the Crestone study site

Figure 7. 2003 (left) and 2004 (right) photos from plot 7 at the Crestone study site

Nolan Gulch

The Nolan Gulch site is one of the larger sites (607 ha) and is located on the northwestern side of the San Luis Valley approximately 2 miles west of the town of Villa Grove. The site is located on a gently sloping east facing hillside. Soils at this area are sandy with some areas of small gravels. Vegetation is dominated by the Southern Rocky Mountain Pinyon-Juniper Woodland Ecological System (Comer et al. 2003). Trees at this site are primarily pinyon pine (*Pinus edulis*), although some Rocky Mountain juniper (*Juniperus scopulorum*) are also present.

Four plots were installed at the Nolan Gulch site (plot numbers: 2, 3, 4, and 5). Locations of the plots are shown in Figure 8. Representative photos from the site are shown in Figure 9.

Fuel treatment at the Nolan Gulch site significantly reduced the density and cover of trees on the site. Tree Density on the site decreased from an average 6.9 trees per $225m^2$ to 1.0 trees per $225m^2$ following treatment. Following treatment, tree cover significantly decreased from an average of 8.0% to 0%. Changes in tree density and tree cover are displayed in Figure 2 and Figure 3.

The dominant shrub species observed at the Nolan Gulch site include *Artemisia dracunculus, Artemisia frigida, Chrysothamnus viscidiflorus, Ericameria nauseosus, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha, Ribes cereum,* and *Symphoricarpos spp.*. The average shrub density at the Nolan Gulch site changed significantly following the fuel treatments. In 2003 the average shrub density was 9.8 plants per $225m^2$, whereas in 2004 it was 17.7 plants per $225m^2$. The difference was significant (p=0.05). The average cover of shrubs at the Nolan Gulch site was less than 2% in both 2003 and 2004. In 2003 the average shrub cover was 1.6%, whereas in 2004 it was 1.8%. The change in shrub cover following site treatment was not significant (p=0.05). Descriptive statistics for shrub density and shrub cover at the Nolan Gulch site are presented in Table 12.

Table 12. Descriptive statistics for shrub density and shrub cover at the Nolan Gulch site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	76	9.8	290.9	17.1	2.0
2004	76	17.7	483.3	22.0	2.5
Shrub Cover					
2003	52	1.6	6.7	2.6	0.4
2004	52	1.8	7.2	2.7	0.4

Herbaceous cover at the Nolan Gulch site is sparse and is composed primarily of graminoid species. Dominant graminoid species observed at the site include *Agropyron cristatum, Bouteloua gracilis, Carex spp*., and *Pascopyrum smithii*. Average cover of graminoids did not significantly change following treatment (p=0.05). Average graminoid cover in 2003 was 9.9% and in 2004 following treatment was 7.8%. Cover of forb species is composed primarily of *Lappula occidentalis, Descurainia incise,* and *Chenopodium leptophyllum*. Average cover of forbs did not change significantly following treatment (p=0.05). Average forb cover in 2003 was 2.0%, and in 2004 following treatment was 1.8%. The overall frequency of the dominant graminoid and forb species was low at the Nolan Gulch site. The average frequency of graminoids did not change significantly following treatments (p=0.05). The average frequency of forb species did change significantly following treatments (p=0.05). Before treatment in 2003 the average frequency of forbs was 1.4, and in 2004 following treatment it was 0.8. Descriptive statistics for the cover and frequency of graminoids and forbs at the Nolan Gulch site are presented in Table 13.

Table 13. Descriptive statistics for cover and frequency of herbaceous vegetation at the Nolan Gulch site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	54	10.0	98.3	9.9	1.3
2004	54	7.8	57.3	7.5	1.0
Forb Cover					
2003	54	2.0	28.0	5.2	0.7
2004	54	1.8	18.5	4.3	0.5
Graminoid Frequency					
2003	54	1.6	0.6	0.7	0.1
2004	54	1.9	1.0	1.0	0.1
Forb Frequency					
2003	54	1.4	2.4	1.5	0.2
2004	54	0.8	0.5	0.7	0.1

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the Nolan Gulch site. Average cover of litter did not change significantly following treatment (p=0.05). Average cover of litter in 2003 was 35.4%, and in 2004 following treatment was 32.8%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did change significantly following treatment (p=0.05). Average cover of rock/bare ground in 2003 was 41.3%, and in 2004 following treatment was 54.1%. Descriptive statistics for litter and rock/bare soil cover at the Nolan Gulch site are presented in Table 14.

Table 14. Descriptive statistics for litter and rock/bare soil cover at the Nolan Gulch site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	54	35.4	989.1	31.4	4.2
2004	54	32.8	1199.1	34.6	4.7
Rock/Bare Soil Cover					
2003	54	41.3	994.6	31.5	4.2
2004	54	54.1	1209.1	34.7	4.7

