ESTANCIA BASIN WATERSHED HEALTH AND MONITORING PROJECT: 2009 ANNUAL REPORT

Prepared for

ESTANCIA BASIN WATERSHED HEALTH, RESTORATION AND MONITORING STEERING COMMITTEE

Composed of: Claunch-Pinto Soil and Water Conservation District, Edgewood Soil and Water Conservation District, East Torrance Soil and Water Conservation District, Estancia Basin Water Planning Committee, Chilili Land Grant, Manzano Land Grant, New Mexico State Forestry, New Mexico Environment Department, New Mexico Forest and Watershed Restoration Institute, New Mexico Department of Agriculture
(with funding through the New Mexico Water Trust Board)

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EXECUTIVE SUMMARY

The Estancia Basin Watershed Health, Restoration and Monitoring Steering Committee (Steering Committee) oversees forest thinning projects and monitoring of forest and watershed health in the Estancia Basin in coordination with the New Mexico Forest and Watershed Restoration Institute. The primary goals of the Steering Committee are to improve forest health and create defensible space from wildfire. Funding for forest and watershed monitoring has been provided by the New Mexico Water Trust Board.

In 2007, SWCA Environmental Consultants (SWCA) was awarded a contract to conduct monitoring for forest thinning effectiveness on the eastern slopes of the Manzano Mountains. SWCA finalized a comprehensive monitoring plan in March 2008—which is available online at the New Mexico Forest and Watershed Restoration Institute's website (http://www.nmfwri.org/images/stories/pdfs/Estancia_Basin_Monitoring/EstanciaBasinMonitoring.pdf)—that provides background information, research questions, and a discussion of methods relative to forest thinning and monitoring. The monitoring plan calls for two years of pre-thinning data to provide background information on all study sites prior to implementing thinning treatments and monitoring treatment effectiveness. Results from the 2008 monitoring season are presented in the 2008 Annual Report, which can also be found on the New Mexico Forest and Watershed Restoration Institute's website. The principal goals of forest and watershed monitoring are to determine the effectiveness of standard prescribed forest thinning on soils, hydrology, water yield and quality, vegetation, and wildlife. SWCA is responsible for planning and implementing forest thinning monitoring in order to evaluate these resources. SWCA has also assumed responsibility for the South Mountain Weather Station that was previously installed by another contractor in 2006. After monitoring began, three major wildfires (Ojo Peak, Trigo, and Big Spring) occurred in the monitoring area in late 2007 and early 2008. The Trigo fire destroyed one of the forest thinning monitoring sites, which was replaced during summer 2008. SWCA has additionally initiated a monitoring study of post-Trigo fire recovery on private forest lands.

This 2009 Annual Report provides information on the results of forest thinning and post-wildfire monitoring during the calendar year 2009. We also provide summaries of weather data from the South Mountain Weather Station, which serves as a baseline for monitoring area climate data. Initial baseline pre-treatment monitoring data from permanent monitoring study sites provide information on rainfall, ambient and soil temperatures, soil moisture, soil surface profiles to assess erosion over time, soil surface stability, soil chemistry, bird and small mammal composition and relative abundance, and vegetation composition, structure, and cover. The monitoring sampling design employs paired monitoring plots at two piñon/juniper (*Pinus edulis/Juniperus monosperma*) woodland sites and two ponderosa pine (*Pinus ponderosa*) sites. One plot of each pair was randomly selected and designated to be treated by forest thinning in early 2010. We will then monitor the above mentioned parameters until at least 2011 to examine the impacts and effectiveness of forest thinning treatments. Not only will paired study plots be compared to each other in a treatment/control design, but also each treated plot will be monitored over time in order to assess change resulting from thinning treatments.

Results from the second year of pre-treatment baseline monitoring show that few differences in parameters were measured between the paired study plots. In situations where we did find

differences between paired treatment and control plots, we will be able to interpret future monitoring data from those naturally occurring differences and focus more on study plot assessments of change over time, relative to each of the paired plots.

Second-year results from the post-wildfire monitoring suggest that the Trigo fire area is slowly regenerating. The high burn severity plots supported a dramatic increase in herbaceous ground cover and reduction in bare ground, with dominance by seeded annual grasses such as Italian rye (*Lolium perenne*) and tall wheatgrass (*Thinopyrum ponticum*), as well as a variety of native forbs and naturally seeded grasses, such as blue grama (*Bouteloua gracilis*). Gambel oak (*Quercus gambelii*) and gray oak (*Q. grisea*) were prevalent throughout the high-severity plots, and alligator juniper (*Juniperus deppeana*) that was 100% consumed by the fire showed basal sprouting from most dead stumps. The low-severity plots also exhibited elevated herbaceous cover when compared to 2008 measurements and were beginning to take on similar patterns of cover to the unburned reference plots. Much of the high-severity plots had experienced 100% mortality of the trees, and many of these trees had begun to fall, particularly as a result of wind throw. The low-severity plots had exhibited patchy mortality in 2008; some of the worse-hit trees, those that were more than 50% scorched, had begun to die as a result of the physiological stress. Of the trees that were tagged as live in 2008, 15% were dead in 2009. These ranged from small-diameter overtopped trees to larger-diameter dominant canopy trees that received high levels of scorch and damage to the cambium through basal charring. Some of the trees that received less scorch and basal char are surviving, however, and their status will be monitored through 2010.

Soil erosion on the fire plots that appeared to be elevated in 2008 was reduced in 2009, but soil movement was highly variable across plots. Soil movement bridge measurements revealed both erosion and deposition at small scales. Regrowth of the herbaceous layer, dominance of seeded grasses, dead and fallen trees, and increased litter layers all contributed to the maintenance of the soil layer. Soil movement measurements will continue through 2010.

The automatic wildlife cameras that were installed in late 2008 took a number of pictures of wildlife using the study area. Mule deer (*Odocoileus hemionus*) was the dominant species captured in photographs. The wildlife cameras are being moved among the three watersheds on a quarterly basis.

Forest thinning treatments will be implemented early in 2010, and we will then begin monitoring post-thinning treatment conditions in spring 2010. Post-wildfire monitoring will continue through 2010 and perhaps beyond depending on the availability of funding. At this time, we do not anticipate changes in the current monitoring designs or methods.

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1.0 INTRODUCTION

This 2009 Annual Report provides summaries of monitoring data collected during the 2009 calendar year for the Estancia Basin Watershed Health, Restoration and Monitoring Steering Committee (Steering Committee). Details about research questions and the background and administration of this monitoring project may be found in the ―Estancia Basin Watershed Health and Monitoring Project: Monitoring Plan Evaluation" (2008 Monitoring Plan) (SWCA Environmental Consultants [SWCA] 2008), which is available at the New Mexico Forest and Watershed Restoration Institute (Restoration Institute) website (http://www.nmfwri.org). The 2008 Monitoring Plan provides detailed information on the background knowledge of forest thinning in the Southwest and presents the goals and methodologies for the Estancia Basin forest thinning monitoring project. The 2008 Annual Report (SWCA 2009) also provides important background information for the Trigo wildfire monitoring project that was initiated in 2008.

The Steering Committee oversees forest thinning and effectiveness monitoring of forest thinning on ponderosa pine (*Pinus ponderosa*) forests and piñon/juniper (*Pinus edulis/Juniperus monosperma*) woodlands on private and state lands on the eastern slopes of the Manzano Mountains, New Mexico. Principal members of the Steering Committee include the Claunch-Pinto, East Torrance, and Edgewood soil and water conservation districts; New Mexico State Forestry; and the Restoration Institute. The Restoration Institute is additionally providing oversight and public relations for forest thinning and monitoring activities.

The principal goals of the Steering Committee are to create defensible space around homes and other structures from wildfire and to improve overall forest health, following forest thinning prescriptions determined by New Mexico State Forestry. The primary goals of forest thinning monitoring are to determine the impacts of standard prescribed forest thinning on soils, hydrology, water yield and quality, vegetation, and wildlife.

The scope of work for this monitoring project was described in the Steering Committee's 2007 request for proposals as follows:

1. Plan and implement methods to determine how vegetation thinning and removal affect water yield.
2. Plan and implement methods of establishing reliable and repeatable vegetation monitoring methods to allow for both qualitative interpretation and quantitative documentation of change in vegetative structure and composition over time.
3. Plan and implement methods of monitoring small mammal and avian populations, which are indicators of ecosystem health.

SWCA is currently under contract for five years of monitoring, beginning in 2007, and is responsible for study site maintenance, data collection, data management, data analysis and interpretation, and information dissemination (including monthly meetings, monthly reports, and annual reports). The current Steering Committee plan calls for two years of baseline pre-thinning treatment monitoring (2008 and 2009), thinning treatments implemented in 2010, and three years of post-treatment monitoring (2010–2012).

Several new subprojects were added to the overall monitoring project in 2008, including post-fire monitoring of soils, hydrology, vegetation, and wildlife on private forest lands following the Trigo wildfire. These tasks involve developing and implementing ephemeral stream and groundwater monitoring to assess the effects of both forest thinning and the Trigo fire on water resources, as well as assuming the operation and reporting for the South Mountain Weather Station (SMWS), initiated by EnviroLogic in 2006. A map of all study sites for these projects is presented in Figure 1.1 (note that the SMWS is located north of Edgewood, New Mexico, and is not on the map presented in Figure 1.1, but is on the map presented as Figure 5.1).

This 2009 Annual Report is similar in format to the previous 2008 Annual Report, and it provides complete data files (appended on DVD) and summaries of findings from field monitoring measurements conducted during the calendar year 2009 for the four primary subprojects: 1) forest thinning monitoring of weather, soils, hydrology, vegetation, and wildlife; 2) post-Trigo wildfire monitoring of soils, vegetation, and wildlife; 3) overall Manzano watershed ephemeral stream and groundwater monitoring, associated with both forest thinning and post-wildfire monitoring; and 4) SMWS weather and soil moisture data, including addenda representing the four quarterly 2009 reports. Data collected in 2008 and 2009 represent baseline conditions prior to forest thinning treatments, which are scheduled to commence in early 2010. Data collected after thinning in 2010 will then provide measures of thinning treatment effectiveness (tree basal area measurements) and a comparison of post-treatment environmental conditions. Monitoring data from subsequent years will provide data on thinning treatment effects over time. Post-fire monitoring data collected in 2008 and 2009 likewise provide information on the recovery of soils and vegetation following the Trigo fire, and data from subsequent years will provide information on the rate of recovery and change following the impacts of that wildfire.

Numerous discrete datasets have been collected, and SWCA has been active in creating data collection, storage, and management plans for each of the subprojects. SWCA has created metadata for each of these datasets that outline the date range of each dataset, the collection methods, the unit measurements, and the abbreviations and codes used within each data file. The metadata files will also state any caveats or general comments to which the viewer should be aware before analyzing the data.

SWCA intends to make these data available in a form that can be easily disseminated, using readily available software packages such as Microsoft Word and Excel. Some information, such as those data collected from the WatchDog Mini Weather Stations, is collected using proprietary software. These data are converted into Microsoft Excel files so they can be viewed by the general public. We also intend to make the data available in forms that are easy to analyze. Some data, such as those related to the flumes, which are recorded in five-minute intervals, must be partitioned into several files, as the data exceeds Microsoft Excel's capacity of data rows. All of these data are being made available to the Restoration Institute for dissemination on its website. Note that measurements from various aspects of the monitoring are reported in English units (e.g., feet, acres), while others are reported in metric units (meters, hectares). The protocols for monitoring measurements were obtained from different sources that use different units of measure. The U.S. Department of Agriculture (USDA) Agricultural Research Service Rangeland Monitoring Manual (Herrick et al. 2005) uses metric units, while the U.S. Forest Service (USFS) Forest Inventory and Analysis Guide (USFS 2005) uses English units. In general, scientific research worldwide has adopted the metric system as the standard for measurements, while some federal and state agencies use English units of measure. For ease of comparison, values are presented in this report with both English and metric units, except where not feasible.

This 2009 Annual Report provides summaries of findings from field monitoring measurements conducted during the calendar year 2009 for the above mentioned projects and subprojects. This report is partitioned into different sections for each subproject: 1) forest thinning monitoring; 2) post-wildfire monitoring; 3) ephemeral stream and groundwater monitoring, associated with both forest thinning and post-wildfire monitoring; 4) SMWS data; and 5) overall plans for 2010 (year three).

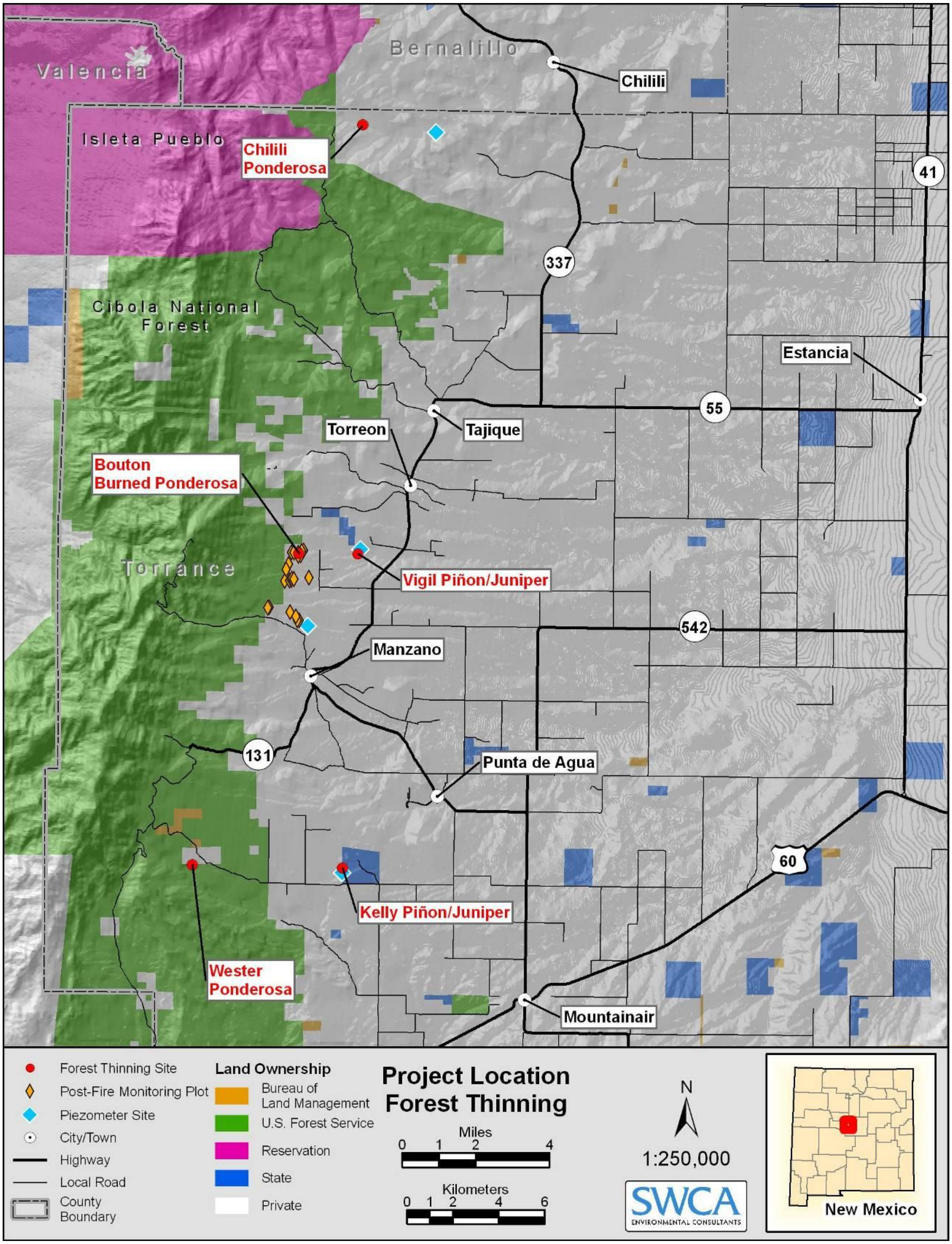

Figure 1.1. Map of all Estancia Basin forest and watershed monitoring locations addressed in this report.

2.0 FOREST THINNING MONITORING

Details of forest thinning monitoring are provided in the 2008 Monitoring Plan (SWCA 2008). Background information on the known environmental effects of forest thinning on southwestern forest ecosystems is presented in the 2008 Monitoring Plan, along with detailed discussions of the experimental study design and methods used in this research to measure various environmental responses to forest thinning treatments.

Forest thinning projects on private lands on the eastern slopes of the Manzano Mountains are overseen by the Steering Committee and include projects in both ponderosa pine forests and piñon/juniper woodlands. Forest thinning monitoring has been designed to address forest thinning in both of these forest types, so four monitoring study sites have been established: two in ponderosa pine forests and two in piñon/juniper woodlands. Each ponderosa pine site has been paired with a piñon/juniper site in the same watershed, so that each of two watersheds has a ponderosa pine and a piñon/juniper monitoring site. One pair of sites is situated at the northern end of the study area (eastern slopes of the Manzano Mountains), and the other at the southern end (see Figure 1.1). Two paired study plots have been installed at each of the four study sites. Descriptions of physical site characteristics such as slope, aspect, parent materials, plant associations, and habitat types are provided in the 2008 Monitoring Plan (SWCA 2008). All study sites chosen are representative of the surrounding area; for example, all sites, excluding the Wester property, undergo a livestock grazing regime, which is typical of the private land use in the Manzano Mountains. One plot of each pair will be randomly selected for forest thinning treatments, and the other plot of the pair will serve as an untreated control. Parameters being measured for monitoring at each of the eight study plots include rainfall, ambient temperature, soil moisture and temperature, soil chemistry, soil movement, soil surface stability, soil surface hydrology runoff, vegetation canopy cover and species composition, vegetation vertical structure, tree stand structure, density, composition and health, and bird and small mammal species composition and abundance.

Actual forest thinning treatments will not be implemented until early 2010, so this 2009 report presents the second year pre-thinning treatment baseline data and comparisons of paired study plots. Once forest thinning treatments have been implemented, the various environmental parameters being measured will be compared between the treatment and control study plots, and each study plot will be compared to itself over time.

2.1 AUTOMATED RAIN GAUGE AND TEMPERATURE RECORDING STATIONS

Spectrum WatchDog automated data-logging rain gauges installed at each of the paired vegetation and soils monitoring plots (Figure 1.1) have run continuously since they were installed in November 2007 (Figure 2.1). The WatchDog stations are located in openings in the tree canopy in order to reduce effects of interception. Additional details regarding the setup of the weather stations are provided in the 2008 Monitoring Plan (SWCA 2008). The tipping bucket rain gauges on the WatchDog stations are set to record rainfall and snowmelt sums at one-hour intervals continuously. In fall 2008, a graduated cylinder rain gauge was added to each of the automated rain gauge locations to serve as backups in case of power failure or other malfunction of the data logger (Figure 2.2). These graduated rain gauges and their recorded values are checked monthly when Time Domain Reflectometer (TDR) soil moisture and temperature readings are taken (with a Field Scout TDR 200 unit) and mineral oil is added to these gauges to prevent evaporation of water collected. The WatchDog stations are set to record ambient temperature, soil moisture 10 cm (4 inches) below the soil surface (-10 cm), and soil temperature -10 cm, all at one-hour increments. Soil moisture and temperature data from each WatchDog station provide baseline comparisons for the Field Scout TDR 200 soil water content and soil temperature data that are sampled monthly at each study plot. All data from the stations are off-loaded approximately every three months and entered into a database. Summaries for precipitation, ambient temperature, soil moisture, and soil temperature from 2009 on the Wester ponderosa site and the Kelly piñon/juniper woodland site are presented as examples below.

Figure 2.1. WatchDog weather station at the Wester ponderosa pine site.

Figure 2.2. Graduated rain gauges are used for backup in the case of failure from one of the WatchDog weather stations.

2.1.1 PRECIPITATION

Hourly precipitation totals have been summed to monthly totals and show similar monthly precipitation totals between the paired study plots (1 and 2) at the Kelly piñon/juniper (Figure 2.3) and Wester ponderosa study sites (Figure 2.4). Precipitation amounts at the Kelly and Wester site plots are especially similar with very little deviation from one another. Precipitation amounts in September at the Wester study plots vary slightly more than the Kelly plots, indicating spatial variation in rainfall from thunderstorms and between subwatersheds.

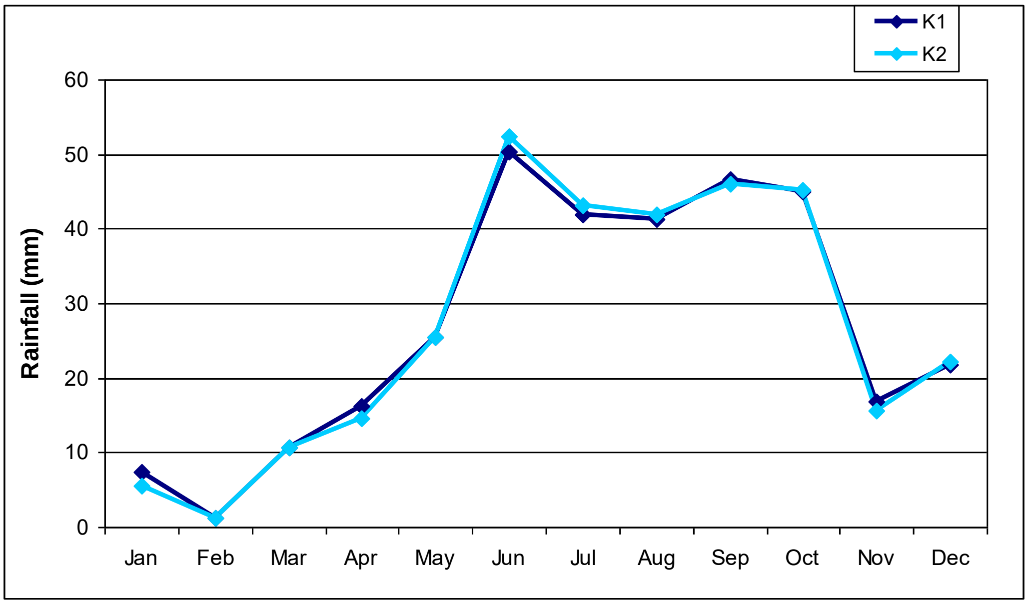

Figure 2.3. Monthly cumulative precipitation (rainfall and snow) from the two paired Kelly piñon/juniper study plots.

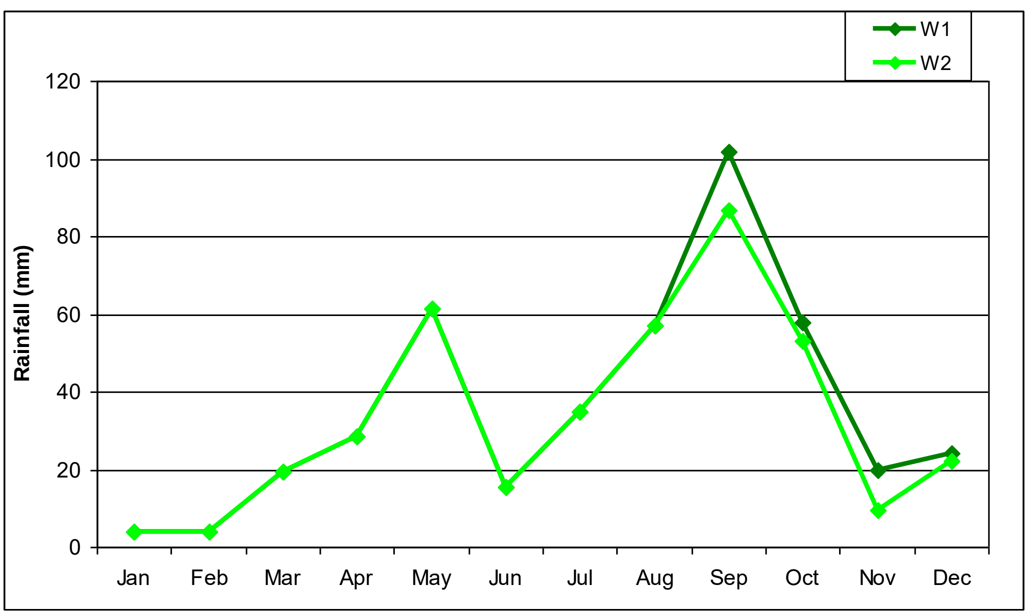

Figure 2.4. Monthly cumulative precipitation (rainfall and snow) from the two paired Wester ponderosa pine study plots.

Precipitation was not recorded at the Chilili ponderosa sites on either WatchDog weather station from sometime in December 2008 until November 4, 2009. However, the graduate cylinders that serve as a backups to the WatchDog stations recorded the precipitation events during this period, but only on a monthly basis (not daily), which makes it difficult to analyze flow events. The likely cause of this malfunction was due to black bear (*Ursus americanus*) damage, which occurred throughout 2009. The bear activity resulted in one of the WatchDog rain buckets being removed from the station and subsequently needing replacement (Figure 2.5). Bear activity also managed to unplug the other rain bucket from the unit, causing no precipitation to be recorded. This precipitation bucket, however, was functional once plugged back into the unit.

Figure 2.5. Photo taken in April 2009 showing initial bear damage caused to the WatchDog station.

In order to prevent future damage from bear activity at this site, an electric fence was built around one of the stations during summer 2009 with a ―dummy" fence set up around the other (Figure 2.6). Unfortunately, the dummy fence failed to keep a bear out of the station, and sometime in the fall the rain gauge was once again disturbed (Figure 2.7). To further protect the rain gauges, the dummy fence will be equipped with a charging unit in spring 2010 once purchased and should prevent any further damage to the WatchDog stations.

Figure 2.6. Charging station for the electric fence constructed around the WatchDog station at the Chilili ponderosa pine study site in 2009 to combat the bear problems.

Figure 2.7. Photo taken October 27, 2009, at the Chilili ponderosa pine site showing bear damage to the precipitation bucket causing precipitation not to be recorded.

2.1.2 AMBIENT TEMPERATURE

Monthly averages of hourly ambient temperatures are presented for the Kelly piñon/juniper (Figure 2.8) and Wester ponderosa sites (Figure 2.9). These graphs show similar monthly average ambient temperatures between the paired study plots (1 and 2) at both study sites.

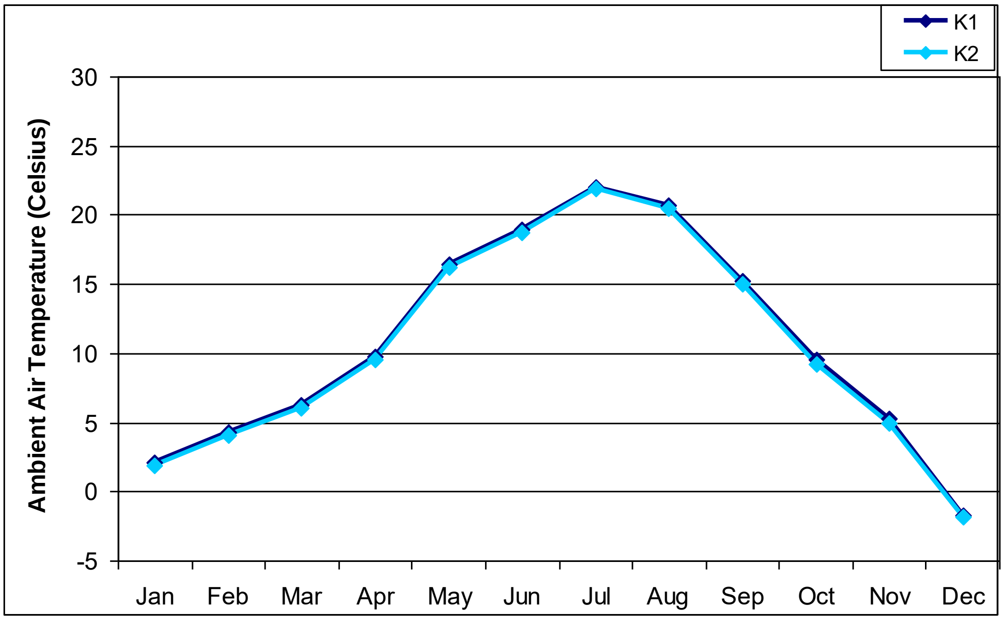

Figure 2.8. Monthly average ambient temperatures from the two paired Kelly piñon/juniper study plots.

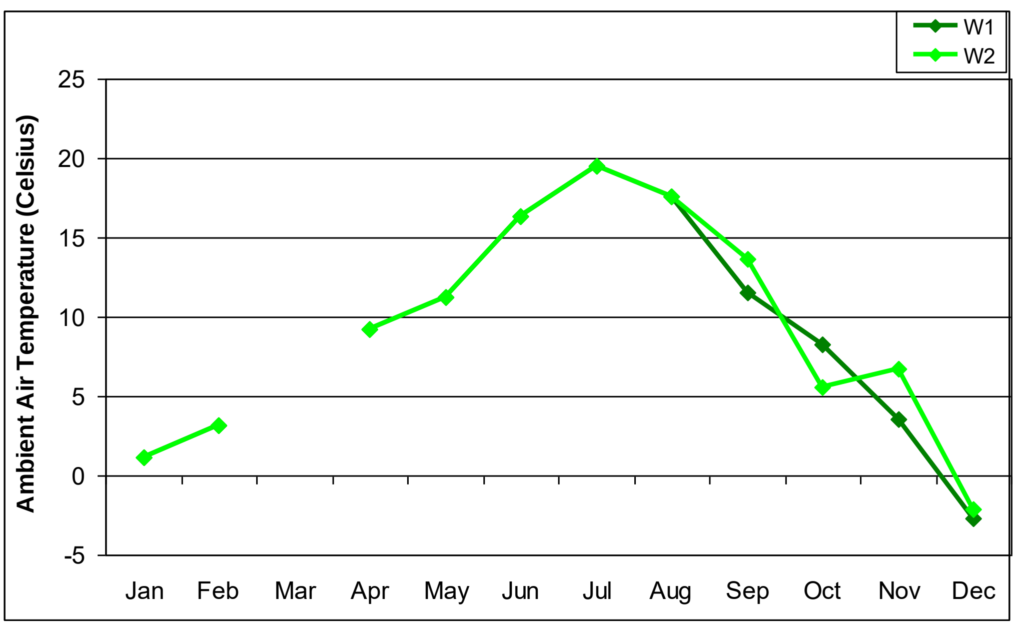

Figure 2.9. Monthly average ambient temperatures from the two paired Wester ponderosa pine study plots.

The only data issue with any of the stations was during the month of March when something caused both stations at the Wester site to malfunction and not record ambient air temperature (as seen by the gap in Figure 2.9). This was the only time period in which temperature was not recorded, and the station seemed to start recording again on its own without any type of maintenance required.

2.1.3 SOIL MOISTURE

Monthly averages of hourly -10 cm soil moisture readings are presented for the Kelly piñon/juniper and Wester ponderosa sites (Figure 2.10 and Figure 2.11). Soil moisture was measured with Watermark soil moisture probes that measure soil water tension in kilopascal (kPa) values that are directly equivalent to California Bearing Ratio (cbr) values for soil water saturation.

Figure 2.10 and Figure 2.11 show similar monthly average soil moisture tension totals between the paired study plots (1 and 2) at both study sites, except for Kelly where the sites differed considerably in January, September, and October. We are unsure what caused these considerable differences, but it could be due to site variability or possibly a malfunctioning sensor. This station will continue to be monitored to ensure the sensors are in working order.

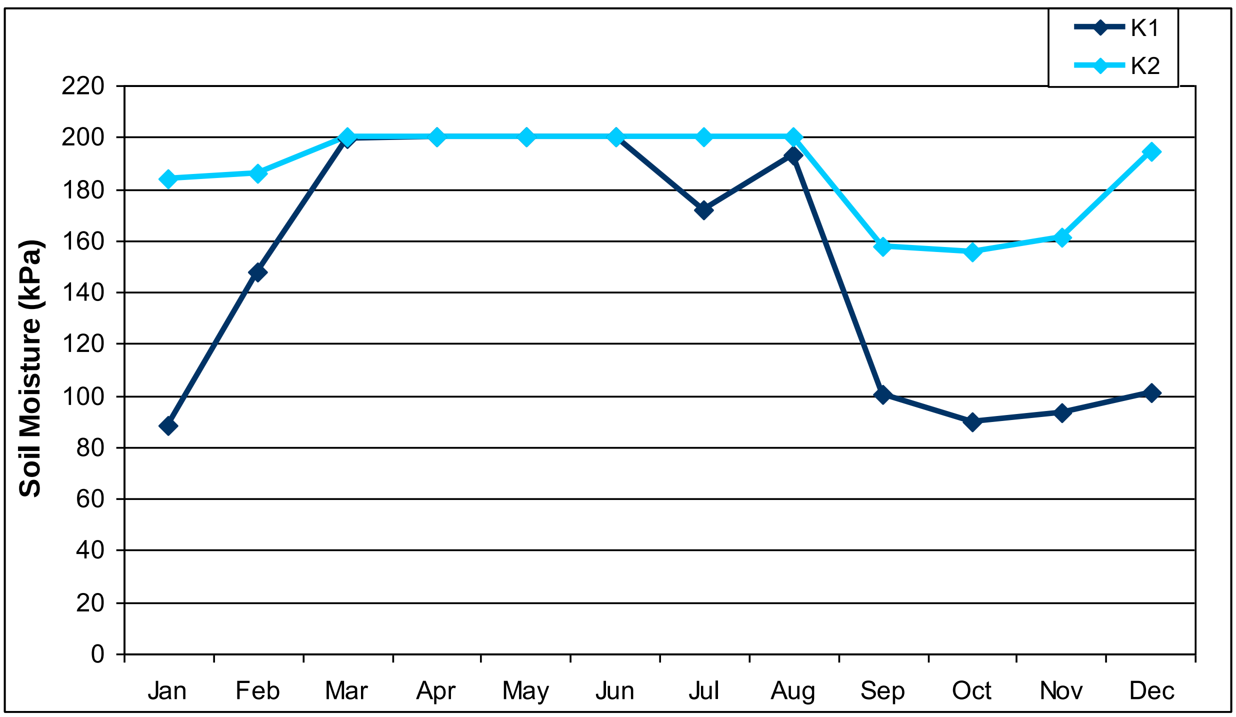

Figure 2.10. Monthly average soil moisture tensions (-10 cm) from the two paired Kelly piñon/juniper study plots showing significant differences in January, September, and October.

