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THE LA MESA FIRE

Studies and Observations from 1975 through 2012

Teralene S. Foxx
Leslie Hansen, Rebecca Oertel, Collin Haffey, Kay Beeley

Dedicated to Loren Potter, my mentor, who got me interested in fire ecology.

Paintings by T.S. Foxx

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Photography by Teralene S. Foxx

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ACKNOWLEDGMENTS

If I have learned anything from this project, it is that it is difficult to do such a massive amount of work alone. Early in the study, my mentor, Loren Potter, taught me how to observe in the field, the techniques necessary for proper observation, and the joy of the study of fire ecology. We never expected a simple project to become such a large study. The La Mesa Fire was a serendipitous event as far as the research went. However, the study did not have much money. Field assistants were not generally available for the nominal fee that was paid; therefore, my children were—sometimes forcibly and sometimes willingly—my assistants. They held the measuring tape, stood patiently as I used them to act as scale in photographs, and helped carry equipment. At other times, intrepid friends accompanied me in the field.

In 1993, in preparation for a symposium, and in 1998-1999, studies were done through Los Alamos National Laboratory. With field crews the work went faster and more efficiently. There were many students and staff that helped me through the years, including Aletha Banar, David Keller, Kathy Bennett, James Biggs, and Elena Ramirez. Marjorie Wright, Carey Bare, Todd Haagenstad, and Leslie Hansen were instrumental in helping collect data in a timely manner. Marjorie Wright did an exceptional job in helping me pull together data that had sat dusty for over 22 years! In 2010, Bandelier National Monument generously provided personnel that have made it possible to finish this project. I specifically want to thank Craig Allen, Rebecca Oertel, Collin Haffey, and Kay Beeley for helping me resurrect this unfinished document. Rebecca and Collin patiently hiked with me to various areas while we searched for plots I had not seen in 12 years. Their patience with my plodding was much appreciated.

Graphics and maps are essential to telling the story of the La Mesa Fire. The skills of Kathy Bennett and Marjorie Wright from Los Alamos National Laboratory and Kay Beeley from Bandelier National Monument have enhanced the document and clarified words through images.

To other researchers in the area, including Craig Allen, John Hogan, Patrick Valerio, Randy Balice, and Sam Loftin, I appreciate the opportunity to interact on questions and ideas. John Lissoway, now retired from Bandelier National Monument, was supportive throughout the study.

The early studies were supported by the National Park Service and the Eisenhower Consortium. Before my retirement, the more recent studies have been supported by Los Alamos National Laboratory. I appreciated the continued support of my Group Leader, Diana Webb, Team Leader, Carey Bare, and the Chief Scientist for the Ecology Group, Wayne Hansen. They gave me resources to complete this work that would have otherwise disappeared when I retired—but now has resulted in this document plus two companion documents, *Fire Effects on Plants of the Jemez Mountains* and *Photographic Records of Various Study Plots Established for the La Mesa Fire*.

In these last few years, I have followed the plots on my own, without funding. I appreciate my husband's patience as I used some of our personal resources to complete the task. I am indebted to Friends of Bandelier who have supported the cost of editing these documents and the encouragement of Jason Lott, superintendent of Bandelier National Monument.

To Hector Hinojosa who has edited and reviewed these documents, my heartfelt thanks. To the editors and compositors, such a work would not have the quality without your help. So to you I say thank you. To Beth Cortright, thanks for your help. You gave me the energy to complete this task.

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PREFACE

In 1975, I had the opportunity to work with Loren Potter of the University of New Mexico as a technician on a project related to prescribed fire. Unknown to me at the time, this study would help frame my career as an ecologist.

Prescribed fire had been used extensively in the eastern US but, in 1977, was just beginning to be used in the western US. Bandelier National Monument wanted to understand the frequency of historic fires so they could determine how often to use fire to reduce accumulating fuels that were becoming dangerously high. We selected areas to study from the fire atlas maintained at the Monument. Each site had a fire at least 10 acres or greater that had been recorded on fire maps. We had almost completed the project when on June 16, 1977, the La Mesa Fire, a major conflagration, burned over these previously selected plots. As I stood in my yard in White Rock, I did not see the serendipity of the event. For years I had been told that all forest fires were bad—at least that is what Smokey the Bear said. Ash and burning debris fell on our houses and the sky was amber with smoke. The fire raged for over a week eventually burning acreage in Santa Fe National Forest, Bandelier National Monument, and Los Alamos National Laboratory. The day the fire jumped the road near Ponderosa Campground burning into the Laboratory's Technical Area 24 was a frightening one for it seemed the fire was not to be stopped by human intervention. It was not. As with most large conflagrations, a change in weather patterns was what stopped the fire's forward progress.

A few days after the fire had burned over my study areas, I was allowed into the site. It was early morning and I stood looking at the blackened remains of a once dense forest. The silhouettes of the charred trees stood against the dawn. My heart wept for the once green forest. Just then the sun arose over the Sangre de Cristo Mountains and I saw something that has given me hope in many things. For out of the blackened earth sprung little sprigs of grass, emerald green fed by the nutrients from the burning. Each sprig was tipped with a drop of dew. New life was springing out of the ashes.

That was only the first lesson and observation I made after the fire. Out of the ashes sprung new life. I marveled at the fields of wildflowers, the spurt of growth from newly nourished plants, and the process of standing dead trees falling. As I have had the opportunity to observe over the past 37 years, I have been amazed at the changes. Areas charred with no sign of life in 1977 are now meadows of grass and shrub lands. Areas that were dense with trees are now representative of forests before fire suppression, trees widely enough spaced you could run a horse through them. Trees that had branches nearly to the ground are now tall and naturally pruned. Where the fire burned hot, soil crusts are profuse. Trees I expected to die are alive, and some I expected to live are dead.

As I worked on this document, another fire burned over the plots. The Las Conchas Fire, a mega-fire in 2011, considered New Mexico's largest fire, burned 156,000 acres. Many more areas will now be converted to shrub lands, but others are regenerating quickly at higher, wetter elevations.

From my 37 years of observation, I am convinced that fire is one of the most—if not the most—important natural process to keep the forest healthy in the ecosystem. As we move into the 21st century, we have a big job to do. Forests of the Pajarito Plateau need the refreshing cleansing of fire to protect the health and safety of us all. For now, because of fire suppression, forests burn hot and are dangerous to those sent to suppress them. We must work with the forests we have remaining to protect them from other raging fires that threaten life and property.

The La Mesa Fire is now considered a very small fire in terms of what is happening today. Megafires are now burning over hundreds of thousands of acres. In 2011, the Las Conchas Fire made the record books as the largest fire to ever burn in New Mexico, burning over 156,000 acres. This summer, 2012, the Whitewater-Baldy Complex Fire in the Gila Mountains burned two times the area of the Las Conchas Fire (over 296,000 acres).

The discouraging thing is that, in 1977, the 14,278-acre La Mesa Fire was considered a very large fire. We called it our wake-up call. But today I hear on the news the same thing we were saying 35 years ago. "The forests are too dense because of fire suppression. Drought intensifies the risk." As I ponder the worthiness and suitability of this long project, I ask myself about where we are headed. Have we learned anything? Is it too late to save our forests? Are we putting our resources into fighting fires only and not into making our forests resilient?

Reading over the early fire reports from Bandelier for this publication, I read a memo to the Region III Superintendents from Harthon L. Bill, Acting Regional Director in 1958:

"*A Supplemental Narrative Report has been required for all Class C and larger fire, and for those involved total suppression cost to the Service of $100 or more (including FFS). Rising costs, particularly personal services, have made the $100 requirement an additional burden to the field as the majority of small fires are costing more than $100. Please advise the field areas that the $100 requirement has been raised to $500."*

It struck me how much we spend today on suppression and rehabilitation. The 2012 equivalency of the 1958 cost would be $3,973.10 or $39.97 per acre. The La Mesa Fire was the largest and most intense fire to burn in the 1970s in Bandelier National Monument. The total cost (suppression and rehabilitation) to the taxpayers was $3,000,000 or $196 per acre. In 2010, the suppression costs for the 42,971-acre Cerro Grande Fire were $15,813,914 or $368 per acre. Rehabilitation costs were $72,097,192. Suppression costs were only eighteen percent of the total $87,911,106 spent on suppression, and rehabilitation. Similar statistics are seen for other fires (Western Forest Leadership Coalition 2010).

Although at times I feel discouraged that we seem to be fighting the same battles 37 years later, I still have a sense of hope. That hope rests in nature itself. Regardless of how we are unable to manage the land as I have wished and hoped, nature heals. Perhaps not the way we want but there is an amazing resiliency in the ecosystem. From those early days until now, when I go out after fire, I have renewed hope when I see new sprouts coming "out of the ashes."

Watching the forested areas recover after fire has taught me not only a sense of hope but also an understanding that change is constant and something we cannot predict.

I have two wishes for this study: 1) give us hope for the future; and 2) help us learn from the past to ensure a better future.

Teralene S. Foxx

Suppression and Rehabilitation Costs of Recent Fires

Fire	Acres	Suppression Costs	Rehabilitation Costs
Cerro Grande*	42,971 (GIS)	$15,813,914	$72,097,192*
Hayman**	137,759	$42,279,000	$39,930,000
Missionary Ridge**	70,000	$37,714,992	$8,623,203
Rodeo-Chedeski**	462,614	$46,500,000	$139,000,000
Las Conchas*	156,593	$48,000,000	undetermined

*personal communication Greg Kuyumjian **Western Forest Leadership Coalition (2010)

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ABSTRACT

In 1996, Swetnam and Baisan stated the following: “The 1977 La Mesa burn was a wake-up call to perhaps the most pressing forest health problem in Southwestern forests—historically anomalous, catastrophic wildfire in the ponderosa pine—created by many decades of fire exclusion.” However, the wake-up call was only momentary and was forgotten until the Dome Fire (1996), Oso Complex Fire (1998), and Cerro Grande Fire (2000) burned lands within the community of Los Alamos, Los Alamos National Laboratory (LANL), Bandelier National Monument (BNM), and Santa Fe National Forest (SFNF). After the Dome Fire, several initiatives were under way to understand the wildland-urban interface and the conditions that have brought the forests of the Pajarito Plateau dangerously close to multiple, large, and intense wildfires. After the Dome Fire, the Interagency Wildfire Management Team was formed, bringing together adjoining agencies to deal with the ever-increasing threat of conflagration that could result in loss of property and human life.

This study is about the history before and after the La Mesa Fire—at the time, the first large wildfire on the Pajarito Plateau in over 80 years. It represents 37 years of research and observations that began when management of fire on the Pajarito Plateau was first being explored by BNM. It documents changes in vegetation composition since June 1977 and shows the progression of change in understanding fire’s essential place in the ecosystems of the Pajarito Plateau.

The study began in 1975 and 1976, when Loren Potter and I examined previously burned areas to determine a fire frequency for the east Jemez Mountains. We had examined areas of 10 acres or more that had burned at various times, e.g., 1939, 1945, 1950, 1955, 1960, and 1976. A year and a half into the study, the La Mesa Fire ignited on Mesa del Rito, ultimately burning about 15,000 acres of BNM, SFNF, and LANL, including our established plots. After the fire, we set up 20- by 50-meter permanent plots along four ornithological transects established by ornithologist Roland Wauer. Wauer’s transects were mostly in ponderosa pine, with one in mixed conifer and one in the piñon-juniper woodland. Plots within the ponderosa pine were visited in 1977, 1978, 1985, 1992, 1998, 1999, 2010, 2011 and 2012. We mapped the standing trees, photographed each plot, and collected data on the understory components. Transects in the mixed conifer were visited in 1977, 1992, 1999, 2010 and 2012. Plots in the piñon-juniper were visited in 1977, 1999, and 2010 for taking photographs and data years after the fire. Additionally, plots were established in LANL Technical Area 49 as a control to post-fire seeding. We visited these plots in 1977, 1992, and 1998.

Ironically, this study ends with another large fire burning over the plots we have followed all these years. In June 2011, the Las Conchas Fire became the largest fire in New Mexico’s history to that time and burned most of the area of the La Mesa Fire and the plots studied over the years.

In this report, we summarize information about the vegetation changes within the boundaries of the La Mesa Fire. Thirty-seven years of observations and studies have provided long-term data related to regeneration of trees, water relations of grasses and pines, the influence of seeding with non-native grasses, pyrodendrochronology, and plant succession as related to fire.

1.0 INTRODUCTION

1.1 Physiography

Bandelier National Monument (BNM) and Los Alamos National Laboratory (LANL) are in juxtaposition on the Pajarito Plateau, a flat skirt-like extension of the Sierra de los Valles of the Jemez Mountains. The Jemez Mountains are a volcanic pile, located in north-central New Mexico, that resulted from volcanic activity nearly a million years ago (Figure 1.1).

Figure 1.1. The Jemez Mountains (NASA photo)

The eastern portion of the mountain range includes a giant caldera, the Valles Caldera. The eastern rim of the caldera forms a series of peaks called the Sierra de los Valles (Figure 1.2). The high peaks include Pajarito, Guaje Mountain, Cerro Grande, Caballo, and Tschicoma. The highest peak being Tschicoma at 11,561 feet.

Figure 1.2. The Sierra de los Valles

A flattened table-like extension from the mountains—called the Pajarito Plateau—ranges in elevation from 8000 to approximately 6500 feet. The plateau was formed by an ash flow from the volcanic activity that resulted in the formation of the giant caldera. The caldera consists of a series of valles (valleys), 12 miles west of the main gate to BNM. This giant depression is approximately 12 miles in diameter and is a byproduct of the tectonic disturbances that formed the mountains of the Rockies, Sangre de Cristos, Sierra Nacimientos, and San Pedros. Forces of erosion have since carved the flat plateau into linear mesas and canyons. A series of deep canyons and a system of smaller secondary canyons make the terrain of the plateau rough and sometimes remote. Within the roadless wilderness of BNM, some places are virtually inaccessible. White Rock Canyon, a 1000-foot-deep canyon through which the Rio Grande flows, forms the southern boundary of the plateau (Figure 1.3) (Burton 1982, Olinger 1974, Nyhan et al. 1978, Goff 2009).