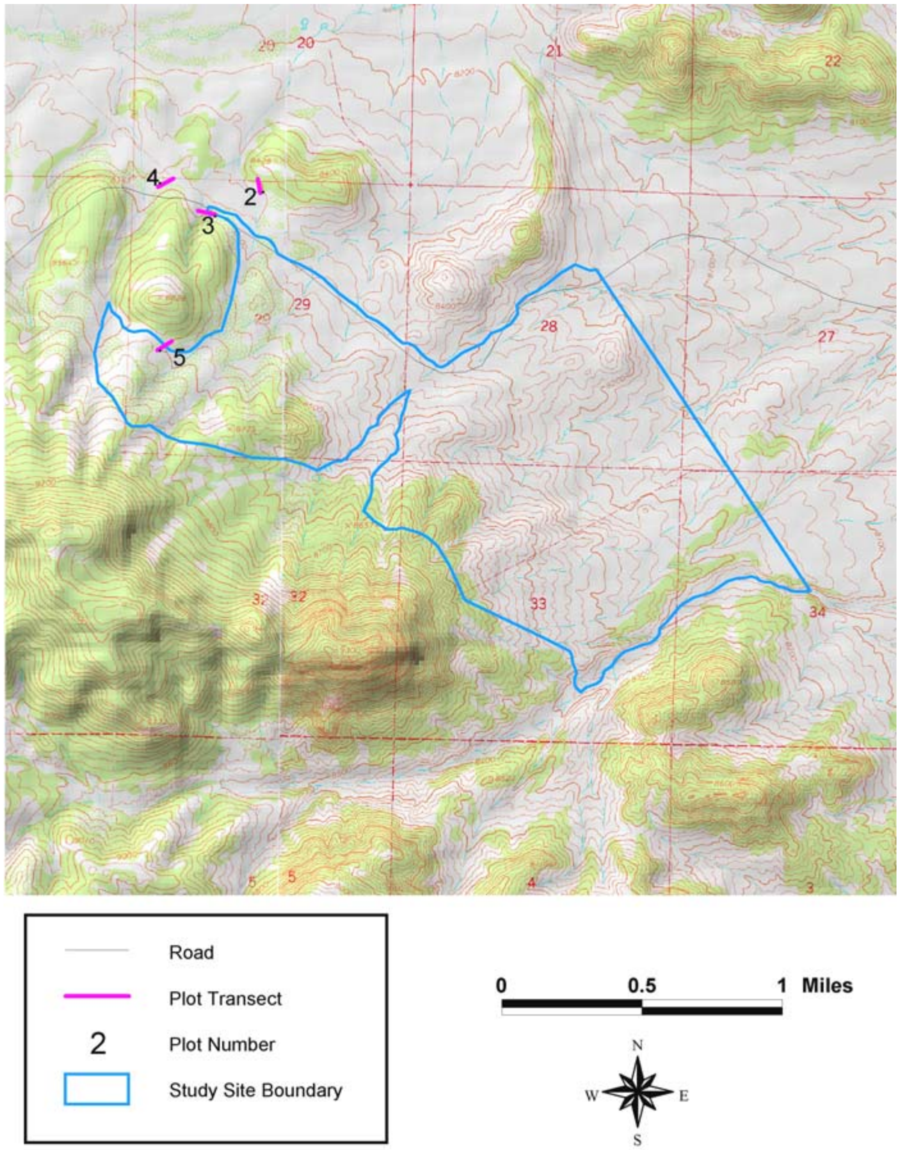


Figure 8. Four transects were sampled at the Nolan Gulch study site

Figure 9. 2003 (left) and 2004 (right) photos from plot 4 at the Nolan Gulch study site.

South Fork

This is the smallest site in the project area. Only one plot was monitored at this site in both years. An additional plot was added and monitored at this site in the second year. However the initial plot site was not treated and therefore serves as a control.

The South Fork site is a small site (65 ha) located on the southwestern side of the San Luis Valley just across the river from the town of South Fork. The initial plot site (plot number 34) is located on a gentle south facing hillside that was formerly the location of the Town of South Fork dump.

The plot established in the second year was located on a moderately steep, east facing hill side. The vegetation of the site includes the Southern Rocky Mountain Pinyon-Juniper Woodland Ecological System and the Southern Rocky Mountain Ponderosa Pine Woodland (Comer et al. 2003). Trees at the South Fork site are primarily ponderosa pine (*Pinus ponderosa*) and pinyon pine (*Pinus edulis*), although some Rocky Mountain juniper (*Juniperus scopulorum*) are also present in adjacent areas.

Two plots were installed at the South Fork site (plot numbers: 34 and 45). The plot locations are shown in Figure 10. Representative photos from the site are shown in Figure 11.

Fuel treatment at the South Fork site was not completed at either of the sites at the time of field survey in 2004. The plot initially installed (#34) was located in an area that did not receive any treatment. The plot installed in the second year (#45) was installed prior to treatments occurring in the area.

There was no significant change in the density or cover of trees on the South Fork site. Tree density on the site averaged 8.5 trees per $225m^2$ in both 2003 and 2004. Tree cover was 34% in both years sampled.

The dominant shrub species at the South Fork site include *Artemisia frigida, Chrysothamnus viscidiflorus, Ericameria nauseosus,* and *Opuntia polyacantha*. The average shrub density at the South Fork site did not change significantly following the fuel treatments. In 2003 the average shrub density was 6.2 plants per $225m^2$, whereas in 2004 it was 11.0 plants per $225m^2$. The difference was not significant (p=0.05). The cover of shrubs at the South Fork site was less than 4% in both 2003 and 2004. There was a significant change (p=0.05) in average shrub cover following the site treatment. In 2003, average shrub cover was 1.0%, whereas in 2004 it was 3.3%. Descriptive statistics for shrub density and shrub cover at the South Fork site are presented in Table 15.

Table 15. Descriptive statistics for shrub density and shrub cover at the South Fork site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	20	6.2	106.5	10.3	2.3
2004	20	11.0	353.8	18.8	4.2
Shrub Cover					
2003	10	1.0	2.2	1.4	0.4
2004	10	3.3	9.5	3.0	0.9

Herbaceous cover at the South Fork site is sparse and is composed primarily of graminoid species. Dominant graminoid species observed at the site include *Achnatherum hymenoides*, *Bouteloua gracilis,* and *Pascopyrum smithii*. Average cover of graminoids did not significantly change following treatment (p=0.05). Average graminoid cover in 2003 was 10.8% and in 2004 following treatment was 7.3%. Cover of forb species is composed primarily of *Chenopodium leptophyllum*. Average cover of forbs did change significantly following treatment (p=0.05). Average forb cover in 2003 was 1.3%, and in 2004 following treatment was 3.7%. There is insufficient data to calculate the overall frequency of the dominant graminoid and forb species at the South Fork site because the site has only one transect that was sampled in both years. Descriptive statistics for graminoid and forb cover at the South Fork site are presented in Table 16.

Table 16. Descriptive statistics for graminoid and forb cover at the South Fork Site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	18	10.8	167.4	12.9	3.0
2004	18	7.3	78.5	8.8	2.0
Forb Cover					
2003	18	1.3	12.4	3.5	0.8
2004	18	3.7	31.6	5.6	1.3

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the South Fork site. Average cover of litter did not change significantly following treatment. Average cover of litter in 2003 was 37.1%, and in 2004 following treatment was 39.1%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did not change significantly following treatment. Average cover of rock/bare ground in 2003 was 38.4%, and in 2004 following treatment was 44.7%. Descriptive statistics for litter and rock/bare soil cover at the South Fork site are presented in Table 17.

Table 17. Descriptive statistics for litter and rock/bare soil cover at the South Fork site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	18	37.1	1214.0	34.8	8.2
2004	18	39.1	2083.1	45.6	10.7
Rock/Bare Soil Cover					
2003	18	38.4	832.8	28.8	6.8
2004	18	44.7	1460.8	38.2	9.0