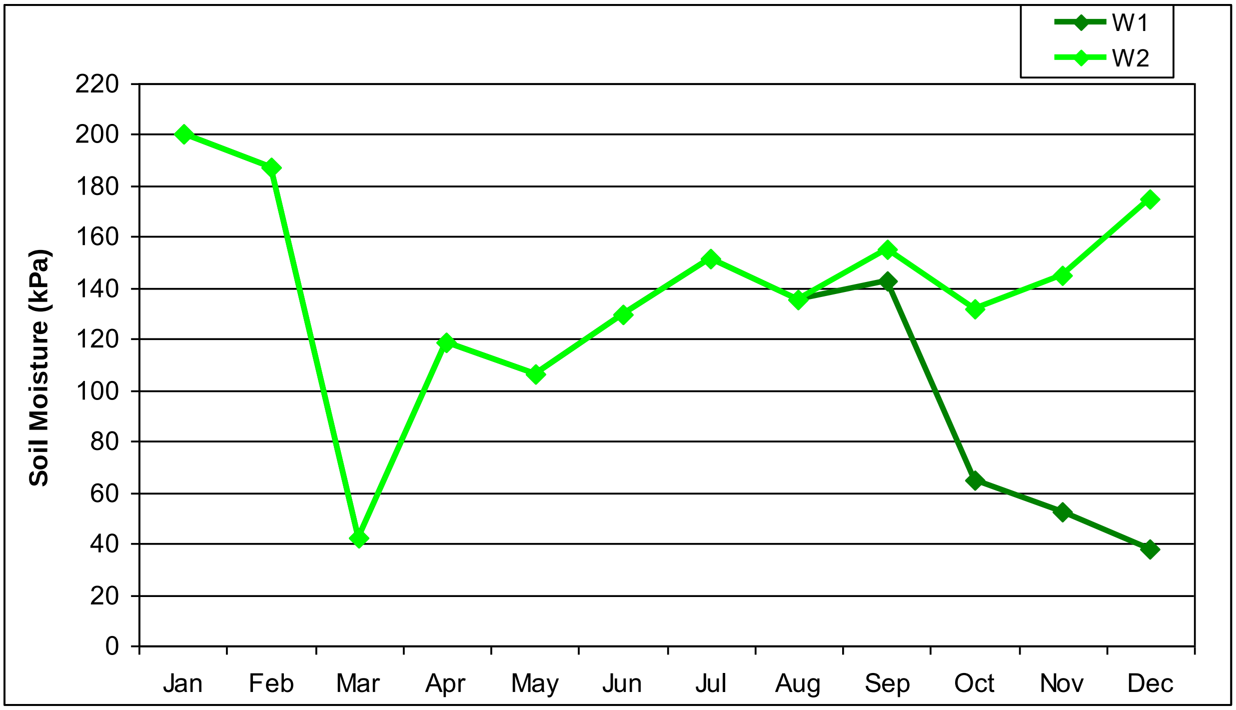

Figure 2.11. Monthly average soil moisture tensions (-10 cm) from the two paired Wester ponderosa pine study plots.

2.1.4 SOIL TEMPERATURE

Monthly averages of hourly -10 cm soil temperature readings are presented for the Kelly piñon/juniper and Wester ponderosa sites (Figure 2.12 and Figure 2.13). The graphs show similar monthly average soil temperatures between the paired study plots (1 and 2) at both study sites.

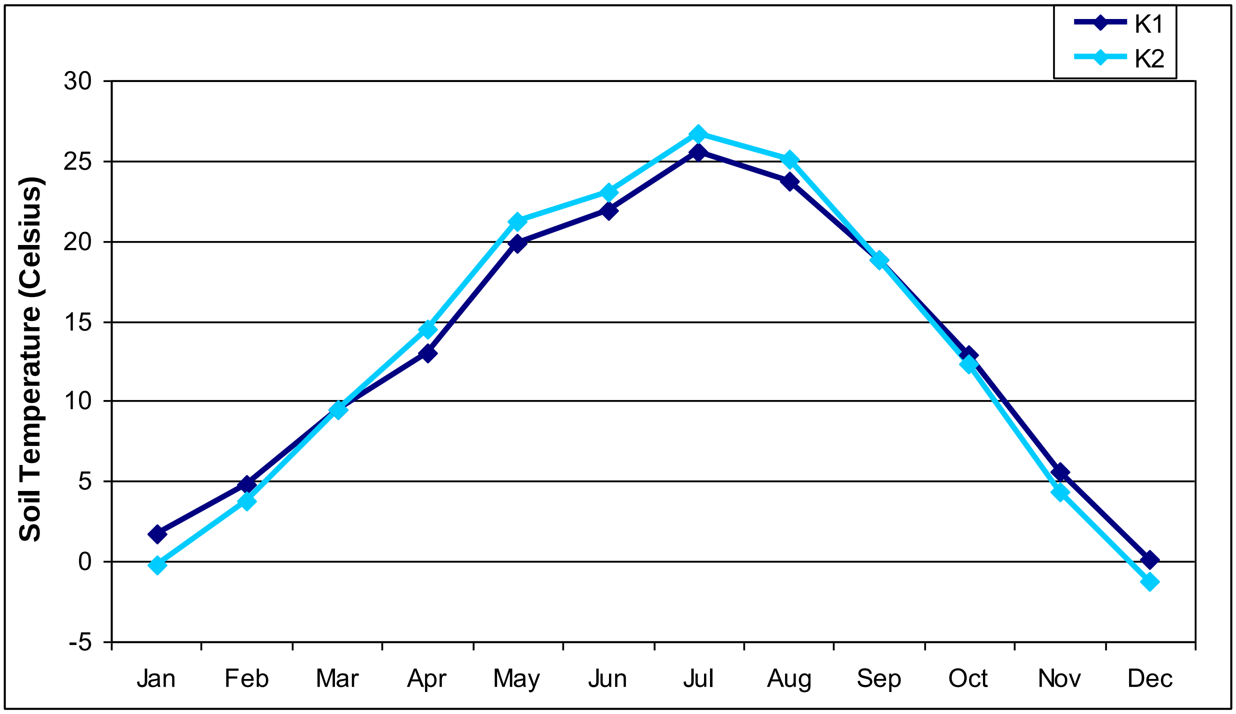

Figure 2.12. Monthly average soil temperature (-10 cm) from the two paired Kelly piñon/juniper study plots.

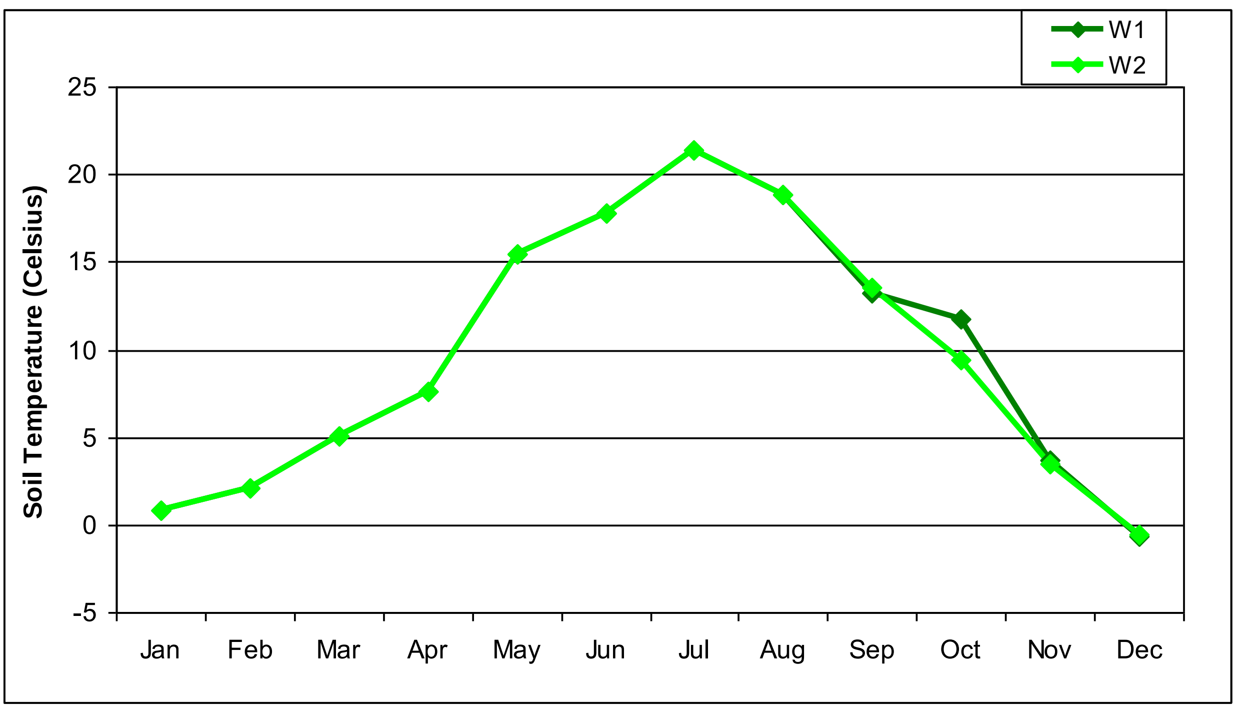

Figure 2.13. Monthly average soil temperature (-10 cm) from the two paired Wester ponderosa pine study plots.

All sensors were in working order except for the soil temperature sensor at the Chilili west ponderosa pine study site, which seemed to be properly functioning until May 2009. The cause of the malfunction could be attributed to the bear activity seen at this site throughout the year. This sensor will be replaced during the next offload in early January 2010 or whenever the weather permits.

2.2 Entire Study Plot Soil Water Content and Temperature (TDR)

Continuous hourly soil moisture and temperature measurements recorded by the WatchDog station at each plot only provide a single reference point measurement for each plot, measured and recorded hourly. In order to sample soil moisture and temperature from locations throughout each vegetation and soil monitoring plots, a portable Field Scout TDR 200 soil moisture meter was used. Further information on the detailed methods can be found in the 2008 Annual Report (SWCA 2009).

Results of average percent soil volumetric water content and temperature readings from the Kelly and Vigil piñon/juniper vegetation and soil study plots are shown in Figure 2.14 through Figure 2.17. These figures indicate little difference in soil water content and soil temperatures between the two paired plots at both the Kelly and Vigil sites. These baseline data show that the subwatersheds are functioning similar in regards to soil moisture and temperature, which similar to the WatchDog data showed in Figure 2.10 through Figure 2.13. After thinning treatments are implemented, any significant differences, if they exist, then likely can be attributed to the treatment.

There were several issues with the equipment and weather that did not allow for all the measurements to be taken on a monthly basis. The TDR probe broke sometime after the May measurements and was sent back for repair in June. This probe was returned in working order in September. The soil temperature probe also had mechanical issues, and subsequently data were not gathered in July and August; however, these probes were replaced by September so that the data collection could continue.

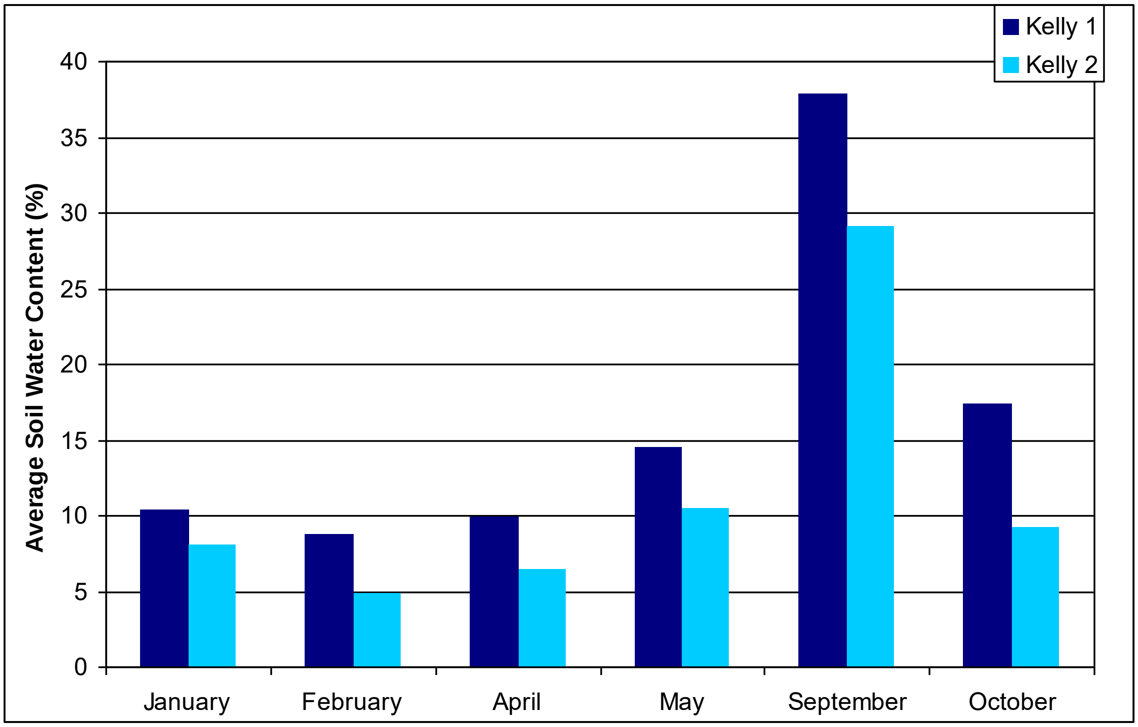

Figure 2.14. Soil moisture readings taken in 2009 with the Field Scout TDR 200 at the Kelly piñon/juniper study plots.

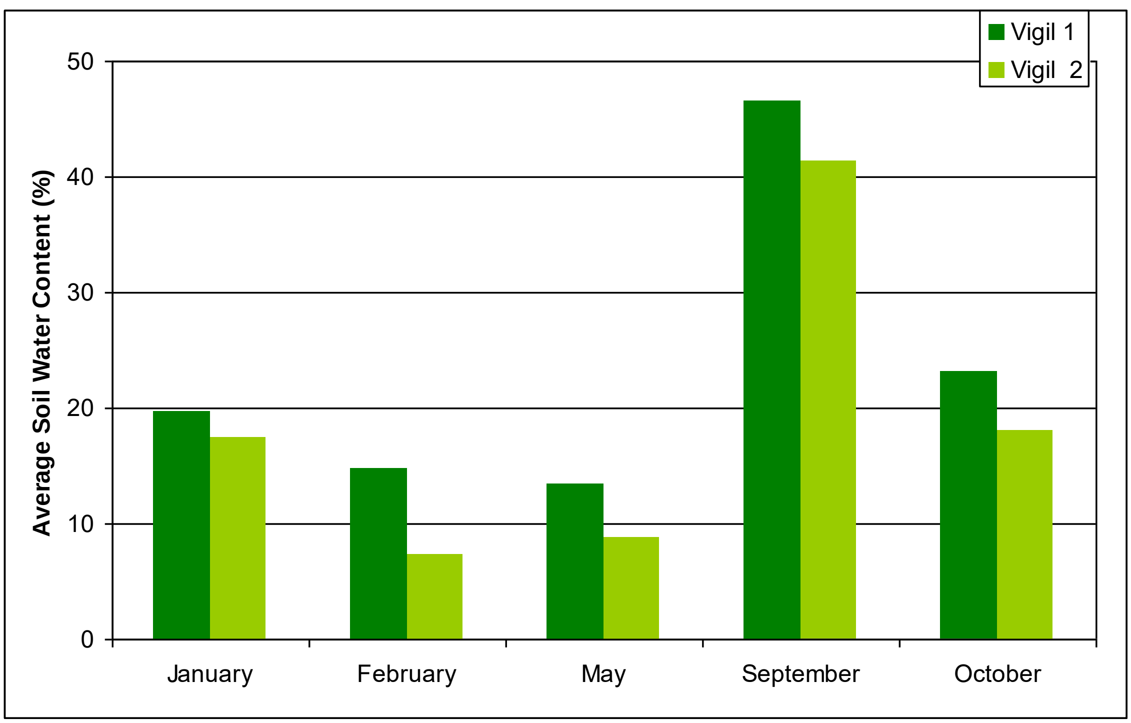

Figure 2.15. Soil moisture readings taken in 2009 with the Field Scout TDR 200 at the Vigil piñon/juniper study plots.

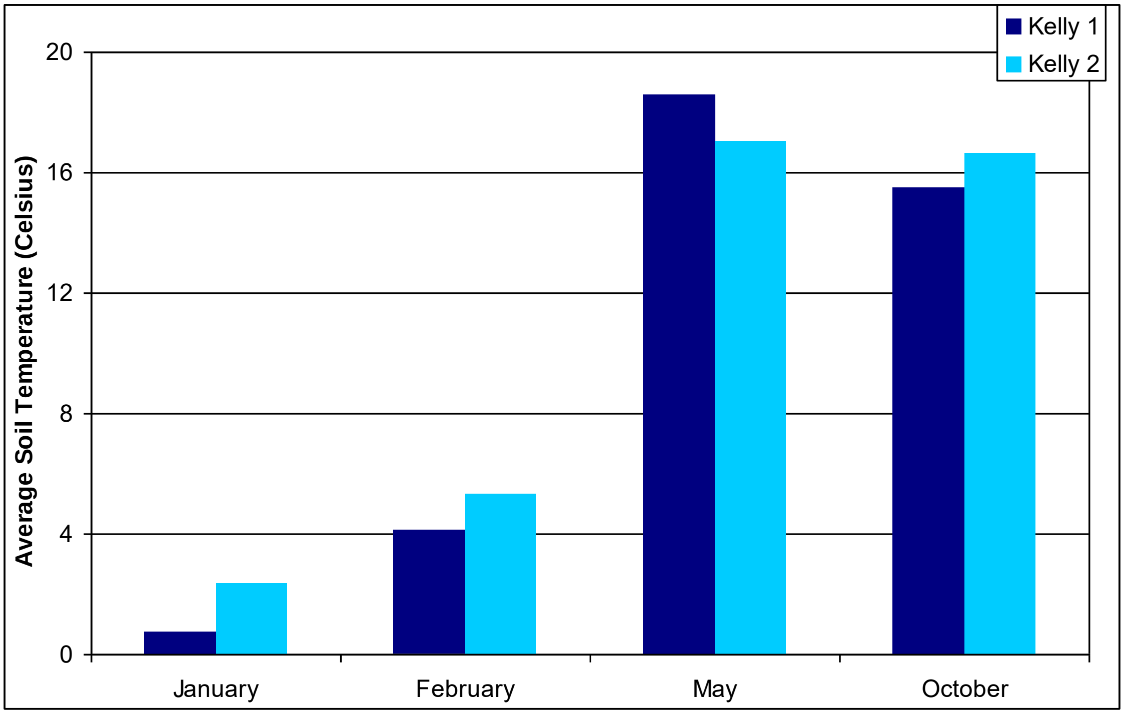

Figure 2.16. Soil temperatures readings taken in 2009 with the portable temperature probe at the Kelly piñon/juniper study plots.

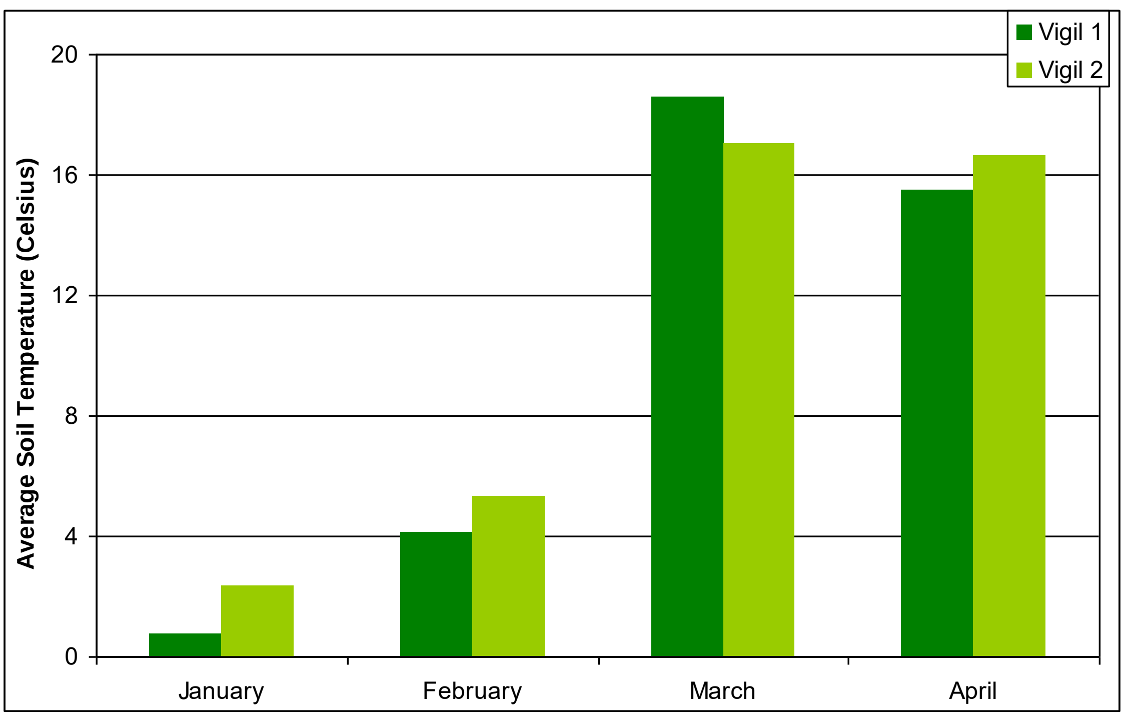

Figure 2.17. Soil temperatures readings taken in 2009 with the portable temperature probe at the Vigil piñon/juniper study plots.

2.3 SOIL SURFACE STABILITY

Soil surface stability was measured and scored in May 2009 using the Soil Stability Test Kits developed by the USDA Agricultural Resource Service (Herrick et al. 2005) (Figure 2.18). Further details of the measurement methods and a review of the literature can be found in the 2008 Monitoring Plan (SWCA 2008). Figure 2.19 provides average soil surface stability scores for each of the eight subplots representing each of the vegetation and soils sampling plots from the four sites (Chilili, Kelly, Vigil, and Wester). Scores are partitioned by subplot and overstory vegetation canopy type. Figure 2.20 provides average soil subsurface (1 cm below the soil surface, or -1 cm) stability scores for each of the eight subplots.

Figure 2.19 and Figure 2.20 display both surface and subsurface stability and show considerable variation in stability scores across plots, subplots, and vegetation types. In general, soils under tree canopies had higher scores than at other sites, which was also the case in 2008. The higher scores here are due largely to the large accumulation of organic matter that occurs underneath tree canopies, especially within the ponderosa pine vegetation type, which can add as much as 2,000 pounds/acre/year of fine fuels (Ffolliott et al. 1968). Most of those soils at the sites measured were underneath litter layers and contained organic material and fungi. Statistical tests will be conducted next year after treatment to see if the restoration treatments have any effect on soil stability scores.

Figure 2.18. Soil stability test in use on the study sites.

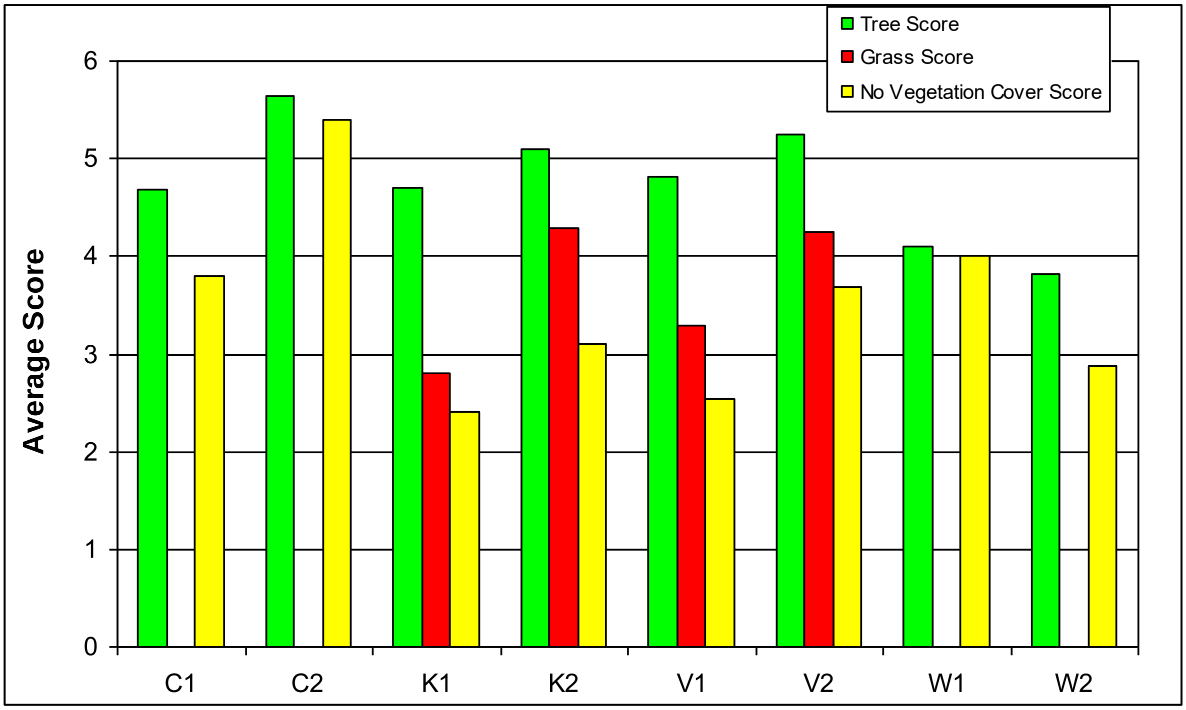

Figure 2.19. Soil surface stability average scores by site, plot, subplot (18 subsamples/subplot), and overstory vegetation canopy type; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

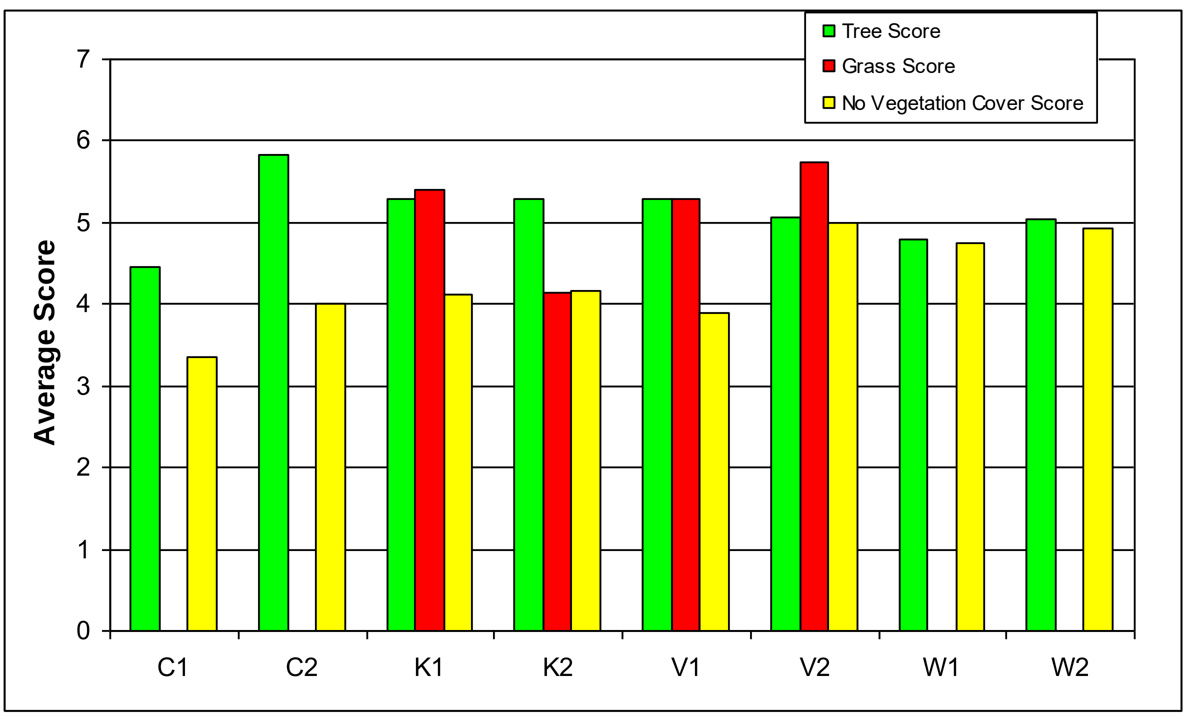

Figure 2.20. Soil subsurface (-1 cm) stability average scores by site, plot, subplot (18 subsamples/subplot), and overstory vegetation canopy type; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

2.4 SOIL MOVEMENT BRIDGES

Soil movement was monitored using soil movement bridges (called soil erosion bridges in the 2008 report) (Figure 2.21) modeled after White and Loftin (2000). Permanent bridge support posts were installed at consistent, systematically determined, and unbiased locations at one of each of the vegetation and soil subplots for a total of three bridges at each paired plot at all four sites. Please refer to the 2008 Annual Report for detailed monitoring protocols and literature associated with soil movement (SWCA 2009). Figure 2.22 shows the micro-soil topography profile from the Wester ponderosa pine site for both 2008 and 2009. The graph clearly shows the yearly variability associated with soil movement on a plot. The processes of soil erosion and soil deposition can clearly be seen when plotting data from 2008 and 2009. After thinning treatments are completed, post-treatment data will be available to compare with pre-treatment data. These comparisons will allow us to assess the changes in soil movement potentially caused by restoration treatments. Over a series of years, this study will document losses and/or gains to the soil surface profiles at each bridge site and will provide average values for each of the eight plots in this study (Chilili, Kelly, Vigil, and Wester).

Figure 2.21. Measurement of soil surface topography using a soil movement bridge helps understand the yearly variability associated with soil topography.

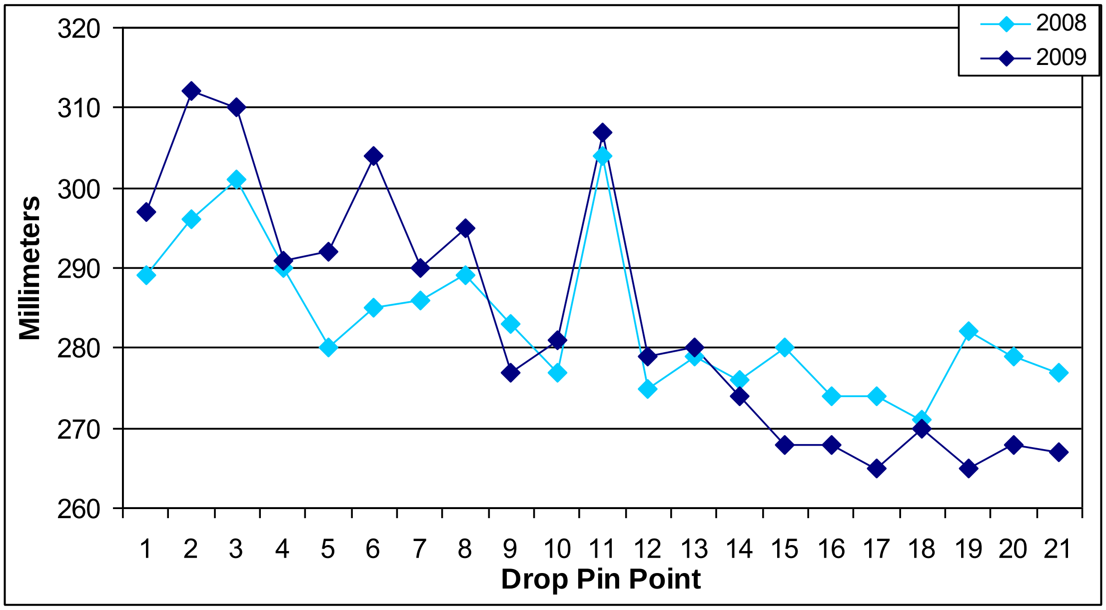

Figure 2.22. Soil surface profile from the soil movement bridge located at the Wester ponderosa pine site 1 during the 2008 and 2009 measurement season. Each point 1–21 on the X axis represents one measurement point from the soil surface to the level bridge above the surface.

2.5 SOIL CHEMISTRY

The chemistry comprising the soil is an important parameter in the overall health and functioning of a watershed. In particular, the top layer of soil, the A-horizon, is important because it is the zone where most biological activity occurs and therefore the most fertile layer. The A-horizon is also the layer of soil most susceptible to disturbance because it is exposed at the surface to the elements of nature and man. Soil chemistry plays a key role in sustaining the productivity of plants and soil biota, which directly affect the ability of soil to infiltrate water. Understanding the chemical makeup of a soil before treatment or disturbance can shed light on how restoration techniques affect the chemical composition of the soil.

Baseline measurements of soil chemistry were obtained in 2008 and 2009 before thinning treatments at the Kelly, Vigil, and Wester sites; Chilili was not included until the 2009 sampling because this plot had yet to be established. The purpose of taking these measurements is to quantify changes to soil chemistry potentially caused by thinning activities. The methods used in 2008, however, were slightly different than those used in 2009 and can be a reason for any large differences seen between years. The soil samples were obtained using a 4-cm-diameter, 20-cm-deep impact soil corer at the four corners of the three established vegetation plots (Figure 2.23). In 2008 the 12 subsamples were placed in labeled separate bags in order to attempt in house analysis with Cardy soil kits. The variability associated with these kits, however, proved to be too great for reliable results, so the subsamples were combined into one bag for each site and sent to the laboratory for further analysis. In 2009, the collection of the 12 subsamples was combined into the same bag at the time of sampling. These samples were considered to be representative of the study areas. These methods followed the USFS Forest Inventory and Analysis Guide procedures (USFS 2005).

Figure 2.23. Soil cores were taken using an impact corer, shown above, for chemical analysis.

The chemical analysis of the soil samples was conducted by the Soil, Water, and Agriculture Testing Laboratory located at New Mexico State University (NMSU). The variables measured by NMSU included saturated paste pH, electronic conductivity, total soluble salts (sodium, calcium, and magnesium), sodium adsorption ration, organic matter, total Kjeldahl nitrogen (TKN), nitrate-nitrogen, bicarbonate phosphorous, potassium, and a texture estimate. The initial results of soil organic matter and the macro nutrients, nitrogen (measured using TKN), phosphorus, and potassium, from samples taken in 2008 and 2009 are displayed below in Figure 2.24 through Figure 2.27.

The Chilili site had the highest levels nitrogen and organic matter. This can be attributed to the high productivity of this site and the large amounts of litter that ponderosa pine trees drop every year. Estimates of the other variables some show the similarity between years. There are a couple exceptions for the phosphorus concentrations on the Kelly piñon-juniper site and Vigil piñon-juniper site plot 2. The differences seen here could be attributed to the different sampling procedures used in 2008 and 2009, site variability, sample contamination, or sampling error. Any small visual differences in values other than the instances at the Kelly and Vigil sites can likely be attributed to the naturally occurring variability of the site and the variability associated with the analytical techniques. These initial estimates will serve as baseline measurements to be compared with future measurements taken after the completion of the thinning treatments.