Figure 1.3. White Rock Canyon

Land Ownership
Land in the east Jemez Mountains is managed by five different entities: BNM, LANL, Santa Fe

National Forest (SFNF), Valles Caldera National Preserve, (VCNP) and the County of Los Alamos (LAC) (Figure 1.4). BNM is comprised of approximately 51 square miles, or 33,000 acres, and LANL approximately 43 square miles.

The areas of interest in this report are the lands within BNM, LANL, and the surrounding SFNF. These lands are located approximately 35 miles from Santa Fe and 50 air miles from Albuquerque. The Monument extends from the Rio Grande to the top of one of the highest peaks of the Sierra de los Valles, Cerro Grande (10,199 ft). The Laboratory extends along the Rio Grande to the West Jemez Road, along the Pajarito Mountain watershed, to an elevation of approximately 8000 feet.

BNM headquarters are situated in Frijoles Canyon. All other canyons, as well as the upper portion of Frijoles, are located in the backcountry, a wilderness area with many hiking trails. Within the Monument the upper parts of the canyons have water nearly year-round. The streams are ephemeral in lower canyons, being swollen with water only during the rainy season or spring snowmelt. The Rito de los Frijoles is the only stream that flows throughout the year.

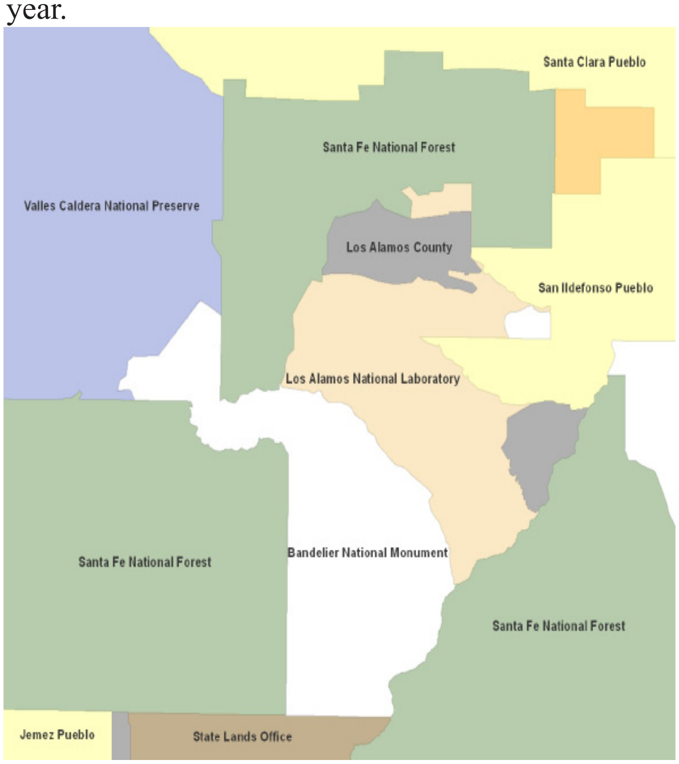


Figure 1.4. Land ownership

Most of the facilities within LANL are on the mesatops. Within LANL, streams are ephemeral and run only during spring snowmelt or heavy thunderstorms.

1.2 Plant Communities

Because of the diverse terrain, elevation, climatic gradients, and variable water resources, there are a variety of plant communities within the study area. Fire has had a major impact since 2000 in the vegetative composition of the higher slopes. Over 200,000 acres have been burned in the last 12 years.

Historically, piñon-juniper and ponderosa pine dominate the mesa tops. The north-facing slopes of the canyons and higher elevations are generally mixed conifer. Perennial and some ephemeral streams have riparian communities that include narrow-leaf cottonwood, box-elder maple, and shrubs. The peaks are dominated by spruce-fir and open meadows (Figure 1.5) (Allen 1984, Foxx and Hoard 1995, Barnes 1983, Balice et al. 1997, Koch et al. 1996, Moir and Ludwig 1979, Potter and Foxx 1981).

The nearly pure juniper stands at lower elevations near the Rio Grande grade into piñon-juniper woodlands, which extend upward to approximately 6500 feet. The latter woodlands, in turn, form an ecotone with pure stands of ponderosa pine at elevations of approximately 7500 feet. This type merges with mixed conifer, composed of Douglas fir, white fir, ponderosa pine, Southwestern white pine, and limber pine, at elevations of 8500 to 9000 feet. At high elevations spruce-fir and aspen are common. These border high meadows composed of many grasses and forbs. Aspen also occurs within the mixed conifer mostly on large burns, areas of previous logging, areas of blowdown, and moist north slopes at the heads of narrow, shaded canyons.

Areas burned by the 2000 Cerro Grande Fire and the 2011 Las Conchas Fire—much of BNM and areas of the east face of the Sierra de los Valles—have been altered to a shrub or shrub-grassland community (Figure 1.6). Only remnants of aspen and

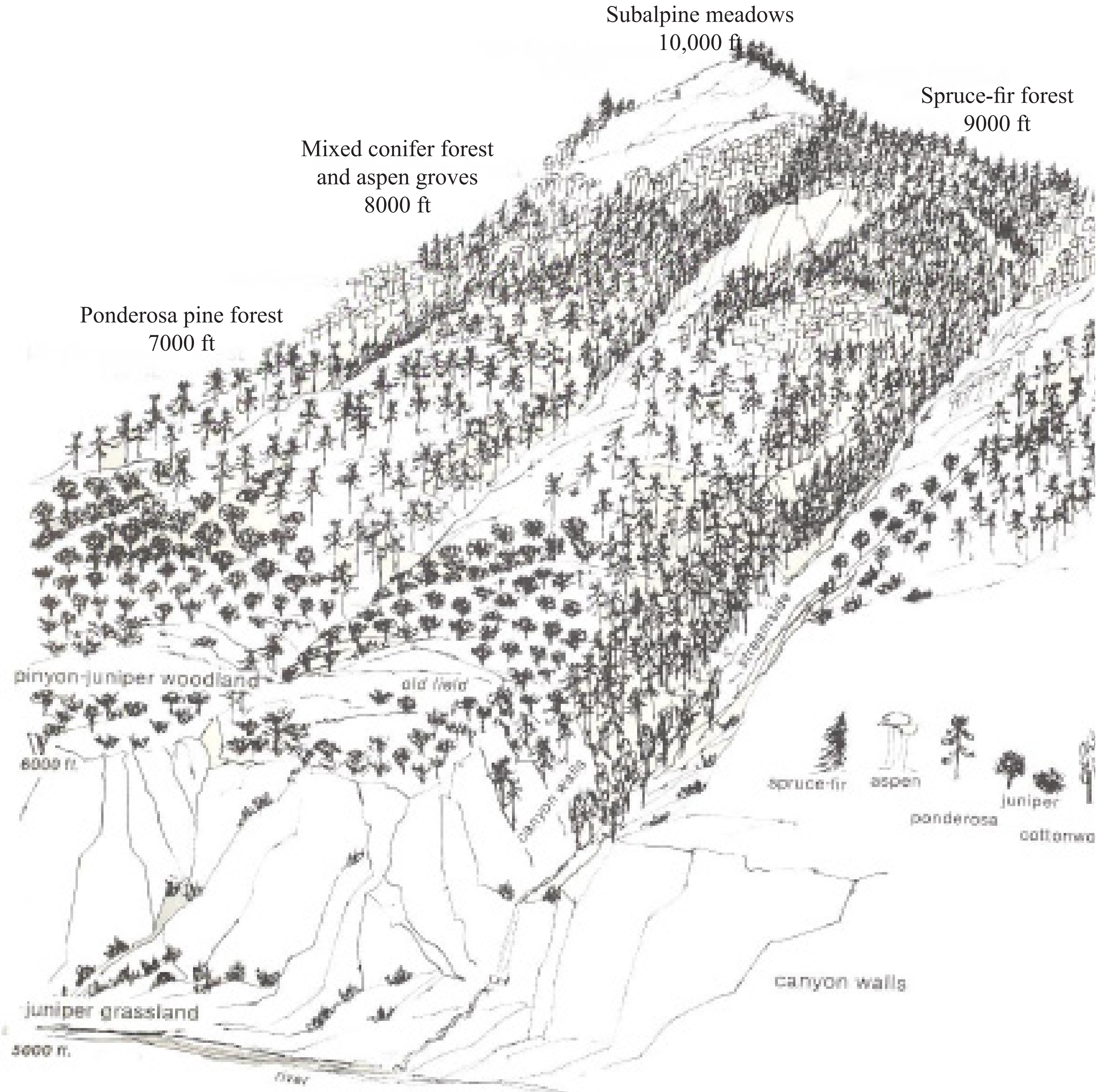


Figure 1.5. Historical view of the slopes of the Sierra de los Valles and Pajarito Plateau before the Cerro Grande and Las Conchas fires (Foxx and Hoard 1995)

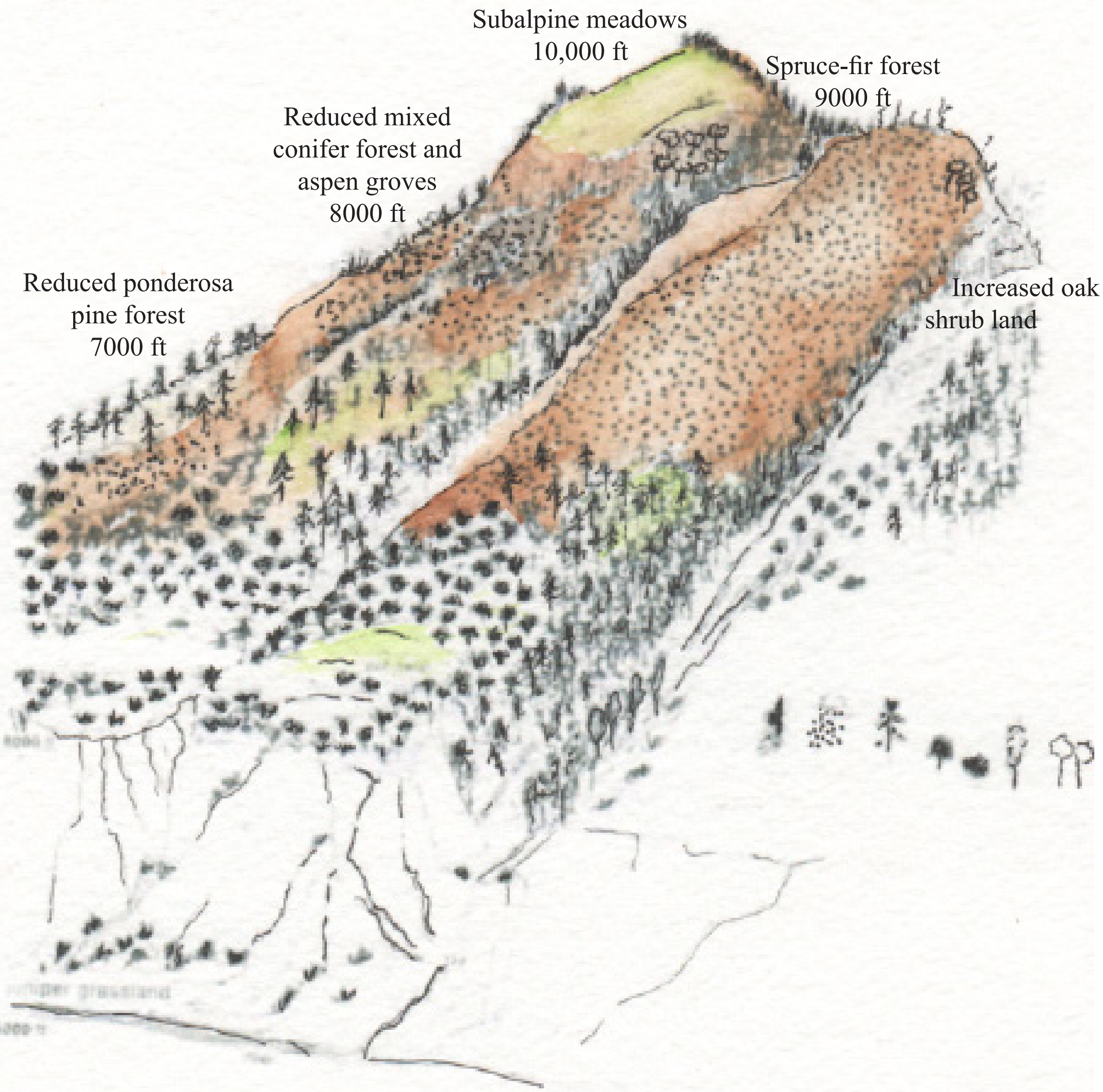


Figure 1.6. The present view of the slopes of the Sierra de los Valles and Pajarito Plateau (after Foxx and Hoard 1995) brown = changed area; green = meadows

ponderosa pine and mixed conifer remain on large expanses. The Las Conchas Fire burned intensely in the upper areas of the Pajarito/Frijoles and Bland/Cochiti watersheds, as well as on the Santa Clara reservation. It also burned into the piñon-juniper woodland of BNM and areas previously burned by the Dome and La Mesa fires.

After the Las Conchas Fire many of the upper canyons were severely burned, causing flooding (Figure 1.7a and b).

1.3 Climatology

Climatological records for the area have been maintained at the Monument headquarters and at LANL. The information at the Monument is limited to file records of precipitation and temperature readings from the headquarters area dating from 1933. More extensive records have been maintained at LANL (Weather Machine n.d., Bowen 1992).

The plateau has a semiarid continental mountain climate. Annual precipitation averages slightly more than 18 inches, and, at Monument headquarters, 15 inches. The most precipitation received in one year was 30.3 inches with 6.80 inches being the least. Seventy-five percent of the precipitation is received during the months of July and August—the monsoon season. The maximum 24-hour rain recorded for Los Alamos is 3.48 inches. On the average, a trace or more of precipitation occurs on 140 days of the year.

Shower activity reaches its peak in August, when rainfall of one-tenth inch or more can be expected one day out of four. The convective showers normally develop in the afternoon or early evening and are relatively brief. Hail may accompany more severe thunderstorms. Most of the winter precipitation falls as snow, with an average snowfall of 50 inches.