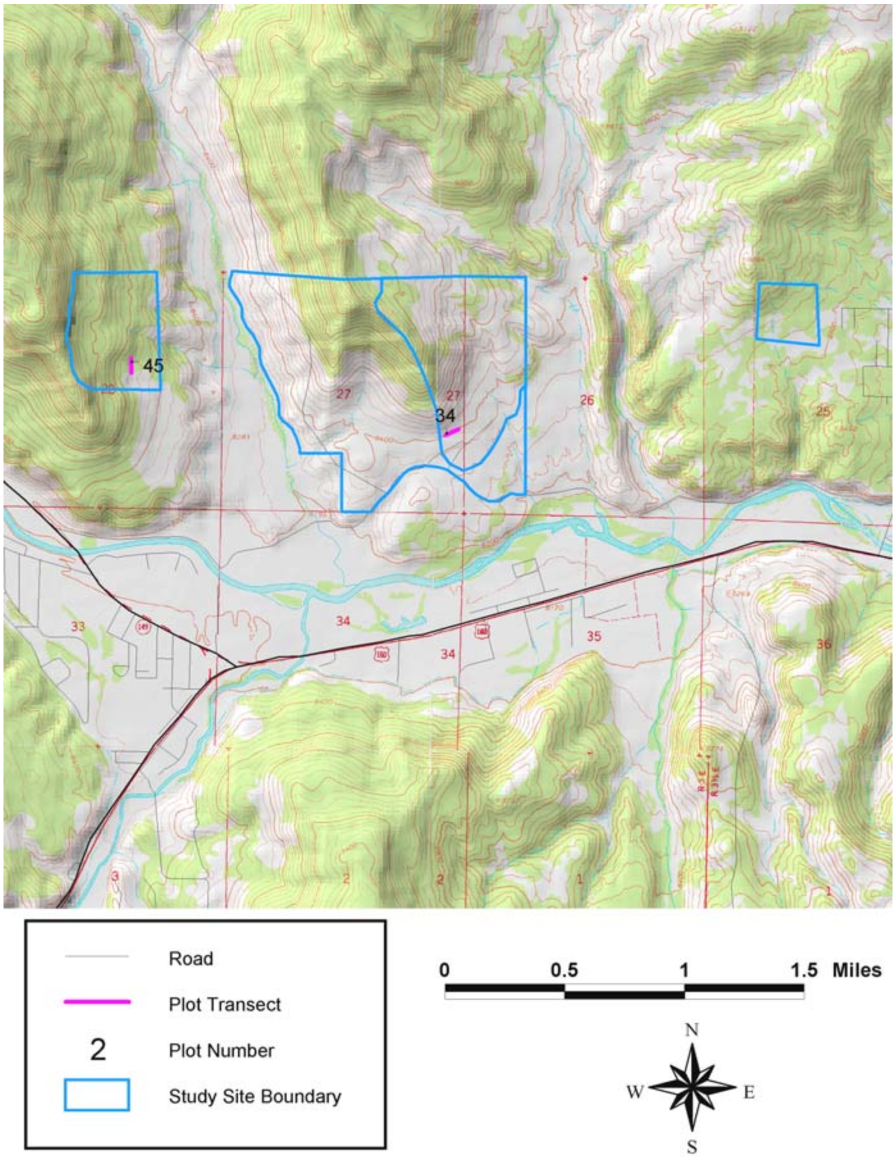


Figure 10. Two transects were sampled at the South Fork study site

Figure 11. 2003 (left) and 2004 (right) photos from plot 34 at the South Fork study site

Wolf Mountain

The Wolf Mountain site is a moderately sized site (283 ha) located on the southwestern side of the San Luis Valley approximately 5 miles east of the town of South Fork. The site is located on a gently to steeply sloping north facing hillside. The site is dominated by the Southern Rocky Mountain Pinyon-Juniper Woodland Ecological System (Comer et al. 2003). Trees at this site are primarily pinyon pine (*Pinus edulis*), although some Rocky Mountain juniper (*Juniperus scopulorum*) are also present in the area.

Five plots were installed at the Wolf Mountain site (plot numbers: 18, 19, 20, 21, and 22). The plot locations are shown in Figure 12. Representative photos from the site are shown in Figure 13.

Fuel treatment at the Wolf Mountain site significantly reduced the density and cover of trees on the site. Tree Density on the site decreased from 9.6 trees per 225m^2 to 4.2 trees per 225m^2 following treatment. Following treatment, tree cover did not significantly decrease (28.3% to 23.5%). Changes in tree density and tree cover are displayed in Figure 2 and Figure 3.

The dominant shrub species observed at the Wolf Mountain site include *Artemisia frigida, Cercocarpus montanus, Chrysothamnus viscidiflorus, Gutierrezia sarothrae, Opuntia polyacantha, Symphoricarpos spp.,* and *Yucca glauca*. The average shrub density at the Wolf Mountain site changed significantly following the fuel treatments. In 2003 the average shrub density was 3.8 plants per 225m^2, whereas in 2004 it was 10.6 plants per 225m^2. The difference was significant (p=0.05). The average cover of shrubs at the Wolf Mountain site was less than 2% in both 2003 and 2004. There was a significant change (p=0. 05) in average shrub cover following the site treatment. In 2003 the average shrub cover was 0.4%, whereas in 2004 it was 1.6%. Descriptive statistics for shrub density and shrub cover at the Wolf Mountain site are presented in Table 18.

Table 18. Descriptive statistics for shrub density and shrub cover at the Wolf Mountain site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	94	3.4	121.9	11.0	1.1
2004	94	10.6	315.3	17.7	1.8
Shrub Cover					
2003	55	0.4	1.8	1.3	0.1
2004	55	1.6	6.2	2.5	0.3

Herbaceous cover at the Wolf Mountain site is sparse and is composed primarily of graminoid species. Dominant graminoid species observed at the site include *Bouteloua gracilis, Carex spp., Festuca dasyclada,* and *Muhlenbergia montana*. Average cover of graminoids did not significantly change following treatment (p=0. 05). Average graminoid cover in 2003 was 8.2% and in 2004 following treatment was 8.1%. Cover of forb species is composed primarily of *Chenopodium berlandieri* and *Chenopodium fremontii*. Average cover of forbs did not change significantly following treatment (p=0. 05). Average forb cover in 2003 was 0.7%, and in 2004 following treatment was 1.7%. The overall frequency of the dominant graminoid and forb species was low at the Wolf Mountain site. The average frequency of graminoids did change significantly following treatments (p=0.05). Before treatment in 2003 the average frequency of graminoids was 1.6, and in 2004 following treatment it was 2.1. The average frequency of forb species did not change significantly following treatments (p=0.05). Descriptive statistics for the cover and frequency of graminoids and forbs at the Wolf Mountain site are presented in Table 19.

Table 19. Descriptive statistics for cover and frequency of herbaceous vegetation at the Wolf Mountain site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	54	8.2	72.3	8.5	1.1
2004	54	8.1	49.4	7.0	0.9
Forb Cover					
2003	54	0.7	1.5	1.2	0.1
2004	54	1.8	12.9	3.5	0.4
Graminoid Frequency					
2003	54	1.6	0.7	0.8	0.1
2004	54	2.1	1.1	1.0	0.1
Forb Frequency					
2003	54	0.9	1.5	1.2	0.1
2004	54	1.0	0.5	0.7	0.1

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the Wolf Mountain site. Average cover of litter did not change significantly following treatment. Average cover of litter in 2003 was 32.1%, and in 2004 following treatment was 43.3%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did not change significantly following treatment. Average cover of rock/bare ground in 2003 was 44.2%, and in 2004 following treatment was 47.2%. Descriptive statistics for litter and rock/bare soil cover at the Wolf Mountain site are presented in Table 20.