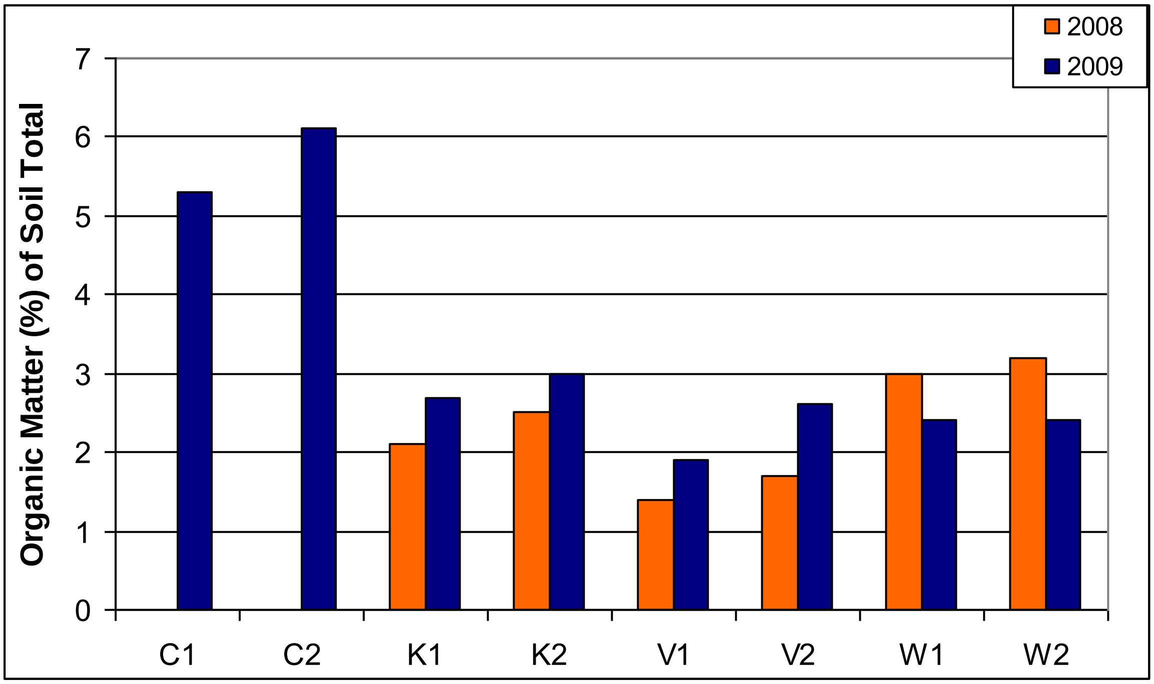

Figure 2.24. Organic matter concentrations measured during 2008 and 2009; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

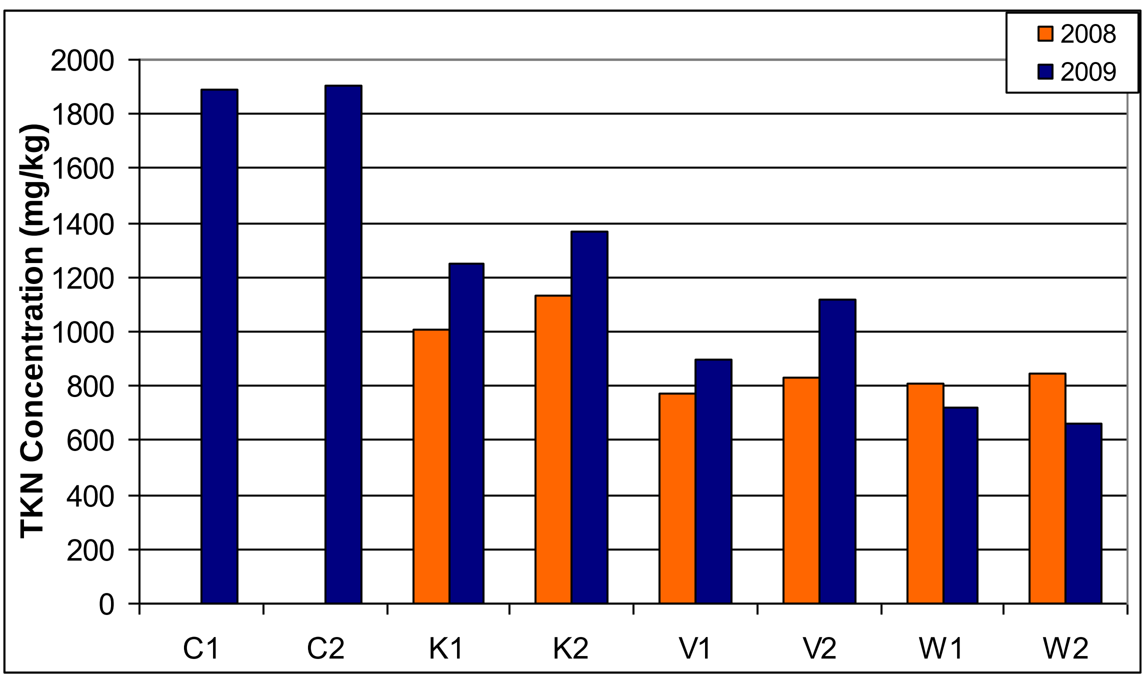

Figure 2.25. TKN concentrations measured during 2008 and 2009 on the sample plots; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

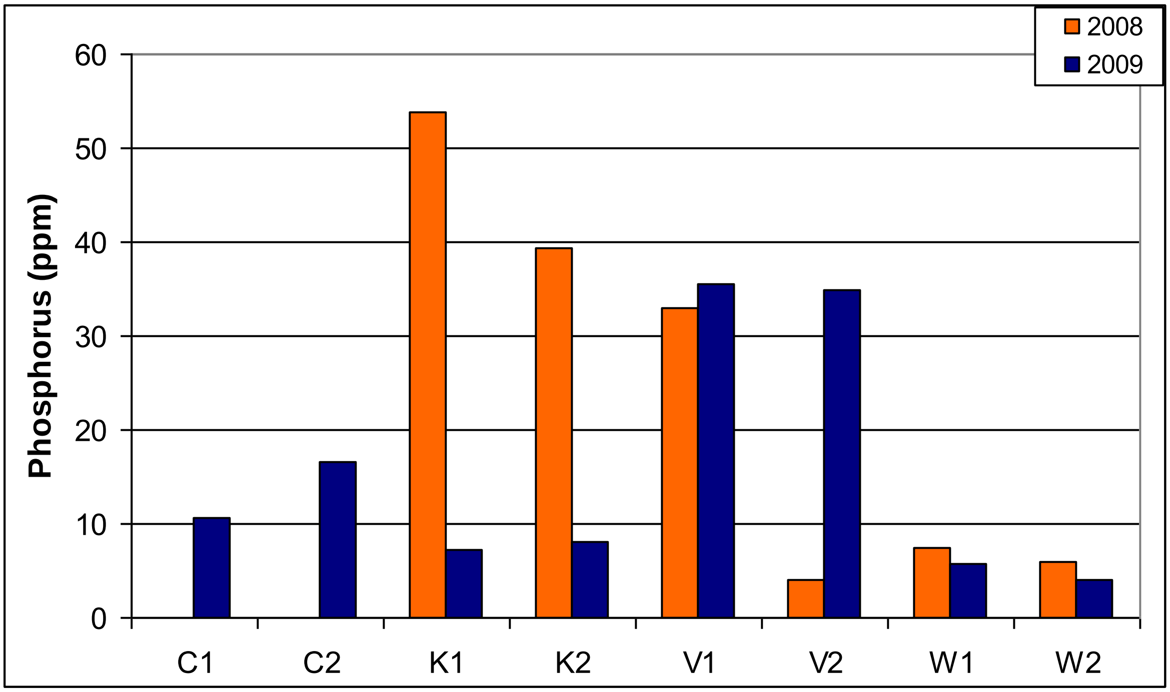

Figure 2.26. Baseline concentrations of phosphorus measured on all the thinning plots during 2008 and 2009; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

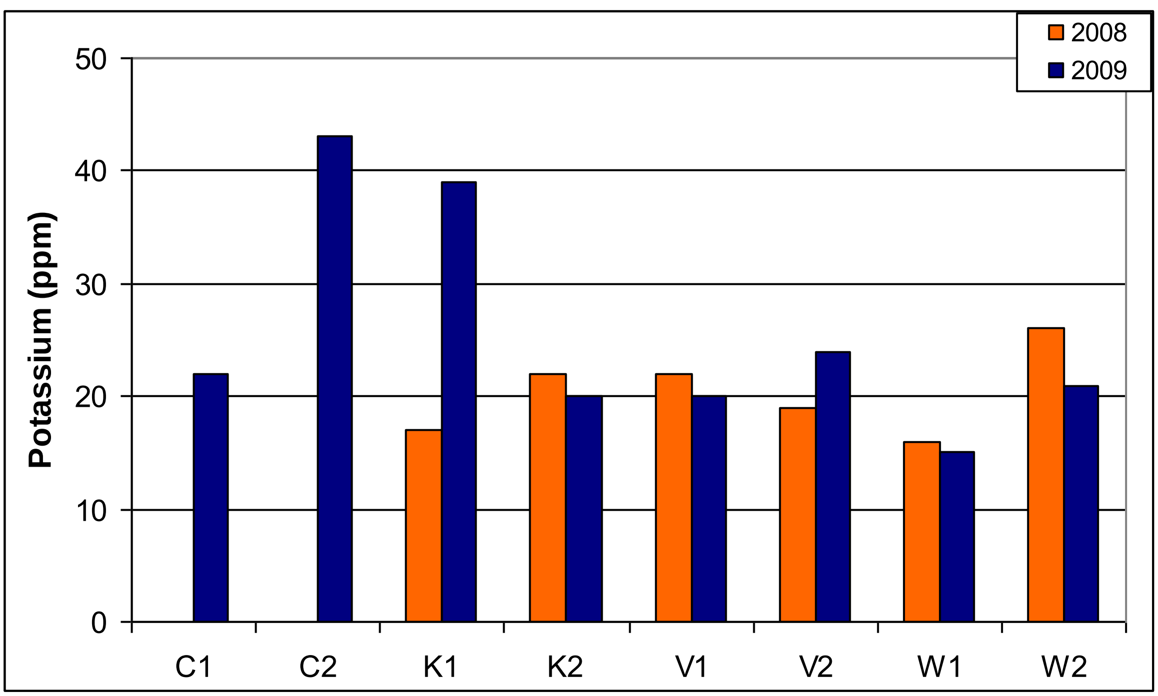

Figure 2.27. Baseline potassium concentrations measured on the Thinning plots during 2008 and 2009; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

2.6 FOREST THINNING HYDROLOGIC MONITORING

Monitoring flumes (Parshall flumes) complete with pressure transducers were installed at study sites in order to study impacts of tree thinning to surface flow. For study this, flumes were installed at all four monitoring sites (Figure 2.28). For more detailed information on the methodology, site location, and relevant background information, please refer to the 2008 Monitoring Plan (SWCA 2008). Since the Chilili watershed information was not included in the 2008 report, both figures of the flumes (Figure 2.29 and Figure 2.30) and watershed map (Figure 2.31) are included. A complete table (Table 2.1) of all the subwatershed acreages is included with data that were not presented in the 2008 Annual Report.

Soil surface runoff flows occurred at all sites during 2009 but not on all subwatersheds, which can be attributed to spatial geographic and topographic differences between subwatersheds. Even though the subwatersheds may seem similar, at the micro-level there are a variety of different slopes, soil types, and vegetation covers that result in different runoff responses. Storm events recorded by the Parshall flumes during 2009 are summarized in Table 2.2 through Table 2.5 below.

A number of calculations were conducted in 2009 using the flow data from the Parshall flumes in order to analyze each flow event individually. The calculations included peak stage, peak flow, flow duration, total volume of flow, volume of flow per acre, total rainfall that resulted in flow, total volumetric rainfall, and rainfall/runoff ratio. These results will be used to make comparisons with flow data once treatments have been implemented to asses any changes potentially caused by the thinning activities. Below is an explanation of how each factor was calculated in the summary tables:

- **Peak Stage**: Height of water in the stream measured using the Parshall flumes (feet).
- **Peak Flow**: Water moving through the flume at the time of maximum flow (cubic feet per second [cfs]).
- **Flow Duration**: Amount of time the flow event occurred on the subwatersheds (minutes).
- **Total volume of flow**: Total volume of water that flowed through the flume during the event (cubic feet [ft^3]).
- **Volume of flow per acre**: Total volume of flow divided by the size of the watershed (ft^3/acre).
- **Total rainfall**: Amount of rainfall recorded during flow event from the WatchDog weather stations (inches).
- **Total volumetric rainfall**: Total amount of rainfall divided by the size of the subwatershed (ft^3).
- **Rainfall/Runoff ratio**: A relationship referred to as the rainfall-runoff relation indicates that a threshold of rainfall intensity exists above which severe flash floods occur (Moody and Martin 2001) and can be calculated by dividing the total volume of flow by the total volumetric flow.

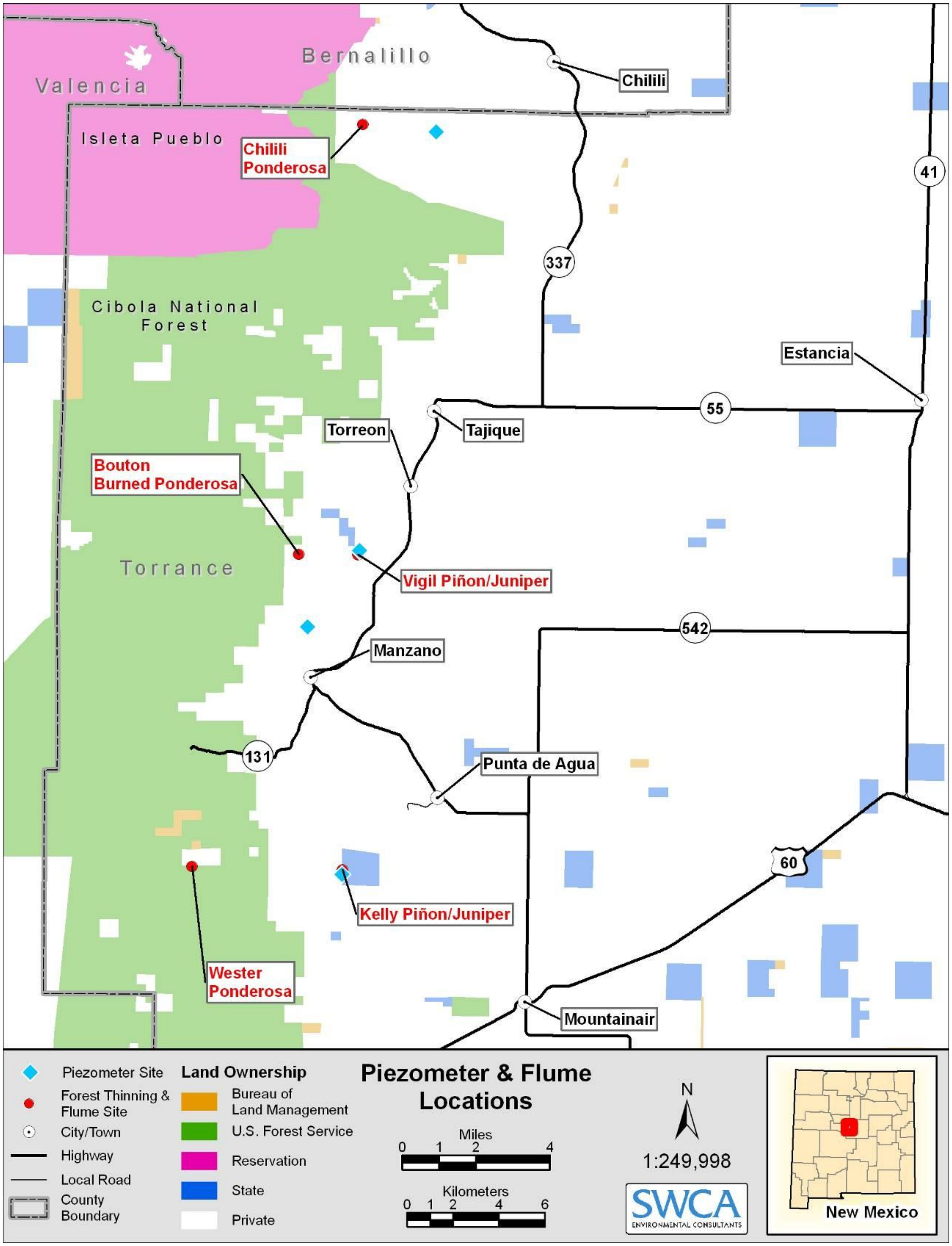

Figure 2.28. Location of the Parshall flumes throughout the Estancia Basin.

Figure 2.29. Parshall flume located at Chilili site plot 1.

Figure 2.30. Parshall flume located at Chilili site plot 2.

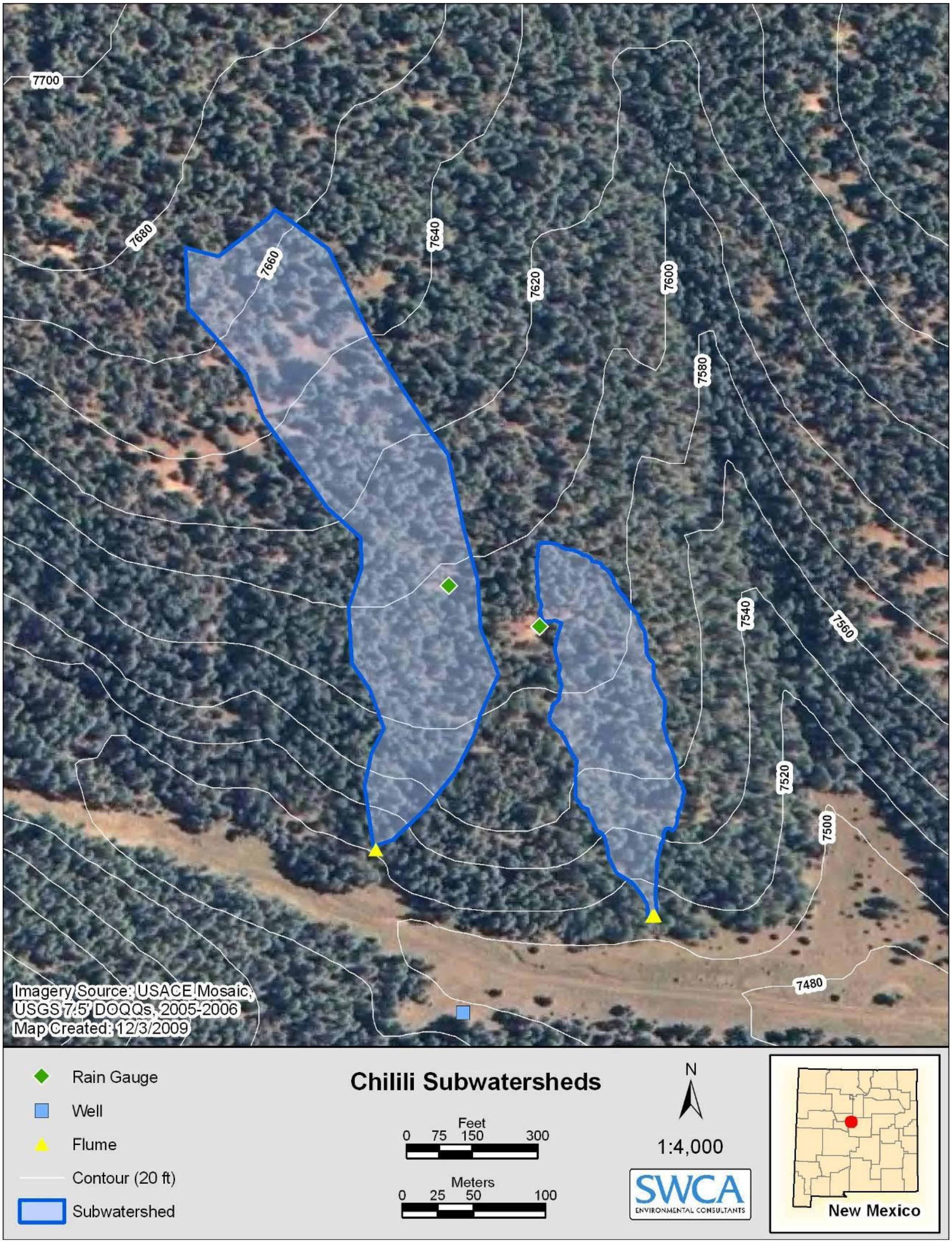

Figure 2.31. Chilili subwatersheds. The Chilili plot 1 is on the east, and plot 2 is on the west.

Table 2.1. Acreages of the Subwatersheds Containing Flumes

Subwatershed	Acreage
Bouton Ponderosa W	2.06
Bouton Ponderosa E	1.60
Wester Ponderosa W	6.76
Wester Ponderosa E	1.03
Kelly Piñon/Juniper W	0.31
Kelly Piñon/Juniper E	0.29
Vigil Piñon/Juniper W	0.10
Vigil Piñon/Juniper E	0.68
Chilili Ponderosa W	9.20
Chilili Ponderosa E	3.51

Table 2.2. Summary of the Flow Event on the Chilili 1 Subwatershed during the Basin-wide Storm Event on September 16–17, 2009

Chilili 1	9/17/2009
Flow Start	7:05
Flow Stop	21:25
Peak Stage	0.29 feet
Peak Flow	0.146 cfs
Flow Duration	9hr 20 minutes
Total Volume of Flow	7,981 ft^3
Watershed Area	3.5 acres
Volume of Flow per Acre	2,280 ft^3/acre
Total Rainfall	NA
Total Volumetric Rainfall	NA
Runoff Ratio	NA

Table 2.3. Summary of Three Different Flow Events on the Chilili 2 Subwatershed during the Basin-wide Storm Event on September 16–17, 2009

Chilili 2	9/17/2009	9/17/2009	9/17/2009
Flow Start	5:45	9:05	14:30
Flow Stop	6:45	9:40	15:10
Peak Stage	0.32 feet	0.18 feet	0.17 feet
Peak Flow	0.170 cfs	0.070 cfs	0.064 cfs
Flow Duration	60 min	35 min	40 min
Total Volume of Flow	443 ft^3	140 ft^3	97 ft^3
Watershed Area	9.2 acres	9.2 acres	9.2 acres
Volume of Flow per Acre	48.2 ft^3/acre	15.2 ft^3/acre	10.5 ft^3/acre
Total Rainfall	NA	NA	NA
Total Volumetric Rainfall	NA	NA	NA
Runoff Ratio	NA	NA	NA

Table 2.4. Summary of the Flow Event on the Wester 2 Subwatershed during the Basin-wide Storm Event on September 16–17, 2009

Wester 2	9/17/2009
Flow Start	4:57
Flow Stop	5:27
Peak Stage	0.149 feet
Peak Flow	0.052 cfs
Flow Duration	30 min
Total Volume of Flow	55.8 ft^3
Watershed Area	6.76 acres
Volume of Flow per Acre	8.25 ft^3/acre
Total Rainfall	0.4 inches
Total Volumetric Rainfall	938 ft^3
Runoff Ratio	0.06

Table 2.5. Summary of Four Different Flow Events Recorded on the Vigil 1 Subwatershed during the 2009 Sampling Period

Vigil 1	7/26/2009	9/5/2009	9/9/2009	9/17/2009
Flow Start	22:20	16:50	14:25	6:30–8:05
Flow Stop	22:50	17:30	14:55	7:40–8:25
Peak Stage	0.140 feet	0.168 feet	0.169 feet	0.158 feet
Peak Flow	0.047 cfs	0.064 cfs	0.064 cfs	0.058 cfs
Flow Duration	30 min	40 min	30 min	90 min
Total Volume of Flow	55.5 ft^3	99.9 ft^3	80.7 ft^3	233 ft^3
Watershed Area	0.68 acres	0.68 acres	0.68 acres	0.68 acres
Volume of Flow per Acre	82 ft^3/acre	147 ft^3/acre	119 ft^3/acre	343 ft^3/acre
Total Rainfall	0.56 inches	0.76 inches	0.59 inches	1.03 inches
Total Volumetric Rainfall	1,382.3 ft^3	1,876 ft^3	1,456.4 ft^3	2,542 ft^3
Runoff Ratio	0.04	0.05	0.06	0.09

Based on the height of water recorded, the flow can be determined, as can the total volume of water leaving the watershed. Figure 2.32 is a hydrograph from the Chilili plot 1 subwatershed showing a flow event with indicators of when the event started and stopped. The drainage area feeding into each flume has been delineated, and the acreage of each watershed can be seen in Table 2.1 above. Information was then controlled for precipitation, which was accomplished by comparing the flume data with those data downloaded from the WatchDog weather stations installed near each flume. These data also provide an indication of the ratio between total volume of precipitation and total volume of runoff (the rainfall/runoff ratio).

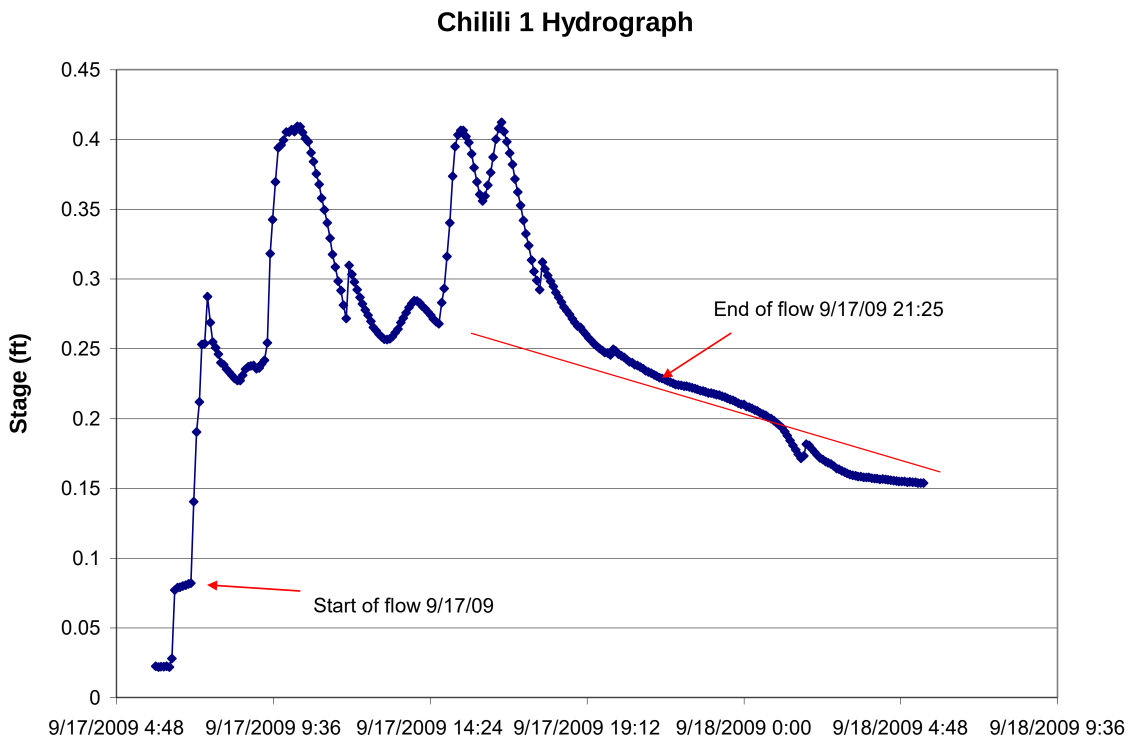

Figure 2.32. Hydrograph showing a flow event on Chilili subwatershed 1 on September 17, 2009.

Once enough data become available, statistical differences in runoff ratios between treatments and controls can be analyzed. Forest thinning is scheduled to be conducted in early 2010 with the preliminary analysis of the differences among sites scheduled to begin late in 2010.

A widespread rain storm event took place on September 16 and 17, 2009, which dropped an average of nearly 2 inches of rain over the eastern slopes of the Manzano Mountains. The precipitation amounts varied across the sites (Table 2.6). Due to the unique nature of each site, not all flumes recorded flow. The largest and longest flow events were seen at Chilili site plot 1; however, since the rain gauge was not recording during this event, it is impossible to say how much precipitation fell on site causing these flows. What is known, however, is that this flow event lasted over nine hours and resulted in a total volume of flow of nearly 8,000 ft^3. This storm event occurred during the fall sampling period, allowing us to take photographs of this unique hydrologic event. Figure 2.33 and Figure 2.34 show before and after pictures of overland flow occurring at the Vigil site. Figure 2.35 shows a normally dry arroyo flowing at bank full at the Vigil site, while Figure 2.36 shows the Bouton sites during the storm event. Notice the flow is sediment laden, which means high levels of surface or channel erosion was occurring on the surrounding landscape.

Table 2.6. Precipitation Amounts Seen across the Sites during the Two-day Storm Event on September 16–17, 2009

Site	September 16 Rainfall (inches)	September 17 Rainfall (inches)	Two-day Total	Flow Event Recorded
Kelly 1	0.68	0.71	1.39	No
Kelly 2	0.68	0.69	1.37	No
Vigil 1	0.31	1.62	1.93	Yes
Vigil 2	0.37	1.95	2.32	No
Wester 1	0.67	1.76	2.43	No
Wester 2	0.67	1.76	2.43	Yes

Figure 2.33. The two-day storm event on September 16–17, 2009, caused high flows to occur at the Vigil site, which recorded nearly 2 inches of rain over the course of 36 hours.

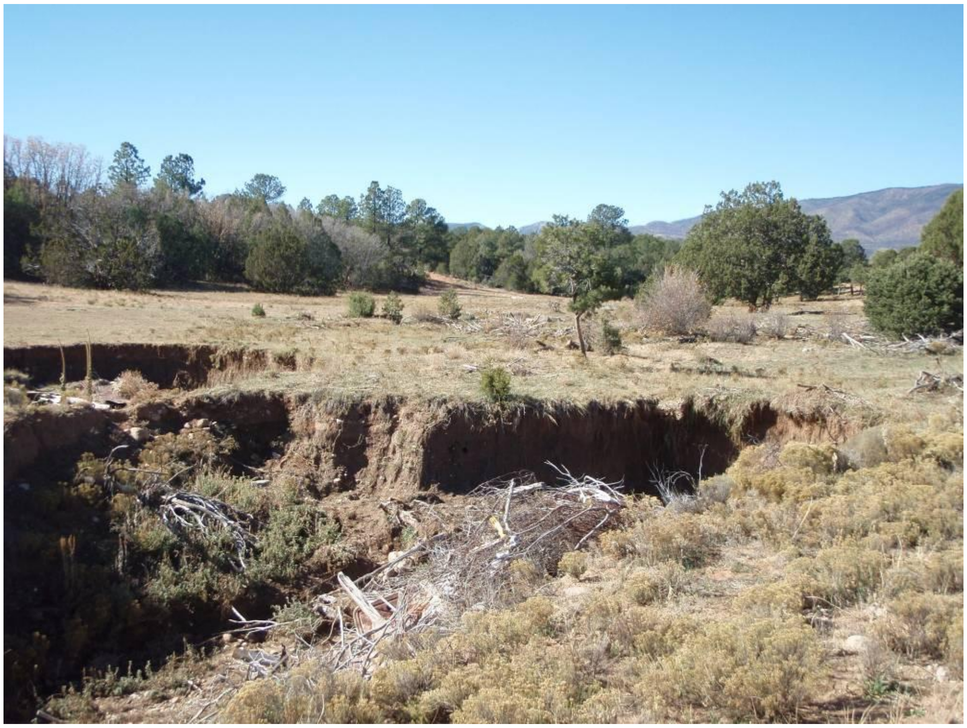

Figure 2.34. Photo taken in November 2009 at the Vigil site showing the once-raging arroyo as a dry headcut.

Figure 2.35. A normally dry arroyo flows bank full at the Vigil site during the storm occurring on September 17, 2009.

Figure 2.36. Overland flow and erosion occurring at the burned Bouton site, which received more than 1.8 inches of rain on September 16–17, 2009.

All of the Parshall flumes were functioning properly during the 2009 season except for the transducer located at Vigil site plot 2. The transducer seemed to be recording properly; however, when the analysis of the flow was conducted, it was clear that the readings were erroneous and could not be trusted. Further consultation with the project hydrologist confirmed these findings; therefore, the transducer was replaced in order to proceed with data acquisition. There was also an issue at the Bouton site, which did not record any flow events from the storm because the channel going into the flume was blocked due to off-road vehicle traffic near this control section. SWCA personnel cleared the channel, and the flume returned to good working order.

2.7 VEGETATION

For details regarding the research questions, monitoring protocols, and plot design for the vegetation monitoring, as well as a full literature review, please refer to the 2008 Monitoring Plan (SWCA 2008).

2.7.1 REPEAT PHOTO POINTS

Repeat photo points provide a visual means for qualitatively assessing change in woody and herbaceous vegetation over time, and repeat photographs are useful to help interpret quantitative vegetation measurement data from the same locations. Permanent photo points were established on each of the three 10 × 30–m (33 × 98–foot) vegetation and soils measurement subplots for a total of three repeat photographs taken at each of the eight study plots (24 photos in all). The first baseline photographs were taken in 2008. Repeat second year photographs were again taken in

2009. An example of those repeat photographs comparing the west vegetation subplot of plot 1 and the Vigil site 2008 and again in 2009 is shown in Figure 2.37. These photographs show little change in vegetation composition and structure between the two years.

a.

b.

Figure 2.37. Repeat photographs of the Vigil piñon/juniper site, west vegetation subplot photographed in a. fall 2008, and b. fall 2009.

2.7.2 HERBACEOUS VEGETATION

An updated list of all plant species found at each of the four study sites is presented in Appendix A. At this time, we are still identifying some plant species that we could not identify in the field, but voucher specimens were collected and have been assigned temporary code names. We anticipate completing these identifications in early 2010 and will update the species lists, data, and data analysis for herbaceous vegetation once those identifications are complete.

Vegetation canopy cover was measured as relative values by species on a continuous line-intercept transect across each vegetation and soils monitoring subplot, and as absolute cover per square meter on vegetation quadrats on each subplot. Figure 2.38 shows overall herbaceous vegetation cover averaged over three 30-m (98-foot) transect lines from each of the four paired study plots, measured in fall 2009. We will continue to assess differences in vegetation cover between paired study plots, and ultimately we will examine differences in vegetation based on life form, life history, and certain dominant species relative to forest thinning treatments.

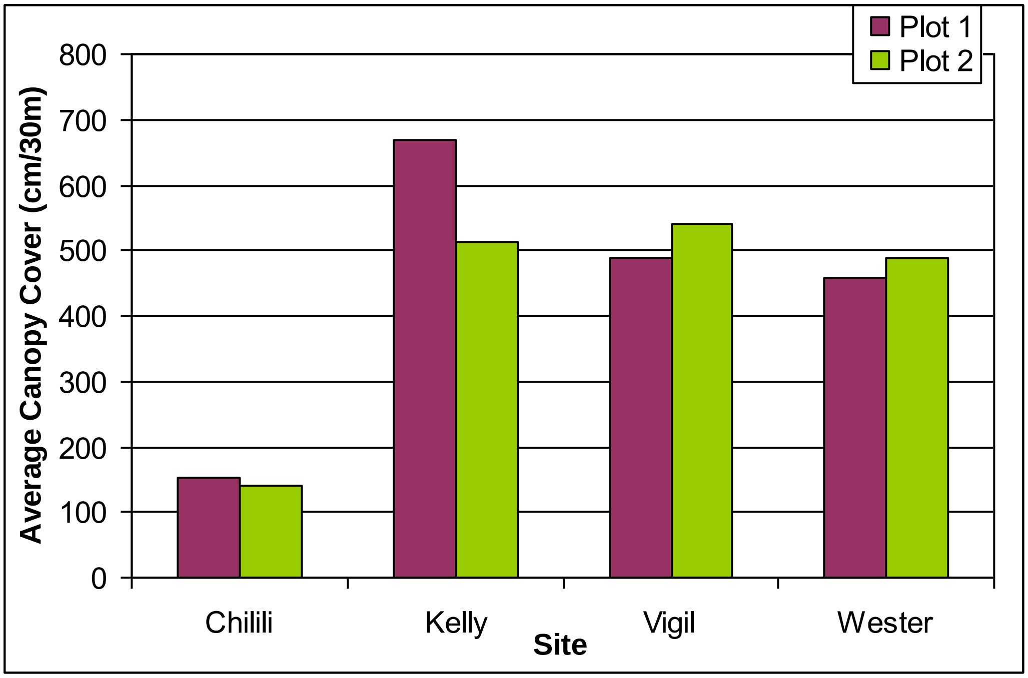

Figure 2.38. Linear measurements (cm/30 m) of herbaceous vegetation canopy cover averaged over three 30-m transect lines measured at each of the paired study plots in 2009.