1.4 Ecology of Fire in the East Jemez Mountains

The Problem

Species diversity and structural patterns in Southwestern forest communities are not maintained without fire. Evidence gained through dating of fire scars (pyrodendrochronology) has shown that—before various modern anthropogenic factors such as grazing of cattle and sheep and fire suppression—fire was a common occurrence within the ponderosa pine forests of the Southwest, including those of the Pajarito Plateau. Before modern fire suppression, the ponderosa pine forests burned every eight to 12 years (Arno 1976, Laven et al. 1980, Show and Kotok 1924, Wagener 1961, Weaver 1951, 1955). These frequent creeping fires were important in keeping the forest a mosaic of even-aged stands in an uneven-aged forest (Cooper 1960).

Anthropogenic Changes on the Pajarito Plateau

Prehistoric Era

Many anthropogenic changes within the ecosystems of the Pajarito Plateau did not begin until the late 1100s, at which time settlement of the Keres and Tewa speaking peoples began (Steen 1977, 1982). The first to arrive were the Keres, whose decendents now live at Cochiti and other Keresan-speaking pueblos. Later the Tewa arrived from Mesa Verde and Chaco Canyon. Large pueblos developed in Frijoles and Pajarito canyons, but numerous outlying sites have also been found.

Fire as a tool for hunting or increasing food supplies does not appear to have been used by the pueblo people. Adoph Bandelier (1892) indicated that the Cochiti (descendants of these early peoples) practiced communal hunts by rounding up animals and forcing them off precipices near the Rio Grande, but there is no mention of fire. Although the people may not have used fire as a hunting tool, fire was recognized as a natural phenomenon. In a letter to the Southwest National Monuments, C.A. Thomas (1940) quotes an old Taos Indian as having said, "*Before the White Man came to the mountains, bugs and disease seldom killed the forests, because when bugs attacked the trees, a few (trees) died, and the gods seeing the dead trees sent the lightning to set*

Figure 1.7a. Upper Frijoles Canyon after the La Mesa Fire in June 1977. Only spot fires were in the canyon.

Figure 1.7b. Upper Frijoles Canyon after the Las Conchas Fire in June 2011 (photo by C. Haffey)

them afire. The fire burned up the dead trees and the bugs and no more trees were harmed for a long time." Vierra and Foxx (2002) found that a number of species increased after fire and may have been important to gatherers. Abandonment of the plateau by early inhabitants began in the 1500s, and, by the time the Spanish arrived in New Mexico in 1597, these Indian groups lived in the valley areas near the Rio Grande (Hill and Trierweiler 1986).

Allen (2002) reviewed the cultural history of fire in the Southwest mountains, including the Jemez Mountains. He found scanty to nonexistent evidence of landscape-scale fire used by aboriginal people in the Southwest, with most information based on anecdotal accounts. The high level of lightning-ignited fires in the Southwest better explains the frequent return intervals indicated by fire scar records.

Historical Era

Areas south of Frijoles Canyon were without roads and remote. Consequently, the greatest anthropomorphic changes happened on lands north of Frijoles Canyon where grazing, homesteading, and lumbering began to change the landscape and then development of the community of Los Alamos and Los Alamos Scientific Laboratory, now LANL, through the years. There is no historical evidence of use or habitation on the mesa by the Spanish until 1742 when Pedro Sanchez was given a Spanish Land Grant, which later became known as the Ramon Vigil Grant (Figure 1.8).

For nearly 100 years, the grant remained within the Sanchez family and was used for grazing and pastoral herds. In 1851, Antonio Sanchez sold eight interests of the land to Ramon Vigil who used it for grazing sheep, goats, and cattle (Chambers 1974, Chambers and Aldrich 1999).

The biggest anthropomorphic changes for the area began to occur in the late 1800s. The economy after the Civil War, laws made in Texas to prevent overgrazing, the opening of northern New Mexico to the railroad and lumbering, and the Homestead Act all provided massive land-use changes in the area. In 1884, Winfield Smith and Edward P. Shelton bought the Ramon Vigil Grant and opened it to grazing and lumbering. From 1885 to 1887, W.C. Bishop (a Texas cattleman) ran 3000 head of cattle on the 32,000-acre grant. In 1897, the owners of the grant sold the timber rights to H.S. Buckman who removed 36,000,000 board feet of lumber (Figures 1.9–1.11) (Stout 1970).

The opening of the Chili Line—a narrow-gauge railroad—in Española and Santa Fe in 1880, enabled shipping to market the products of farming, logging, and grazing. Homesteading began in 1894, but much of the area was still used only as a summer grazing area for Española Valley families. Sheep were a common commodity (Chambers 1974, Chambers and Aldrich 1999, Gjevre 1971, Carlson 1969, Dorman 1972).

Early in the 1900s, Frank Bond, rancher from Española, bought the grant as a waystation for stock being shipped from summer ranges on the Valle Grande. The stock were herded to Buckman on the Rio Grande across the rickety Buckman Bridge (see Figure 1.10). He continued to graze animals here until the 1940s, when the area was taken over for the secret Manhattan Project (development of the first atomic bomb)(Grubbs 1958, Carlson 1969). Grazing has since been excluded from both BNM and LANL. Feral burros were grazing on BNM land at the time of the La Mesa Fire. In the 1970s, burros were still roaming the area and burro wallows were apparent. Eradication of the burros was not complete until the 1980s (Rothman 1988).

Logging occurred within the SFNF, but on a small scale. Until the 1950s, access to US Forest Service (USFS) lands and the Valle Grande was limited to animal trails and unpaved roads (Hoard 2009).

Since the advent of the Manhattan Project, the mesas and some canyons within LANL have been developed. The urbanized areas of White Rock and Los Alamos have spread along mesa tops and many roads have been developed (Chambers and Aldrich 1999, Truslow 1973).

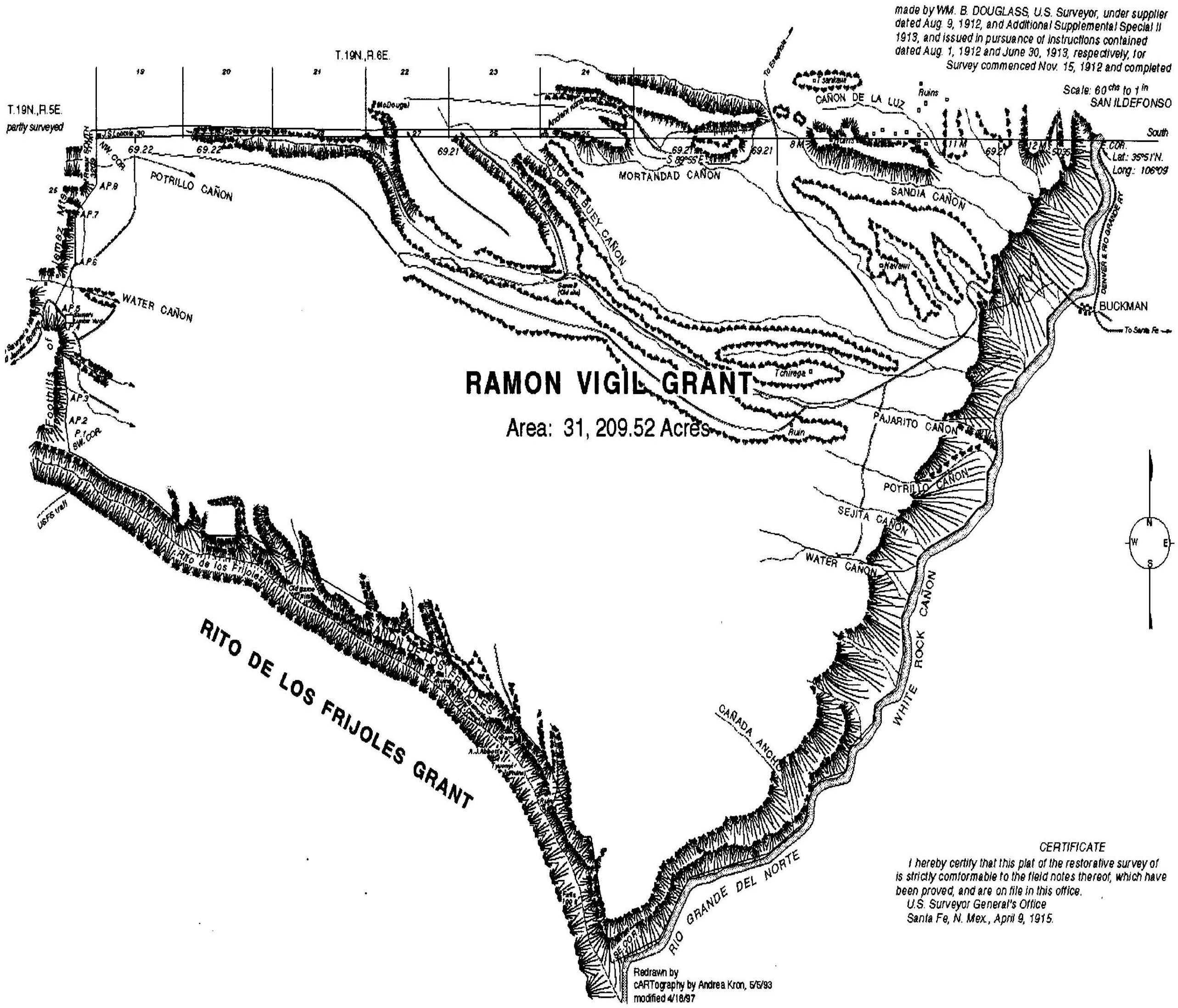


Figure 1.8. The Ramon Vigil Grant

Figure 1.9. Cattle were common in the early part of the 20th century on the plateau.

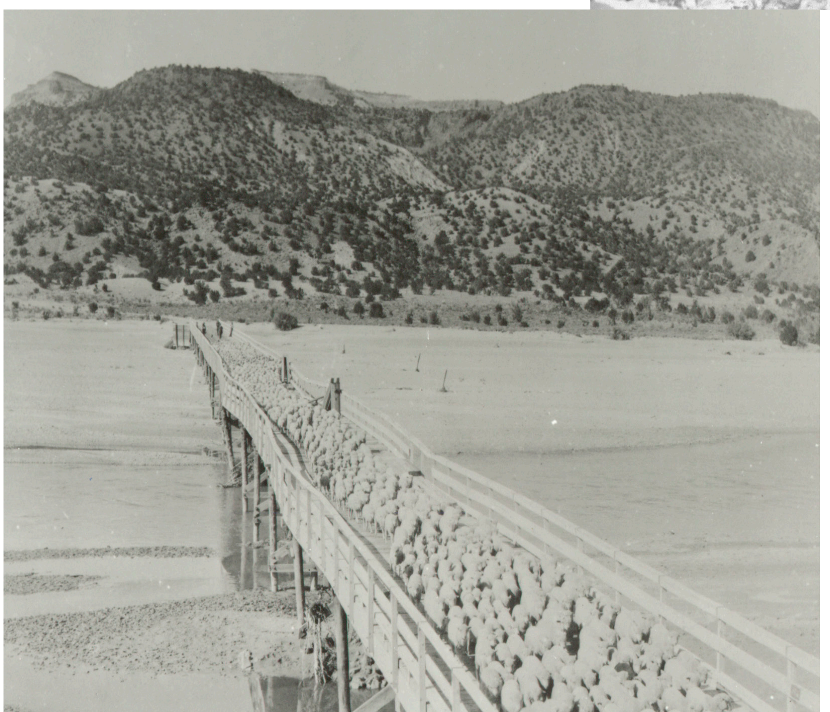
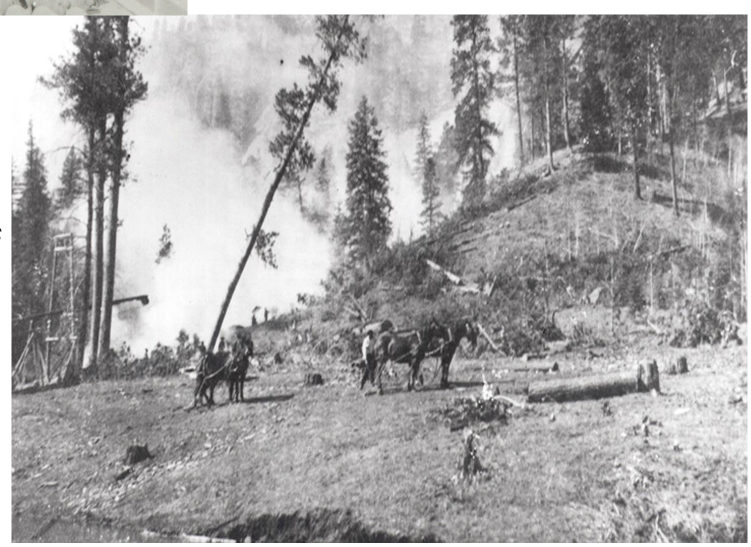


Figure 1.10. Sheep herded across Buckman Bridge (1922)

Figure 1.11. Logging on the Pajarito Plateau (Photos on this page courtesy of the Los Alamos Historical Society)



Fire Suppression

Ponderosa pine forests of the Southwest are in a lightning bioclimate (Komarek 1967, 1968, 1969). In a 22-year period from 1945 through 1966, Komarek (1969) reported 33,965 lightning-set fires on 20,407,885 acres comprising the national forests of Arizona and New Mexico. The average was one lightning-set fire per 601 acres during that period.

During the same period of time, the SFNF, adjacent to BNM, recorded 1431 lightning-set fires on 1,440,511 acres. Humankind has been able to change the general nature of the forest through fire suppression, but cannot change the main source of natural ignition of historic and prehistoric fires.

Fire suppression has changed the composition and character of the ponderosa pine forest. Early explorers described the forests as open and unencumbered by underbrush (Beal 1858, Dutton 1881, Muir 1894, 1901). King (1871) gives an account of running his horse through forests of the Sierra Nevada. Fires in this environment were not as destructive as the ones seen today. The fires crept along the ground and only occasionally ignited treetops. Those fires reduced the pine needle accumulations, culled diseased trees, and thinned young stock, resulting in a forest with a more park-like appearance (Muir 1901). Major changes in Southwestern forests began in the late 1800s with logging, accumulation of slash, and suppression of fire in the 1900s.