Table 20. Descriptive statistics for litter and rock/bare soil cover at the Wolf Mountain site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	54	32.1	1321.0	36.3	4.9
2004	54	43.3	1680.2	40.9	5.5
Rock/Bare Soil Cover					
2003	54	44.2	1196.5	34.5	4.7
2004	54	47.2	1713.7	41.3	5.6

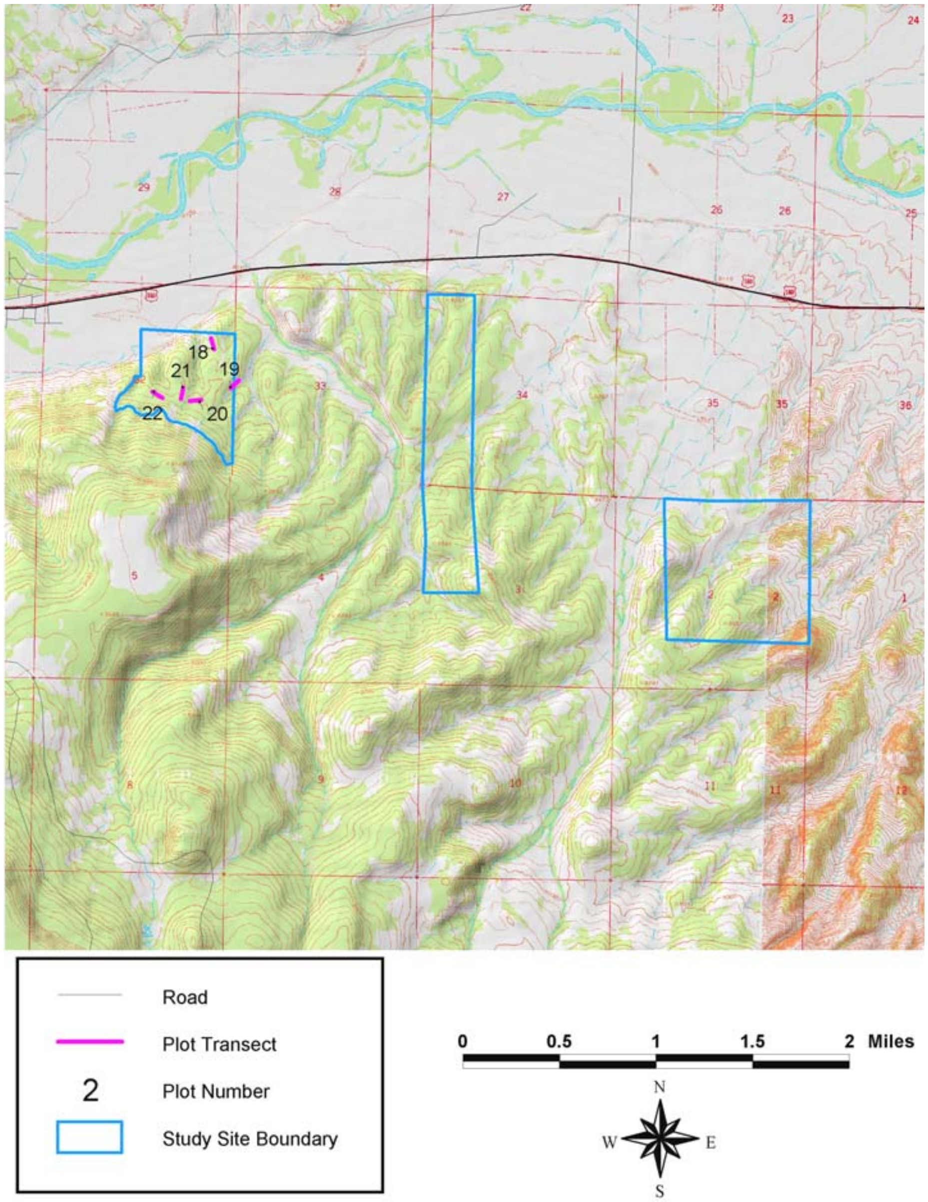


Figure 12. Five transects were sampled at the Wolf Mountain study site

Figure 13. 2003 (left) and 2004 (right) photos from plot 19 at the Wolf Mountain site

Zapata

The Zapata site is a large site (850 ha) located on the eastern side of the San Luis Valley approximately 10 miles south of the town of Crestone and 30 miles northeast of Alamosa. The site is located on a gently sloping west facing hillside. The soils at this site are mostly thin gravely soils with often high proportions of large cobble and small boulders. The site is dominated by the Southern Rocky Mountain Pinyon-Juniper Woodland Ecological System (Comer et al. 2003). Trees at this site are primarily pinyon pine (*Pinus edulis*), although some Rocky Mountain juniper (*Juniperus scopulorum*) are also present in the area.

Thirteen plots were installed at the Zapata site (plot numbers: 10, 11, 12, 13, 14, 15, 16, 17, 23, 24, 25, 26, and 27). The plot locations are shown in Figure 14. Representative photos from the site are shown in Figure 15.

Fuel treatment at the Zapata site significantly reduced the density and cover of trees on the site. Tree Density on the site decreased from 21.0 trees per $225m^2$ to 4.4 trees per $225m^2$ following treatment. Following treatment, tree cover significantly decreased from 43.5% to 29.9%. Changes in tree density and tree cover are displayed in Figure 2 and Figure 3.

The dominant shrub species observed at the Zapata site include *Artemisia dracunculus, Artemisia frigida, Eriogonum jamesii, Opuntia polyacantha, Pinus edulis,* and *Ribes cereum.* The average shrub density at the Zapata site changed significantly following the fuel treatments. In 2003 the average shrub density was 2.9 plants per $225m^2$, whereas in 2004 it was 9.6 plants per225 m^2. The difference was significant (p=0.05). The average cover of shrubs at the Zapata site was less than 1% in both 2003 and 2004. There was no significant change (p=0. 05) in shrub cover following site treatment. In 2003 the average shrub cover was 1.0%, whereas in 2004 it was 0.8%. Descriptive statistics for shrub density and shrub cover at the Zapata site are presented in Table 21.