2.7.3 VEGETATION STRUCTURE

Vegetation vertical canopy structure was measured on each of the four vegetation and soils subplots. The method was adapted from Herrick et al. (2005) and consisted of a 2-m-long (6.5-foot-long), 5-cm-diameter (2-inch-diameter) white Polyvinyl chloride (PVC) pipe pole partitioned into three different 2-m (6.5-foot) height layers, each with continuous 10-cm (4-inch) black/white increment markings (Figure 2.39). The 2-m PVC measurement pipe was partitioned into four different vertical 0.5-m segments or heights above the ground surface: segment one = 2.0–1.5 m, segment two = 1.5–1.0 m, segment three = 1.0–0.5 m, and segment four = 0.5–0.0 m above the ground surface. An observer recorded vegetation canopy obstruction of the black and white marked areas on the pole, while another person held the pole vertical at three locations across the center line of each 30-m (98-foot) vegetation and soils monitoring subplots, one reading at 10 m (33 feet), one at 20 m (66 feet), and one at 30 m (98 feet). The observer was located 10 m (33 feet) toward the center of the plot from the pole for each canopy measurement. An overall visual obstruction average score was then calculated for each segment of the pole over each of the three lines per subplot, and an overall average score for each segment was then calculated for each plot. Scores for the Kelly and Wester plots are shown in Figure 2.40. Vertical vegetation structure at all four segments was similar between paired plots at the Kelly piñon/juniper site, and between the plots at the Wester ponderosa pine site. Monitoring vertical vegetation structure profiles is not only important for assessing wildlife habitat, but also for fire fuels structure.

Figure 2.39. Photograph of vegetation structure pole used to quantify vertical vegetation canopy structure (photograph taken in 2008).

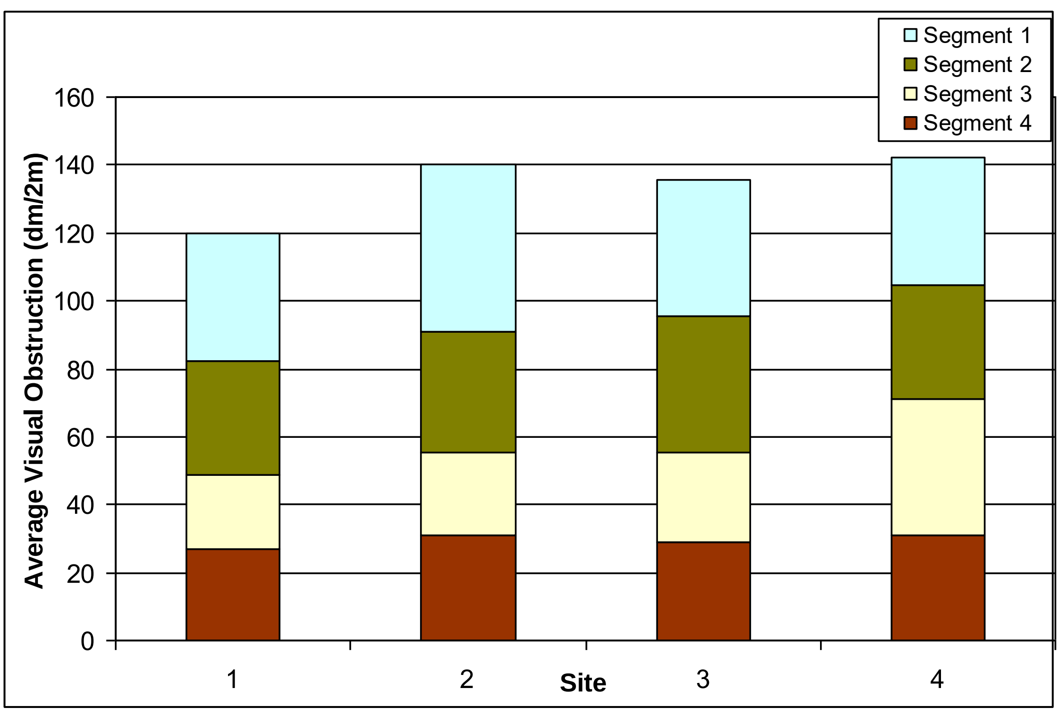

Figure 2.40. Average visual obstruction values by vegetation foliage from the Kelly piñon/juniper and Wester ponderosa pine study plots measured in 2009.

2.8 TREES

Tree monitoring measurements in fall 2009 were limited to observations of canopy dieback, disease or damage, and live and dead status. Other tree measurements were excluded because we expected very little difference in diameter at breast height (DBH) and height compared to 2008 measurements; in the future SWCA will conduct these measurements every three years.

In order to prepare for the thinning treatment in early 2010, SWCA personnel with assistance from Lawrence Crane (New Mexico State Forestry) carried out measurements of basal area on each thinning plot for all species of trees combined (Figure 2.41). The basal areas were measured using the cruisers crutch method (Avery and Burkett 2001) and a basal area factor of 10 and 8 to 10 random points for each plot. Figure 2.41 illustrates that the basal areas are relatively consistent for each forest type and between the paired watersheds. Measurements of basal area will facilitate comparison between pre- and post-thinning basal area.

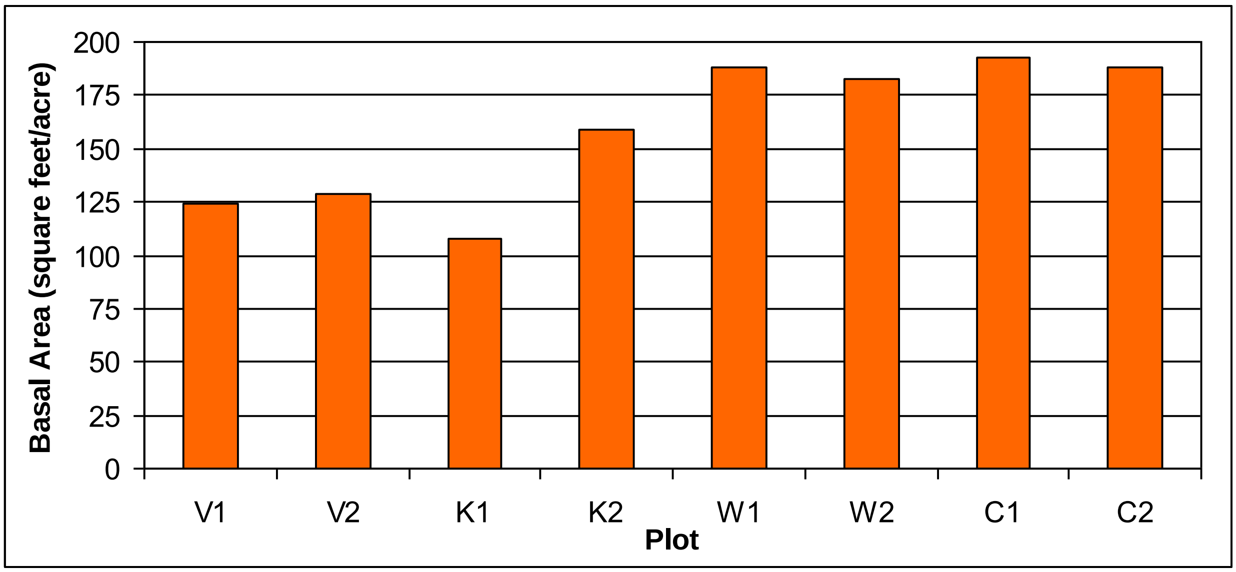

Figure 2.41. Average basal area for each thinning plot for all species of trees combined, measured using the cruisers crutch method; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

In fall 2009 SWCA randomly selected which plot in each paired watershed would be treated in early 2010 (Table 2.7). We delineated the treatment boundaries for each treatment plot in preparation for thinning.

Table 2.7. Treatment Designation for All Plots (with Basal Area Totals)

Site	Treatment or Control	Average Basal Area (square feet/acre)
Chilili 1	Treatment	192.5
Chilili 2	Control	188.3
Vigil 1	Treatment	123.8
Vigil 2	Control	128.8
Wester 1	Treatment	188.3
Wester 2	Control	182.9
Kelly 1	Control	107.8
Kelly 2	Treatment	158.8

2.8.1 CROWN DIEBACK

Percent crown dieback is the percentage of the leafy canopy of each tree that showed signs of physiological stress (i.e., brown needles and leaves). Crown dieback could result from a number of environmental factors, for example, drought, insect attack, competition, and disease. Measurement of crown die-back is highly dependent on the time of year; as a result, efforts are made to take measurements consistently during late September to early October each year. Figure 2.42 illustrates crown dieback across all sites.

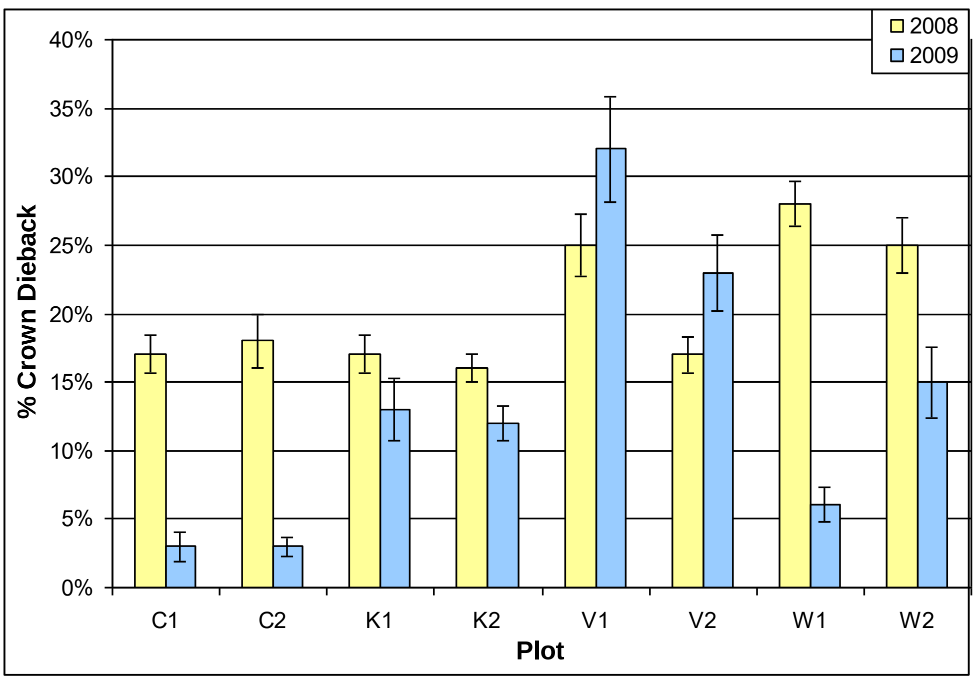

Figure 2.42. Average percent crown dieback of tree canopies for each thinning plot, 2008–2009; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

Excluding the Vigil site, all plots showed a decrease in crown dieback between 2008 and 2009 (see Figure 2.42); dieback increased at both Vigil sites over this time period. SWCA personnel observed that the piñon pine and one-seed juniper at both Vigil sites appeared to be exhibiting higher crown stress in 2009 than 2008. Furthermore, 2008 dieback levels at Vigil were higher than the piñon/juniper plots at the Kelly site. At this point in the study, it is not possible to isolate the cause of the stress, although observations were made of beetle attack on some trees at the Vigil site. Both ponderosa sites, Chilili and Wester, appeared to have significantly lower levels of dieback in 2009 compared to 2008 levels. Although crown dieback of individual trees can be highly variable across a plot based on tree size and position, the standard error bars in Figure 2.42 suggest the variation to be minimal for both 2008 and 2009 datasets.

2.8.2 TREE MORTALITY

A total of 613 trees were tagged across all watersheds in this study with species composition from ponderosa pine, piñon pine, one-seed juniper, and alligator juniper (*Juniperus deppeana*). Of these 613 trees only eight had died between 2008 and 2009, giving percent mortalities at each site of 0.48% at Kelly, 0.48% at Wester, 0.16% at Chilili, and 0.0% at Vigil. It appears that although the percent crown dieback was relatively high, particularly for the piñon/juniper sites, total tree mortality was relatively low across the sites.

2.8.3 FUELS

Fuel measurements were taken using Brown's transect protocols (Brown 1974) in fall 2009 within the four circular tree plots on each paired watershed. Please refer to the 2008 Monitoring Plan for detailed monitoring protocols and explanation of fuel class sizes (SWCA 2008). Figure 2.43 illustrates the percent cover by the various fuel classes on each thinning plot, and Figure 2.44 displays the average duff and litter depths at each plot.

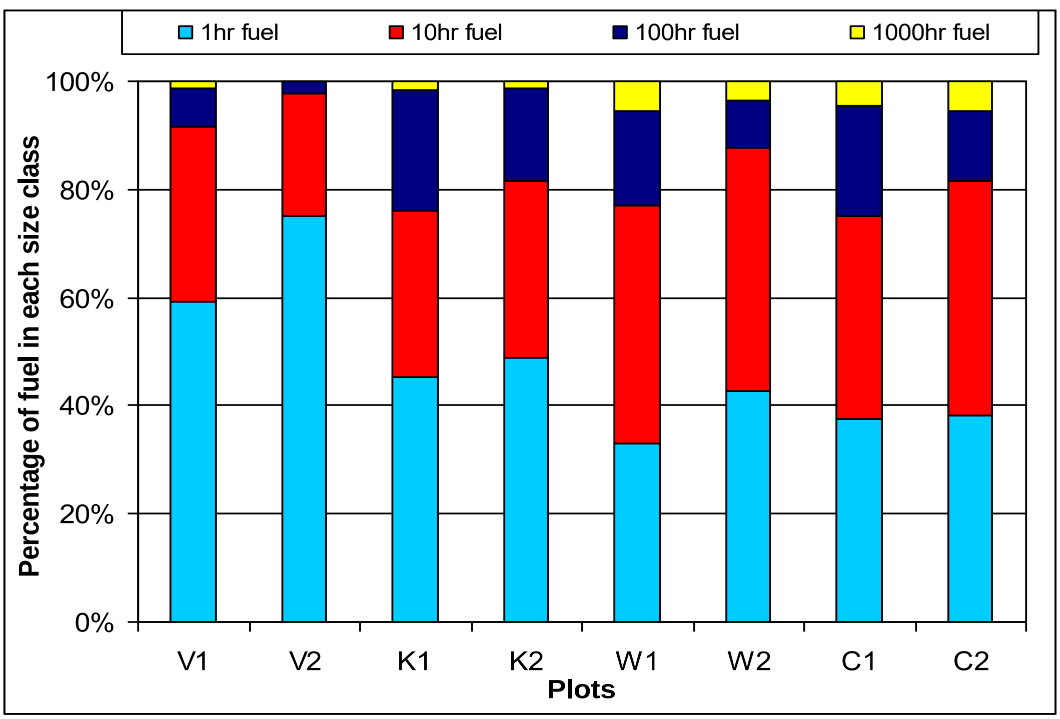

Figure 2.43. Percentage of fuel in each size class on all thinning plots; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

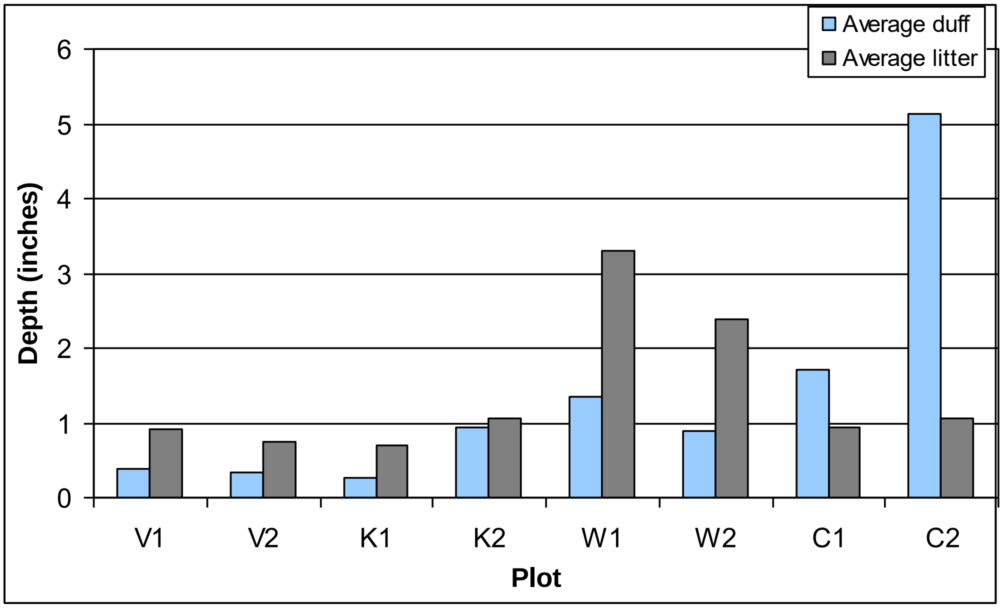

Figure 2.44. Average duff and litter depths on all thinning plots, measured in inches; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

With reference to Figure 2.43, the piñon/juniper plots tended to have a slightly higher accumulation of 1-hour fuels (fine fuels 0.0–0.6 cm [0.00–0.25 inches] in diameter) compared to the ponderosa plots. Conversely 1,000-hour fuels (woody debris > 8 cm [3 inches] in diameter) were more common at the ponderosa sites, particularly Chilili 2. Each paired plot was relatively consistent in terms of fuel loading by size class (see Figure 2.43). Figure 2.44 shows that Chilili 2 had considerably more duff than the other plots. Interestingly both Chilili plots had greater duff depths than litter, while the Wester site had greater litter than duff. The volume of litter and consequently duff found on the forest floor is related to both productivity and decomposition. The variation in litter and duff between the Wester and Chilili sites could be related to differing decomposition rates as a result of differences in elevation and moisture regimes. Decomposition has been found to be positively correlated with moisture gradient with greater decomposition on more productive sites (Keane 2008), this would explain the greater depths of duff at Chilili (a higher elevation and more productive forest) versus Wester (a lower elevation, dryer and more open stand forest). Overall duff and litter depths were higher on the ponderosa plots (Figure 2.45) than the piñon/juniper sites, which is to be expected since litter and duff cover in ponderosa pine is almost continuous across the landscape while litter and duff is isolated in patches immediately below the canopies of trees in piñon/juniper woodlands (Figure 2.46).

Figure 2.47 shows the tons/acre of woody dead and downed fuels at each site. The piñon/juniper sites had relatively low fuel loading compared to the ponderosa sites, because the piñon/juniper sites tended to have fewer large diameter woody fuels. The piñon/juniper sites exhibited greater fine fuel loading, however (see Figure 2.43), likely due to lower canopy cover that permits the growth of graminoids and forbs. Shrub cover was limited at both piñon/juniper sites. The Wester 2 plot also had low loading; this site was relatively open, and although it exhibited higher levels of 1-hour fuels (see Figure 2.43), there were less 1,000-hour fuels (Figure 2.48, see Figure 2.43) consequently lowering the tons/acre totals. In contrast, Chilili 2 has noticeably higher fuel loadings than all other sites; this is a dense plot with many more 1,000-hour fuels (many downed trees and stumps) (Figure 2.49), which raised its total tons/acre.

Figure 2.45. Continuous litter and duff cover and accumulations in an arroyo at Chilili 1.

Figure 2.46. Patchy cover of litter and duff at Vigil 1.

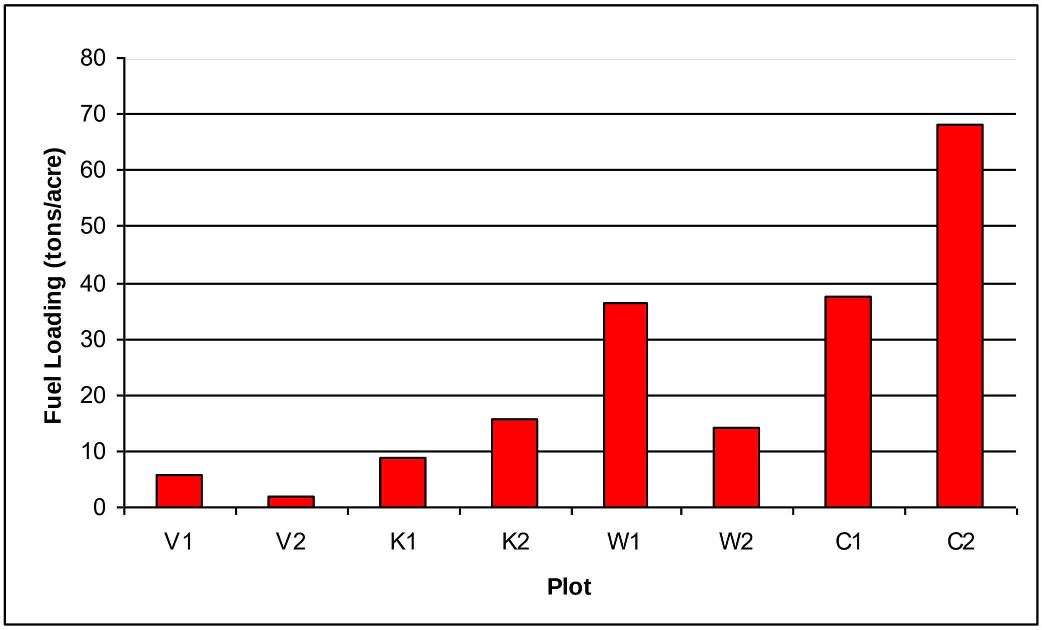

Figure 2.47. Fuel loading (in tons/acre) of dead and downed woody debris for all thinning plots; C= Chilili, K = Kelly, V = Vigil, and W = Wester.

Figure 2.48. Wester 2, showing the low fuel loading on the plot and lack of large-diameter dead and downed fuels

Figure 2.49. Chilili 2, showing high fuel loading with evidence of large diameter dead and downed fuels.

Fuel measurements will be repeated in fall 2010 following treatment at each plot to determine changes to fuel loading as a result of thinning.

2.9 WILDLIFE

Birds and small mammals are being monitored in order to determine if forest thinning affects native wildlife species. Both birds and small mammals were recorded from separate 50 × 50–m (164 × 164–foot) wildlife study plots that are immediately adjacent to each of the two vegetation and soils monitoring study plots at the four study sites. Birds and mammals were measured in late spring (May) and early fall (September/October) 2009 for three consecutive days on each study plot.

2.9.1 BIRDS

The species composition and relative abundance of birds on all study plots were recorded by observing birds by point counts from one location at the center of each wildlife study plot. Each point count was conducted for 20 minutes at dawn for three consecutive mornings on each study plot in both spring and fall. Spring counts are intended to assess breeding bird use of the forest and woodland habitats, and fall counts are intended to assess migratory bird use of the same habitats. Many of the bird observations were based on hearing songs and calls and identifying those to species. Additionally, visual observations were often recorded. A list of all bird species observed across the four study sites and counts of individuals are presented in Appendix B. We encountered a total of 40 bird species from all of the study sites.

The total numbers of birds observed during the spring and fall counts across the four sites and paired plots in 2009 are shown in Figure 2.50 and Figure 2.51. Numbers of birds were similar between the paired plots at each site during both seasons. More birds were recorded at the Chilili and Vigil sites in spring than in fall, while the opposite pattern was found at the Kelly and Wester sites.

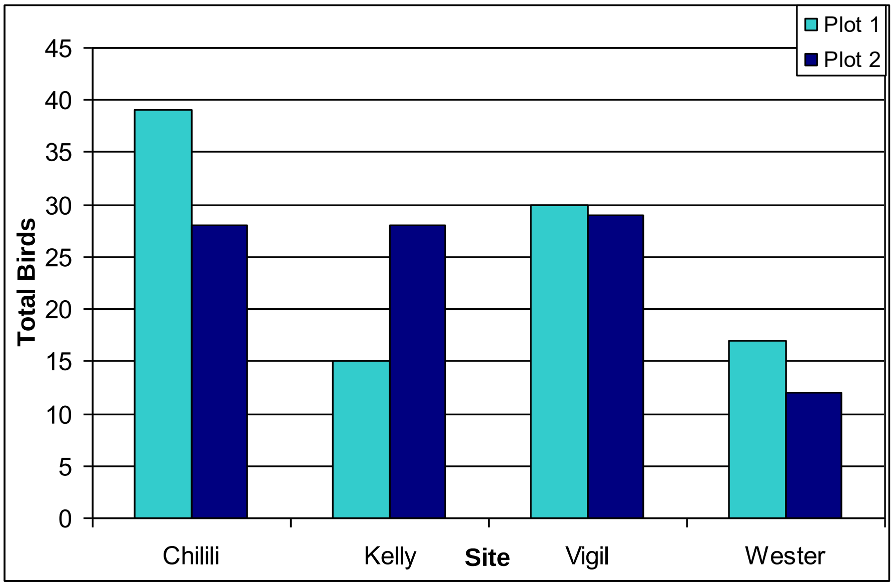

Figure 2.50. Numbers of birds observed in spring 2009 from point counts.

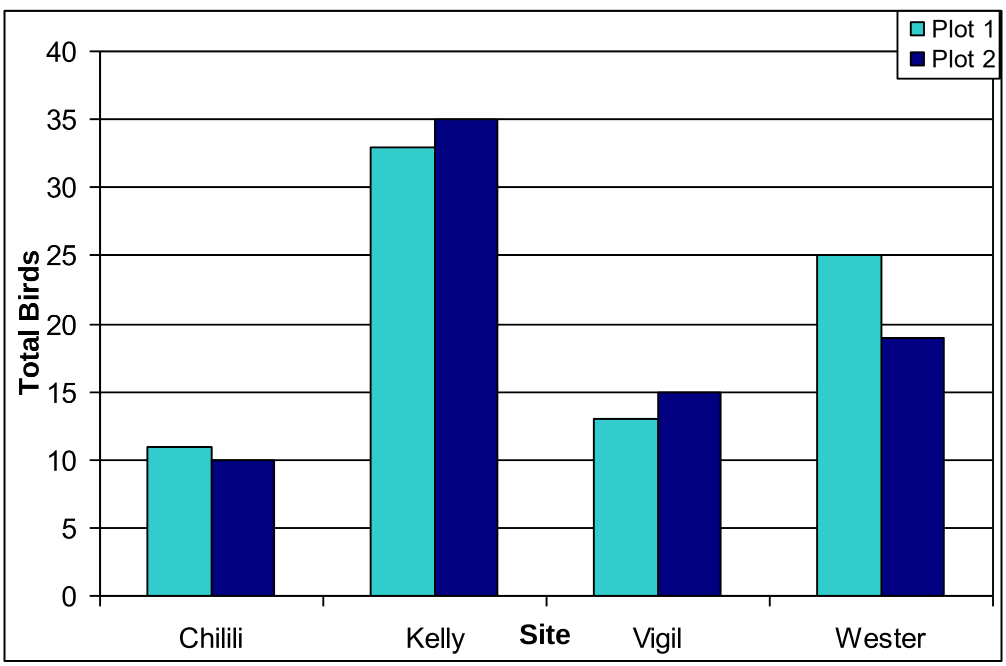

Figure 2.51. Numbers of birds observed in fall 2009 from point counts.

Figure 2.52 provides an example of the comparative total numbers of individuals of all bird species observed from paired plots for the Wester site in fall and illustrates differences in the species composition between the paired plots. Such local differences are particularly pronounced during the fall migration period as individual birds and flocks of both transient and resident birds move across the landscape.

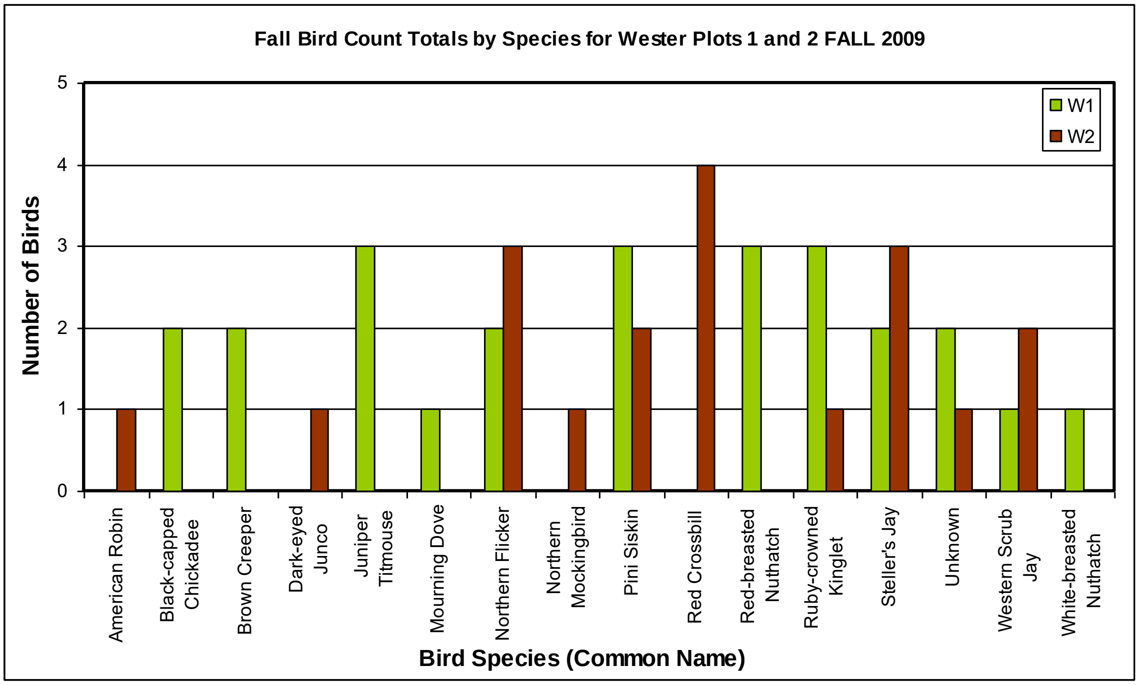

Figure 2.52. Numbers of birds observed at the Wester plots in fall 2009 from point counts.

2.9.2 SMALL MAMMALS

Small mammals (rodents) were sampled from a single 6 trap × 6 trap grid (36 traps total) of live-capture rodent traps set at 10-m (33-foot) intervals on each of the wildlife monitoring plots for three consecutive nights in spring and fall. Samples from spring and fall are useful to follow trends in adults and juveniles in order to assess breeding status and production over the year.

We encountered a total of five rodent species from all study sites (see Appendix A). The total numbers of rodents observed on study plots in spring 2009 are presented in Figure 2.53, and total numbers observed in fall 2009 are presented in Figure 2.54, showing that rodent densities were generally similar between paired plots, but varied across sites and seasonally. The Kelly site consistently had the highest rodent densities, dominated by the piñon mouse (*Peromyscus truei*), and the Chilili site consistently had the lowest densities, dominated by the deer mouse (*P. maniculatus*). Rodent densities decreased between spring and fall at the Vigil and Kelly piñon/juniper sites, and increased over the same period at the Chilili and Wester ponderosa sites. We attribute this difference to increasing populations of both deer mice and piñon mice at the ponderosa sites and a decreasing population of piñon mice at the piñon/juniper sites over the summer period. Figure 2.55 and Figure 2.56 show differences in rodent species composition between the paired plots at the Wester site in both spring and fall 2009. Note that proportions of deer mice between the plots remained the same over that time, but piñon mice shifted. Such a pattern is likely due to transient dispersing individual piñon mice through the area, relative to more stable resident deer mice. Piñon mice prefer piñon juniper habitats, while deer mice prefer ponderosa pine and mixed-conifer.

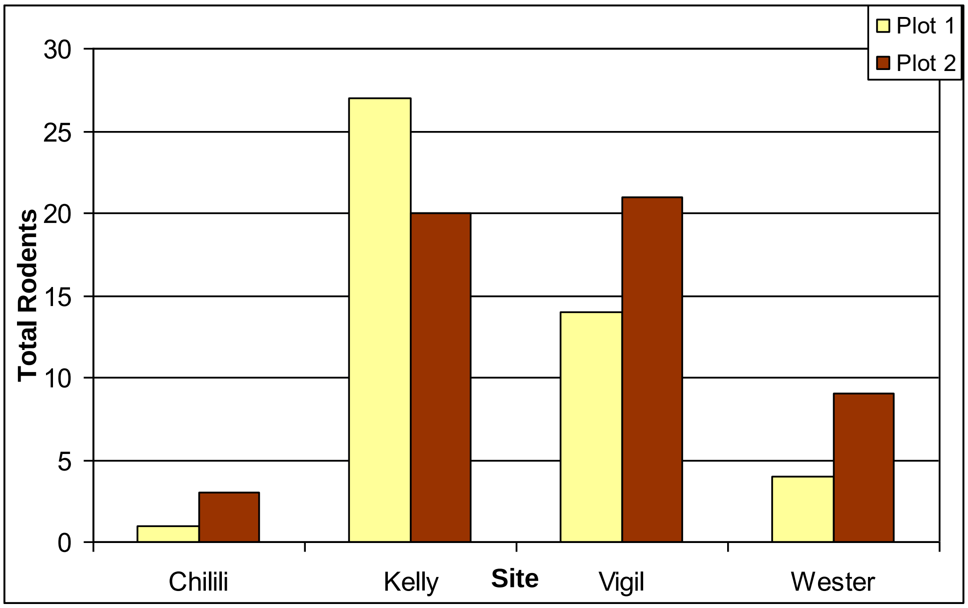

Figure 2.53. Total numbers of rodents trapped from each study plot across the four study sites in May 2009.

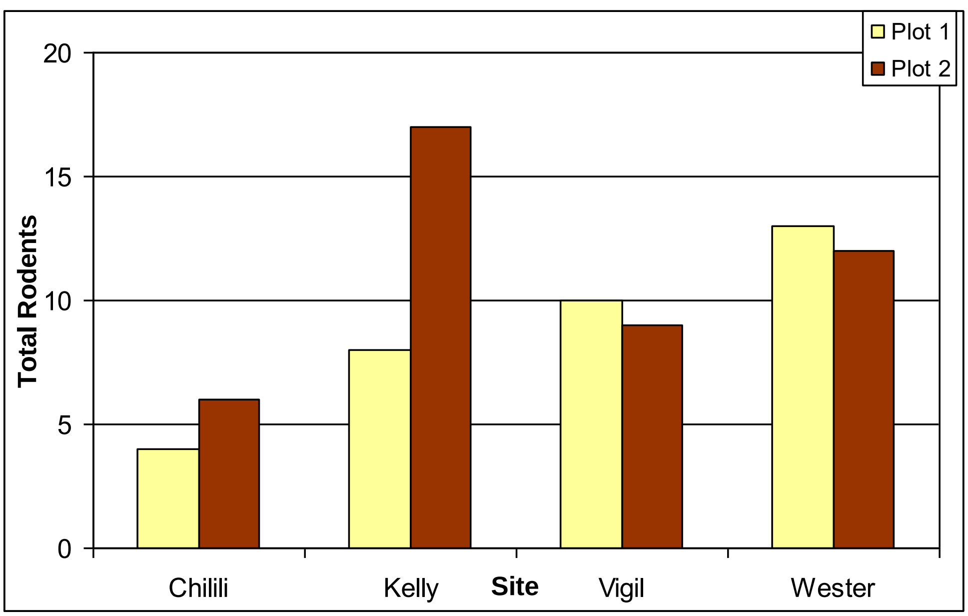

Figure 2.54. Total numbers of rodents trapped from each study plot across the four study sites in October 2009.