Exclusion of fire from these forests has resulted in heavy fuel accumulations. Dieterich (1976) collected samples from 54 stands of mature ponderosa pine in various areas of Arizona and New Mexico that had an average of 12.7 tons per acre of ground fuel and 10.6 tons per acre of down dead woody material. Fuel loadings of this magnitude have the potential of producing extremely hot fires. It is estimated that 12.5 tons per acre of accumulated fuel consumed by the fire front is 1.322 BTUs per second per fireline foot. Damage to mature trees can be expected from 700 BTUs (Sackett 1976).

Biswell et al. (1966) have found that 2.2 to 6.9 tons of litter per hectare are accumulated on the forest floor each year. This becomes a serious problem in the warm dry climates of the Southwest, where decay is slow. Dodge (1972) indicates the effectiveness of an exclusion policy has been that 95 percent of the wildfires are extinguished while small; however, the 3 percent to 5 percent that get out of control cause 95 percent of the damage.

Fire is a natural thinning agent, reducing competition and over-stocking. Ponderosa pine needs full sunlight for maximum photosynthetic activity. Young trees are susceptible to fire, but older trees are protected by thick bark. In the dense, stagnant stands produced because of fire exclusion, trees are weakened and susceptible to disease and insect attack. Thinning of the forest produces a more vigorous, rapidly growing stand of trees and reduction in trees killed by such diseases as mistletoe (Wicker and Leaphart 1976). There is also some indication that smoke produced by fire may have a sterilizing effect on the forest—thus reducing certain disease organisms (Parmeter and Uhrenholdt 1976).

Researchers warned against the total fire exclusion policy soon after its inception; however, the problem has only became a widespread concern since the mid-20th century. Researchers like Weaver were early leaders in prescribed burning experiments (Weaver 1943, 1951, 1955, 1961, 1967a, 1967b).

Today the tools used to reduce canopy density are burning, thinning, and thinning/burning (Allen et al. 2002, Fulé et al. 2012, Cram and Baker 2012, Balice et al. 2012).

Fire History

The history of fire is hard earned for the Pajarito Plateau. Few records are available and nearly all early and late fire histories have been obtained through dendrochronological studies. Additionally, fire history and fire use have been dependent on the various management styles of various agencies that manage land within the east Jemez Mountains.

Bandelier National Monument

BNM came into the National Park system in 1916 by presidential proclamation for the "preservation, protection, and study of its archaeological resources." There is no record of fire management until 1932, when the management of land changed from the USFS to the National Park Service (NPS). Additional land was added to the Monument in 1959, 1963, 1976, 1998, and 2000 (Rothman 1988, Public Law 105, 1998). Because these additions were under different jurisdictions, both federal and private, there is often little information about fire before acquisition.

There are four ways that fire history has been obtained for the Monument area. The first was from the fire records and fire atlases maintained at the Monument from 1932 to 1976 and the second was dendrochronological studies done by Foxx and Potter (1978) and samples sent to the Tree Ring Laboratory at the University of Arizona (Robinson 1978). In more recent years more extensive dendrochronological studies have been conducted in the Jemez by other researchers, including Craig Allen, Tom Swetnam, and others (Allen 2001a, b, 2002; Touchan et al. 1996, Dewar et al. 2012, Haffey et al. 2012). The third was from articles and dialogues found in the atlas, newspapers, and personal recollections of citizens (Appendix I). A fourth approach has reconstructed fire histories from charcoal concentrations in local bog sediments that extend back many thousands of years (Allen et al. 2008).

Los Alamos National Laboratory

The Laboratory was established in the early 1940s for the then secret Manhattan Project and development of the atomic bomb. As with most other Department of Energy (DOE) and Department of Defense sites, land management was not the primary mission, until recently. Until then, much of the area was under the USFS and homesteaders. There is pictorial and some historical evidence of fire in the east Jemez Mountains. Articles in early Laboratory publications mention fire. Figure 1.12 is a picture taken in the 1920s that shows areas along the east side of the Pajarito watershed. The mountain behind Los Alamos was known as Burnt Mountain before the white-washed rocks were placed changing the name to LA Mountain (Martin 1998). Old photographs indicate this mountain was burned before the Ranch School days. Dendrochronology shows that the last major fire in and adjoining the Los Alamos town site was in 1883 (Allen 2002).

There is also a record of a fire in 1954 above S Site (Sewell, dialogue, Balice et al. 1999, *Santa Fe New Mexican* 1954). Interviews with Homer C. Pickens, a former resident and forester from Los Alamos, provided some information on fire within the previous holdings. Additionally, Albro Rile, Fire Marshal of Los Alamos at the time, was contacted in the 1970s for information about the fires (Foxx and Potter 1978). Other small fires have been generated from explosives experiments. A controlled burn was also conducted in Potrillo Canyon in the mid-1990s. There is no record of the fire frequency within the confines of the Laboratory and even today fire suppression is the usual. Thinning mitigation has taken place along the Laboratory perimeter and within the County (LANL 2003 and personnal observation).

Data Analysis

Because there was no systematic compilation of fires within the Laboratory, the data presented in this report are primarily for BNM. Information for the specific study areas is also somewhat limited because until 1963, the study areas on Burnt and Escobas mesas were under the jurisdiction of the Atomic Energy Commission (AEC), the predecessor to the DOE. The AEC provided the necessary fire suppression efforts, and no systematic records were maintained; therefore, there was little or no information available. In 1963, the NPS obtained the area and had policy of total fire suppression until the late 1970s (Figure 1.13). During the study period, two fires occurred on these mesas, one in 1975 on Burnt Mesa and one in 1976 on Escobas Mesa. Photographs were taken at established photo points in each of these fires (Foxx n.d.[a]). The 1976 Escobas Mesa Fire became part of the comparative data set after the 1977 La Mesa Fire. Additionally, in recent years the areas on Burnt and Escobas mesas have been burned by prescribed fires ignited to reduce fuel loads in BNM.

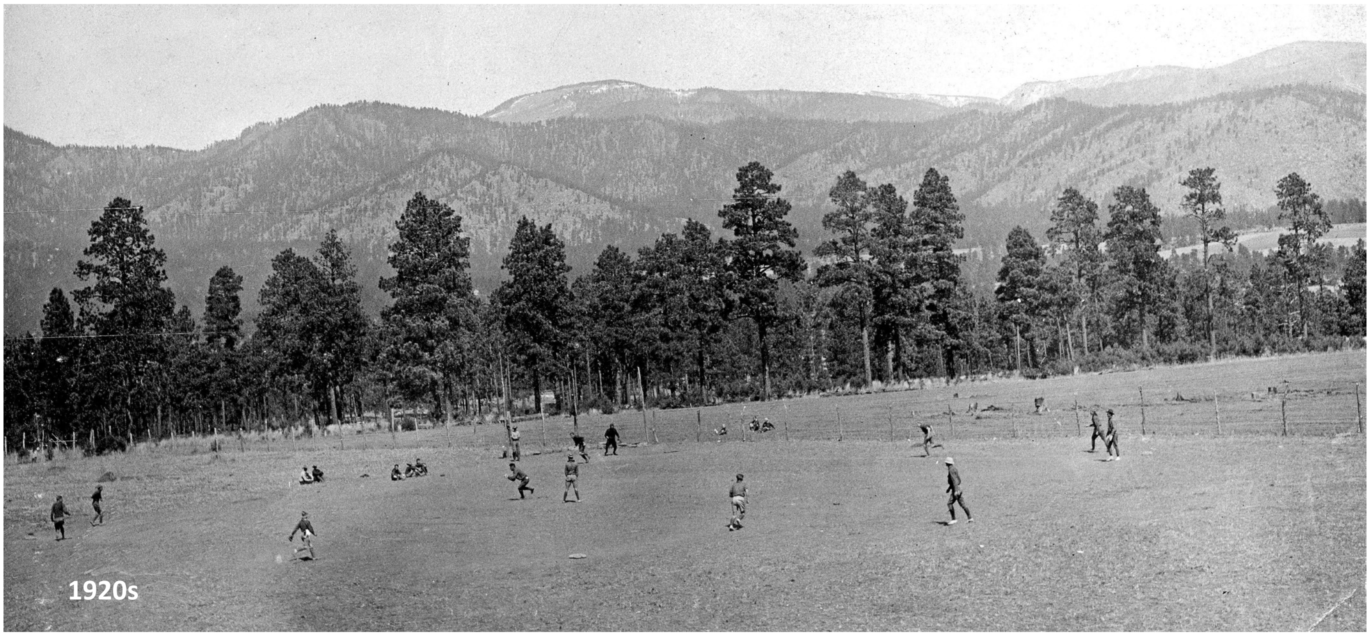


Figure 1.12. The Jemez Mountains in the early 1920s showing open stands on the mountain slopes (Courtesy Los Alamos Historical Society)

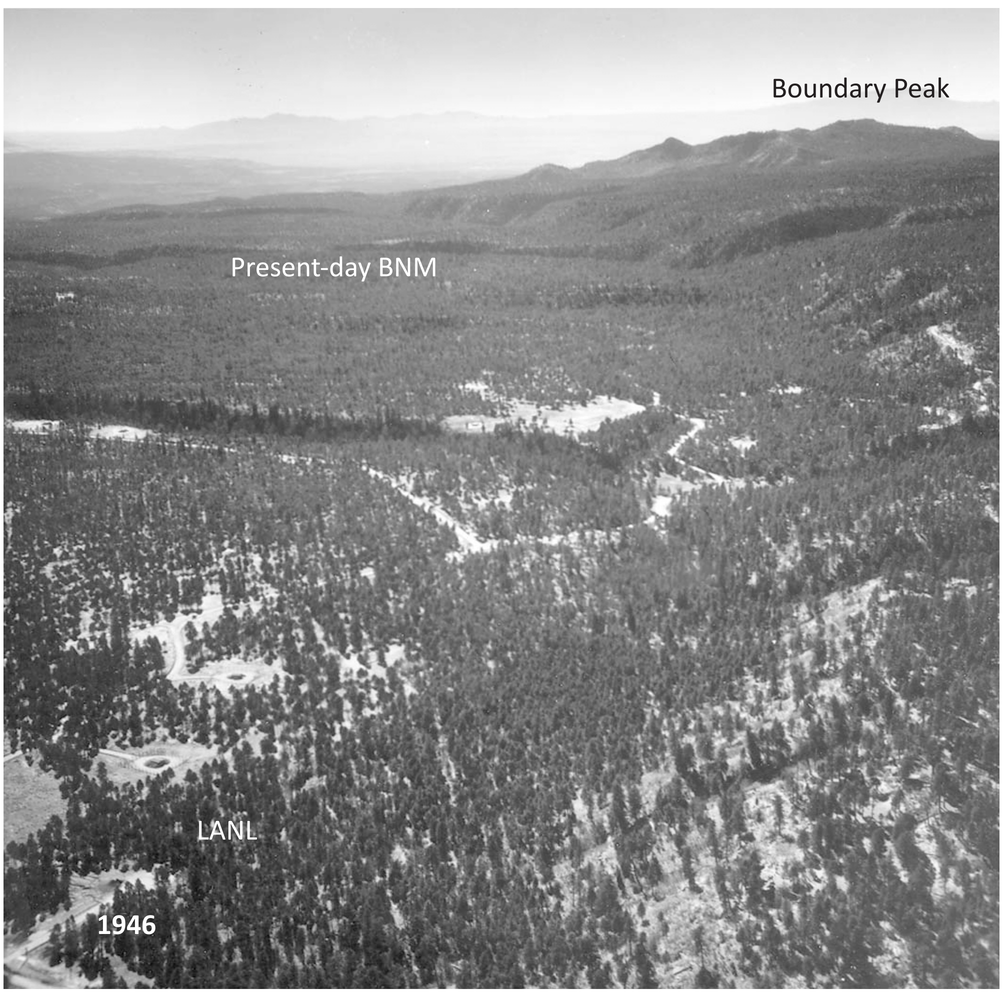


Figure 1.13. Picture taken in 1946. This area has been burned by either the La Mesa, Dome, or Cerro Grande fires. Most was re-burned by the Las Conchas Fire.

In 1975 and 1976, Foxx and Potter (1978) summarized the information in the fire atlases and fire reports maintained at the Monument. Information obtained from the fire atlas maintained from 1932 through 1969 is summarized in Table 1.1.

From the record and fire atlas information, we found that, from 1931 to 1977, 224 fires were recorded, 86 of which were lightning caused. Of these, 72 percent were less than a quarter-acre, 25 percent were a quarter to nine acres, and three percent were 10 or more acres. This is an average of approximately six fires per year. More than 30 percent of the fires occurred during July, which is considered the peak fire month, followed by June and August. Most of the fires occurred between May and September.

Using forest fire statistics for the period 1960 to 1975, Barrows (1978) found that 80 percent of New Mexico fires were ignited by lightning, and about 20 percent were anthropogenic fires. Foxx and Potter (1978), Allen (1984), and Allen (2002) found 85 percent of the fires recorded in Bandelier were ignited by lightning, with a peak in July and smaller peaks in June and August. Generally, all local fires occurred between April and September. Barrows (1978) found that this seasonal pattern of ignitions occurred throughout the Southwest, but fires that started in June caused the greatest area to be burned (72% of all fires in June were due to lightning).

Potter and Foxx (1979a) looked at 18 fire-scarred tree samples from Escobas and Burnt mesas. They found that over 50 percent of the samples had fires recorded for 1797, 1806, 1822, 1842, 1870, 1878, and 1893. The average fire interval was between five to 18 years (Figure 1.14).

Touchan et al. (1996) found abundant and well-preserved fire history records in the Jemez Mountains. They identified 1858 fire events representing 221 separate fire years. Major fires ceased after the 1890s. They found the minimal fire interval for ponderosa pine to be one to 12 years and the maximum ranged from 16 to 51 years. Before 1900, fire regimes in ponderosa pine forests were characterized by high-frequency, low-intensity surface fire. They found a WMPI (Weibull median probability fire interval) of 6.5 to 7.5 years, which was consistent with other Southwestern ponderosa pine forests (4.9 to 10.2 years) (Weaver 1951, Dieterich 1980, 1983, Swetnam and Dieterich 1985).