Table 21. Descriptive statistics for shrub density and shrub cover at the Zapata site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Shrub Density					
2003	180	2.9	56.8	7.5	0.5
2004	180	9.6	471.2	21.7	1.6
Shrub Cover					
2003	65	1.0	4.9	2.2	0.2
2004	65	1.0	3.3	1.8	0.2

Herbaceous cover at the Zapata site is sparse and is composed primarily of graminoid species. Dominant graminoid species observed at the site include *Achnatherum pinetorum, Bouteloua gracilis, Carex spp*., and *Muhlenbergia montana*. Average cover of graminoids did not significantly change following treatment (p=0.05). Average graminoid cover in 2003 was 3.1% and in 2004 following treatment was 3.0%. Cover of forb species is composed primarily of *Chenopodium fremontii, Chenopodium leptophyllum, Heterotheca villosa, Ipomopsis longifolia, Tetraneuris acaulis,* and *Stenotus armerioides*. Average cover of forbs did not change significantly following treatment (p=0.05). Average forb cover in 2003 was 3.2%, and in 2004 following treatment was 2.7%. The overall frequency of the dominant graminoid and forb species was low at the Zapata site. The average frequency of graminoids did not change significantly following treatment (p=0.05). The average frequency of forb species did change significantly following treatment (p=0.05). Before treatment in 2003 the average frequency of forbs was 2.0, and in 2004 following treatment it was 1.5. Descriptive statistics for the cover and frequency of graminoids and forbs at the Zapata site are presented in Table 22.

Table 22. Descriptive statistics for cover and frequency herbaceous vegetation at the Zapata site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Graminoid Cover					
2003	234	3.1	29.1	5.4	0.3
2004	234	3.0	30.0	5.4	0.3
Forb Cover					
2003	234	3.2	18.2	4.2	0.2
2004	234	2.7	23.0	4.7	0.3
Graminoid Frequency					
2003	234	1.2	1.0	1.0	0.1
2004	234	1.1	0.9	0.9	0.1
Forb Frequency					
2003	234	2.0	1.9	1.3	0.1
2004	234	1.5	1.3	1.1	0.1

Cover of litter, bare ground, and exposed rock dominates the overall ground cover at the Zapata site. Average cover of litter did change significantly following treatment (p=0.05). Average cover of litter in 2003 was 47.2%, and in 2004 following treatment was 60.5%. Cover of bare ground and exposed rock were combined for analysis of ground cover. Average cover of rock/bare ground did not change significantly following treatment. Average cover of rock/bare ground in 2003 was 37.4%, and in 2004 following treatment was 32.6%. Descriptive statistics for litter and rock/bare soil cover at the Zapata site are presented in Table 23.

Table 23. Descriptive statistics for litter and rock/bare soil cover at the Zapata site

Sample	N	Mean	Variance	Standard deviation	Standard-error
Litter Cover					
2003	234	47.2	1495.1	38.6	2.5
2004	234	60.5	1226.8	35.0	2.2
Rock/Bare Soil Cover					
2003	234	37.4	1274.4	35.7	2.3
2004	234	32.6	1108.9	33.3	2.1

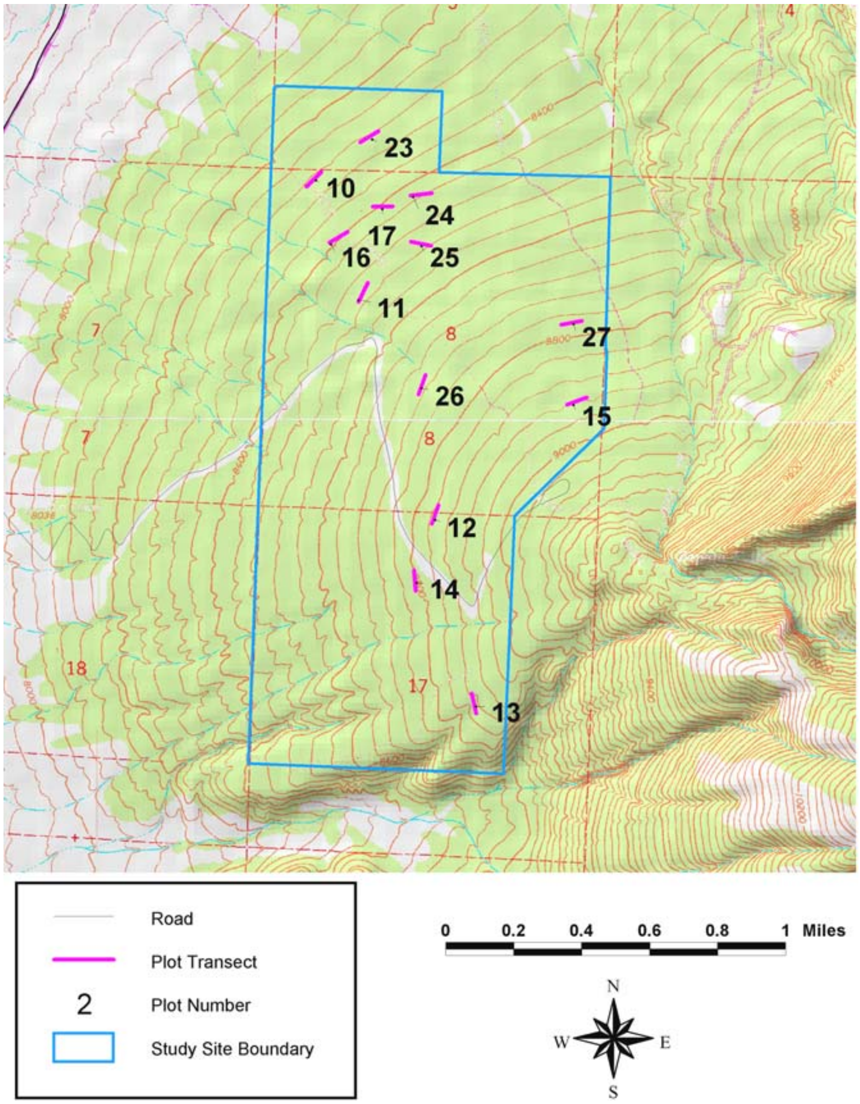


Figure 14. Thirteen transects were sampled at the Zapata study site

Figure 15. 2003 (left) and 2004 (right) photos from plot 10 at the Zapata study site

DISCUSSION

The purpose of the fuel treatment projects is based on the BLM's land use and ecosystem restoration objectives. The land use objective for the treatment sites is to reduce the density and cover of live fuels, specifically the overstory trees. The ecosystem restoration objectives for the sites are to maintain or increase the cover of herbaceous species, increase the litter cover, decrease the cover of bare ground, and increase the cover of woody shrub species.

The monitoring program conducted prior to and following the treatments indicates that tree cover and density were significantly reduced in all of the sites, with the exception of the South Fork site. The South Fork site is a small site initially containing one transect, and treatments conducted there did not occur in the area where the plot was located. Additionally, tree cover at the Wolf Mountain site did not change significantly. This is due to the fact that two of the transects at that site were located in an area where treatment did not occur. Based on the results from the other sites, however, the treatments were effective at reducing the cover and density of trees on the sites. Therefore, the project has successfully met the BLM's land use objectives.

The average tree density across all sites prior to treatment was 14 plants per $225m^2$. Following the treatments, the average tree density across all sites was 4 plants per $225m^2$. The reduction in average tree density achieved by the treatments ranged from a low of 69% at the Crestone site to a maximum of 86% at the Nolan Gulch site. The Crestone site, while originally one of the denser sites, was partially hand thinned due to the steepness of the slopes on part of the area. While still a significant reduction, the hand thinning method is more labor intensive and may have been less effective in reducing the average tree density on the site.