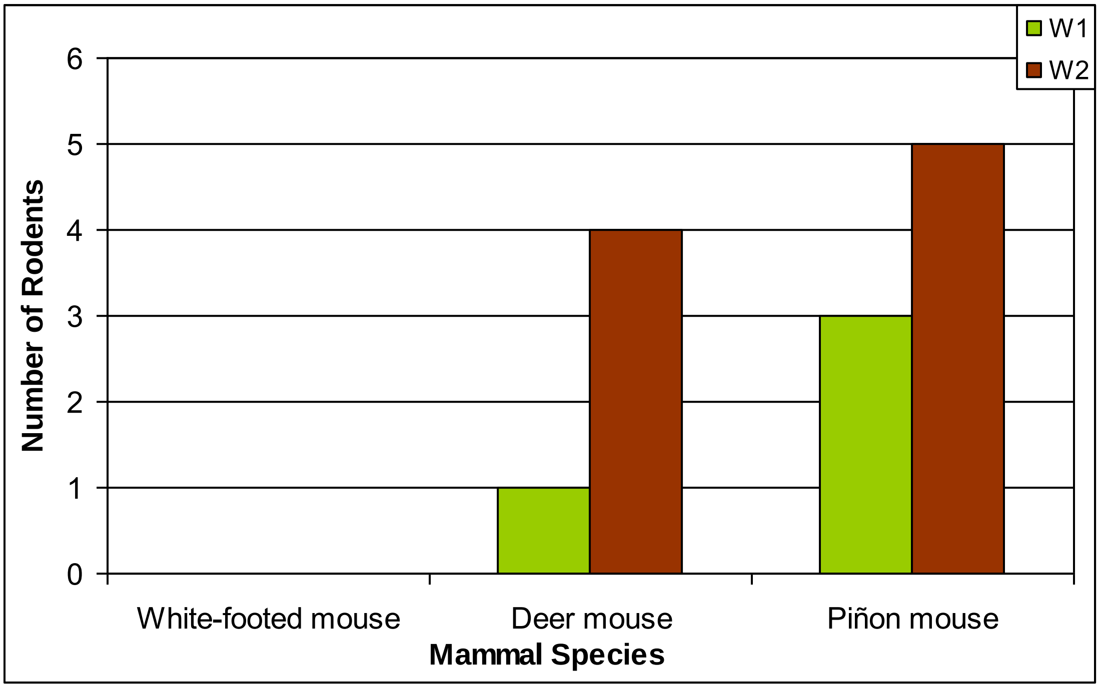

Figure 2.55. Numbers of individuals of each rodent species found on the paired study plots at the Wester site in May 2009.

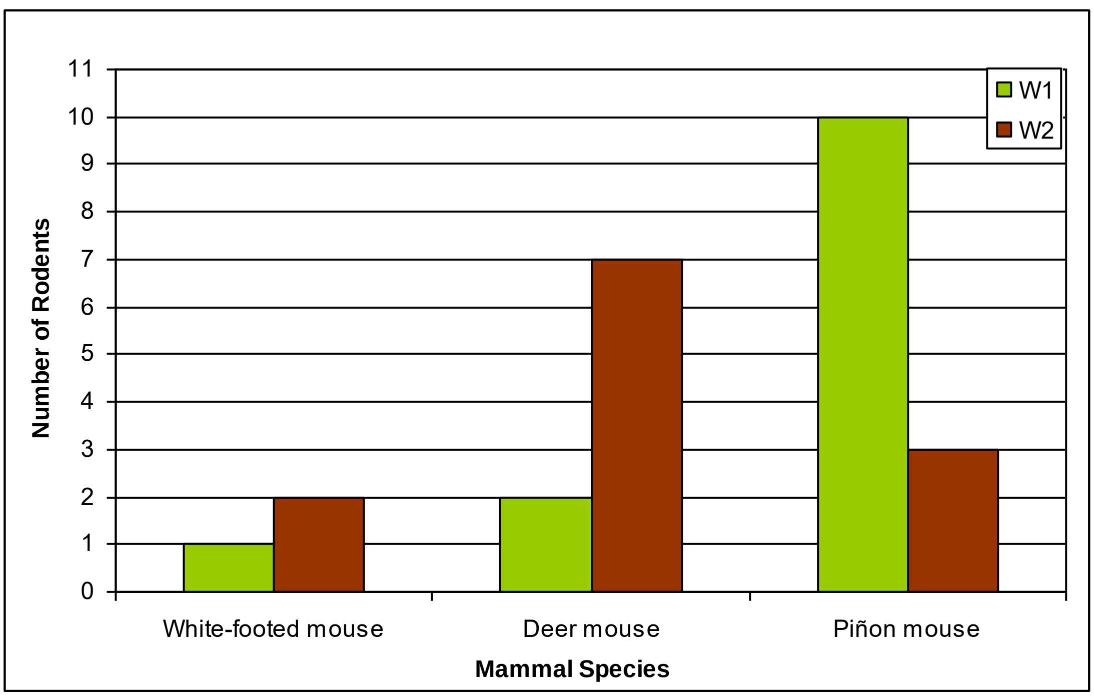

Figure 2.56. Numbers of individuals of each rodent species found on the paired study plots at the Wester site in October 2009.

2.10 FOREST THINNING TREATMENTS

One study plot of each forest thinning monitoring pair (plots 1 and 2) was randomly selected to be treated with the standard prescribed thinning treatment (piñon/juniper or ponderosa pine prescriptions) in early 2010. The minimum proposed area and boundaries for thinning treatments were determined for each of those four plots, and mapped with a sub-meter accuracy global positioning system (GPS) unit in October and November 2009. These GPS coordinates were used to produce geographic information system (GIS) maps of the proposed treatment areas and boundaries for each of the four treatment study plots (Figure 2.57 through Figure 2.60). The proposed thinning treatment areas for each of those plots includes the entire subwatershed that was previously defined and mapped in 2007, the vegetation/soils measurement plot, and the mammal and bird sampling plot, all within the area of each treatment plot to be thinned. A minimum treatment buffer area of 10 m (33 feet) was extended from the boundaries of each subwatershed and study plot to ensure that all areas from which soil, hydrology, vegetation and animal measurements are being collected are thinned on those treatment plots. Actual forest thinning treatments are scheduled to take place during early 2010, prior to spring (May/June) monitoring measurements on the study plots.

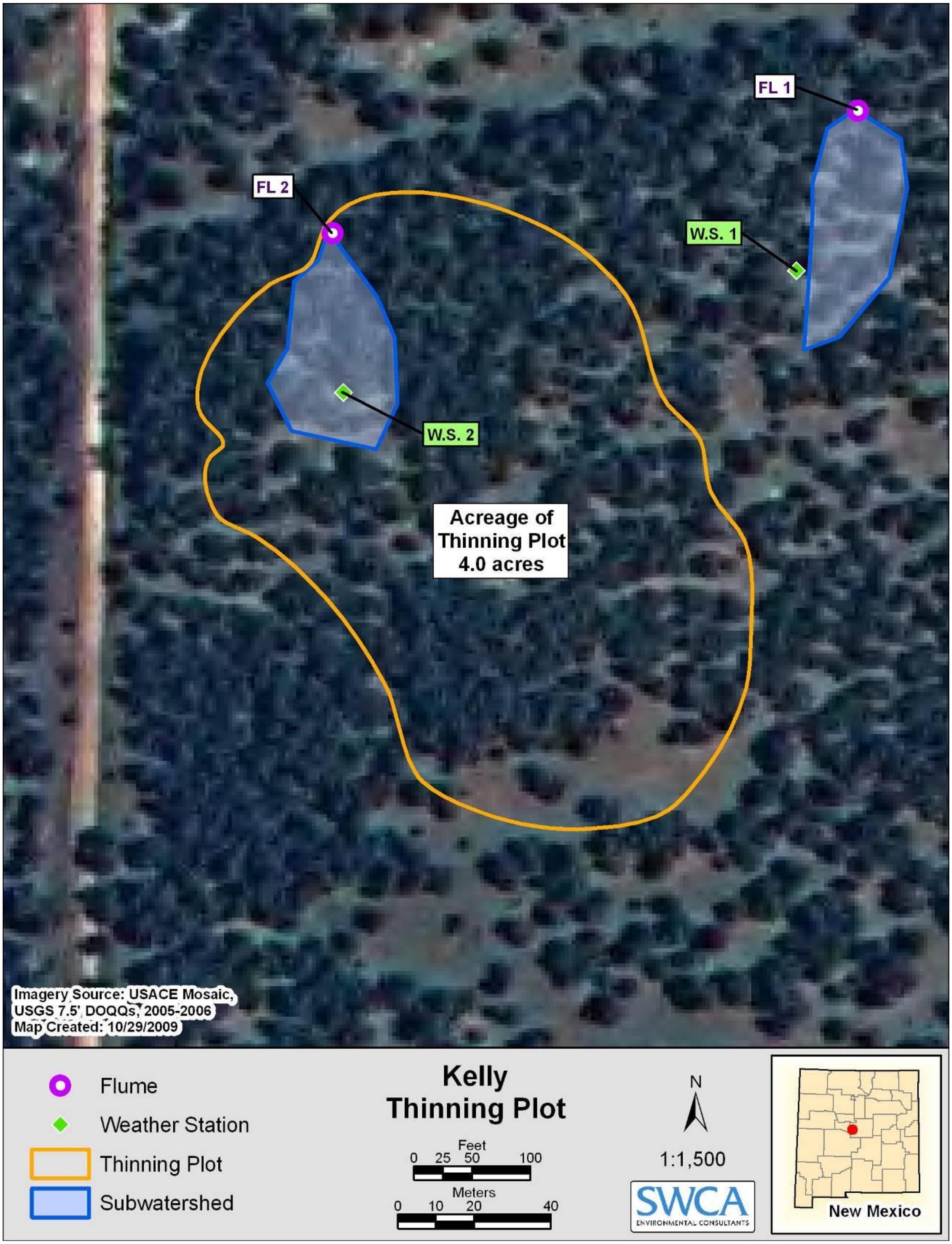

Figure 2.57. Kelly forest thinning monitoring plots showing the proposed thinning treatment boundary around plot 2.

Figure 2.58. Wester forest thinning monitoring plots showing the proposed thinning treatment boundary around plot 1.

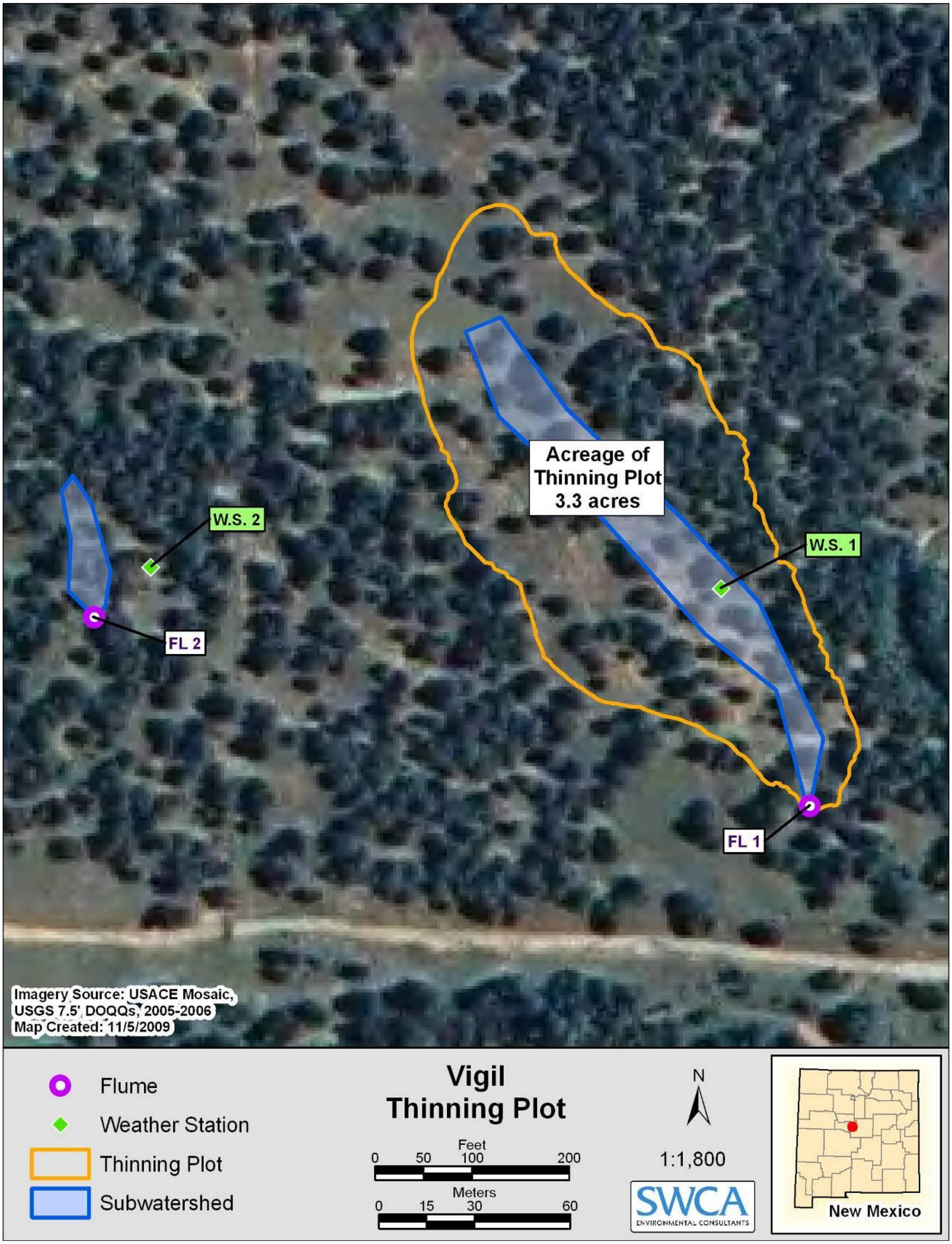

Figure 2.59. Vigil forest thinning monitoring plots showing the proposed thinning treatment boundary around plot 1.

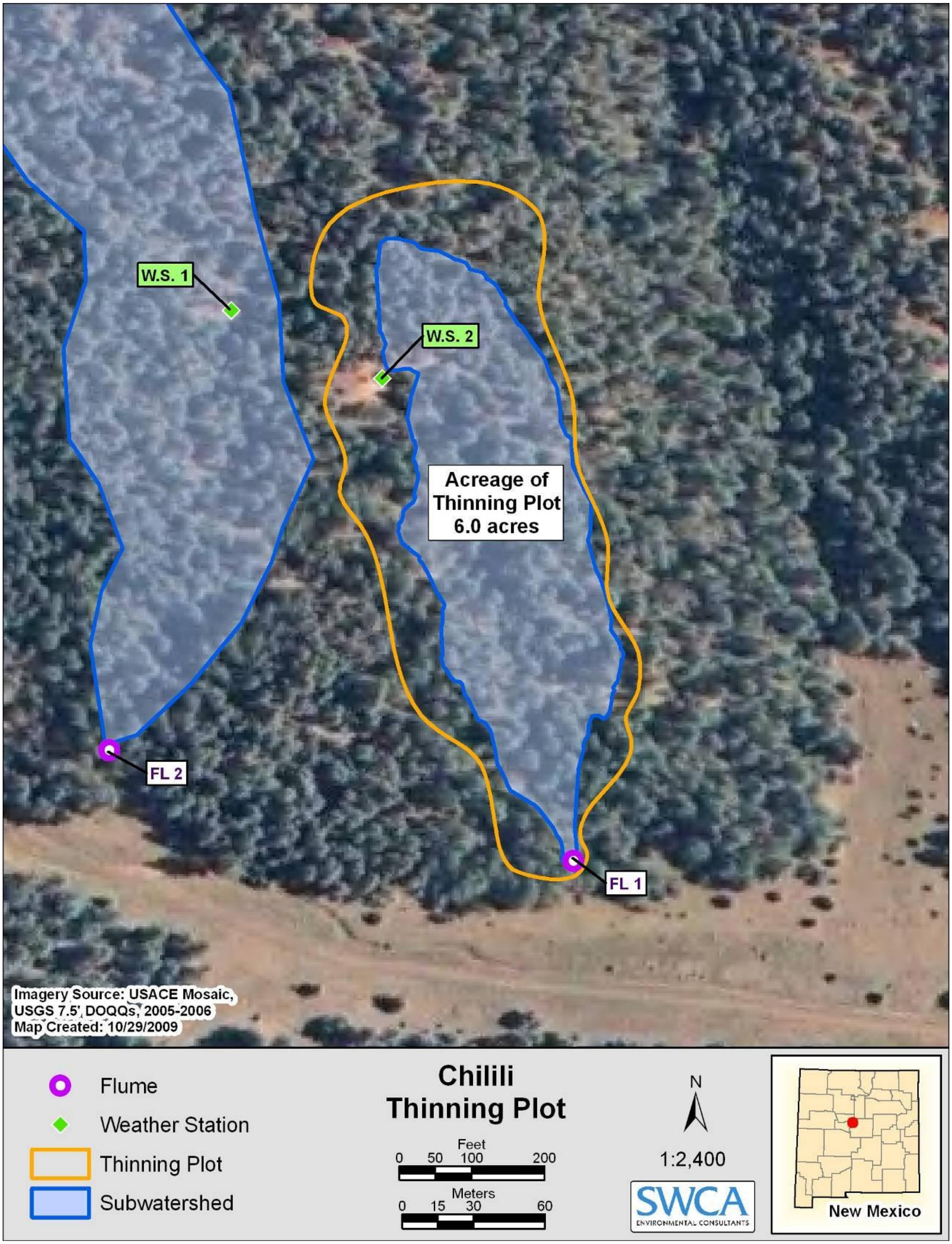

Figure 2.60. Chilili forest thinning monitoring plots showing the proposed thinning treatment boundary around plot 1.

3.0 POST-FIRE MONITORING

In April 2008 a large area of the Estancia Basin watershed was burned in the 13,709-acre Trigo fire. This burn area encompassed a large portion of the Cibola National Forest and also included 3,712 acres of private land on its eastern fringe. Since three large wildfires (Ojo Peak, Trigo, and Big Spring) have now burned a considerable portion of the eastern slopes of the Manzano Mountains the impacts of wildfire on Estancia Basin watershed health are likely significant. The Steering Committee awarded SWCA additional funding to develop and implement post-fire monitoring to evaluate wildfire impacts to Estancia Basin watershed health. The Trigo fire was chosen for the monitoring because it was the largest of the three fires and was centrally located within the study region and relative to our existing forest thinning monitoring site. The full fire monitoring plan for this project was prepared and submitted to the Steering Committee in July 2008 (SWCA 2008), and the first year of monitoring was reported in the 2008 Annual Report (SWCA 2009).

The Trigo post-fire monitoring plots were selected in Arroyo de Cuervo (Cuervo 1 and Cuervo 2) and in the Arroyo de Manzano (Manzano1) watersheds. Three low-severity (Figure 3.1) and three high-severity (Figure 3.2) plots were identified in each watershed, and three unburned plots were located across the watersheds. With the permission of landowners, the plots were selected on seven different private parcels of land: Bouton (BOU), Sanchez (SAN), Manzano Mountain Retreat (MMR), Salazar (SAL), Candelaria (CAN), Mitchell (MITT), and Neff (NEFF), totaling 21 plots for the entire study (Figure 3.3).

This was the second year of monitoring for the Trigo fire study. . Monitoring on the 21 fire plots was completed by SWCA in fall 2008 and spring and fall 2009. Please refer to the 2008 Annual Report (SWCA 2008) for background information, research questions, monitoring protocols, site descriptions, and a full literature review.

Figure 3.1. Typical low burn severity plot in the Trigo burn area.

Figure 3.2. Typical high burn severity plot in the Trigo burn area.

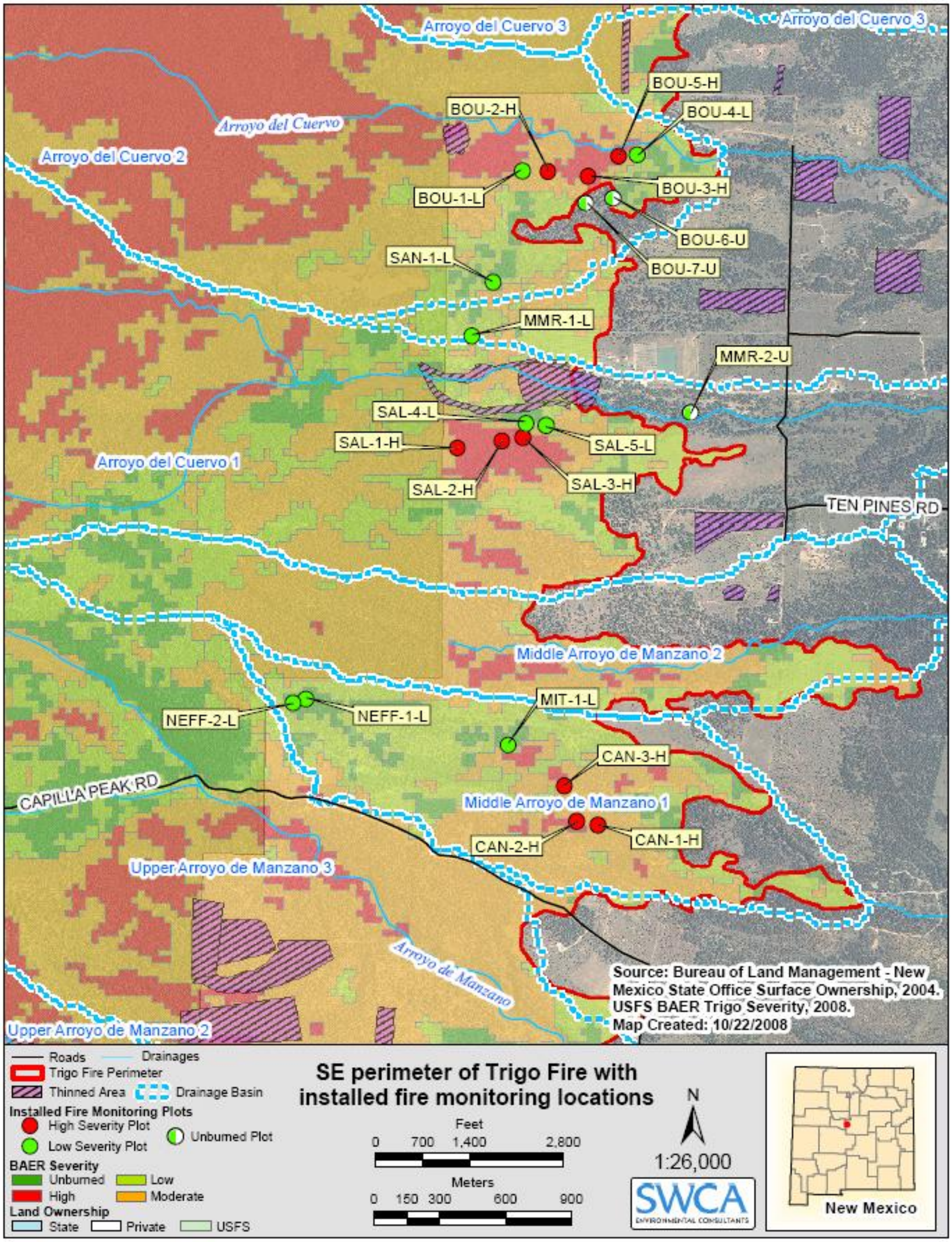

Figure 3.3. **Fire monitoring plot locations: BOU=Bouton, SAN=Sanchez, MMR=Manzano Mountain Retreat, SAL=Salazar, CAN=Candelaria, MITT=Mitchell, NEFF=Neff; H=High, L=Low, U=Unburned.**

3.1 TREES

Tree measurements were completed in fall 2009 only, and were limited to observations of live and dead status. Tree measurements such as DBH and height were not taken in 2009 because we expect very little change in these parameters on an annual basis. In the future SWCA plans to carryout diameter and height measurements every three years in the fall.

Tree monitoring involved recording live and dead status of tagged trees in order to determine tree mortality compared to 2008 levels. Observations regarding the apparent cause of mortality (other than direct fire caused mortality) were taken when possible. This included recording beetle infestation, dwarf mistletoe, and wind throw, and these data will be presented in the 2010 Annual Report. Mortality data were only collected for the low-severity plots, as all high-severity plots received 100% tree mortality. Mortality was noted in relation to the degree of scorch that each individual tree received during the fire in 2008. Figure 3.4 illustrates this relationship and the change in status of trees between 2008 and 2009. Some of the trees that were killed by the fire in 2008 had also fallen over during this period.

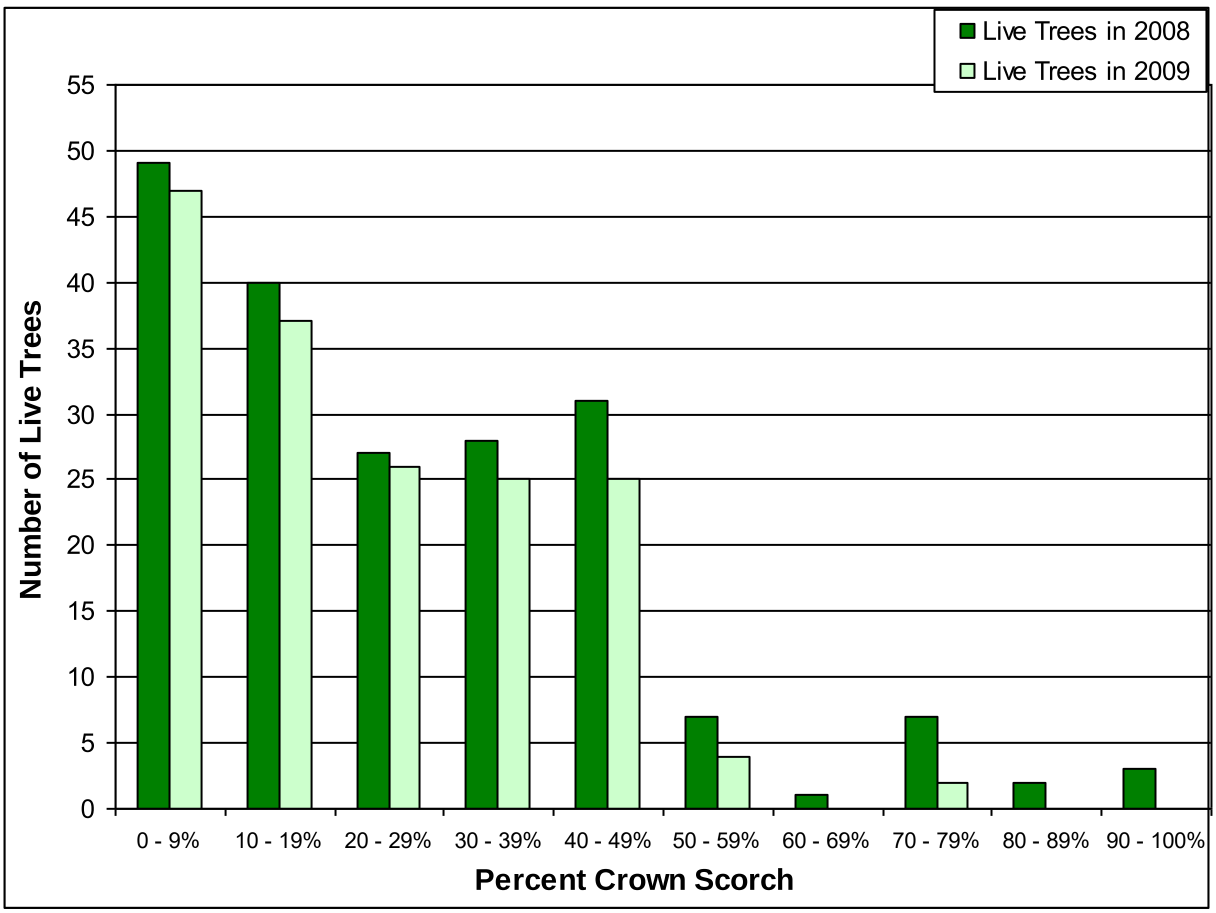

Figure 3.4. Number of live trees in relation to percent crown scorch recorded during 2008 measurements.

Figure 3.4 indicates that even if trees survived the first year after the fire, they did not necessarily survive through to 2009; 15% of the trees that were live in 2008 were recorded as dead in 2009. The greatest losses were recorded in the more severely burned trees (> 50% mortality); only two of the 15 trees in these categories were still surviving in 2009. Similar high levels of post-fire mortality have been recorded in other studies. Ffolliott et al. (2008) observes that 60% of ponderosa exposed to high-severity fire during the Rodeo-Chediski Fire (Arizona 2002) were dead two years after the event. Fowler and Sieg (2004) find that fire-related mortality was observed from one to three years post fire. The Trigo fire data also show a notable threshold scorch level (approximately 50% of the crown) past which tree survivorship is compromised (see Figure 3.4). Similar findings have been noted on other fires in ponderosa pine; Lynch (1959) notes that ponderosa trees with more than 50% crown injury suffer the most mortality. Mortality data will be collected in 2010 to determine if additional mortality occurs.

A number of trees that were standing and tagged in 2008 had fallen by the fall 2009 monitoring period. The worst-hit trees were the small diameter trees that were fully consumed by the fire and had received deep basal charring.

3.2 HERBACEOUS VEGETATION

Herbaceous vegetation measurements were carried out in fall 2008, spring 2009, and fall 2009. Dramatic changes in ground cover were observed over this time period, particularly for the high-severity plots (Figure 3.5–Figure 3.9).

Figure 3.5. Candelaria high severity (fall 2008).

Figure 3.6. Candelaria high severity (fall 2009).

Figure 3.7. Bouton 3 High West (fall 2008).

Figure 3.8. Bouton 3 High West (spring 2009).

Figure 3.9. Bouton 3 High West (fall 2009).

3.3 LINE INTERCEPT DATA

Line intercept data were taken at each plot on four 23-m (75-foot) transects, recording cover by growth form. Figure 3.10 through Figure 3.12 illustrate the change in cover type from 2008 to 2009 by severity (low, high, and unburned). In 2008, 90% of the cover along transect lines in a representative low-severity plot (Bouton low-severity plot 1) was leaf litter (see Figure 3.10). In 2009, however, leaf litter fell to 40%, similar to levels for grass cover in the same year. Forb cover and shrub cover remained minimal in both years. Bare ground was less than 1% in both years.

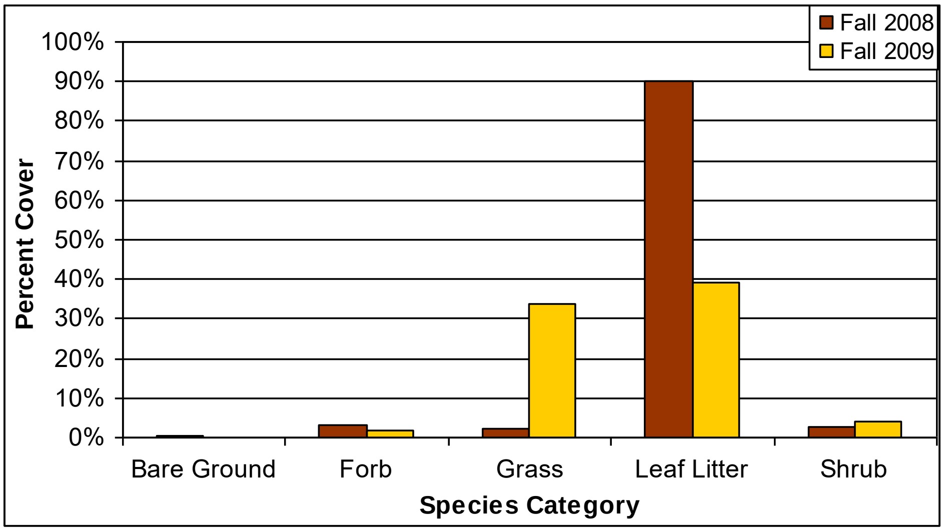

Figure 3.10. Percentage of cover by growth form for Bouton low-severity plot 1, fall 2008–2009.

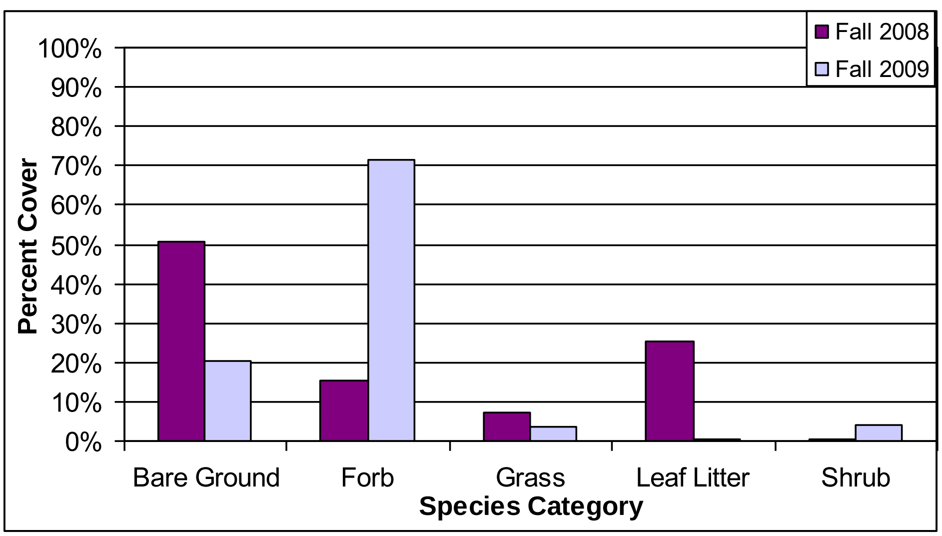

Figure 3.11. Percentage of cover by growth form for Bouton high-severity plot 2, fall 2008–2009.