There was a clear cessation in widespread fire occurrence at all sites after 1893. The end of frequent and extensive fire coincided with the onset of the documented period of intensive livestock grazing across northern New Mexico (Wooton 1908, Allen 1989), which reduced the continuity of herbaceous fine fuels (e.g., grasses) and, hence, the ability of fire to spread. The buildup of livestock numbers in the late 1800s was a regional phenomenon. Concurrent with the increase in livestock, sharp declines in the fire frequency were observed in most other southwestern fire scar studies (Weaver 1951, Dieterich 1980, Dieterich and Swetnam 1984, Allen 1989, Swetnam 1990, Swetnam and Baisan 1996).

Fires in the Jemez and the Study Area

At the beginning of the 1975 study, we selected sites that had burned from 1931 to 1975 greater than 10 acres (Class C fire, Table 1.1).

Over the past century, both the ponderosa pine and mesic mixed-conifer forest sustained changes in species composition and stand structure. The once fire-frequented forests have changed to doghair thickets, decreased undercover, and increased fuel-loading (Covington and Moore 1994). Shade-tolerant, less-fire-resistant species, such as white fir, have increased in many mixed conifer stands (Harrington and Sackett 1990). These changes in forest structure and species composition have increased the probability of high-intensity fires that has been demonstrated in the past 37 years in the east Jemez Mountains exemplified by the five major fires—La Mesa, Dome, Oso Complex, Cerro Grande, and Las Conchas—since 1977 (Table 1.2).

Some areas studied after the 1977 La Mesa Fire were burned in the 1996 Dome Fire. Although no data were collected, selected photography was

Table 1.1. Fire History from 1931 to 1977 by Classes of Fire Size, Causes, and Month plus Annual Precipitation at BNM Headquarters

Year	A*	B	C	Total	Lightning	Human											Precip**
							Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	un-dated	
1931	None																	23.68
1932	None																	14.26
1933	None																	14.61
1934	1	2	0	3	1	2							3					9.79
1935	2	0	0	2	1	1	1				1							12.80
1936	1	0	0	1	1	0			1									15.17
1937	0	2	1	3	2	1				2		1						14.81
1938	0	4	0	4	2	2											4	10.96
1939	No info																	17.08
1940	3	1	0	4	3	1				1	2	1						18.27
1941	0	0	0	0	0	0												27.25
1942	0	0	0	0	0	0												16.35
1943	2	2	0	4	2	2	1		1	1			1					12.75
1944	1	0	0	1	1	0						1						15.62
1945	4	4	1	9	7	2			1	3	3		1			1		16.60
1946	5	4	0	9	9	0					6	2	1					9.61
1947	2	1	0	3	3	0						3						12.65
1948	2	0	0	2	2	0				1		1						16.45
1949	1	0	0	1	1	0	1											19.97
1950	1	2	0	3	2	1			3									9.60
1951	No info																	12.11
1952	No info																	16.13
1953	2	0	0	2	2	0					2							11.22
1954	3	1	0	4	3	1			1	1	2							16.26
1955	1	1	1	3	3	0					2	1						9.25
1956	2	1	0	3	2	1			1	1	1							5.77

Year	A*	B	C	Total	Lightning	Human												Precip**
							Mar	April	May	June	July	Aug	Sept	Oct Nov	Nov	Dec	un-dated	
1957	5	1	0	6	0	2					2	4	3					14.04
1958	2	1	0	3	3	0					1	2						21.70
1959	5	0	0	5	5	0			1		4							17.85
1960	0	1	1	2	1	1			1				1					16.96
1961	No info																	17.02
1962	6	0	0	6	0					1	3	2						11.72
1963	11	0	0	11	0					3	3	2	3					16.62
1964	16	4	0	20	17	3			2	4	9	5						12.11
1965	14	8	0	22	16	6			1	3	5	10	3					21.10
1966	7	4	0	11	11	0				2	5	2	1	1				14.99
1967	10	1	0	11	11	0				3	2	2	4					16.48
1968	no info																	16.85
1969	13	0	0	13	0				1	6	2	4						26.82
1970	2	0	0	2	2	0						2						14.48
1971	10	7	0	17	14	3		2	1	2	6	6						12.63
1972	3	0	0	3	3	0				2	1							18.49
1973	2	0	0	2	2						1	1						20.58
1974	4	0	0	4	4					1	3							12.20
1975	5	1	1	7	6	1				1	3		2	1				18.70
1976	8	1	1	10	8					4	5		1					11.19
1977	6	1	1	8	7	1		1	4	3								10.88
Total	**162**	**55**	**7**	**224**	**193**	**31**	**3**	**4**	**26**	**49**	**76**	**46**	**14**	**1**	**0**	**1**		
Yr mean	**4.2**	**1.4**	**0.2**	**6.0**	**5.0**	**0.8**	**0.08**	**0.1**	**0.7**	**1.3**	**1.9**	**1.2**	**0.4**	**0.03**		**0.03**		

*Class A = one-fourth acre or less, Class B = more than one-fourth acre but less than 10 acres, Class C = 10 acres or more.
**Annual water year precipitation for BNM Headquarters 1929–2010

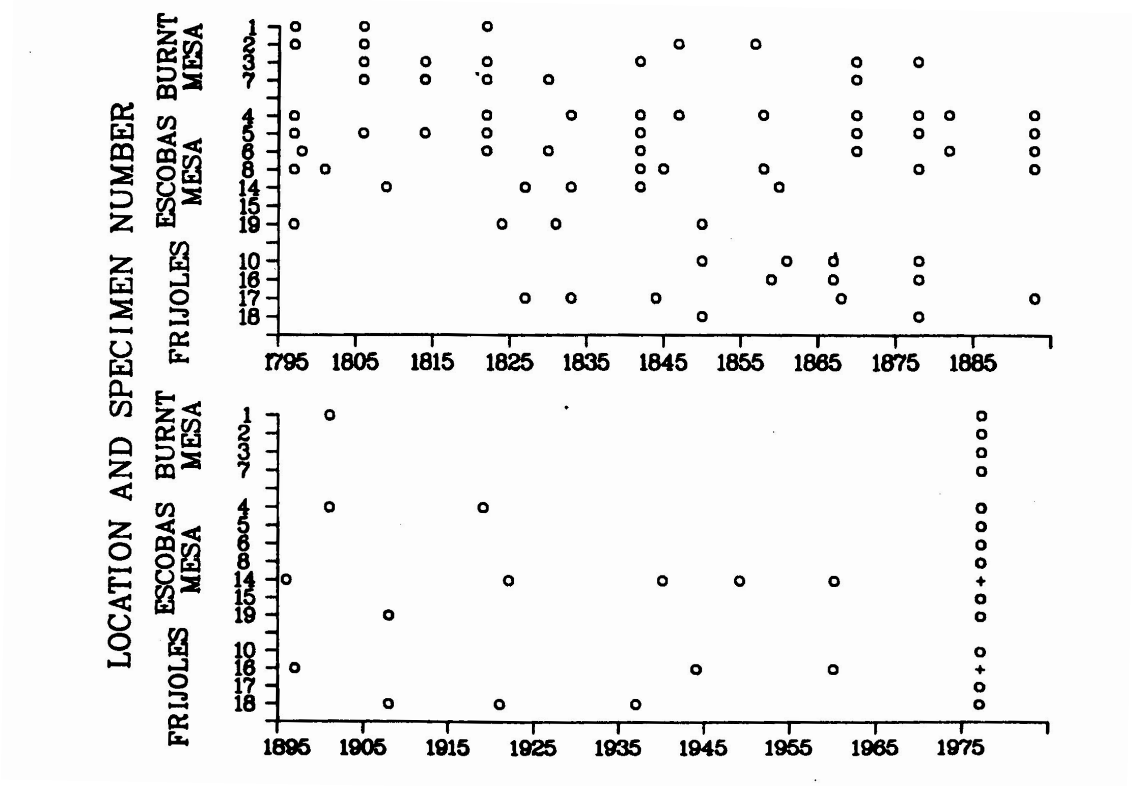


Figure 1.14. Fire scar history of 18 samples (Foxx and Potter 1978)

Table 1.2. Wildfires in the East Jemez Mountains Greater Than 1000 Acres Since 1900

Fire	Year	Date	Acres	Location
Water Canyon	1954	6/5/1954	3000	SFNF
La Mesa	1977	6/16/1977	14,278	SFNF, BNM
Dome	1996	4/26/1996	16,516	SFNF, BNM
Oso Complex	1998	6/20/1998	5,280	SFNF, Santa Clara Pueblo
Cerro Grande	2000	5/4/2000	42,971	SFNF, Santa Clara Pueblo, BNM
Las Conchas	2011	6/26/2011	156,593	SFNF, Santa Clara Pueblo, BNM, Valles Caldera National Preserve

Figure 1.15. View from overlook on State Route 4 of the mesas and canyons burned by the La Mesa Fire (1985)

done. All the plots, with the exception of those at Technical Area (TA) 49, were re-burned by the Las Conchas Fire. Figure 1.15 is a 1985 photograph of the mesas and canyons burned by the La Mesa Fire. Figure 1.16 shows the past fires and the overlay of the fires on the study area.

1.5 Description of Fires 1937 to 1977

At the beginning of the 1975 study, Foxx and Potter (1978) selected study areas related to fires that had burned greater than 10 acres. Also, during the study, fires occurred on Burnt Mesa (1975), Escobas Mesa (1976), and Alamo Canyon (1976). Information about these fires and other information gleaned from fire atlas, personal recollection, newspapers, and other media are found in Appendix I.

1.6 Description of the La Mesa Fire

Information reported by Foxx and Potter (1978) outlines the specifics of the La Mesa Fire summarized from USFS notes on fire behavior and weather prediction. We present here a summary.

Progression of the Fire

The La Mesa Fire was first reported at 1556 hours, June 16, 1977, by the St. Peter's Dome Lookout and, within 20 minutes of the original sighting, flames and heavy smoke were noted. The fire burned out of control for seven days, but then weather patterns shifted and scattered thunderstorms produced heavy rains and reduced temperature. The fire was declared controlled at 1600 hours June 23, 1977. Locations of pre-La Mesa Fire plots and spread of the fire are given in Figure 1.17.

The fire began in a pile of slash on Mesa del Rito approximately two miles from the western boundary of the Monument. Investigations by the USFS personnel deemed it to be human-caused, either deliberate or accidental. The area was dense ponderosa pine logged 20 years previously. The slopes were angled at 10 percent to 15 percent, but steep in the draws and precipitous to the edge of the mesa that dropped into Alamo Canyon. At 1730, on June 16th, an aerial reconnaissance flight revealed the fire to be

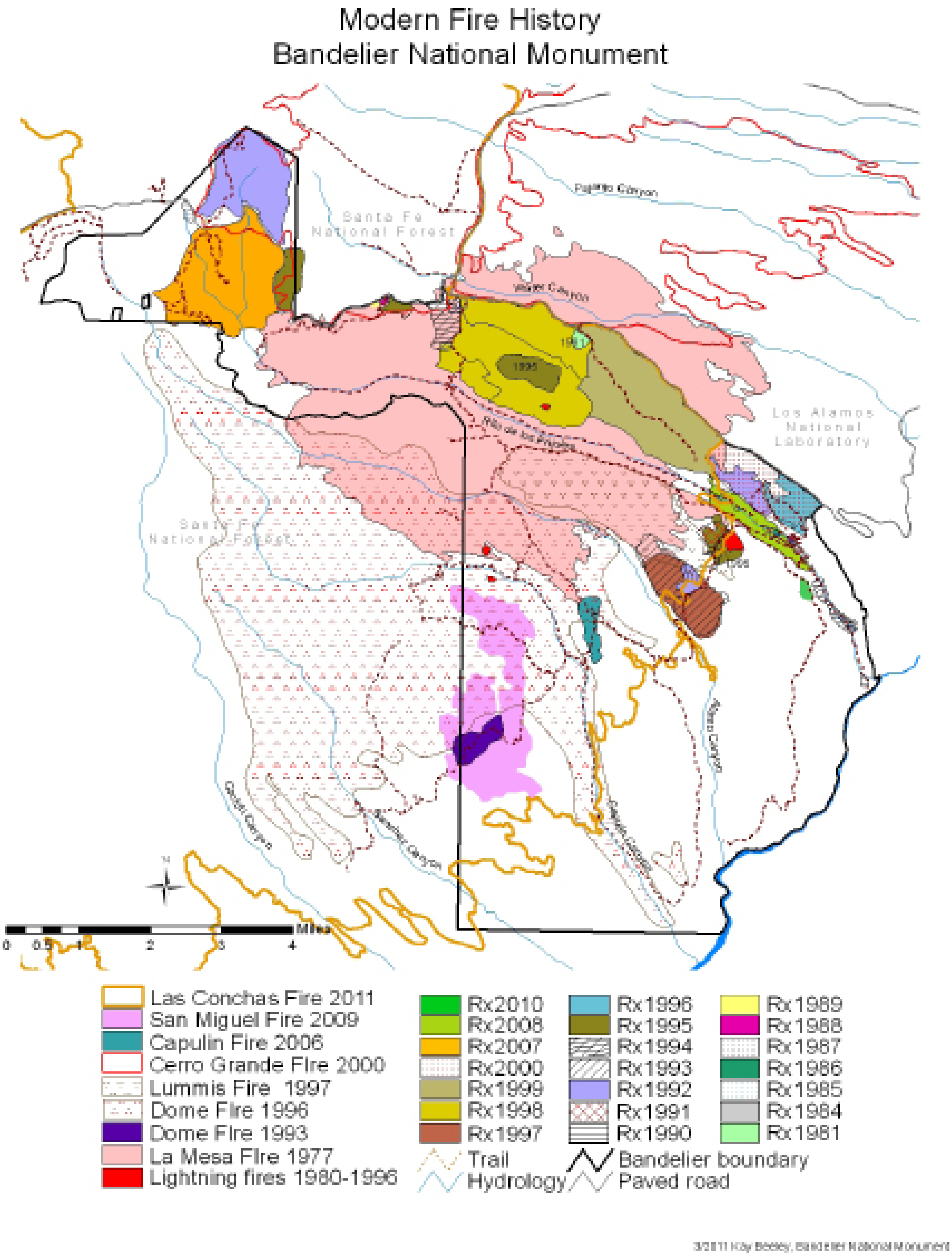


Figure 1.16. Modern fire history, Bandelier National Monument (K. Beeley, BNM)