Prior to treatment, the average cover of trees across all sites was 34.5% and ranged from a maximum of 43.5% at the Zapata site to a minimum of 8% at the Nolan Gulch site. The average reduction of tree cover following the treatments across all sites was 38%. The greatest reduction in tree cover occurred at the Chiquita site, which decreased from 29% cover to 7% after treatment (75% reduction). The lowest reduction in tree cover occurred at the Zapata site, which decreased from 43% cover to 30% after treatment (30% reduction). Although these data indicate an initial cover of 8% and reduction of 100% at the Nolan Gulch site, it is doubtful that these values are correct. Initial tree cover there was likely greater than 8% and was not reduced by 100%. This is most likely a bias in the data that has to do with the fact that treatment of the area was almost complete when sampling was started. As a result, the plots are all located at one end of the project area and may not fully represent the characteristics of the remainder of the area and its treatments. It is doubtful that the pretreatment average cover of trees at the Nolan Gulch site was only 8% and that the treatment resulted in 100% removal of trees.

The ecosystem restoration objectives are to maintain or increase the cover of litter and herbaceous species, decrease the cover of bare ground, and increase the cover of woody shrub species. Based on the monitoring results, it is less clear that the projects have been successful in meeting all aspects of the stated objective. While the data suggest an increase in the average overall cover of woody shrubs and litter, the cover of bare ground did not change significantly, and the cover of herbaceous species decreased.

Overall shrub density showed a significant increase for the sites as a whole. Overall shrub density increased at some of the sites and remained unchanged at other sites. Given that the treatments were to include removal of some of the shrubs such as mountain mahogany (*Cercocarpus montanus*) and wax current (*Ribes cereum*), and that most of these are woody longer-lived species it is unlikely that an increase in the density of these shrubs actually occurred, but rather is due to non-sample errors (e.g. differences in data collection from the first year to the second year). This could be a result of observer differences, or differences in the visibility of many of the shrub species following removal of the trees.

A significant decrease in average herbaceous cover (forb and graminoid) across all sites was also observed. Prior to treatment the average herbaceous cover across all sites was 8%. Following the treatments this had decreased to 6.5%. When separated, average forb cover across all sites decreased significantly, while average cover of graminoids did not change significantly. Forb cover across all sites dropped from 2.8% to 2.0%.

The overall average frequency of forbs and graminoids paralleled changes in the cover of forbs and graminoids. Similar to graminoid cover, the average frequency of graminoids did not change significantly between the 2003 and 2004 sampling periods. Only forb frequency showed a significant change (p=0.05). The values for the overall average frequency of forbs decreased from 1.5% to 1.1% between 2003 and 2004.

The Zapata site was aerially seeded in 2003, prior to the initiation of the fuel treatments. The monitoring data do not indicate a significant increase in the cover or frequency of graminoids or forbs at the Zapata site at this time. Results of monitoring planned for the 2006 and 2008 seasons may definitively show significant change in herbaceous cover and frequency at the Zapata site.

A limitation of the Hydro-Axe method appears to be in its inability to remove or kill branches that are close to the ground. In the rocky terrain that comprises most of these sites, the operators are hesitant to lower the cutting head all the way to the ground for fear of hitting rocks and damaging the blades. It was apparent in 2004 that the treatment crews were unable to remove or kill all the branches on many of the trees. This was particularly noticeable at the Zapata site, which is generally rockier than the other sites. We observed numerous stumps there, and at the other sites, with one or two remaining branches. These remaining branches appeared very healthy and typically were turning upward. Without further treatment, it is likely that these “seedlings with tree-sized root systems” will easily survive and develop into trees. Due to the large root system supporting them, it is also possible that these “seedlings” will have a faster than normal growth rate.

Initial monitoring was conducted at the Trickle Mountain site and at one transect on the South Fork site. A second year of monitoring will need to be conducted in the summer of 2005 at the sites where treatments were initiated in the summer of 2004.

The monitoring data for the fuel treatment sites indicate that the treatments were wholly successful at achieving the project land use objective of reducing the cover and density of trees on the treatment sites.

REFERENCES

Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A. S. Weakley. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types. The Nature Conservancy, Arlington, Virginia, USA. 502 p.

Bailey RG. 1995 Description of the ecoregions of the United States. 2nd edition. Miscellaneous publication no.1391 (rev.), USDA Forest Service, Washington DC. 108 pages with separate map at 1:7,500,000.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K.Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia.

Daubenmire, R. 1959. A Canopy-cover Method of Vegetation Analysis. Northwest Science, 33:43-64.

Elzinga, Caryl L., Daniel W. Salzer, and John W.Willoughby. 1998. Measuring and monitoring plant populations. BLM technical reference 1730-1. U.S. Dept. of the Interior, Bureau of Land Management, National Applied Resource Sciences Center. Denver, Colorado. 490p.

Grossman D.H., Faber-Langendoen D., Weakley A.S., Anderson M., Bourgeron P., Crawford R., Goodin K., Landaal S., Metzler K., Patterson K.D., Pyne M., Reid M., and Sneddon L. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I, The National Vegetation Classification System: development, status, and applications. The Nature Conservancy: Arlington, VA.

Jennings, M., O. Loucks, D. Glenn-Lewin, R. Peet, D. Faber-Langendoen, D. Grossman, A. Damman, M. Barbour, R. Pfister, M. Walker, S. Talbot, J. Walker, G. Hartshorn, G. Waggoner, M. Abrams, A. Hill, D. Roberts, and D. Tart. 2003. Guidelines for describing associations and alliances of the U.S. National Vegetation Classification. The Ecological Society of America, Vegetation Classification Panel, Version 3.0 November 2003. 100 pp. (+ Appendices)

Kartesz, J.T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. In: Kartesz, J.T. and C.A. Meacham. Synthesis of the North American flora [computer program]. Version 1.0. North Carolina Botanical Garden: Chapel Hill, NC.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.4. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

Ott, Lyman. 1993. An introduction to statistical methods and data analysis. 4th ed. Wadsworth Publishers, Belmont, California. 1152 p. Includes bibliographical references and index.

Savage, M., 2002. Community Monitoring for Restoration Projects in Southwestern Ponderosa Pine Forests. The Southwest Community Forestry Research Ctr., http://www.theforesttrust.org/research.html. The Forest Trust. Sante Fe, N.M.

USDA NRCS. 2004. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Zar, Jerrold H. 1999. Biostatistical analysis. 4th ed. Prentice Hall Books, Upper Saddle River, N.J. 662 p. Includes bibliographical references, index, appendices.

APPENDIX A. List of plant species identified in the treatment areas.