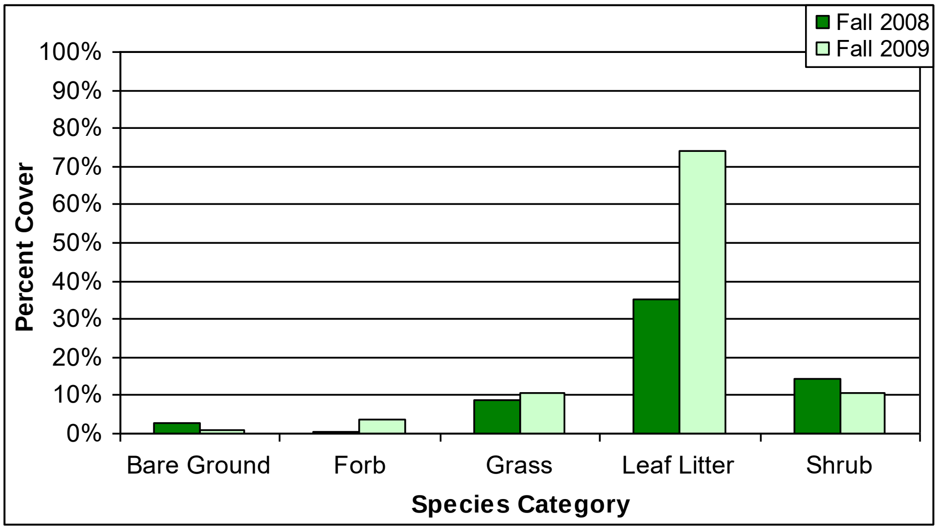

Figure 3.12. Percentage of cover by growth form for Bouton unburned plot 7, fall 2008–2009.

For the Bouton high-severity plot 2, the dominant cover along transects in 2008 was bare ground; in 2009, bare ground fell by ~30%. The dominant cover in 2009 was forb cover, which increased drastically from 2008 levels (15%–70%). Leaf litter was relatively high in 2008 but fell to just 1% in 2009. Grass and shrub levels were low in both years.

In the unburned reference plot leaf litter was the dominant cover for both years, with higher levels for 2009; bare ground and forb levels are low and grass and shrubs make up only ~10% each. The relative cover of each form in the unburned plot is similar to the low-severity plot, suggesting the low-severity plot more closely resembles natural unburned conditions. The high-severity plot exhibited abnormally high levels of bare ground and forbs compared to the reference site.

Vegetation monitoring was also completed in 2009 in the spring. Because plots were not established until summer 2008, spring measurements cannot be compared to 2008 levels. SWCA personnel will complete spring measurements in 2010 to compare the cover of spring annuals as the fire plots recolonize.

3.4 QUADRAT DATA

Quadrat data were recorded in spring 2009 and fall 2008 and 2009. Figure 3.13 through Figure 3.15 illustrate the data for both fall monitoring periods. Kruskal-Wallace statistical tests were used to assess differences. Spring data will be included in the 2010 Annual Report when spring 2010 is available for comparison.

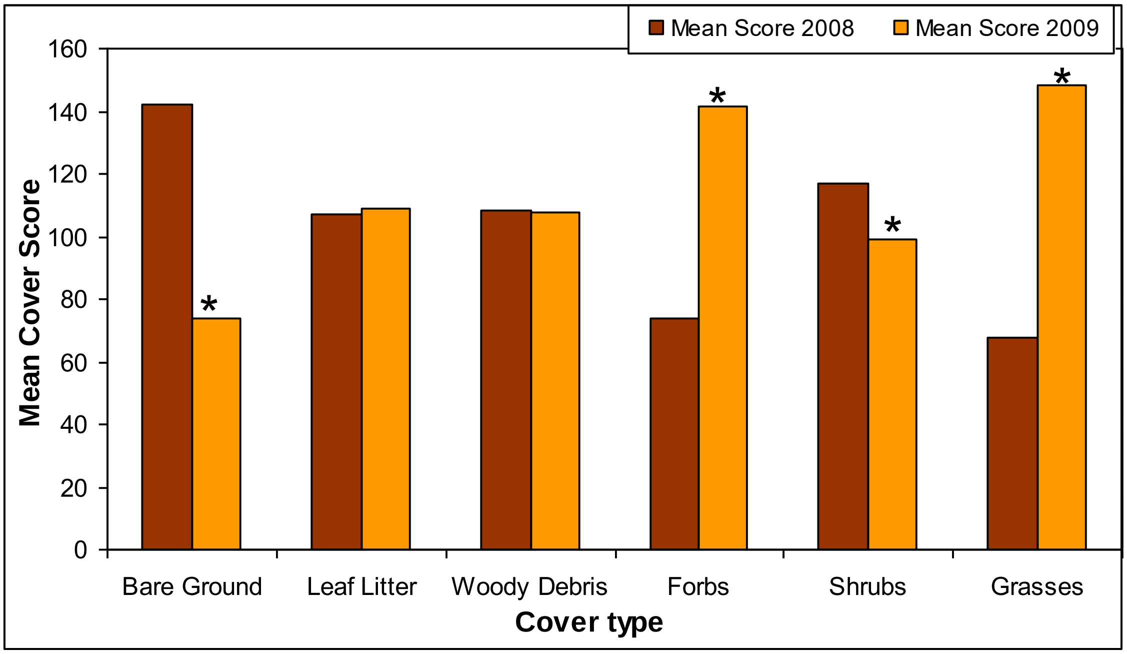

Figure 3.13. Vegetation cover in quads for all high-severity burn plots.

*Note: * denotes a significant difference between 2008 and 2009 data using the Kruskal-Wallis non-parametric test for variance.*

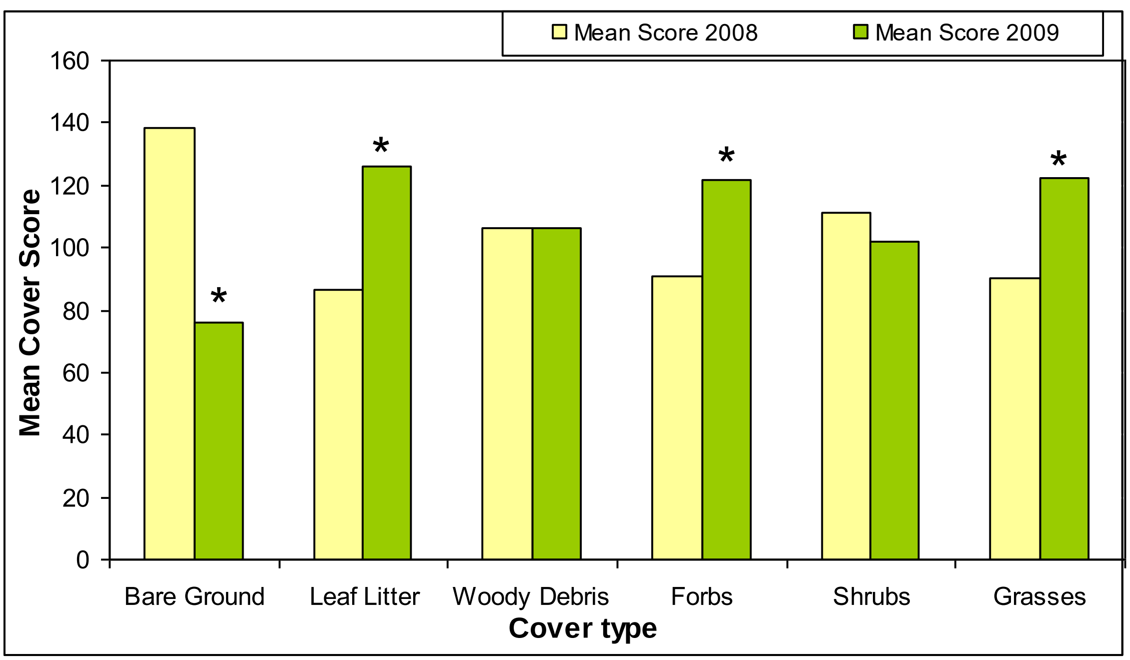

Figure 3.14. Vegetation cover in quads for all low-severity burn plots.

*Note: * denotes significant difference between 2008 and 2009 data using the Kruskal-Wallis non-parametric test for variance.*

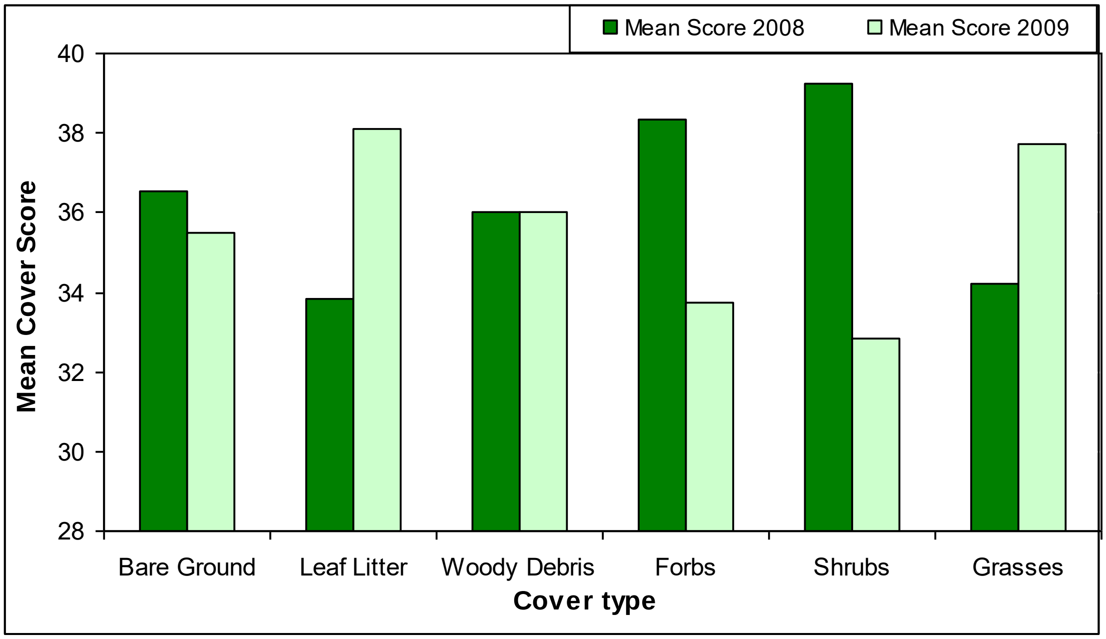

Figure 3.15. Vegetation cover in quads for all unburned plots.

*Note: * denotes significant difference between 2008 and 2009 data using the Kruskal-Wallis non-parametric test for variance.*

Figure 3.13, Figure 3.14, and Figure 3.15 above show the variation in cover by various vegetation forms between the fall measurement sessions. The high-severity plots (see Figure 3.13) reflect dominance by bare ground in 2008, which decreased significantly in 2009 (p-value: <0.0001). Conversely, forbs and grasses that were relatively low in cover in 2008 increased significantly in 2009 (forb p-value: <0.0001; grass p-value: <0.0001). In addition, the high-severity plots exhibited a significant decrease in shrub cover in 2009 (p-value: 0.0029), but leaf litter and woody debris remained constant. The low-severity plots (see Figure 3.14), which were dominated by bare ground in 2008, show a significant decrease in bare ground between 2008 and 2009 (p-value: <0.0001) and a significant increase in forb and grass cover (forb p-value: <0.0001; grass p-value: <0.0001). In addition, these plots show a significant increase in leaf litter in 2009 (p-value <0.0001), likely related to the increased herbaceous layer. The unburned plots (see Figure 3.15) reflect some variation in cover between the two monitoring sessions, including increased grass cover and decreased forb and shrub cover in 2009; however, statistical tests determined that the variation in cover types between the years is not significantly different.

Table 3.1 details a species list for the most common plants found on the fire plots. Figure 3.16 through Figure 3.21 illustrate the 10 most dominant species in quads by severity type from fall 2008 and 2009.

Table 3.1. Most Common Vegetation Species at All Fire Plots with Species Code, Common Name, and Scientific Name

CODE	Common Name	Scientific Name
ARCA	Carruth's sagewort	*Artemisia carruthii*
ARLU	white sagebrush	*Artemisia ludoviciana*
ASHU	Groundcover milkvetch	*Astragalus humistratus*
ASNU	Smallflowered milkvetch	*Astragalus nuttallianus*
BADI	Ragleaf bahia	*Bahia dissecta*
BLTR	Pine dropseed	*Blepharoneuron trichophyllum*
BOGR	Blue grama	*Bouteloua gracilis*
BRJA	Japanese brome	*Bromus japonicus*
BRYO	Bryophyte	*Bryophyte* sp.
CHFR	Fremont's goosefoot	*Chenopodium fremontii*
CHGR	Fetid goosefoot	*Chenopodium graveolens*
CHLE	Narrowleaf goosefoot	*Chenopodium leptophyllum*
CYFE	Fendler's flatsedge	*Cyperus fendlerianus*
DALA	Purple dalia	*Dalia lanata*
ELCA	Canada wildrye	*Elymus canadensis*
ERDI	Spreading fleabane	*Erigeron divergens*
ERFL	Trailing fleabane	*Erigeron flagellaris*
ERME	Mexican lovegrass	*Erogrostis mexicana*
ERRA	Redroot buckwheat	*Eriogonum racemosum*
GECA	Parry's geranium	*Geranium caespitosum*
GUSA	Broom snakeweed	*Gutierrezia sarothrae*
KOMA	Prairie junegrass	*Koeleria macranthus*
LOPE	Italian ryegrass	*Lolium perenne*
LOWR	Wright's deervetch	*Lotus wrightii*
ORMI	Littleseed ricegrass	*Oryzopsis micrantha*
PHHE	Ivyleaf groundcherry	*Physalis hederifolia*
QUGA	Gambel oak	*Quercus gambelii*
QUGR	Gray oak	*Quercus grisea*
SPAE	Alkali sacaton	*Sporobolus aeroides*
SPAN	Copper globemallow	*Sphaeralcea angustifolia*
THME	Hopi tea greenthread	*Thelesperma megapotamicum*
THPO	Tall wheatgrass	*Thinopyrum ponticum*

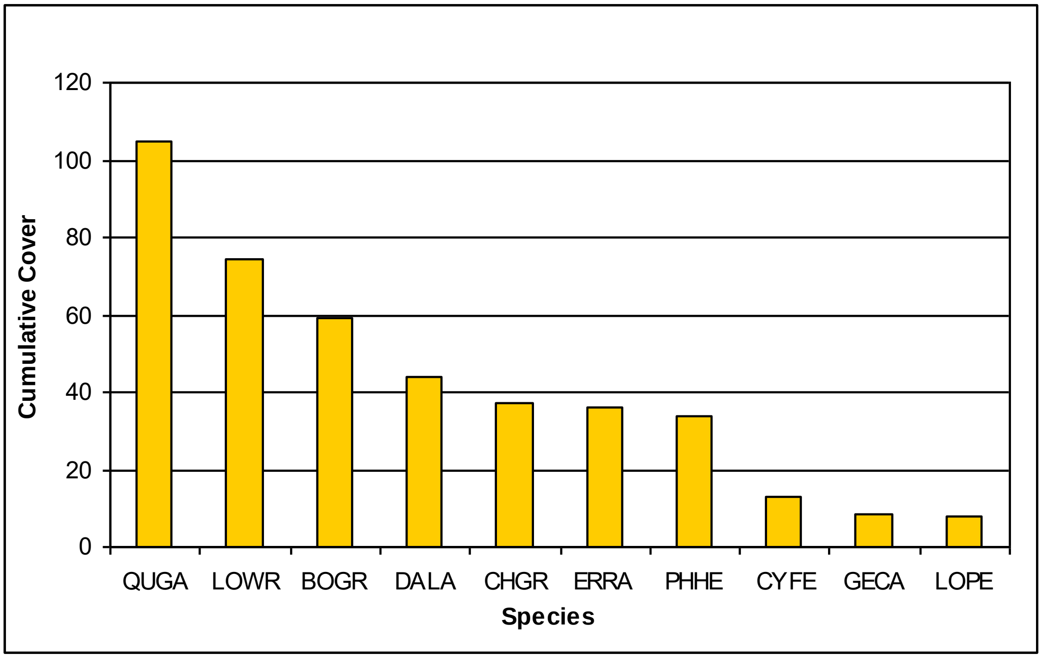

Figure 3.16. Ten most dominant species by cover on all high-severity burn plots, fall 2008.

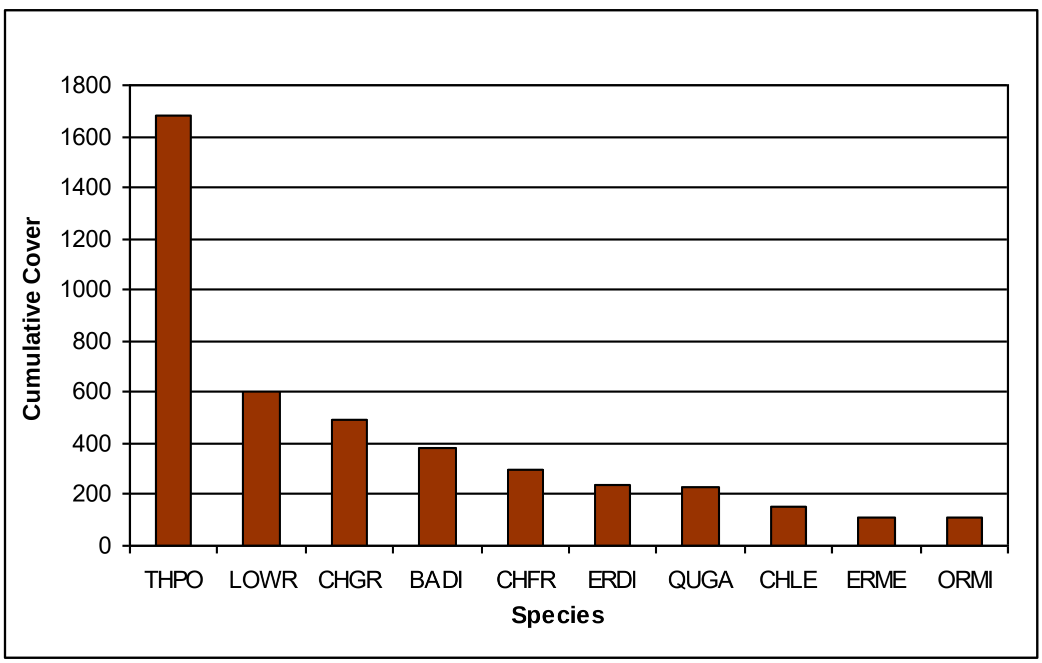

Figure 3.17. Ten most dominant species by cover on all high-severity burn plots, fall 2009.

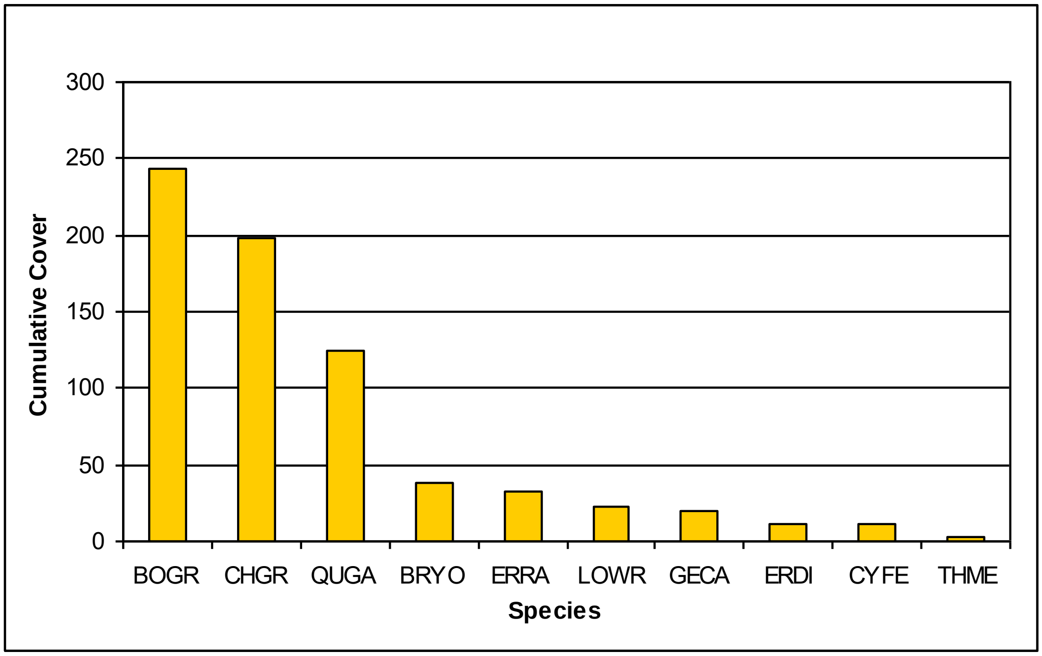

Figure 3.18. Ten most dominant species by cover on all low-severity burn plots, fall 2008.

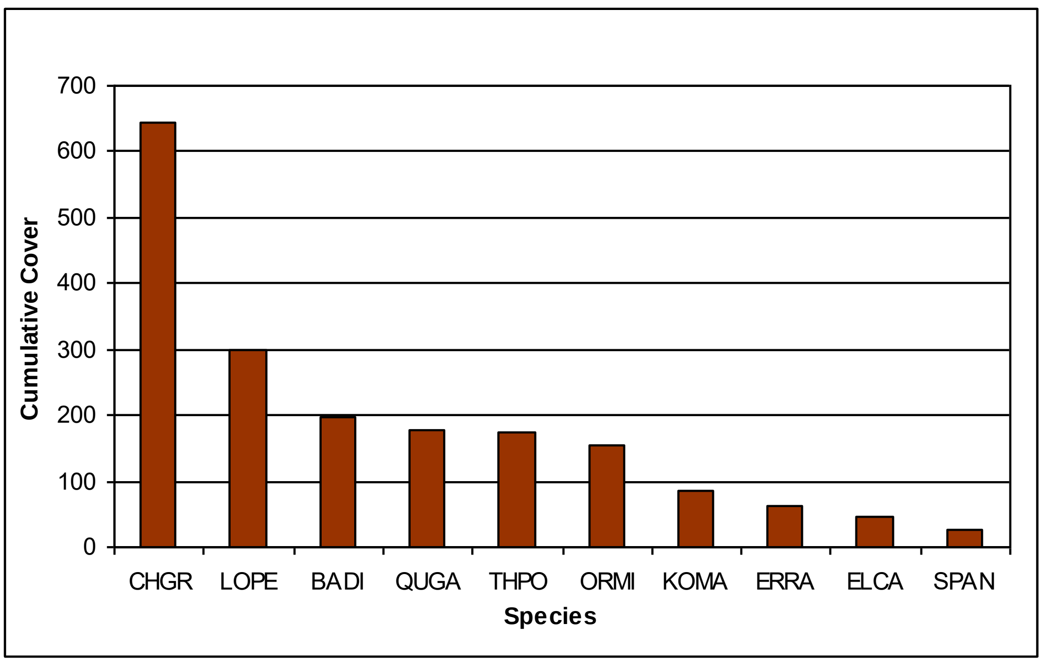

Figure 3.19. Ten most dominant species by cover on all low-severity burn plots, fall 2009.

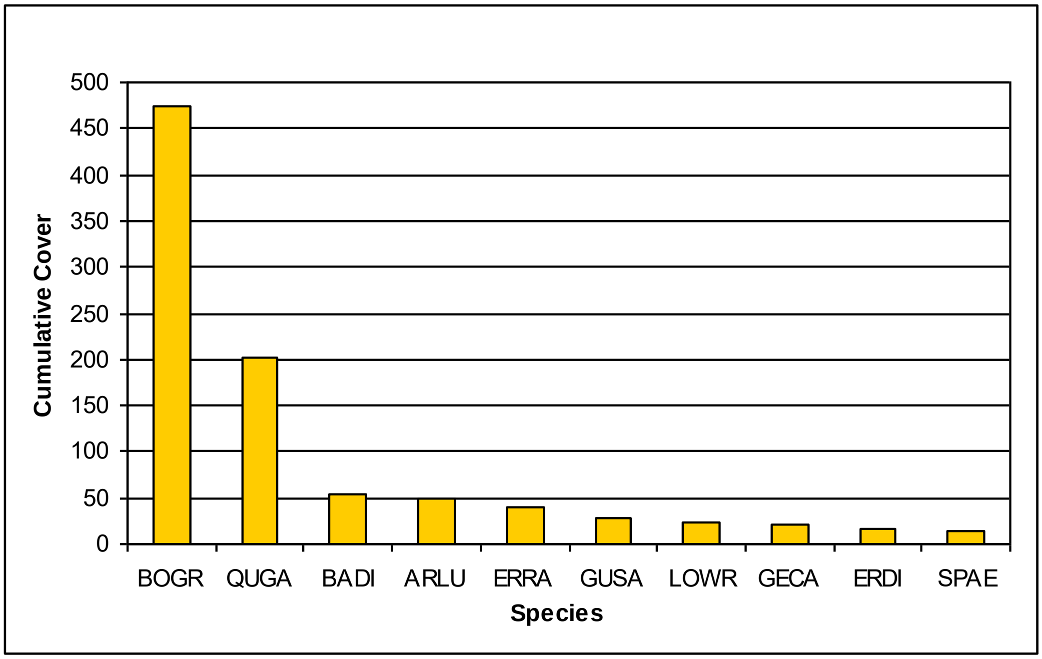

Figure 3.20. Ten most dominant species by cover on all unburned plots, fall 2008.

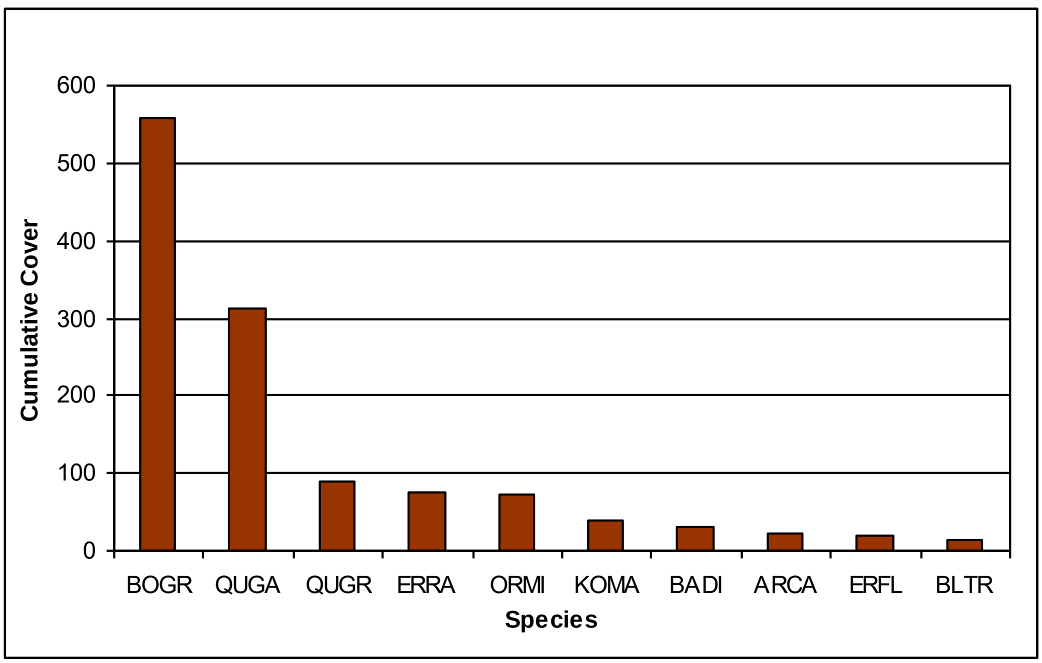

Figure 3.21. Ten most dominant species by cover on all unburned plots, fall 2009.

From Figure 3.16 through Figure 3.21, the most common species across all plots and seasons were blue grama (*Bouteloua gracilis)*, Gambel oak (*Quercus gambelii*), fetid goosefoot (*Chenopodium graveolens*), Wright's deervetch (*Lotus wrightii*), and ragleaf bahia (*Bahia dissecta*). These were all species observed on the unburned plots, suggesting they naturally occur in the area. The high- and low-severity burn sites also exhibited cover of seeded grasses from aerial seeding carried out during rehabilitation efforts in fall 2008. Italian rye grass (*Lolium perenne)* (Figure 3.22) and tall wheatgrass (*Thinopyrum ponticum)* (Figure 3.23) were two large robust grass species present in the seed mix for aerial seeding that were dominant on all plots, particularly on the high- and low-severity plots in fall 2009 (see Figure 3.17 through Figure 3.19). These seeded grasses provided significant cover on the high-severity plots (Figure 3.24).

Figure 3.22. Seeded Italian ryegrass on a high-severity plot, spring 2009.

Figure 3.23. Seeded tall wheatgrass on a high-severity plot, fall 2009.

Figure 3.24. High-severity plot on the Salazar property, showing dominance of grass cover by predominantly seeded grasses, fall 2009.

3.5 SOIL CRUSTS

Biological crusts are formed by living organisms and their byproducts. These organisms create a surface crust that binds soil particles together by the excretion of organic materials like polysaccharides, which are ―sticky" byproducts of living organisms. In some areas, these crusts have been measured having a thickness of up to 10 cm (4 inches). In arid climates like New Mexico, these crusts are fragile and slow growing, taking many years to develop. Soil crusts also require the site to remain undisturbed; however, when disturbance does occur, the site loses organism diversity, soil nutrients, stability, and organic matter (Belnap et al. 2001; Brady and Weil 2002).

Lichens and mosses assist in soil stability by binding particles with rhizines/rhizoids, increasing resistance to wind and water erosion. The increased surface topography of some crusts, along with increased aggregate stability, further improves resistance to wind and water erosion. Soil crusts were observed on the Candelaria site (Figure 3.25).

Figure 3.25. Photograph from the Candelaria site showing the effectiveness of the biological crust in preventing soil erosion.

3.6 SOIL MOVEMENT

Soil movement bridges that had been installed in fall 2008 were monitored in spring 2009 and fall 2009. Figure 3.26 through Figure 3.29 demonstrate the changes in the soil surface profiles between 2008 and 2009 for four Bouton plots burned by differing severities. One plot, BOU 5H, was contour felled as part of the Emergency Watershed Rehabilitation Efforts in late fall 2008; fall 2008 measurements were taken prior to this felling treatment. BOU 2H, which was not felled, is included for comparison. Figure 3.30 shows overland flow occurring at the Bouton site, resulting in erosion and sedimentation.

Variability on the low-severity and unburned bridges may be an artifact of measurement error since the litter layer interferes with the pin and makes it difficult to hit the actual soil surface. Parenthetically, each measurer might have a different idea of where the actual soil surface begins. This is especially true in areas where large amounts of litter and duff have accumulated on the soil surface. What may seem like the soil surface might actually be the duff layer, which is composed of a fermentation layer and a humus layer that looks similar to the soil surface.

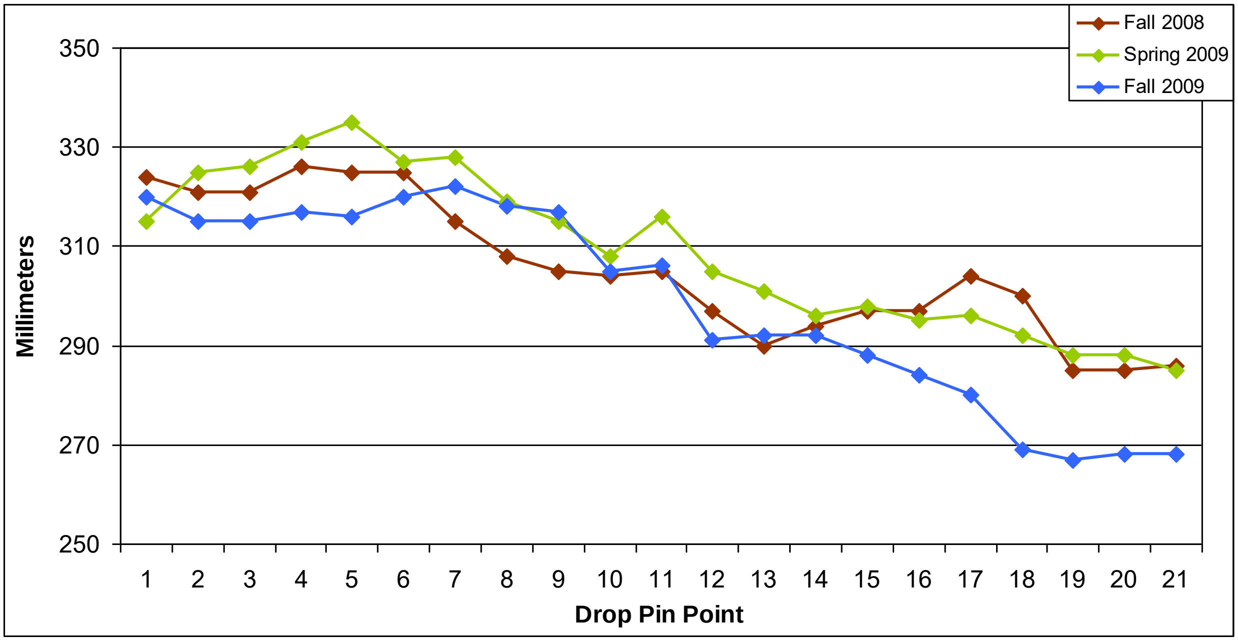

Figure 3.26. Soil movement bridge measurements at BOU 5H.

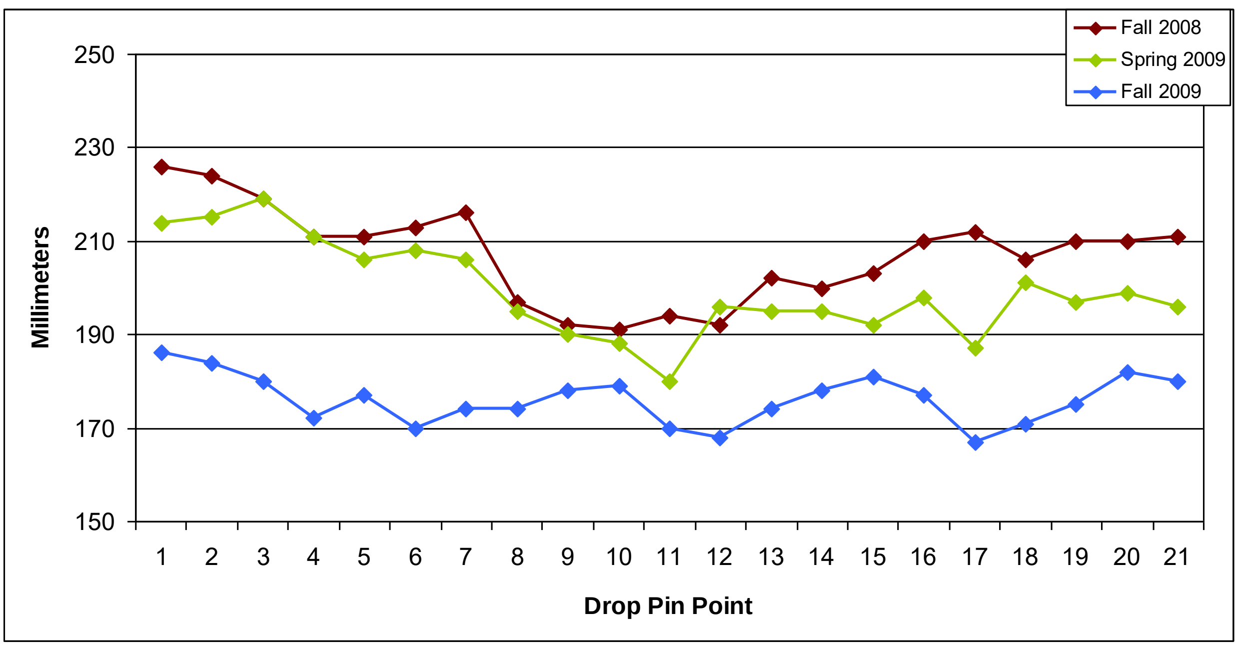

Figure 3.27. Soil movement bridge measurements at BOU 2H.