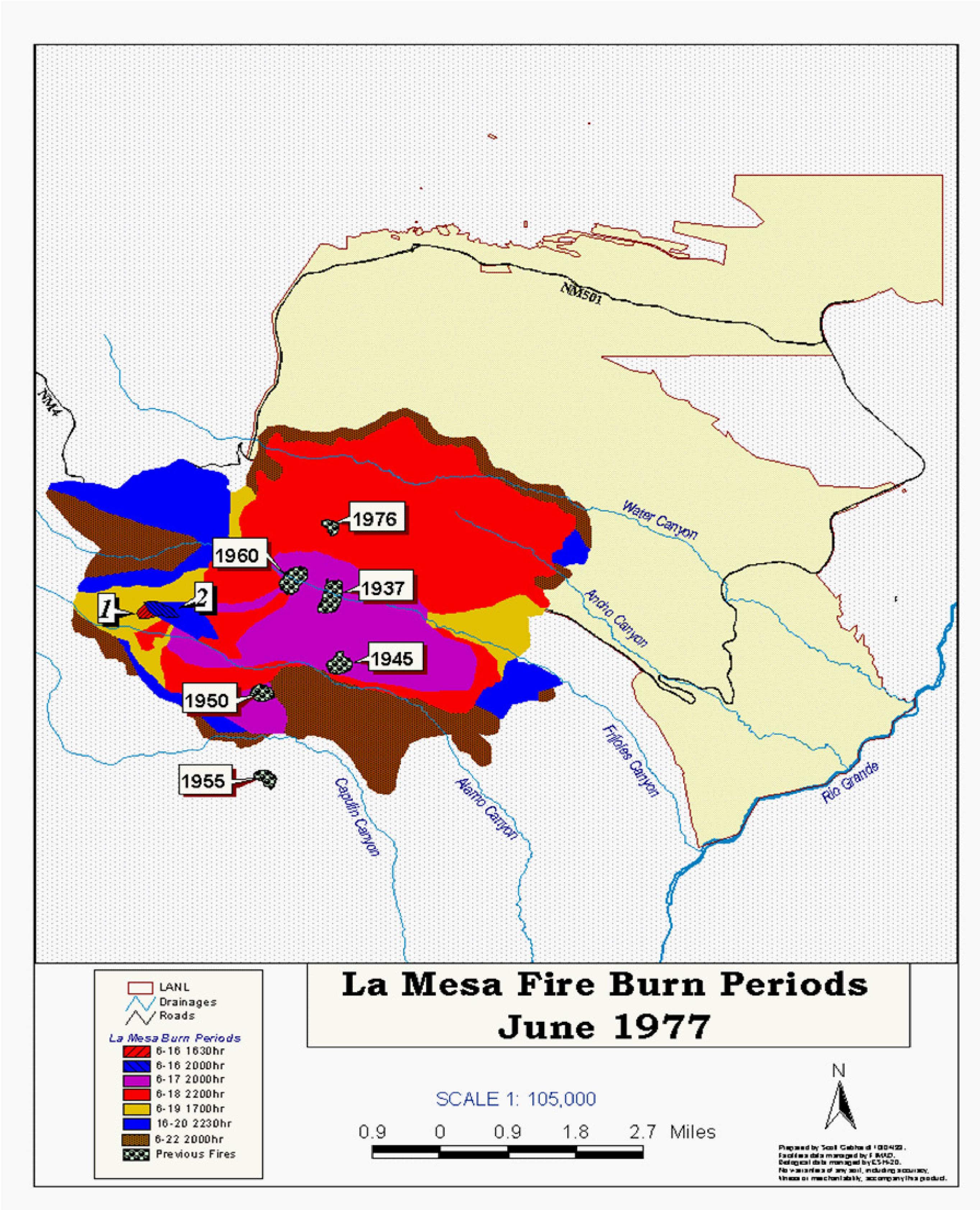


Figure 1.17. The burn intensities and the 1976 plots established before the La Mesa Fire (Foxx and Potter 1978)

approximately 50 acres in size. The fire ultimately consumed approximately 14,278 acres of forested land in SFNF, BNM, and LANL. Approximately 33 percent of the forested land of Bandelier was subject to the fire, a total of 10,630 acres.

Post-Fire Rehabilitation (1977)
After the fire, the NPS participated in a joint project with the USFS to seed native grasses aerially. All of the 14,278 acres were seeded except for a small area on LANL at TA-49. Although native grasses were suggested, seed of most of the grasses were not available; therefore, the USFS substituted similar species for seeding. The seed mixture was chosen because of 1) natural occurrence, 2) soil-holding properties, 3) availability of seeds, and 4) ease of seeding. The seed mixture is seen in Table 1.3.

The canyon bottoms were hand-seeded with species such as *Poa interior* and *Oryzopsis asperifolia,* native to the canyon bottoms. Fire lanes were seeded by hand. The helicopter reseeding began July 12, 1977. Sixty seeds per square foot were spread. In badly burned areas, 70 to 75 seeds per square foot was desirable; and in less severely burned areas, 50 to 55 seeds per square foot was acceptable. Escobas Mesa was seeded July 13 and Burnt Mesa July 14. Germination was first observed the third week in August, after approximately four and a half weeks.

Broadcast Prescribed Burns (1998-99)
BNM implemented a plan that served as an addendum to Bandelier's Resources Management Plan (Lissoway 1997). The document is guided by the NPS Fire Management Guideline (NPS-18-1990), which requires that any area with vegetation capable of supporting fire will develop a Fire Management Plan. The objectives of the plan are to 1) allow prescribed natural fires to function in fire-dependent ecosystems; 2) use prescribed fire to meet management objectives; 3) protect life, property, and park resources from the effects of unwanted fire; and 4) prevent adverse impacts from fire suppression.

Under this plan, BNM has had an aggressive prescribed burning and monitoring program. This includes areas on Burnt and Escobas mesas where plots were established for the La Mesa Fire (Figure 1.18). Prescribed burn areas 28, 29, and 30 (Escobas Mesa) were burned in the spring of 1998 and area 38 (Burnt Mesa) in the spring of 1999.

Both these areas were re-burned by the Las Conchas Fire or the backfires used to stop the fire advance.

1.7 Description of Recent Fires

Major fires in the east Jemez Mountains are shown earlier in Table 1.2 and Figure 1.16. The Dome and Las Conchas fires burned over portions of the study location and have influenced species in the area.

The Dome Fire
The Dome Fire was ignited April 26, 1996, from an improperly extinguished campfire. Areas in Capulin Canyon and the Dome Wilderness were burned. High fuel loading, low fuel moisture, and wind contributed to the extremely rapid spread of the fire. The Dome Fire was significant for pointing out the problems of fighting fires on the Pajarito Plateau and was the immediate inspiration for creation of the Interagency Wildfire Management Team.

This fire burned portions of the 1950 and 1955 plots established in the 1975-76 study. These plots were not followed up after 1978 because of access.

Post-Fire Rehabilitation
The Burned Area Emergency Rehabilitation (BAER) plan called for the seeding mix listed in Table 1.4 on USFS lands but not BNM (Barclay et al. 2004). Rehabilitation efforts did impact the La Mesa Fire plots as related to seed establishment and spreading. Figure 1.19 presents pictures of the area off the Dome Road burned by the 1996 Dome Fire taken in 2008 and 2012.

The Cerro Grande Fire
The Cerro Grande Fire did not burn into most of the study area but general observations after that fire and treatment is pertinent to the long-term studies

Table 1.3. Grass Species Seeded Through Aerial Means After the La Mesa Fire
Sand dropseed (*Sporobolus cryptandrus)*
Blue grama *(Bouteloua gracilis)*
Sheep fescue *(Festuca ovina)*—labels on sacks indicated “hard fescue,” according to Hitchcock (1950) this is *Festuca ovina* var. *duriuscula*, which is an exotic introduced from Europe.
Spike muhly *(Muhlenbergia wrightii)*
Western wheatgrass *(Pascopyrum smithii)*
Slender wheatgrass (*Elymus trachycaulus)*

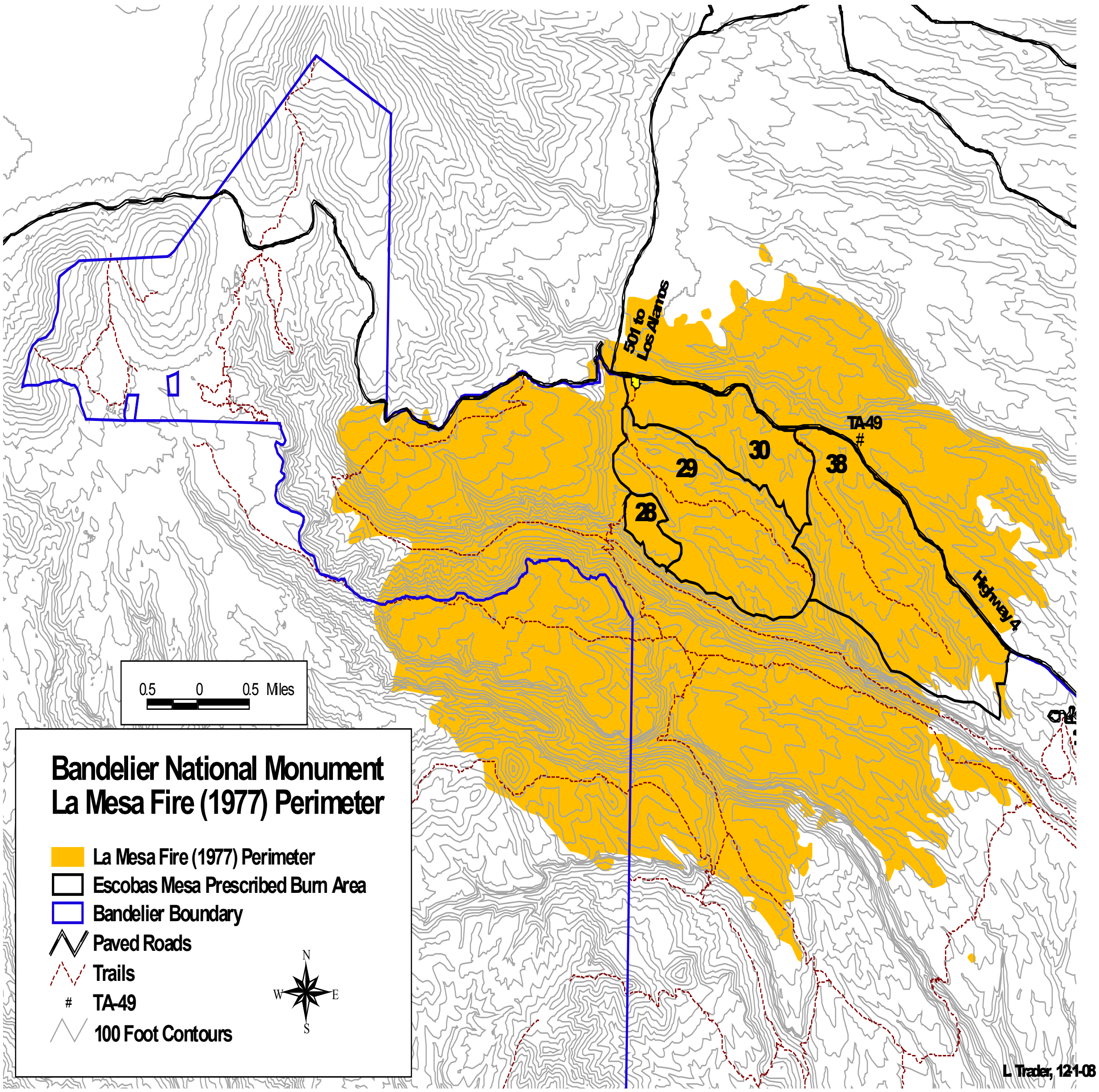


Figure 1.18. La Mesa Fire perimeter in relation to the prescribed burn areas on Burnt and Escobas mesas (see numbers) (NPS 2009)

on Burnt and Escobas mesas and Apache Springs (Foxx n.d.[a]).

The SFNF BAER plan called for aerial seeding, air hydromulch, hand seeding, wattles, contour felling, raking, and straw mulch. Aerial seeding was performed at a rate of 35 pounds per acre. Both aerial and hand seeding were done with a mixture of annual and perennial seeds.

The seed mix included 10 percent annual rye grass (*Lolium perenne* L. ssp. *multiflorum*), 25 percent mountain brome (*Bromus marginatus*), 25 percent slender wheatgrass (*Elymus trachycaulus*), and 40 percent cereal barley (*Hordeum vulgare*) (Buckley et al. 2003).

The Las Conchas Fire

The most recent fire to burn over the plots was in 2011. The Las Conchas Fire was New Mexico's largest wildfire to date. (Until 2012, when the Whitewater-Baldy Complex Fire in the Gila burned nearly 300,000 acres.) The Las Conchas Fire began June 26, 2011, at approximately 1:00 PM when a tree fell on a small powerline. On the first day the fire burned 43,000 acres, driven by strong winds. By the end of the second day it had burned over 61,000 acres. The fire then entered the Santa Clara Pueblo watershed. It was considered 100 percent contained by August 3, 2011 (Incident Information System 2011).

Backfiring was done along State Route 4 to protect the Laboratory facilities. The backfires burned over plots on Burnt and Frijoles mesas. Most of the plot locations were within the low-severity burn (Figure 1.20). Areas located in the original study on Escobas Mesa (rim of Frijoles Canyon), within Frijoles Canyon, on the mesa between Frijoles and Alamos canyons, and the Dome were all burned again by the Las Conchas Fire.

Post-Fire Rehabilitation

August 20, 2011, implementation of BAER treatments for the Las Conchas Fire area within the SFNF was nearing completion. Aerial seeding was completed on 5200 acres and aerial mulching was underway on 1100 acres (BAER Incident Report, 2011). No seeding was done or will be done on the Monument.