Symbol	Scientific Name	Common/Synonym	Family
ACHIL	Achillea L.	yarrow	Asteraceae
ACHY	Achnatherum hymenoides (Roemer & J.A. Schultes) Barkworth	Indian ricegrass	Poaceae
ACPI2	Achnatherum pinetorum (M.E. Jones) Barkworth	pine needlegrass	Poaceae
AGCR	Agropyron cristatum (L.) Gaertn.	crested wheatgrass	Poaceae
ALCE2	Allium cernuum Roth	nodding onion	Liliaceae
ALGE	Allium geyeri S. Wats.	Geyer's onion	Liliaceae
AMAC2	Ambrosia acanthicarpa Hook.	flatspine burr ragweed	Asteraceae
AMUT	Amelanchier utahensis Koehne	Utah serviceberry	Rosaceae
ANPA	Anemone parviflora Michx.	smallflowered anemone	Ranunculaceae
ANTEN	Antennaria Gaertn.	pussytoes	Asteraceae
ARUV	Arctostaphylos uva-ursi (L.) Spreng.	kinnikkinnik	Ericaceae
ARPU9	Aristida purpurea Nutt.	purple threeawn	Poaceae
ARDR4	Artemisia dracunculus L.	tarragon	Asteraceae
ARFR3	Artemisia franserioides Greene	ragweed sagebrush	Asteraceae
ARFR4	Artemisia frigida Willd.	prairie sagewort	Asteraceae
ARLU	Artemisia ludoviciana Nutt.	white sagebrush	Asteraceae
ARTR2	Artemisia tridentata Nutt.	big sagebrush	Asteraceae
ARTR4	Artemisia tripartita Rydb.	threetip sagebrush	Asteraceae
ATCA2	Atriplex canescens (Pursh) Nutt.	fourwing saltbush	Chenopodiaceae
ATRIP	Atriplex L.	saltbush	Chenopodiaceae
BOEC	Botrychium echo W.H. Wagner	reflected grapefern	Ophioglossaceae
BOGR2	Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama	Poaceae
BRIN2	Bromus inermis Leyss.	smooth brome	Poaceae
CAREX	Carex L.	sedge	Cyperaceae
CEMO2	Cercocarpus montanus Raf.	alderleaf mountain mahogany	Rosaceae
CHGE2	Chamaesyce geyeri (Engelm.) Small	Geyer's sandmat	Euphorbiaceae
CHGL13	Chamaesyce glyptosperma (Engelm.) Small	ribseed sandmat	Euphorbiaceae
CHANC	Chamerion angustifolium (L.) Holub ssp. circumvagum (Mosquin) Kartesz, comb. nov. ined.	fireweed	Onagraceae
CHAME2	Chamerion Raf. ex Holub	fireweed	Onagraceae
CHFE	Cheilanthes feei T. Moore	slender lipfern	Pteridaceae
CHBE4	Chenopodium berlandieri Moq.	pitseed goosefoot	Chenopodiaceae

CHFR3	Chenopodium fremontii S. Wats.	Fremont's goosefoot	Chenopodiaceae
CHENO	Chenopodium L.	goosefoot	Chenopodiaceae
CHLE4	Chenopodium leptophyllum (Moq.) Nutt. ex S. Wats.	narrowleaf goosefoot	Chenopodiaceae
CHGR15	Chondrosum gracile Willd. ex Kunth	=Bouteloua gracilis	Poaceae
CHNA2	Chrysothamnus nauseosus (Pallas ex Pursh) Britt.	=Ericameria nauseosa ssp. nauseosa var. nauseosa	Asteraceae
CHRYS9	Chrysothamnus Nutt.	rabbitbrush	Asteraceae
CHVI8	Chrysothamnus viscidiflorus (Hook.) Nutt.	yellow rabbitbrush	Asteraceae
CRCR3	Cryptantha crassisepala (Torr. & Gray) Greene	thicksepal cryptantha	Boraginaceae
DEIN5	Descurainia incana (Bernh. ex Fisch. & C.A. Mey.) Dorn	mountain tansymustard	Brassicaceae
ECVI2	Echinocereus viridiflorus Engelm.	nylon hedgehog cactus	Cactaceae
ERCE2	Eriogonum cernuum Nutt.	nodding buckwheat	Polygonaceae
EREF	Eriogonum effusum Nutt.	spreading buckwheat	Polygonaceae
ERJA	Eriogonum jamesii Benth.	James' buckwheat	Polygonaceae
ERIOG	Eriogonum Michx.	buckwheat	Polygonaceae
EROV	Eriogonum ovalifolium Nutt.	cushion buckwheat	Polygonaceae
FEDA	Festuca dasyclada Hack. ex Beal	oil shale fescue	Poaceae
FRVI	Fragaria virginiana Duchesne	Virginia strawberry	Rosaceae
GASP	Gaillardia spathulata Gray	western blanketflower	Asteraceae
GRDE	Grindelia decumbens Greene	reclined gumweed	Asteraceae
GRSQ	Grindelia squarrosa (Pursh) Dunal	curlycup gumweed	Asteraceae
GUTIE	Gutierrezia Lag.	snakeweed	Asteraceae
GUSA2	Gutierrezia sarothrae (Pursh) Britt. & Rusby	broom snakeweed	Asteraceae
HEMUN	Heliomeris multiflora Nutt. var. nevadensis (A. Nels.) Yates	Nevada goldeneye	Asteraceae
HECO26	Hesperostipa comata (Trin. & Rupr.) Barkworth	needle and thread	Poaceae
HEVI4	Heterotheca villosa (Pursh) Shinners	hairy false goldenaster	Asteraceae
HEPA11	Heuchera parvifolia Nutt. ex Torr. & Gray	littleleaf alumroot	Saxifragaceae
HOLOD	Holodiscus (K. Koch) Maxim.	oceanspray	Rosaceae
HODU	Holodiscus dumosus (Nutt. ex Hook.) Heller	rockspirea	Rosaceae
HOJU	Hordeum jubatum L.	foxtail barley	Poaceae
HYRI	Hymenoxys richardsonii (Hook.) Cockerell	pingue rubberweed	Asteraceae
HYRIF	Hymenoxys richardsonii (Hook.) Cockerell var. floribunda (Gray) Parker	Colorado rubberweed	Asteraceae
IPLO2	Ipomopsis longiflora (Torr.) V. Grant	flaxflowered ipomopsis	Polemoniaceae
JUSC2	Juniperus scopulorum Sarg.	Rocky Mountain juniper	Cupressaceae
KOMA	Koeleria macrantha (Ledeb.) J.A. Schultes	prairie Junegrass	Poaceae
KRLA	Krameria lanceolata Torr.	trailing krameria	Krameriaceae