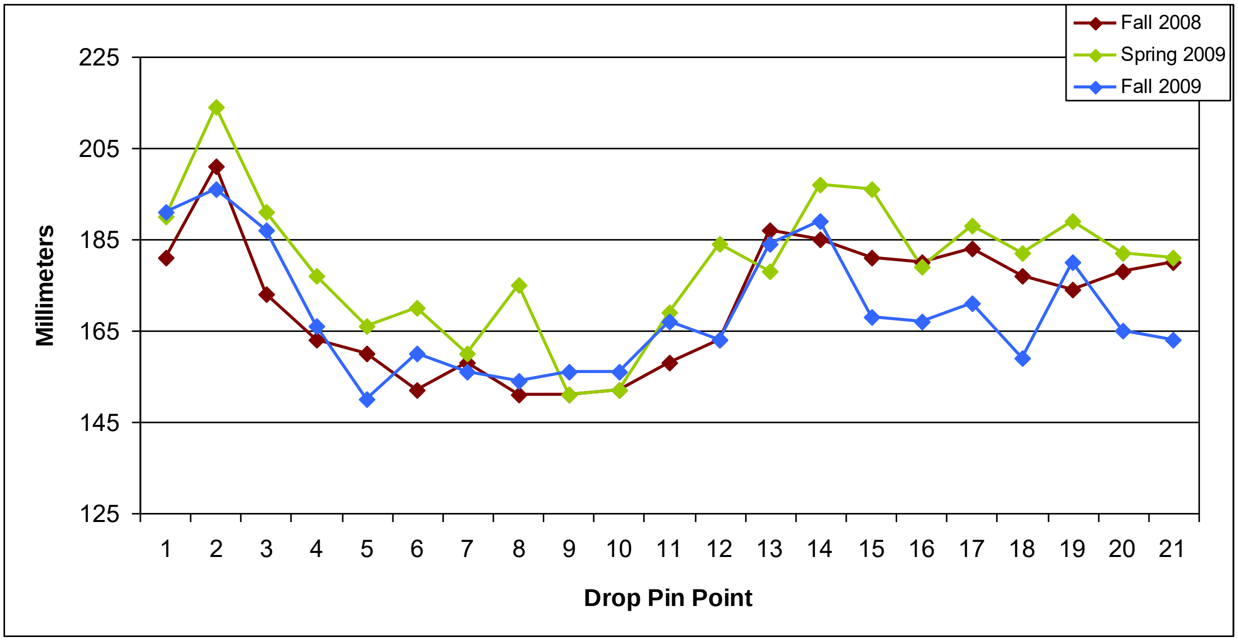

Figure 3.28. Soil movement bridge measurements at BOU 1L.

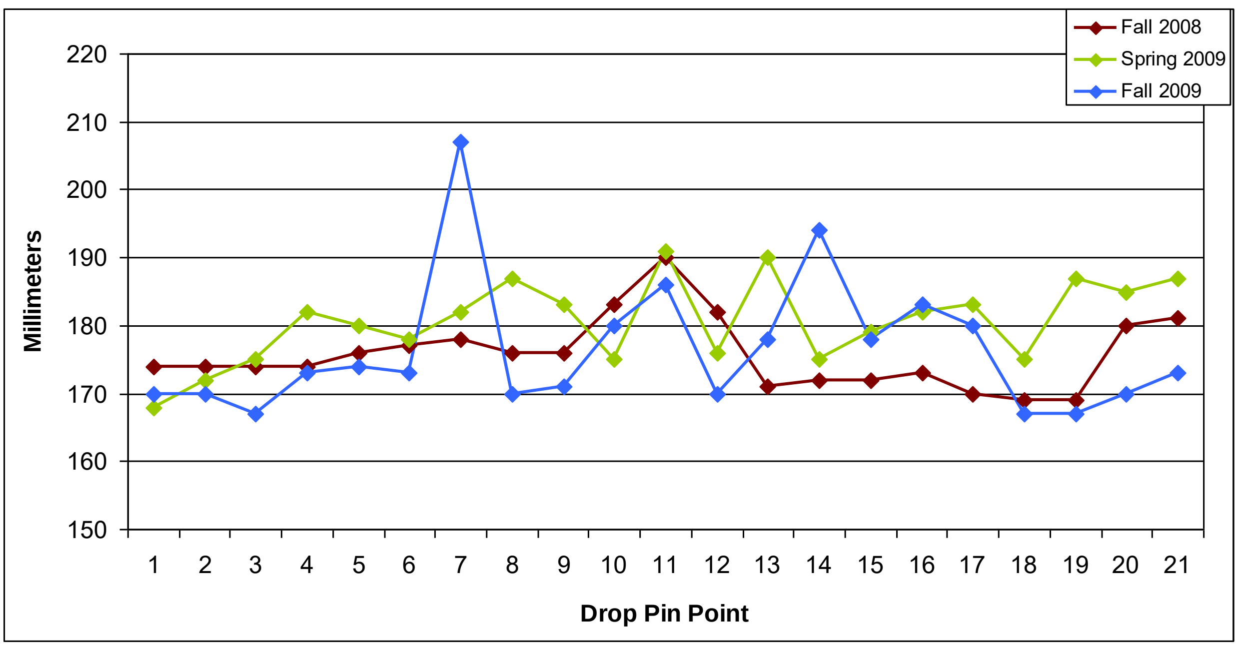

Figure 3.29. Soil movement bridge measurements at BOU 7U.

Figure 3.30. Example of overland flow resulting in sediment-laden flows leaving the Bouton high-severity site in September 2009.

3.7 WILDLIFE

Wildlife cameras were established on the fire monitoring plots in March 2009 in order to establish how wildlife is using the burned areas. The cameras were all Leaf River IR5 infrared cameras that had a detection sensor up to 21 m (70 feet). Three cameras were distributed in one watershed between high-severity, low-severity, and unburned plots. The intent is to move the set of cameras between the three watersheds on a quarterly basis. The first two watersheds were the Cuervo 2 and Cuervo1 watersheds. The cameras were set up at the Manzano 1 watershed for the winter 2009/2010 period.

The wildlife cameras were erected in the center of each plot, approximately 1.2 m (4 feet) from the ground and oriented north. The cameras operate during day and night using a movement sensor (Figure 3.31) and infrared flash. To date, the cameras have photographed a number of animals (Table 3.2).

Figure 3.31. **Wildlife camera.**

Table 3.2. Wildlife Species Detected by Wildlife Cameras at Fire Monitoring Plots

Watershed	Plot	Dates of Monitoring Period	Species Detected	Frequency/Day
Cuervo 2	Bouton high severity	3/5/09–5/27/09	Mule deer	0.302
	Sanchez low severity	3/5/09–5/27/09	Mule deer	0.095
	Bouton unburned	3/5/09–5/27/09	Mule deer	0.127
Cuervo 1	Salazar high severity	5/27/09–9/25/09	None	0.00
	Salazar low severity	5/27/09–9/25/09	Mule deer	0.314
	Manzano Mountain Retreat unburned	5/27/09–9/25/09	Mule deer	0.043
			Turkey	0.022
			Bobcat	0.011

Table 3.2 lists the species and capture frequency for each plot. The most common species captured on the cameras was mule deer (*Odocoileus hemionus*) (Figure 3.32 and Figure 3.33). The presence of some smaller species, such as rabbits, turkey, rodents, etc., may have been obscured by long grasses and thick vegetation, particularly on the high-severity plots where regenerating understory vegetation prevents detection. Furthermore, these faster moving species may not adequately trigger the sensor on the cameras. The plots that exhibited the greatest wildlife frequency (as captured with the cameras) were the Bouton high-severity (Figure 3.34) and the Salazar low-severity plots. Turkey and a bobcat were photographed at the Manzano Mountain Retreat unburned site (Figure 3.35 and Figure 3.36).

Figure 3.32. Mule deer at the Salazar low-severity plot, summer 2009.

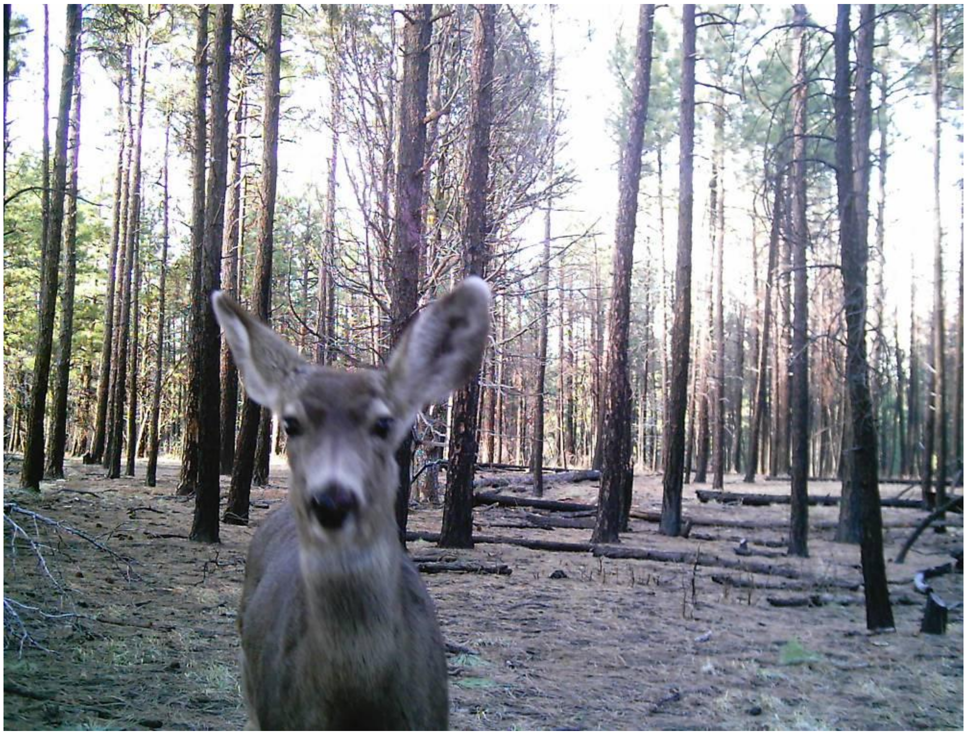

Figure 3.33. Mule deer at the Sanchez low-severity plot, spring 2009.

Figure 3.34. Mule deer at the Bouton high-severity plot, winter 2009.

Figure 3.35. Turkey at the Manzano Mountain Retreat unburned plot, summer 2009.

Figure 3.36. Bobcat at the Manzano Mountain Retreat unburned plot, summer 2009.

3.8 FIRE MONITORING CONCLUSION

Second-year results from the post-wildfire monitoring suggest that the area is slowly regenerating, with increased herbaceous cover and reduced bare ground on the high- and low-severity plots. Aerial seeding efforts were successful on all high-severity plots with dominance of seeded annual grasses. Much of the high-severity plots had experienced 100% mortality of the tree layer, and many of these trees have now begun to fall, particularly as a result of wind throw. The low-severity plots exhibited patchy mortality in 2008; some of the worst-hit trees, those that were more than 50% scorched, have now begun to die as a result of the physiological stress. Soil erosion that appeared to be elevated in 2008 appears to be slowing but is highly variable across plots. Regrowth of the herbaceous layer, dominance of seeded grasses, dead and fallen trees, and increased litter layers are all contributing to the maintenance of the soil layer.

4.0 EPHEMERAL WATERSHED STREAM MONITORING

The hydrologic monitoring protocol was designed to determine how forest thinning and wildfire impacts watersheds and water resources in the Estancia Basin. For details on site selection, research questions, monitoring protocols, and a full literature review please refer to the 2008 Monitoring Plan (SWCA 2008). Wildfire alters the hydrologic response of watersheds, including total amount of water leaving the watershed, peak discharge resulting from rain events, transport of sediment, and rate of erosion and deposition (Martin and Moody 2001; Moody 2001; Veenhuis 2002; Gallaher and Koch 2004; Moody and Martin 2001a, 2001b). Flooding and erosion following wildfires are well-recognized phenomena in montane areas of the western United States (Martin and Moody 2001). The removal of duff litter and the forest canopy along with the physical and chemical alteration of soil by fire increases the erosion potential of burned watersheds (Martin and Moody 2001).

To study the impacts of the Trigo fire, surface water gages were installed in four drainages to measure runoff downstream of the burn area and downstream of control sites (Figure 4.1). To do this, stage-height gages were constructed and installed into the drainage channels. Each of these devices contains a Troll 100 pressure transducer to measure the height of the water. The location of these devices was chosen based on its location downstream of fire monitoring plots. The U.S. Geological Survey also installed gages downstream of the burn perimeter. The pressure transducers provide data on the duration, peak level, and flashiness (the pulse of runoff) in the channel. The profiles of the channels monitored were measured in November 2008; information gathered from channels provides the necessary information that flow rate can be estimated using the Manning equation.

The Kelly piezometer showed no response to any of the rainfall events that occurred throughout 2009, which is likely due to the drainage characteristics where this piezometer is located. The Candelaria piezometer recorded one event (Figure 4.2); however, survey data of the channel are needed in order to determine the actual amount of flow generated by the storm event. The Chilili piezometer experienced the highest flow event during the storm on September 17, 2009, where the stage nearly reached 0.5 m (1.5 feet) (Figure 4.3).

Figure 4.4 through Figure 4.6 show the damage incurred to the stream piezometers during the 2009 season. The piezometer at Chilili was damaged during the 2009 monitoring period either by the large flow event seen in this channel or possibly from cattle or human activity in the channel (e.g., off-road vehicles) (Figure 4.7). The Candelaria piezometer had to be relocated in early 2009 because the site where it was previously installed had flows containing too much debris and subsequently damaged the piezometer during every flow event. Therefore, this piezometer was moved upstream of the source of debris. The transducer at the Vigil site was determined to be malfunctioning and give erroneous data; therefore, it was replaced with a new pressure transducer in October 2009.

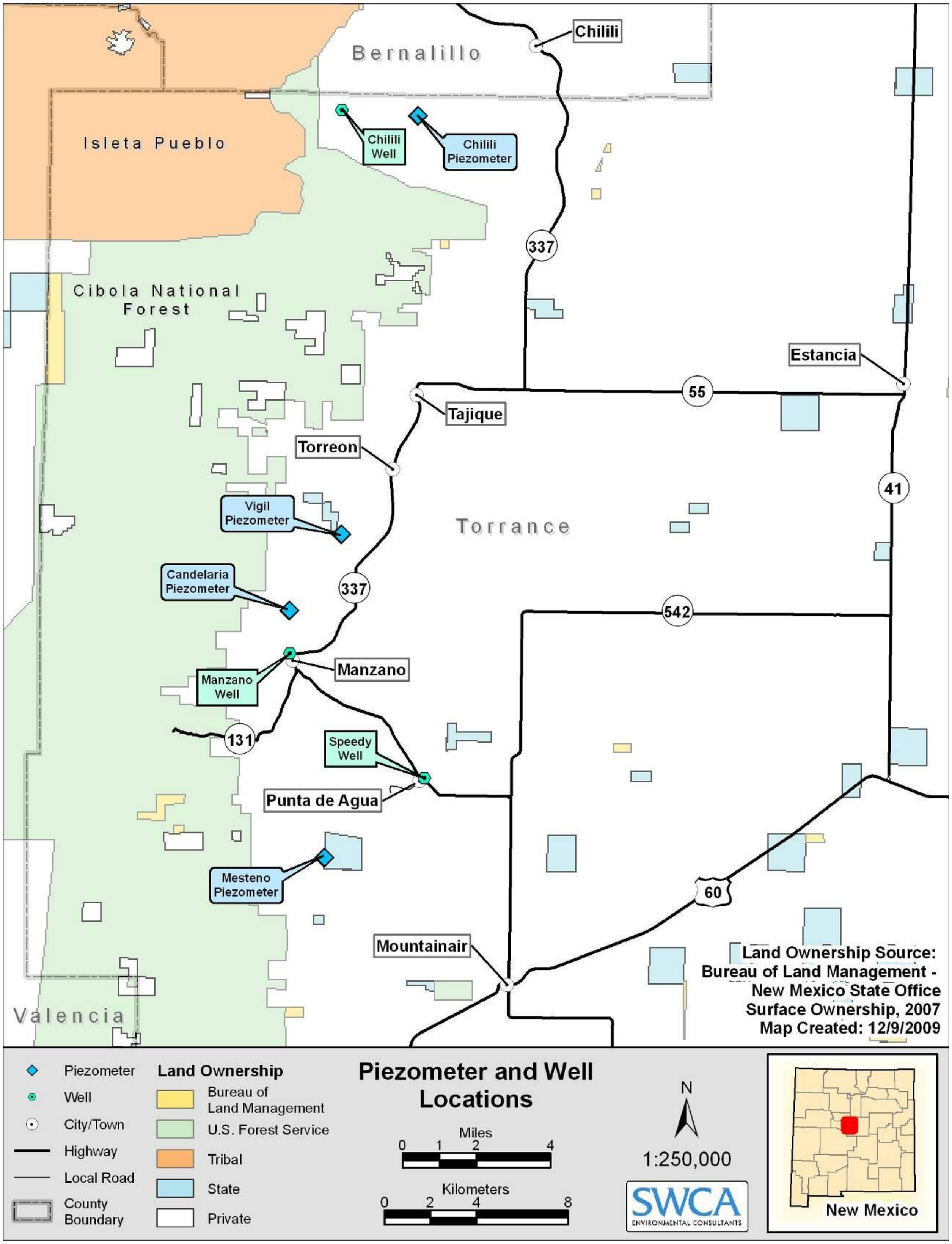

Figure 4.1. Location of the piezometers and wells within the Estancia Basin.

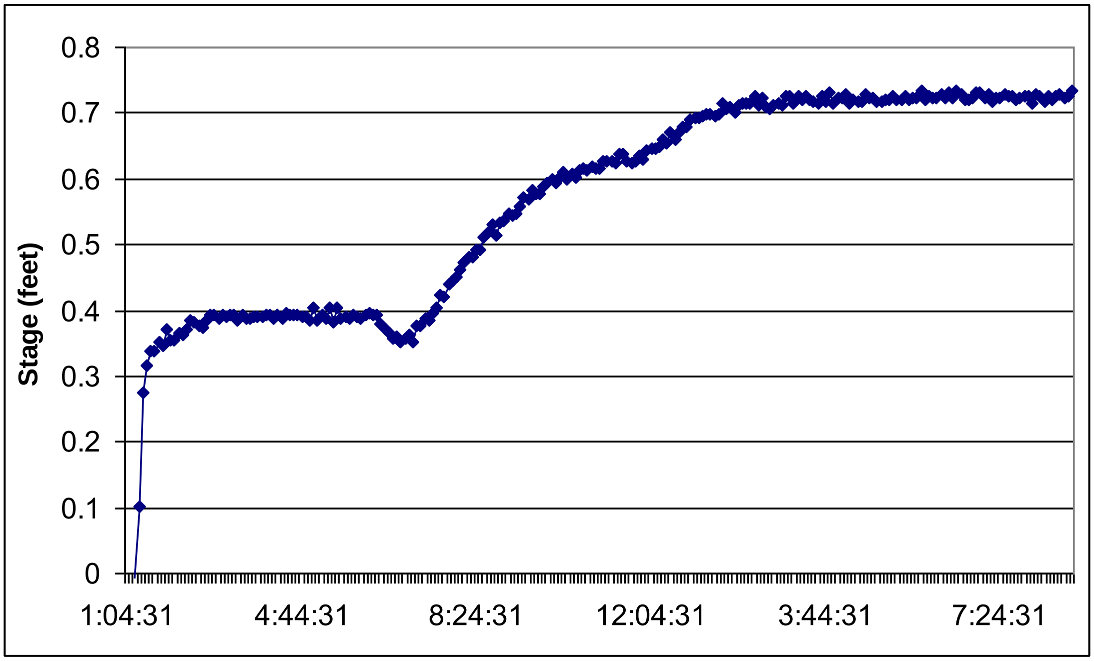

Figure 4.2. Hydrograph from the Candelaria piezometer on September 17, 2009, showing a peak stage of nearly 1 foot. However, notice there is no decline to the peak, which is likely caused by the sediment accumulation seen at the site.

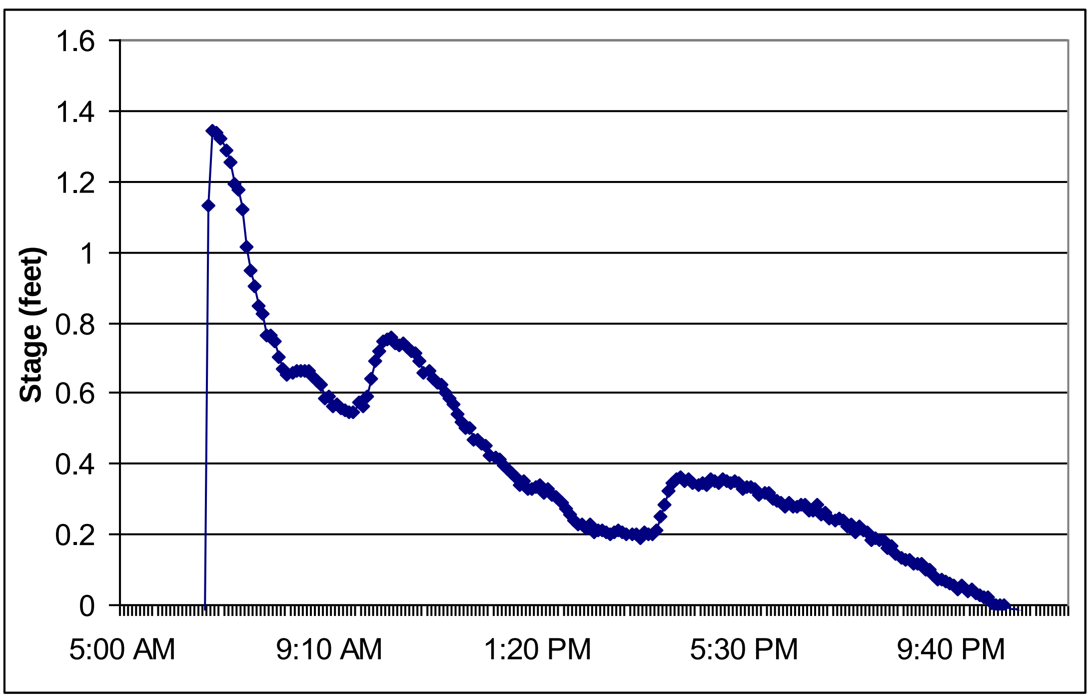

Figure 4.3. Hydrograph from Chilili showing a peak stage of nearly 1.5 feet that was reached during the storm event on September 17, 2009.

Figure 4.4. Large amounts of deposition occurred at the Candelaria site during the summer monsoons. This constantly shifting channel makes calculating volume of flow difficult.

Figure 4.5. Large amounts of deposition and debris accumulation at the Vigil piezometer after a storm event in 2008.

Figure 4.6. **The Vigil piezometer in the fall of 2009 after a storm event lowered the stream bed level to below the piezometer. The blue line represents the high water line determined by the accumulation of debris in the vegetation.**

Figure 4.7. **Damage to the Chilili piezometer in 2009. Even though the end cap was removed, this piezometer was still able to record flow.**

4.1 GROUNDWATER WELL MONITORING

The monitoring study is evaluating infiltration rates in the Estancia Basin by using deep pressure sensors to monitor the level of groundwater in relation to stream flow events. By monitoring the groundwater levels in private wells located close to stream monitoring locations, changes in recharge can be observed, and potentially the impact of thinning and burned areas can be compared to these groundwater levels to asses any changes.

Ideally, this project will evaluate infiltration rates in the control areas versus burned areas and relate this information to nearby groundwater levels. This could be accomplished by monitoring private wells located close to stream monitoring locations. Sandia National Laboratory and the U.S. Geological Survey are currently initiating well monitoring programs. Both entities have been receptive to sharing data when they become available, though neither knows if data would be available near our piezometer locations in the immediate future. The monitoring will use deep pressure sensors to monitor the level of groundwater in relation to stream flow events. If these data are available, they will be compared to the collected data from this project.

SWCA installed three well monitoring devices during early to mid June 2009. These well monitoring locations are at Chilili, Manzano, and Punta de Agua (Figure 4.1). Each monitoring well is equipped with Solinst Levelogger Junior pressure transducers that were programmed to record values hourly. The Chilili site is approximately 30 m (98 feet) from the western flume. The well is approximately 15 m (50 feet) deep, and depth to groundwater when installed is approximately 8 feet (25 feet). The Manzano well is shallow, approximately 8 m (25 feet) deep, and periodically goes dry. The municipal well is nearby and likely contributes to the drawdown in this area. SWCA is looking for an alternative well, but until it is found this well will continue to be monitored. The Punta de Agua well is in ―downtown" Punta. The well is approximately 37 m (120 feet) deep, and depth to groundwater is approximately 28 m (91 feet) when installed. SWCA will off-load data quarterly at each well location.

Figure 4.8 through Figure 4.10 display the well data from each of the three locations monitored in the Estancia Basin. The Chilili well showed the most response to precipitation events and it was the only well that was able to show infiltration from the basin-wide storm that occurred between September 16 and 17, 2009. Neither the site at Punta de Agua nor Manzano showed any response to precipitation events that occurred after installation. The reason these two wells showed no response to precipitation is likely because of their locations and the different geology encountered at each site. The Chilili location is a lot higher in elevation and has limestone formations, which are conducive to infiltration and subsequent deep percolation.

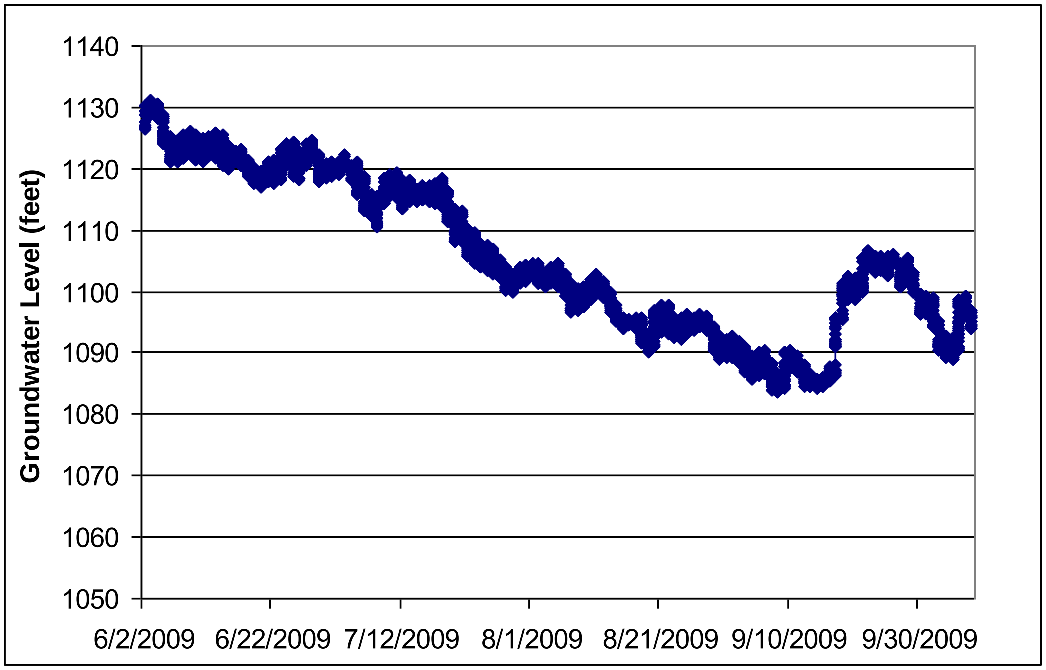

Figure 4.8. **Well data from the Chilili site showing a steady decline over the summer; however, a spike from the September 16–17, 2009, basin-wide storm event can clearly be seen.**

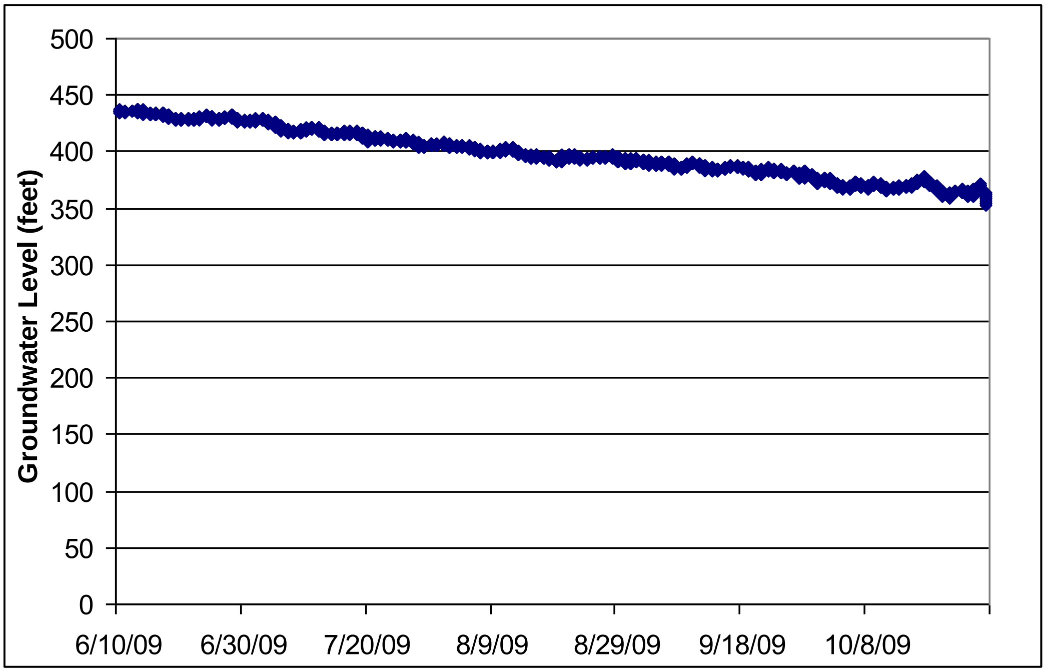

Figure 4.9. **Well data from the Punta de Agua site showing constant drawdown of the groundwater over the summer months.**

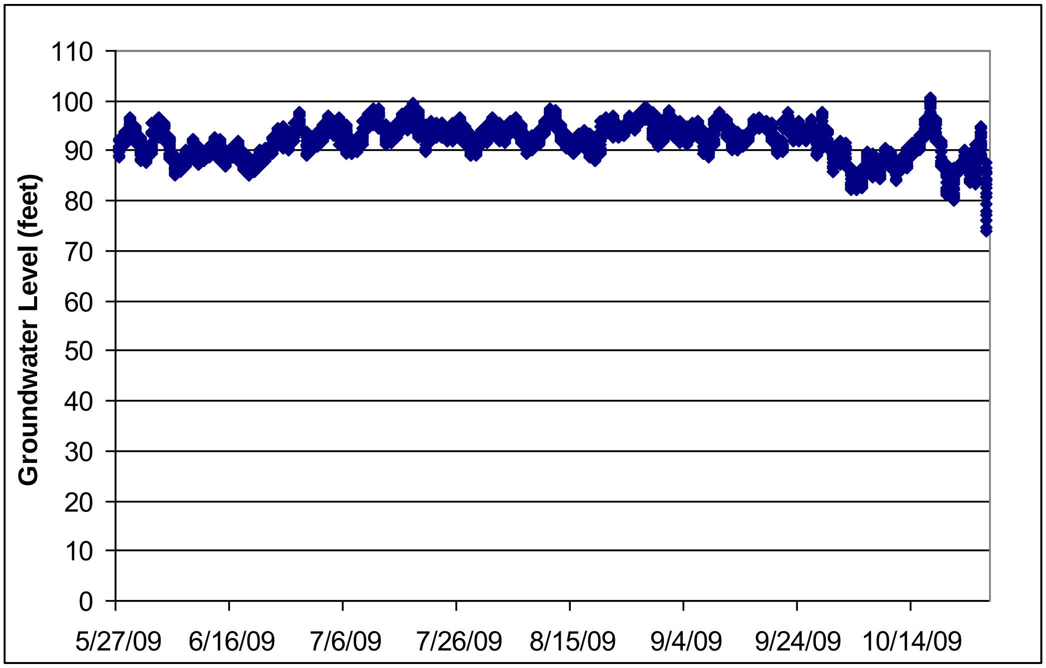

Figure 4.10. Well data from the Manzano site showing the fluctuations in groundwater over the summer months.

5.0 SOUTH MOUNTAIN WEATHER STATION

The SMWS was installed by EnviroLogic, Inc. to provide meteorological, soil moisture, and temperature data as part of the Estancia Basin Watershed Health and Restoration Program overseen by the Steering Committee. EnviroLogic installed the SMWS in September 2006 to initiate site-specific monitoring of rainfall and soil water content at various soil depths. For details on site selection and monitoring protocols, please refer to the 2008 Monitoring Plan (SWCA 2008). For more detailed data summaries please refer to the Addenda at the end of this document. The SMWS is within the Edgewood Soil and Water Conservation District, on the private property, near South Mountain, Santa Fe County, New Mexico, approximately 19 km (12 miles) north of the town of Edgewood (Figure 5.1). The intent of EnviroLogic was to assess water infiltration through soil depths, relate that to meteorological variables, and then compare two measured locations to determine the effects of forest thinning projects on groundwater recharge.

The SMWS measures precipitation, wind speed and direction, air temperature, humidity, and solar radiation. Soil moisture and temperature probes are situated at various depths at two locations with distinct vegetation structure types: one site within a piñon/juniper stand and one site in an adjacent open area consisting of short grasses. EnviroLogic referred to these locations as ―Tree” and ―Meadow,” respectively. The Tree site is situated approximately 30 m (98 feet) northeast of the SMWS within a grouping of one-seed juniper and piñon pine trees. The Meadow site is situated approximately 11 m (36 feet) northwest of the SMWS, in vegetation dominated by blue grama grass and broom snakeweed (*Gutierrezia sarothrae*).

SWCA is now responsible for the management of the SMWS and the maintenance, summation, and distribution of the data collected at this station. The following sections summarize the data collected since SWCA assumed responsibility for SMWS in April 2008. SWCA prepared a report, ―South Mountain Weather Station: History, Data Summaries, and Continued Operation,” summarizing the data collected from 2006 and 2007 by EnviroLogic, and submitted that report to the Steering Committee. This report is available at the Restoration Institute's website (http://www.nmfwri.org/). The data displayed below in Figure 5.2 through Figure 5.8 are summarized as monthly averages of relevant meteorological data. Summaries of daily averages of each of the same variables can be found in the quarterly reports in an addendum to this report.