Table 1.4. Seeds Used for Rehabilitation After the Dome Fire

Seeds	Low-elevation percent of mix	Ponderosa pine percent of mix
Lolium multiflorum	29.19	23.02
Bromus marginatus/carinatus		27.06
Elymus trachycaulus	20.9	19.02
Bouteloua curtipendula	17.13	7.09
Schizachyrium scoparium	5.81	5.66
Oryzopsis hymnoides	4.90	
Dalea purpurea	0.57	0.38

Figure 1.19. Area off the Dome Road previously burned by the 1996 Dome Fire. The top picture was taken in 2008. The one to the right, June 2012 (courtesy Josip Loncaric).

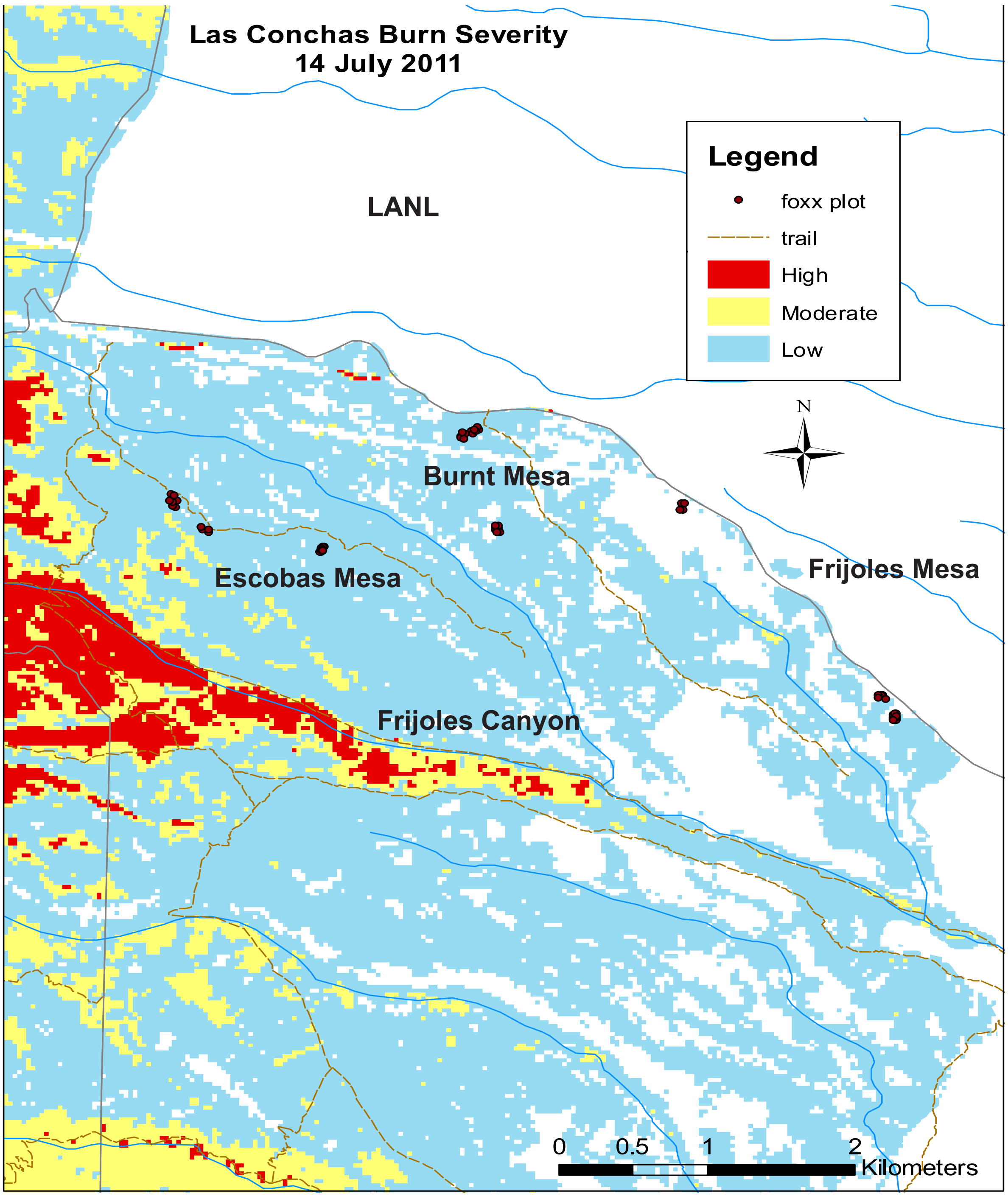


Figure 1.20. Las Conchas burn severity in relation to plots on Burnt Mesa, Escobas Mesa, and Frijoles Mesa (map by Kay Beeley, BNM)

2.0 HISTORY OF LA MESA FIRE STUDIES

2.1 Succession Studies

Pre-La Mesa Fire Studies 1975–1976

In 1975, Professor Loren Potter, from the University of New Mexico, and I were asked to do a study to 1) determine the fire history of the Monument, 2) correlate fire history with climatic data, 3) measure standing biomass of both mature and reproductive forest stock, 4) determine fuel loads in selected areas, 5) make inferences about the succession history from a variety of stands of different ages since they were last burned, 6) determine the influence of fire on the growth rates of dominant tree species, and 7) make recommendations for a fire management procedure, including the possibility of prescribed burning (Foxx and Potter 1978, Potter and Foxx 1985).

We selected areas for study from the known fire history and the BNM fire atlas. The criteria for selection of a sample site was that it had to be at least 10 acres in size (Class C fires).

During 1975 and 1976, within the selected areas and an adjacent control, we collected stand and phytosociological data and measured the fuel loads. Additionally, we collected samples for tree-ring analysis (Foxx and Potter 1978).

When the La Mesa Fire was ignited in 1977, not all selected sites had been examined. However, sites measured before the La Mesa Fire provided a baseline on which to determine the burn severity as related to the previous date or the last known date the area had burned. These sites also provided a baseline for future studies.

These plots, and others that were established after the La Mesa Fire, have been followed through time. The following is a review of the studies that have been done and have emerged from these plots.

Photographic records and data are also compiled for each site and are outlined in Appendix IV.

Table 2.1 lists the studies and publications done over the past 37 years as related to the La Mesa Fire.

Year of the Fire (1977)

1975 Line Strips

The initial study was nearly completed when, June 16 to 23, the La Mesa Fire burned over much of the area, including all the plots except one near Boundary Peak. This plot was burned by the 1996 Dome Fire. Table 2.2 indicates the status of each plot after the La Mesa Fire. Between July and September, we went back to each plot that we had established in 1975 and 1976 and collected stand data. After the fire we included an area that we had dendrochonological information indicating the area had not burned since 1878. Later studies conducted by Allen (1989) with additional samples indicate that the last fire may have been 1893.

The purpose of this post-fire examination was to determine the extent of burn to each plot related to the length of time since the area had previously burned. We classified the overstory into six damage classes from one to six, with six the most severe with all needles being consumed by the fire and one the least severe with trees with no scorching.

1977 20- by 50-Meter Plots

After the La Mesa Fire, we established 20- by 50-meter plots in ponderosa pine, mixed conifer, and piñon-juniper plant communities.

The purpose was to establish some permanent plots that could be followed through time. Most of these plots were visited at intervals over the past 35 years (e.g., 1978, 1985, 1992/93, 1998/99, 2010, 2011, 2012).

Post-La Mesa Fire Studies (1993)

In 1993, we relocated all the areas previously identified before the La Mesa Fire, including the 20- by 50-meter plots on Escobas and Burnt mesas and TA-49. Within these plots we repeated the data gathering, took pictures, and mapped the sites as appropriate. Additionally, we located plots in the mixed conifer and piñon-juniper. Within the mixed conifer plots we repeated the data gathering, took pictures, and mapped the overstory conditions in sites we could relocate. We only re-located two of the original five mixed conifer plots.

In the piñon-juniper, we relocated two of the five plots and took pictures.

Table 2.1. History of Studies and Publications Related to the Pre- and Post-Fire Recovery of the Areas Burned by the La Mesa Fire

1978

Foxx, T.S. and L.D. Potter 1978. Fire Ecology at Bandelier National Monument. Biology Department, University of New Mexico, Contract No. PX 7029-6-07-69, PX 7029-7-0692.

> This publication outlines the 1975–1977 phytosociological studies, burn severity, and observations on both line strip plots and 20- by 50-meter plots.

1979

Potter, L.D. and T.S. Foxx 1979. Recovery and Delayed Mortality of Ponderosa Pine after Wildfire. Final Report (Part I) Contract No. 16-608-GR. Biology Department, University of New Mexico.

> This publication looks at the delayed mortality in fire damaged trees and the factors that influence mortality. The following factors were examined: 1) extent of fire damage to the crown, 2) length of time since the area burned before the La Mesa fire, 3) the density of living trees in the stand, 4) the growth of herbaceous vegetation, and 5) various factors such as beetle infestation.

Potter, L.D. and T.S. Foxx 1979. Success of Seeding Native Grasses after a Holocaustic Fire. Final Report (Part II) Contract No. 16-608-GR, Biology Department, University of New Mexico.

> This publication looks at the germination of seeded grass species as related to factors such as tree cover, presence of native grasses, and burn severity.

1981

Potter, L.D. and T.S. Foxx 1981. Vegetation Studies at Bandelier National Monument. Final Report, Conract No. NPS-PO-PX7029-8-0451, Biology Department, University of New Mexico.

> A summary of data on burro exclosures and a survey of the newly accessioned Cerro Grande area (February 1977) for the purpose of providing vegetation information.

1982

Potter, L.D., T.S. Foxx, F.J. Barnes 1982. Natural Regeneration of Ponderosa Pine as Related to Land Use and Fire History on the Pajarito Plateau. Los Alamos National Laboratory, report LA-9292-NERP.

> Mapping of the total area burned was calculated and a burn severity map was prepared. Leaf water potentials of three grasses were measured periodically to understand the competition between two seeded grasses and one native grass. The presence or absence of pine seedlings in various areas was studied and the microsites were compared.

1983

Foxx, T.S. 1983. Germinant Reforestation of Ponderosa Pine at Bandelier National Monument. Final Report, contract No. PX7120-2-0280, National Park Service.

> This study was initated in July 1982 to determine the feasibility of germinant reforestation to establish ponderosa pine in areas devoid of seed trees as a result of the 1977 La Mesa fire. Germinated pine seeds were planted in various locations, including next to logs, stumps, and areas of cleared vegetation. Survival counts were done one year after the plantings. Subsequent studies compared planting done with 2.0 stock on LANL with germinant reforestation and natural regeneration.

1984

Foxx, T. S. (compiler) 1984. La Mesa Fire Symposium, Los Alamos, NM. October 6–7, 1981. Los Alamos National Laboratory report LA-9236-NERP.

The first La Mesa Fire Symposium summarized various studies done, including those related to geology, surface water, aquatic invertebrates, small mammals, wildlife, and avifauna.

Foxx, T.S. and L.D. Potter 1984. Fire Ecology at Bandelier National Monument, in La Mesa Fire Symposium, Los Alamos, New Mexico October 6 and 7, 1981. Compiled by Teralene Foxx, LA-9236 NERP.

A summary of the La Mesa Fire location and progress.

Potter, L.D. and T.S. Foxx 1984. Postfire Recovery and Mortality of the Ponderosa Pine Forest after the La Mesa Fire. La Mesa Fire Symposium, October 6 and 7, 1981. Los Alamos National Laboratory report LA-9236-NERP.

Found in the first La Mesa Fire Symposium this is dendrochronological data, as well as vegetational succession related to burn severity. The paper is a composite of two major parts: the fire history and the fire damage of various sites as related to their fire history.

Barnes, F. J. 1984. Water Relations on the Dominant Grasses on La Mesa Burn. La Mesa Fire Symposium. October 6 and 7, 1981. Los Alamos National Laboratory report LA-9236-NERP.

This study was made to determine whether there was a significant niche overlap between the grasses on the La Mesa burn and ponderosa pine seedlings. Field observations were made on root structure and seasonal patterns of plant water status and soil moisture to investigate the partitioning of the soil water resources on coexisting species.

1986

Potter, L.D. and T.S. Foxx 1986. Reassessment of Vegetational Recovery Eight Years after the La Mesa Fire, Bandelier. Biology Department, University of New Mexico. Contract No. NPSD PX 7120-50164.

In 1985, areas that had been established before the La Mesa Fire and the 20- by 50-meter plots were re-examined.

1996

Foxx, T.S. 1996. Vegetation Succession after the La Mesa Fire at Bandelier National Monument in Fire Effects in Southwestern Forests, Proceedings of the Second La Mesa fire Symposium, Los Alamos, New Mexico. March 29–31, 1994. USDA Forest Service general technical report RM-GTR-286. p.47-69.

The second La Mesa Fire symposium reported on dendrochronology, avifaunal response, foods, nitrogen cycling, macromycetes, arthropod populations, elk populations, and vegetation succession. We reported on the changes in the line strip plots after 16 years.

2012

Foxx, T.S., L. Hansen, R. Oertel, C. Haffey, K. Beeley 2012. The La Mesa Fire: Studies and Observations from 1975 through 2012. Final Report.

Foxx, T.S. 2012. Fire Effects on Plants of the Jemez Mountains and the Pajarito Plateau. Final Report.

This document summarizes the effects of fire on plants of the area.

Foxx, T.S. 2012. Photographic Records and Data for areas studied.

Matched photography and data are summarized for each of the plot areas from as early as 1975 to after the Las Conchas Fire (when possible).

Table 2.2. The Condition of Plots Identified in the 1975-1976 Pre-La Mesa Fire Study After the La Mesa Fire

Plot	Location	Year Last Burned	Condition after Fire
1976	Escobas Mesa	1976	lightly burned
1960	North Rim Frijoles	1960	lightly burned
1955	Boundary Peak	1955	not burned
1950	Bear Mesa	1950	lightly burned
1945	Between Frijoles and Alamo canyons	1945	lightly burned
1937	North Rim Frijoles	1937	severely burned
1878/1893	North Rim Frijoles	1893	severely burned

The data gathered for the line strip plots established in areas of known fire history were written and presented in the second La Mesa Fire Symposium (Foxx 1996). The 1993 data for the 20- by 50-meter plots are being reported in this publication.