KRASC	Krascheninnikovia Guldenstaedt	winterfat	Chenopodiaceae
LAOC3	Lappula occidentalis (S. Wats.) Greene	flatspine stickseed	Boraginaceae
LEAL4	Lepidium alyssoides Gray	mesa pepperwort	Brassicaceae
LESQU	Lesquerella S. Wats.	bladderpod	Brassicaceae
LEKI2	Leucopoa kingii (S. Wats.) W.A. Weber	spike fescue	Poaceae
LUPIN	Lupinus L.	lupine	Fabaceae
MABI	Machaeranthera bigelovii (Gray) Greene	Bigelow's tansyaster	Asteraceae
MACA2	Machaeranthera canescens (Pursh) Gray	hoary tansyaster	Asteraceae
MUMO	Muhlenbergia montana (Nutt.) A.S. Hitchc.	mountain muhly	Poaceae
MUHLE	Muhlenbergia Schreb.	muhly	Poaceae
OPPO	Opuntia polyacantha Haw.	plains pricklypear	Cactaceae
PAVI2	Panicum virgatum L.	switchgrass	Poaceae
PASM	Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass	Poaceae
PESI	Pediocactus simpsonii (Engelm.) Britt. & Rose	Simpson hedgehog cactus	Cactaceae
PENST	Penstemon Schmidel	beardtongue	Scrophulariaceae
PIED	Pinus edulis Engelm.	Two-needle pinyon	Pinaceae
PIFL2	Pinus flexilis James	limber pine	Pinaceae
PIPO	Pinus ponderosa P.& C. Lawson	ponderosa pine	Pinaceae
PIMI7	Piptatherum micranthum (Trin. & Rupr.) Barkworth	littleseed ricegrass	Poaceae
PLANT	Plantago L.	plantain	Plantaginaceae
POAR11	Polygonum arenastrum Jord. ex Boreau	oval-leaf knotweed	Polygonaceae
PODO4	Polygonum douglasii Greene	Douglas' knotweed	Polygonaceae
POLYG4	Polygonum L.	knotweed	Polygonaceae
POTR5	Populus tremuloides Michx.	quaking aspen	Salicaceae
PORTU	Portulaca L.	purslane	Portulacaceae
POFI3	Potentilla fissa Nutt.	bigflower cinquefoil	Rosaceae
POTEN	Potentilla L.	cinquefoil	Rosaceae
PSME	Pseudotsuga menziesii (Mirbel) Franco	Douglas-fir	Pinaceae
QUGA	Quercus gambelii Nutt.	Gambel oak	Fagaceae
RHTR	Rhus trilobata Nutt.	skunkbush sumac	Anacardiaceae
RICE	Ribes cereum Dougl.	wax currant	Grossulariaceae
RIBES	Ribes L.	currant	Grossulariaceae
ROWO	Rosa woodsii Lindl.	Woods' rose	Rosaceae
SASC	Salix scouleriana Barratt ex Hook.	Scouler's willow	Salicaceae
SATR12	Salsola tragus L.	prickly Russian thistle	Chenopodiaceae

SCLI12	Schoenocrambe linearifolia (Gray) Rollins	slimleaf plains mustard	Brassicaceae
SEDUM	Sedum L.	stonecrop	Crassulaceae
SENEC	Senecio L.	ragwort	Asteraceae
SHAR	Shepherdia argentea (Pursh) Nutt.	silver buffaloberry	Elaeagnaceae
SHCA	Shepherdia canadensis (L.) Nutt.	russet buffaloberry	Elaeagnaceae
SOLID	Solidago L.	goldenrod	Asteraceae
SPCOC	Sphaeralcea coccinea (Nutt.) Rydb. ssp. coccinea	scarlet globemallow	Malvaceae
SPHAE	Sphaeralcea St.-Hil.	globemallow	Malvaceae
SPCR	Sporobolus cryptandrus (Torr.) Gray	sand dropseed	Poaceae
STARA	Stenotus armerioides Nutt. var. armerioides	thrift mock goldenweed	Asteraceae
STHY6	Stipa hymenoides Roemer & J.A. Schultes	=Achnatherum hymenoides	Poaceae
SYMPH	Symphoricarpos Duham.	snowberry	Caprifoliaceae
TAAP2	Talinum appalachianum W. Wolf	=Talinum parviflorum	Portulacaceae
TAOF	Taraxacum officinale G.H. Weber ex Wiggers	common dandelion	Asteraceae
TEGR4	Teloxys graveolens (Willd.) W.A. Weber	=Chenopodium graveolens	Chenopodiaceae
THAL	Thalictrum alpinum L.	alpine meadow-rue	Ranunculaceae
TRAGO	Tragopogon L.	goatsbeard	Asteraceae
VICIA	Vicia L.	vetch	Fabaceae
VIOLA	Viola L.	violet	Violaceae
YUGL	Yucca glauca Nutt.	soapweed yucca	Agavaceae

APPENDIX B. Field Forms.

Tree Cover (100 m line transect)

Site Name: Observer: Joe Stevens

Date: Transect #: Length: 100 m

Distance	Species	Distance	Species	Distance	Species

Shrub Cover

Plot is a 100 m transect. Cover is determined as any portion of a tree or shrub canopy that intersects the line at any whole meter point from 1m to 100 m. Cover is recorded by physiognomic type.

Tree and Shrub Density (15m x 15m square plot @ 30 and 60 meters)

Site Name: Observer: Joe Stevens

Date: Transect #: Length: 100 m

Plot #	Tree species	Count	Plot #	Shrub Species	Count

Herbaceous Frequency (1.0 m^2 nested frequency plot)

Site Name: Observer: Joe Stevens

Date: Transect #: Length: 100 m

Distance	1	2	3	4
3				
8				
13				
18				
23				
28				
33				
38				
43				
48				
53				
58				
63				
68				
73				
78				
83				
88				

Along each 100 m transect a nested frequency plot is placed every five meters starting at the 3 m mark. All plots are on left side of line (looking from 0 m toward 100 m) with 0.1 x 0.1 m plot in lower left corner. Plant must be partially rooted in plot in order to count.
1 = 0.1 x 0.1, 2 = 0.31 x 0.31, 3 = 0.71 x 0.71, 4 = 1.0 x 1.0

Herbaceous Cover (Daubenmire plot)

Site Name: Observer: Joe Stevens

Date: Transect #: Length: 100 m

Distance	Grasses	Forbs	Litter	Bare	Rock
3					
8					
13					
18					
23					
28					
33					
38					
43					
48					
53					
58					
63					
68					
73					
78					
83					
88					

Plot is a 0.25 m^2 frame placed every 5 m along the 100 m transect starting at the 3 m location. Plots are placed on left side of line (from origin looking toward 100 m). Percent cover is assessed by categories for each species in the plot. Cover categories are: 0 - 5% = 1, 6 - 25% = 2, 26 -50% = 3, 51 - 75% = 4, 76 - 95% = 5, 96 - 100% = 6.