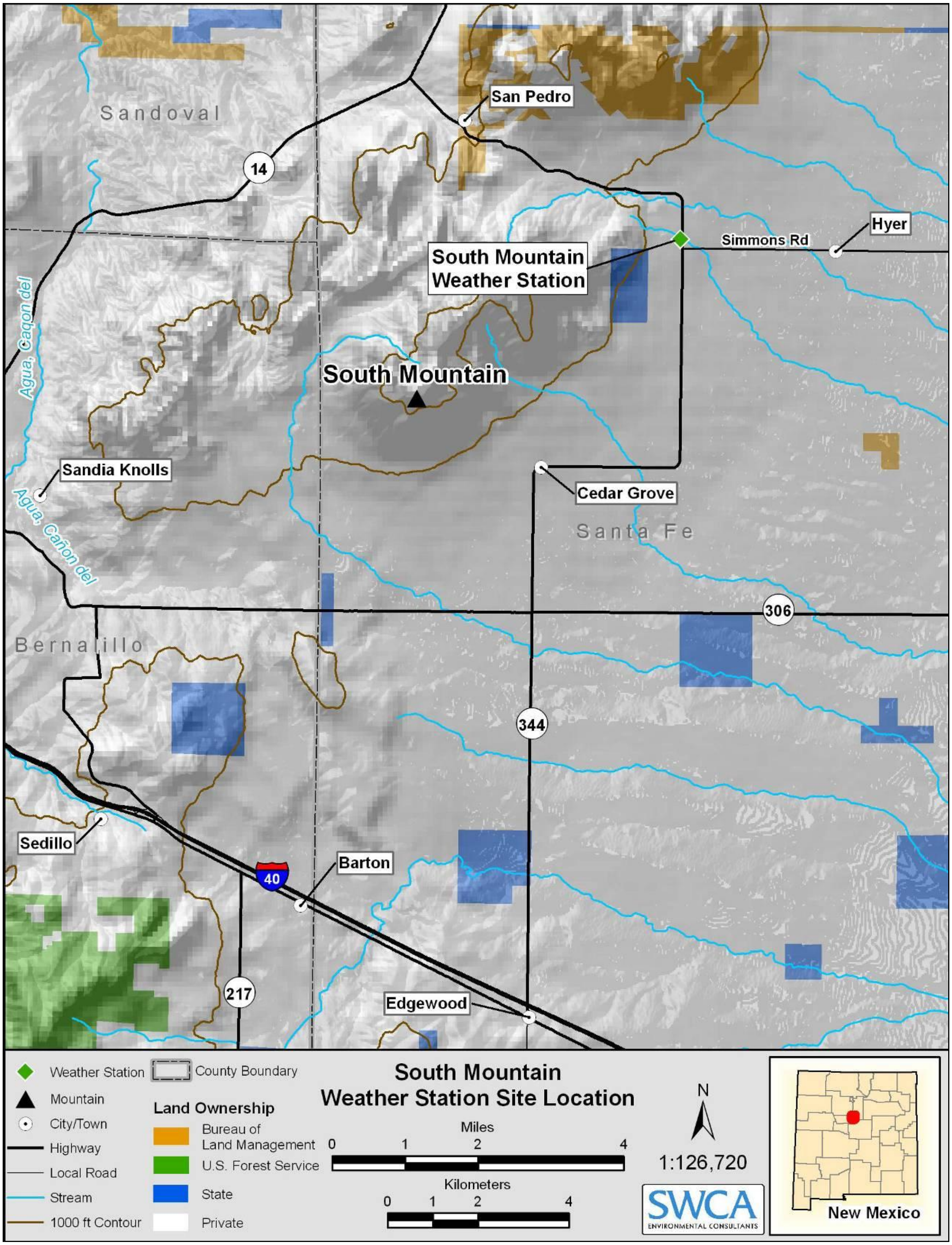

Figure 5.1. Location of the South Mountain Weather Station.

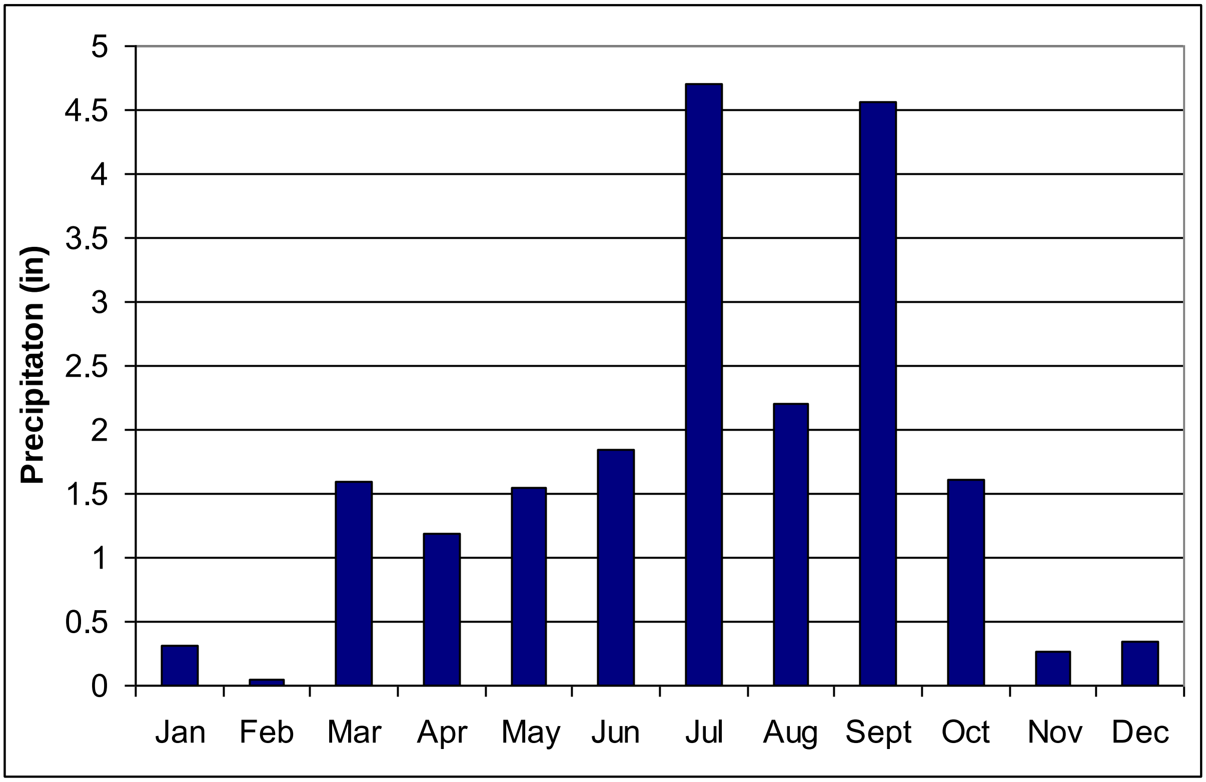

Figure 5.2. Graph showing monthly total rainfall over the course of 2009.

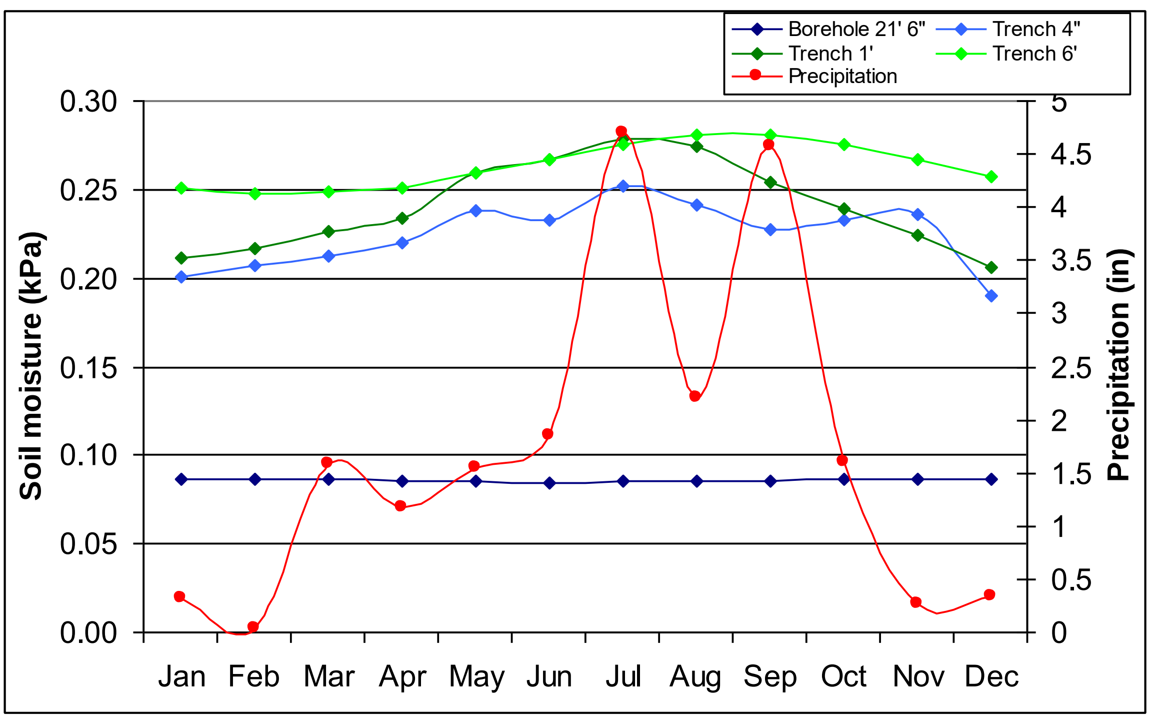

Figure 5.3. Tree site monthly average soil moisture and total precipitation for 2009.

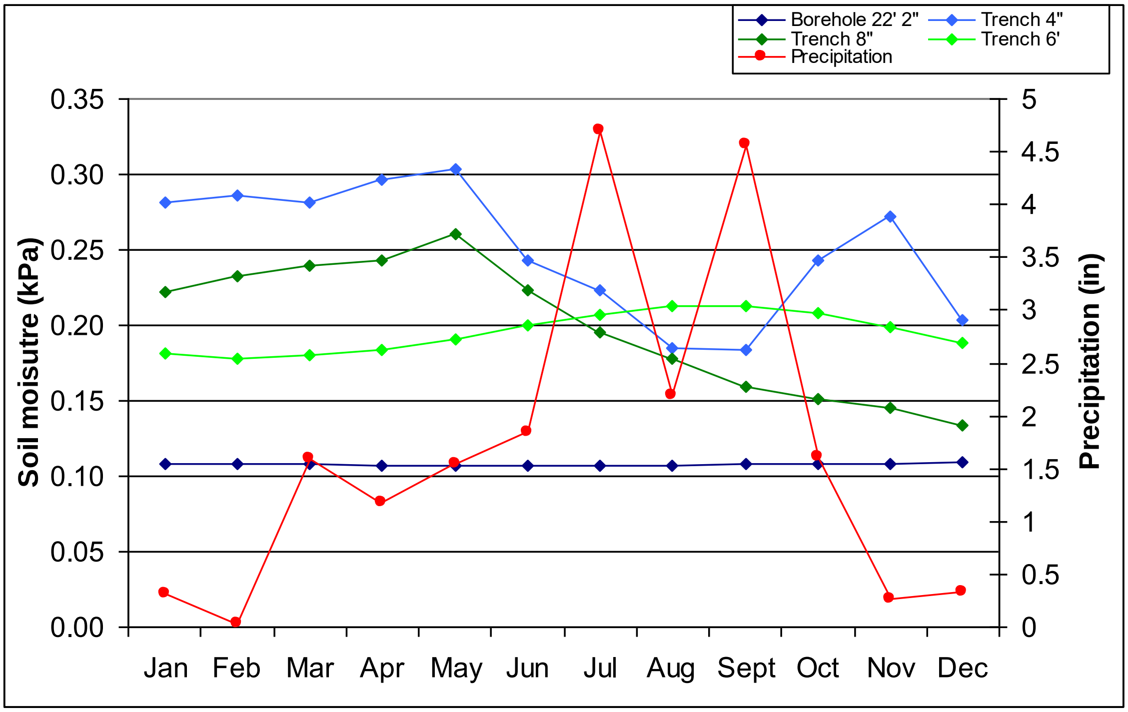

Figure 5.4. Meadow site average monthly soil moisture and total precipitation for 2009.

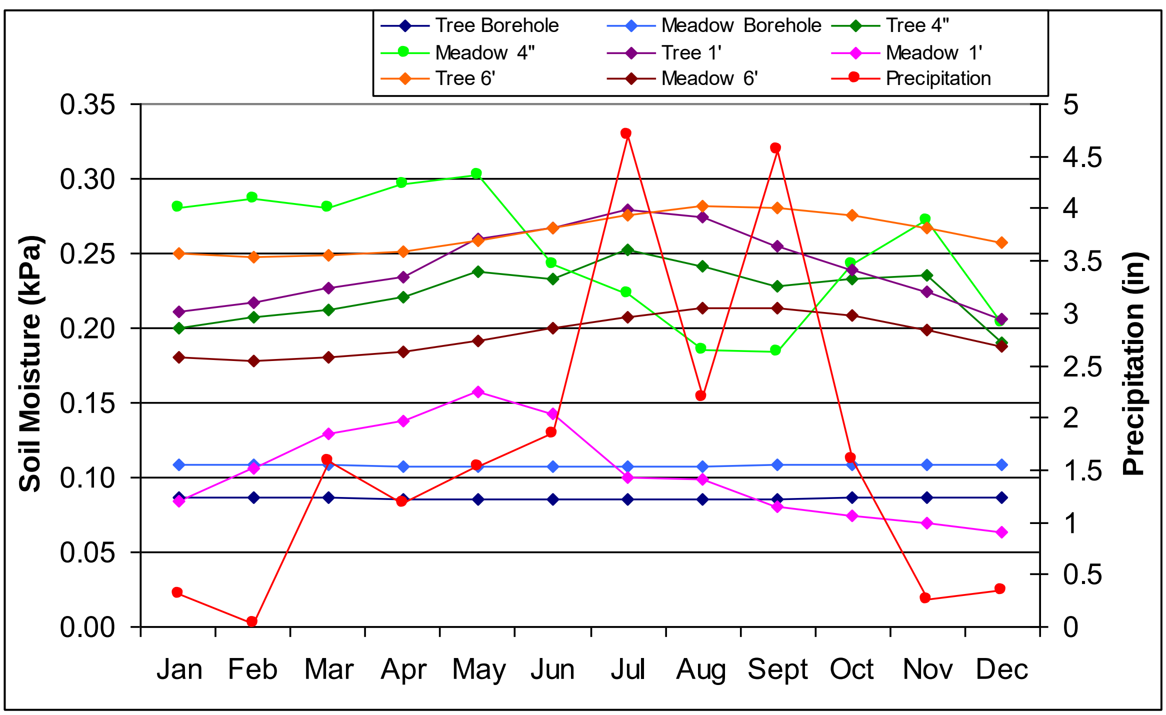

Figure 5.5. Tree and Meadow site average monthly soil moisture and total precipitation for 2009.

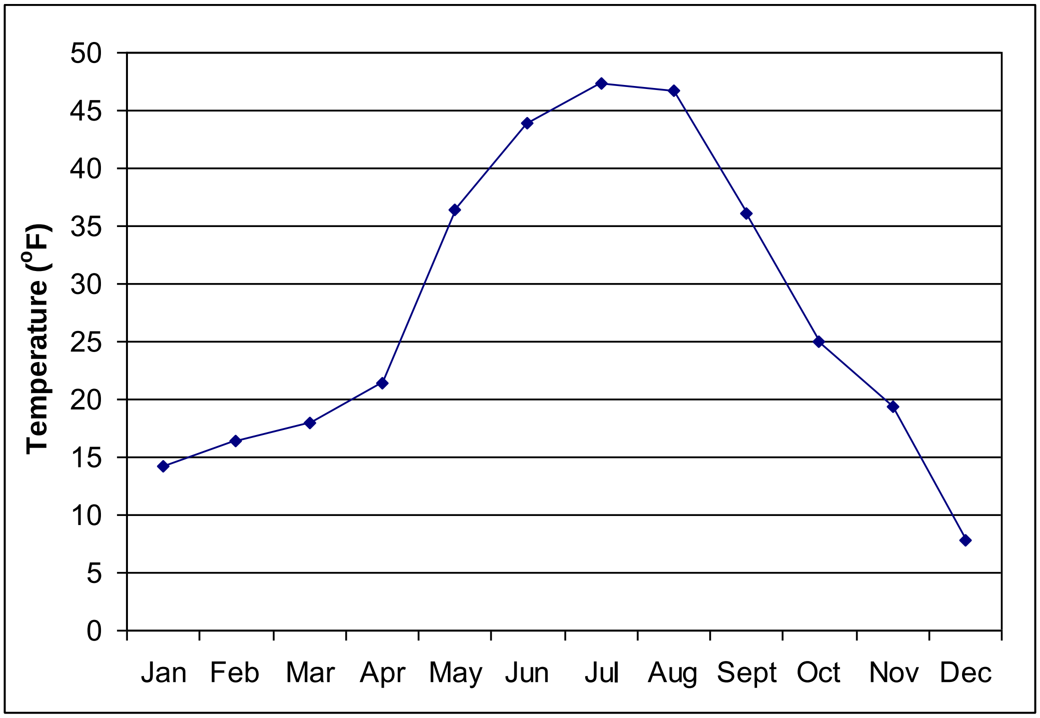

Figure 5.6. Minimum monthly temperature experienced at the SMWS during 2009.

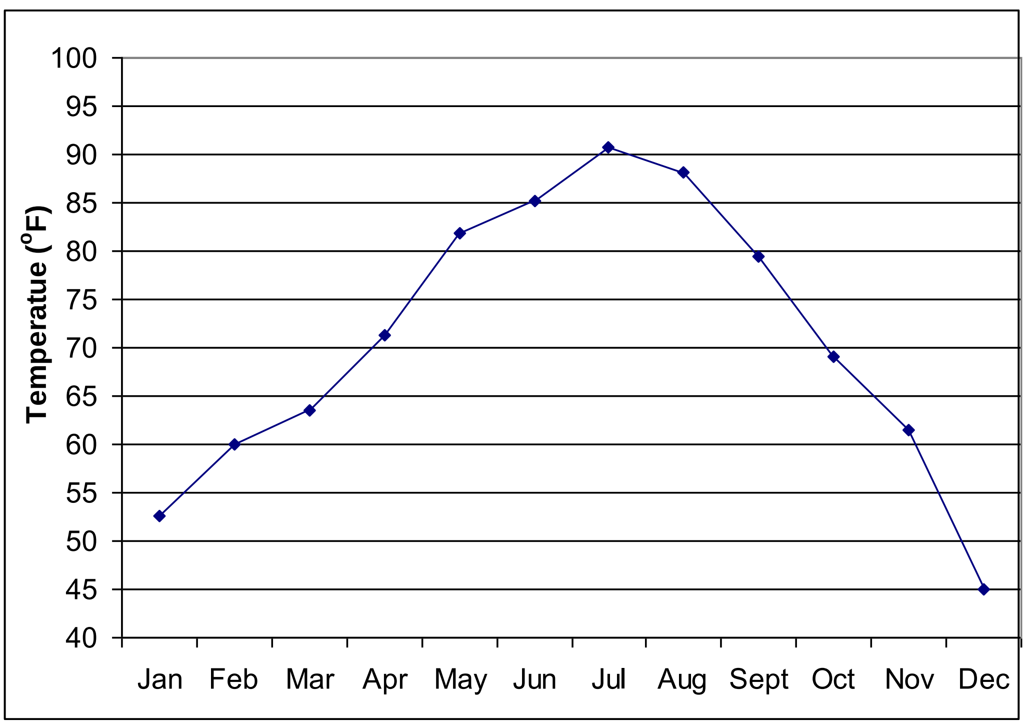

Figure 5.7. Maximum monthly temperature experienced at the SMWS during 2009.

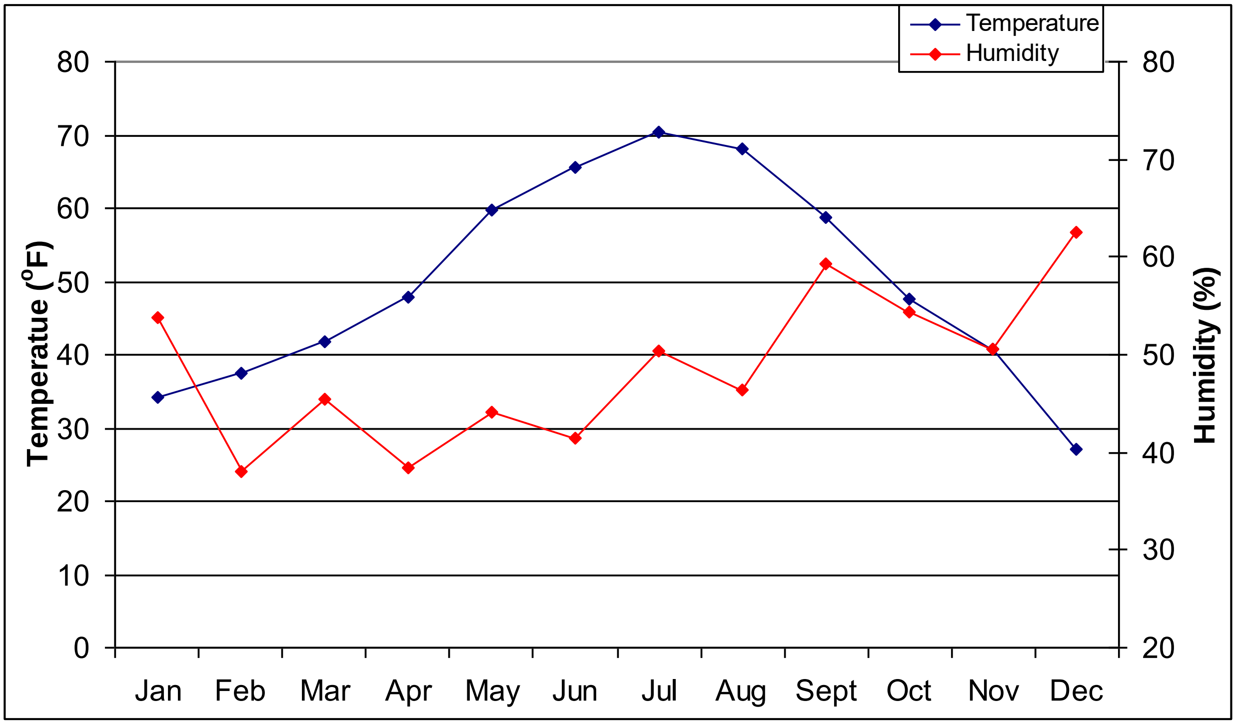

Figure 5.8. Daily average temperature and relative humidity over the course of 2009.

6.0 PLANNED MONITORING FOR 2010 (YEAR THREE)

SWCA will continue the current monitoring efforts for year three of this project, including the operation of SMWS. Forest thinning treatments will be implemented in early 2010, and we will then begin to monitor post-thinning treatment conditions in late spring 2010. SWCA will continue to manage the SMWS and the weather data; however, based on advisement from the Steering Committee, data recordings on the data logger will be changed from every 10 minutes to hourly recordings.

Post-wildfire monitoring will continue through spring 2010, and perhaps beyond depending on the availability of funding. At this time, we do not anticipate changes in the current monitoring designs or methods for forest thinning monitoring. Reporting will include regular monthly progress reports and a 2010 Annual Report.

7.0 ACKNOWLEDGEMENTS AND CONTRIBUTORS

The New Mexico Water Trust Board provided funding for this project. The Estancia Basin Water Planning Committee also contributed funding to install the new Chilili ponderosa pine monitoring study site. The Estancia Basin Watershed Health, Restoration and Monitoring Steering Committee provided oversight and coordination of this project, in cooperation with the New Mexico Forest and Watershed Restoration Institute and New Mexico State Forestry. Deirdre Tarr of the Claunch-Pinto Soil and Water Conservation District and Joe Zebrowski from the New Mexico Forest and Watershed Restoration Institute provided valuable oversight and support. The Bouton, Candelaria, Kelly, Mitchell, Neff, Salazar, Sanchez, Vigil, and Wester families kindly offered access to their land to conduct forest thinning and monitoring research, along with the Chilili Land Grant, Manzano Land Grant, and the Manzano Mountain Retreat. New Mexico State Forestry, the U.S. Forest Service, the U.S. Geological Survey, and the Claunch-Pinto, East Torrance, and Edgewood soil and water conservation districts have all provided advice and support. Vernon Kohler and Kelly Archuleta from the Claunch-Pinto and Edgewood soil and water conservation districts have been assisting with field data collections. Mike Matush from the New Mexico State Environment Department, Surface Water Quality Bureau, has been helpful in designing and installing stream monitoring stations.

SWCA staff Joseph Fluder, David Lightfoot, Vicky Amato, Cody Stropki, Mike Pease, Terri Thompson, LB Meyers, Duncan Wadsworth, Ryan Trollinger, Anne Russell, Justin Elza, Sheri Waldbauer, and Alayne Szymanski contributed to this report and data collection efforts.

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APPENDIX A
LIST OF PLANT SPECIES ENCOUNTERED ON FOREST MONITORING STUDY PLOTS. TAXONOMY AND NAMES FOLLOW SIVINSKI (2007)

Appendix A. List of plant species encountered on forest monitoring study plots. Taxonomy and names follow Sivinski (2007).

Group/Family	Genus	Species	Form	History
Bryophytes	Bryophyte	sp.	cryptogam	perennial
	Microbial crust		cryptogam	perennial
Gymnosperms				
Cypressaceae	Juniperus	deppeana	tree	perennial
Cypressaceae	Juniperus	monosperma	tree	perennial
Cypressaceae	Juniperus	scopulorum	tree	perennial
Pinaceae	Pinus	edulis	tree	perennial
Pinaceae	Pinus	ponderosa	tree	perennial
Angiosperms: Dicotedons				
Amaranthaceae	Amaranthus	albus	forb	annual
Amaranthaceae	Amaranthus	palmeri	forb	annual
Anacardiaceae	Rhus	trilobata	shrub	perennial
Asclepiadaceae	Asclepias	sp. 1	forb	perennial
Asteraceae	Achillea	millefolium	forb	perennial
Asteraceae	Artemisia	dracunculus	forb	perennial
Asteraceae	Artemisia	ludoviciana	forb	perennial
Asteraceae	Artemisia	sp.	forb	perennial
Asteraceae	Bahia	dissecta	forb	annual
Asteraceae	Brickellia	sp.1	forb	perennial
Asteraceae	Brickellia	sp. 2	forb	perennial
Asteraceae	Chaetopappa	ericoides	forb	perennial
Asteraceae	Circium	sp.1	forb	annual
Asteraceae	Circium	sp. 2	forb	annual
Asteraceae	Conyza	sp.1	forb	
Asteraceae	Erigeron	flagellaris	forb	biennial
Asteraceae	Erigeron	sp.	forb	
Asteraceae	Gutierrezia	sarothrae	shrub	perennial
Asteraceae	Gutierrezia	sphaerocephala	forb	perennial
Asteraceae	Heterotheca	villosa	forb	perennial
Asteraceae	Solidago	sp. 1	forb	perennial
Asteraceae	Stephanomeria	exigua	forb	perennial
Asteraceae	Tetraneuris	argentea	forb	perennial

Asteraceae	Thelesperma	megapotamicum	forb	perennial
Asteraceae	Townsendia	eximia	forb	perennial
Asteraceae		sp.	forb	
Berberidaceae	Mahonia	repens	shrub	perennial
Brassicaceae	Arabis	sp.	forb	perennial
Brassicaceae	Lepidium	montanum	forb	perennial
Brassicaceae	Lepidium	sp. 1	forb	perennial
Brassicaceae	Schoenocrambe	linearifolia	forb	perennial
Brassicaceae	Streptanthus	sp.1	forb	annual
Brassicaceae	Streptanthus	sp. 2	forb	annual
Cactaceae	Cylindropuntia	imbricata	succulent	perennial
Cactaceae	Echinocereus	viridiflorus	succulent	perennial
Cactaceae	Grusonia	clavata	succulent	perennial
Cactaceae	Opuntia	engelmannii	succulent	perennial
Cactaceae	Opuntia	macrorhiza	succulent	perennial
Cactaceae	Opuntia	polyacantha	succulent	perennial
Cactaceae	Opuntia	seedling	succulent	perennial
Cactaceae	Opuntia	sp.	succulent	perennial
Chenopodiaceae	Chenopodium	graveolens	forb	annual
Chenopodiaceae	Chenopodium	sp. 1	forb	annual
Chenopodiaceae	Chenopodium	sp. 2	forb	annual
Euphorbiaceae	Chamaesyce	sp. 1	forb	annual
Euphorbiaceae	Chamaesyce	sp. 2	forb	annual
Fabaceae	Astragalus	mollisimus	forb	perennial
Fabaceae	Astragalus	nuttallianus	forb	perennial
Fabaceae	Astragalus	sp.	forb	annual
Fabaceae	Dalea	sp. 1	forb	perennial
Fabaceae	Lotus	wrightii	forb	perennial
Fabaceae	Robinia	neomexicana	tree	perennial
Fabaceae		sp. 1	forb	
Fabaceae		sp. 3	forb	
Fabaceae		sp. 4	forb	
Fagaceae	Quercus	gambelii	tree	perennial
Fagaceae	Quercus	turbinella	tree	perennial
Geraniaceae	Geranium	caespitosum	forb	perennial
Geraniaceae	Geranium	sp. 1	forb	perennial
Linaceae	Linum	sp.1	forb	perennial

Malvaceae	Spheralcea	angustifolia	forb	perennial
Malvaceae	Spheralcea	coccinea	forb	perennial
Monotropaceae	Monotropa	hypopithys	forb	perennial
Nyctaginaceae	Mirabilis	linearis	forb	perennial
Nyctaginaceae	Mirabilis	sp.	forb	perennial
Nyctaginaceae	Boerhavia	sp.	forb	annual
Onagraceae	Oenothera	sp.	forb	annual
Polemoniaceae	Gilia	sp. 1	forb	annual
Polemoniaceae	Ipomopsis	aggregata	forb	annual
Polygonaceae	Eriogonum	microthecum	shrub	perennial
Polygonaceae	Eriogonum	racemosum	forb	perennial
Portulaccaceae	Portulaca	oleracea	forb	annual
Portulaccaceae	Portulaca	pilosa	forb	annual
Ranunculaceae	Thalictrum	fendleri	forb	perennial
Scrophulariaceae	Castilleja	angustifolia	forb	perennial
Scrophulariaceae	Cordylanthus	tenuis	forb	annual
Scrophulariaceae	Penstemon	barbatus	forb	perennial
Scrophulariaceae	Penstemon	sp. 2	forb	perennial
Scrophulariaceae	Penstemon	sp. 3	forb	perennial
Solanaceae	Physalis	hederifolia	forb	perennial
Solanaceae	Solanum	elaeagnifolium	forb	perennial
Solanaceae	Solanum	sp. 1	forb	perennial
Viscaceae	Phoradendron	macrophyllum	shrub	perennial

Angiosperms: Monocyledons

Agavaceae	Yucca	glauca	succulent	perennial
Commelinaceae	Commelina	dianthifolia	forb	annual
Cyperaceae	Carex	sp. 1	grass	perennial
Cyperaceae	Carex	sp. 2	grass	perennial
Liliaceae	Allium	sp. 1	forb	perennial
Poaceae	Alopecurus	sp.	grass	
Poaceae	Andropogon	gerardii	grass	perennial
Poaceae	Aristida	purpurea	grass	perennial
Poaceae	Aristida	sp. 1	grass	perennial
Poaceae	Blepharoneuron	tricholepsis	grass	perennial
Poaceae	Bouteloua	curtipendula	grass	perennial
Poaceae	Bouteloua	gracilis	grass	perennial

Poaceae	Bouteloua	aristidoides	grass	annual
Poaceae	Bromus	sp. 1	grass	annual
Poaceae	Elymus	hystrix	grass	perennial
Poaceae	Eragrostis	ciliaris	grass	annual
Poaceae	Eragrostis	sp.	grass	annual
Poaceae	Lolium	perenne	grass	annual
Poaceae	Muhlenbergia	minutissima	grass	perennial
Poaceae	Muhlenbergia	montana	grass	perennial
Poaceae	Muhlenbergia	torreyi	grass	perennial
Poaceae	Munroa	squarrosa	grass	annual
Poaceae	Oryzopsis	micrantha	grass	perennial
Poaceae	Pascopyrum	smithii	grass	perennial
Poaceae	Pleuraphis	jamesii	grass	perennial
Poaceae	Sporobolus	cryptandrus	grass	perennial
Poaceae		sp. 1	grass	
Poaceae		sp. 2	grass	
Poaceae		sp. 3	grass	

APPENDIX B
ANIMAL SPECIES RECORDED FROM FOREST MONITORING WILDLIFE STUDY PLOTS

Appendix B. Animal species recorded from forest monitoring wildlife study plots.

Bird Species List

Common Name	**Genus**	**Species**
American Crow	Corvus	branchyrhynchos
American Robin	Turdus	migratorius
Ash-throated Flycatcher	Myarchus	cinerascens
Bewick's Wren	Thryomanes	bewickii
Black-capped Chickadee	Poecile	atricapillus
Black-throated Gray Warbler	Dendroica	nigrescens
Broad-tailed Hummingbird	Cynanthus	latirostris
Chipping Sparrow	Spizella	passerina
Common Raven	Corvus	corvax
Common Nighthawk	Chordeiles	minor
Cooper's Hawk	Accipiter	cooperii
Dark-eyed Junco	Junco	hyemalis
Finch sp.	Carpodacus	sp.
Grace's Warbler	Dendroica	graciae
Hermit Thrush	Catharus	guttatus
Juniper Titmouse	Baeolophus	ridgwayi
Organge Crowned Warbler	Vermivora	celata
Mountain Chickadee	Poecile	gambeli
Mourning Dove	Zenaida	macroura
Northern Flicker	Colaptes	auratus
Plumbeous Vireo	Vireo	plumbeus
Pinyon Jay	Gymnorhinus	cyanocephalus
Pygmy Nuthatch	Sitta	pygmaea
Red-breasted Nuthatch	Sitta	canadensis
Red Crossbill	Loxia	curvirostra
Red-tailed Hawk	Buteo	jamaicensis
Ruby-crowned Kinglet	Regulus	calendula
Rufous Hummingbird	Selasphorus	rufus
Sharp-shinned Hawk	Accipiter	striatus
Spotted Towhee	Pipilo	maculatus
Stellar's Jay	Cyanocitta	stelleri
Swainson's Thrush	Catharus	ustulatus
Townsend's Solitaire	Myadestes	townsendii
Turkey Vulture	Cathartes	aura

Western Bluebird	Sialia	mexicana
Western Meadowlark	Sturnella	neglecta
Western Scrub Jay	Aphelocoma	californica
White-breasted Nuthatch	Sitta	carolinensis
Wild Turkey	Meleagris	gallopavo
Yellow-rumped Warbler	Dendroica	coronata

Rodent species list

Common Name	**Genus**	**Species**
Colorado chipmunk	Tamias	quadrivittatus
Deer mouse	Peromyscus	maniculatus
Pinyon mouse	Peromyscus	truei
White-footed mouse	Peromyscus	leucopis
White-throated woodrat	Neotoma	albigula

Attachments

DVD with all raw data files along with an electronic pdf version of the report

Addenda (SMWS quarterly reports)