Post-La Mesa Fire Studies (1998)

In 1998, we relocated photo stations and took pictures. Although our primary goal in 1998 was to relocate each 20- by 50-meter plot and identify the location with geographic information system (GIS) technology, the burning of the plots in Bandelier's prescribed burning program provided a unique opportunity to compare the site from 1992 (post-La Mesa but pre-prescribed burn) to 1998 (post-prescribed burn). Additionally, we decided to collect data on the LANL plots because they had not been burned by the Bandelier prescribed fire.

Post-La Mesa Fire Studies (1999)

Our primary goal in 1999 was to quality check the photographs and some of the location information for the various plots. Most of the effort in 1998 was concentrated on the ponderosa pine plots. In 1999, we revisited the piñon-juniper plots and the mixed conifer plots in Apache Springs. We collected data only on selected plots in the piñon-juniper and mixed conifer. These are reported in this document.

Post-La Mesa Fire Studies (2010)

In 2010, we relocated the 20- by 50-meter plots and photo stations and collected data on Burnt Mesa and Escobas Mesa ponderosa pine plots and the piñon-juniper plots. We also looked for the plots in the mixed conifer in the Apache Springs area, but the vegetation was too dense and we could not find our plot locations.

Post-Las Conchas/La Mesa Fire Studies (2011-2012)

In June 2011, the Las Conchas Fire burned over the plots on Burnt and Escobas mesas. Immediately after the fire we went to both of these areas and took photographs. Photographs were repeated approximately 90 days later and in 2012.

2.2 Mapping, Competition, and Tree Planting Studies

Mapping the La Mesa Fire

In 1981, we used aerial photo coverage to calculate the area devoid of trees and the total area burned by the La Mesa Fire. The total area burned was 60.7 square kilometers and a total of 21 square kilometers (36.3%) devoid of seed trees (Potter et al. 1982). In 1995, as part of the Laboratory's Habitat Management Plan for Threatened and Endangered Species, we developed a land cover map for LANL using a GIS (Koch et al. 1996). Much of the severely burned La Mesa Fire area shows as grass and shrub lands on that map.

Success of Grass Establishment and Competition

Helicopter seeding began July 12 through 17, 1977, one month post-fire. An attempt was made to spread 60 seeds per square foot. In badly burned areas, 70 to 75 seeds per square foot was desirable; and, in less severely burned areas, 50 to 55 seeds per square foot was acceptable. Escobas Mesa was seeded July 13 and Burnt Mesa July 14. Germination was first observed the third week in August, after approximately four and a half weeks.

In 1979 we reported on data related to the success of germination and establishment of the seeded species collected 14 months after the La Mesa Fire (Potter and Foxx 1979a). We found that slender wheatgrass and sheep fescue germinated the best of the six seeded grass species. Slender wheatgrass is a short-lived perennial, which yields well up to five years when production declines. Sheep fescue is a fine-leaved and densely tufted perennial grass that develops slowly but is very competitive with abundant roots. The other seeded grasses did not show significant germination 14 months after the fire. Three species showed negligible germination, including blue grama, sand dropseed, and spiked muhly.

In 1981, we looked at the leaf water potential of two seeded grasses (slender wheatgrass and sheep fescue) and one naturally occurring (mountain muhly). We were interested in determining if the seeded grasses would have any potential for competition with ponderosa pine and if this would suppress natural regeneration of ponderosa in severely burned areas of the fire. This information was reported in Potter et al. (1982) and Barnes (1984).

Tree Planting

Natural regeneration in Southwestern ponderosa pine is slow and unreliable after events such as wildfire. Schubert (1974) reported that for good regeneration of pine there must be a large seed supply, a well prepared seedbed free from competing vegetation, low populations of seed-eating pests, sufficient moisture for germination, and protection from browsing animals. As a result, the common practice until the 1980s was for the USFS to replant areas denuded of trees by fire or logging to prevent erosion and to stabilize the soil.

The USFS and LANL decided to remove all snags and replant the area between Water Canyon and State Route 4 from near Ponderosa Campground to approximately one mile east. It was in this stretch of highway that the fire had jumped the road onto LANL lands. The fire was hot and fast and the area was severely burned. Two-year-old ponderosa pine stock were planted for visual screening of LANL facilities and to prevent erosion.

The NPS took a different approach to reclamation—a non-consumptive policy. The mandate was to retain the naturalness of lands under their control, not to introduce new genetic strains, and to allow natural succession to proceed. This meant two things: 1) they would not remove snags and 2) they would not replant. Initially they did not replant any areas of the fire. However, in 1981 we did try a relatively new reforestation type called germinant reforestation developed by Bruce Buchanan at New Mexico State University. With this forestation application, seeds from the ponderosa of the area are germinated and planted (DeVelice and Buchanan 1978). This pilot project was done along State Route 4, near the present site of Ponderosa Campground. Later they allowed the Boy Scouts to plant 2.0 stock in the area adjacent to State Route 4 and near the campground. This was the only planting of pines in the fire area.

Over the years pictures have been taken in the tree planting area of BNM. After the Las Conchas Fire, pictures were also taken because the area had burned.

Natural Regeneration of Ponderosa Pine (1981)

Because problems of ponderosa pine regeneration were of concern in the Southwest, in 1981, we looked at natural regeneration of pine after the La Mesa Fire as related to various types of land management and restoration processes (Potter et al. 1982). The study had various aspects.

A population of 1431 seedlings with heights of one to 150 centimeters was examined for microsite characteritics. These characteristics included soil texture, litter depth, litter composition, living ground cover, phylogeny of ground cover, growth form of ground cover, vertical canopy, potential tree shade, seedling proximity, need for protective objects, relation to trees, distance to trees, slope, and slope direction.

3.0 METHODS

There were two methodologies used for collecting phytosociological data in the pre- and post-fire studies of the area burned by the La Mesa Fire: Lindsey line strips (Lindsey 1955) and 20- by 50-meter plots.

The pre-La Mesa Fire studies were done in 1975–1976 using the Lindsey line strip methodology to get overstory data and 20- by 50-centimeter Daubenmire (1959) quadrats for understory data collection. The research question to be answered in the pre-fire studies did not include long-term follow-up, thus the use of this methodology.

In addition, the pre-fire studies included data on fuel loads, growth rates, and fire frequency.

In 1977, the La Mesa Fire burned over four areas previously measured in 1975–1976. These four plots were measured again in 1978, 1979, 1985, and 1993 (one year, two years, eight years, and 16 years post-fire) (Foxx 1996).

After the La Mesa Fire, it was determined that long-term follow-up was probable and, therefore, 20- by 50-meter plots were established along pre-existing bird transects (Wauer and Johnson 1984) and were consistent with other studies being conducted. Below, we describe each method of analysis.

In addition to vegetation analysis, photographic information was collected in all sample years. In some cases, photo stations were established.

3.1 Pre-Fire Studies

Selection of Line Strip Plots (1975–1976)
In 1975–1976 the study design called for vegetation transects to determine cover, frequency, biomass, and density of overstory and understory components. Additionally, the amount of fuel loading in each of the selected plots was determined, as well as growth rates of trees. Data were also collected for determining the fire frequencies within the study area.

Vegetation Analysis
The vegetation analysis for the 1975 study was done using a modified Lindsey's (1955) line intercept method. The method provides a measure of foliage cover of tree, shrub, and herb strata; the species composition in all strata; the density (number per area) of trees and shrubs; and the trunk diameter at breast height (dbh) of mature trees. Measures of standing biomass of understory trees, shrubs, and herbs less than three feet tall were also obtained from clip plots.

The sampling unit was a 1000-foot line with a 10-foot strip on either side (Figure 3.1). A right angle, or elb, was made every 200 feet to account for variations in terrain. If it was not possible to make an elb every 200 feet and remain within the burned area, an elb was made at 100 feet. The 1000- by 20-foot strip was in turn divided into 20- by 50-foot plots so that frequencies could be calculated. A steel tape formed the line by which foliage intercept of mature and reproductive stock over three feet tall could be measured.

The percentages of foliage cover of herbs and shrubs less than three feet tall and tree seedlings were estimated using a quadrat placed every 10 feet along the line. Every 100 feet along the line all vegetation was clipped, separated into species, and saved for oven-drying and weighing.

From the data gathered, measures of total foliage cover, relative foliage cover by species, total basal area of mature trees, relative basal area, total density, relative density, frequency index, and relative frequency were determined. From relative cover, relative density, and relative frequency, a single measure of importance value was calculated for each species.

Photo Stations
Photographs were usually taken at the beginning of each transect to document the area. However, in the 1975 Burnt Mesa Fire (unsampled) and the 1976 Escobas Mesa Fire (sampled), photo stations were established. These photo stations consisted of

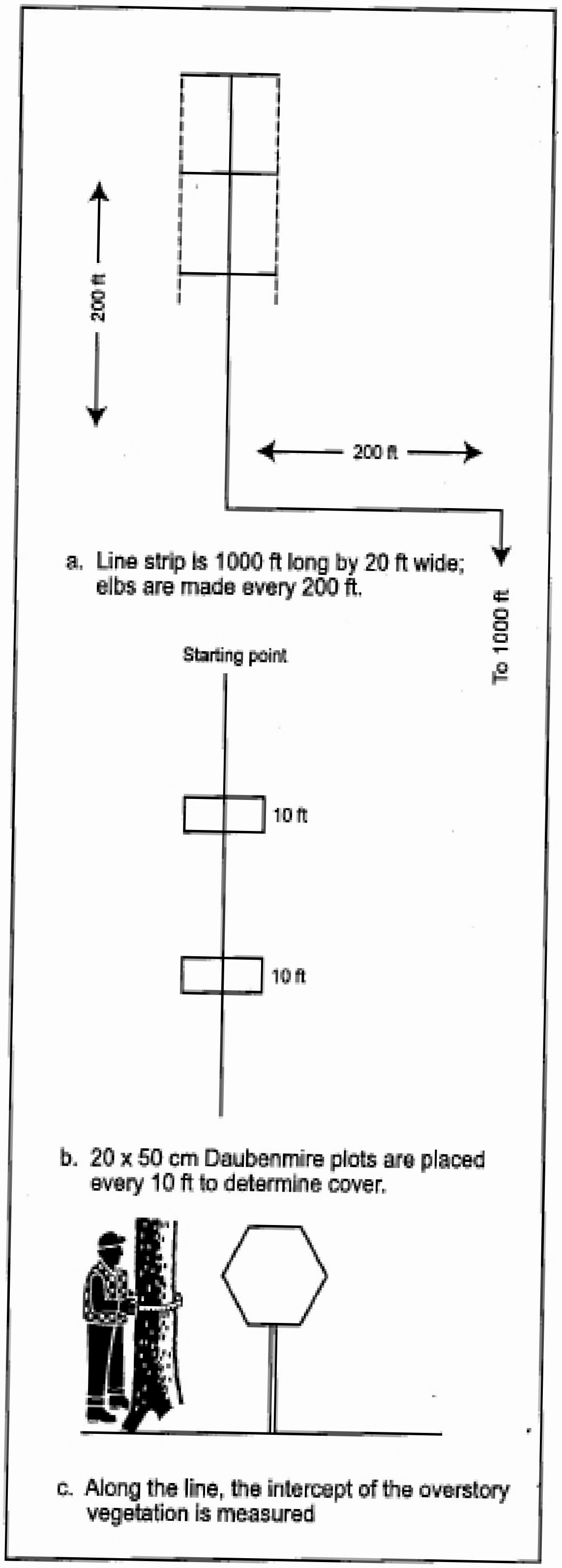


Figure 3.1. Lindsey line strip

a notched pipe with a flat plate, notched below. The camera was attached to the plate and photographs were taken at each notched site (Figure 3.2).

3.2 Post-Fire Studies

Selection of 50- by 20-meter Plots (1977)

Criteria for Plot Establishment

After the La Mesa Fire, representatives of the NPS, LANL, and other investigators determined that permanently staked 20- by 50-meter plots would be important to track post-fire recovery of the vegetation component.

On July 6, 1977, a meeting between representatives of the NPS, LANL, and investigators of the fire ecology study was held to coordinate post-fire studies. At that meeting, a verbal agreement was made concerning the establishment of plots for future succession studies. Los Alamos Scientific Laboratory was setting aside an area that was not to be seeded. It was determined that permanently staked 20- by 50-meter plots would be utilized for measuring areas of varying degrees of fire damage. Previous to the La Mesa Fire, Roland Wauer of the NPS had established transects for ornithological studies (Wauer and Johnson 1984). At his request, the vegetation study plots were placed along these transects in areas of varying degree of burn damage, i.e., severe, moderate, and light.

Classification of the Plots

We classified plot locations in three classes (Foxx and Potter 1978, Potter and Foxx 1979a). Plots were established along transects on Burnt Mesa, Escobas Mesa, Frijoles Mesa, and Apache Springs. Along each transect, we established plots in areas of severe, moderate, and lightly burned areas. The criteria for each site designation is below.

<u>Severe damage:</u> These were areas where tree crowns were completely consumed and the litter and duff were burned to mineral soil.

<u>Moderate damage:</u> These were areas where the tree crowns were only partly consumed and some trees were still green, although most of the understory

Figure 3.2. A photo station

vegetation was consumed and, in some areas, litter and duff to the mineral soil.

<u>Light damage:</u> These areas had a majority of trees remaining alive and litter and duff were only lightly scorched.

Plot Structure and Photo Points

The plots were aligned either east-west or north-south and remained entirely within the category of damage. Each plot was established by compass and lines 50 and 20 meters in length. The 50-meter side was divided into four equal parts. The 20-meter side was marked off into two-meter increments. Photo stations were established at opposite corners and photos were taken with a 35-millimeter camera and a 28-millimeter wide-angle lens to obtain the wid-

est coverage (Figure 3.3). The plots were marked using re-bar and a t-pole. On LANL the plots were marked with angle iron and t-poles. The t-pole was placed where it would be the most visible from a road or trail.

Data Collection

The vegetation was read along each of the 20-meter lines at every two meters, resulting in a total of 50 vegetation plots within the larger 50- by 20-meter plot. Total percent cover of each species was noted in the subplots.

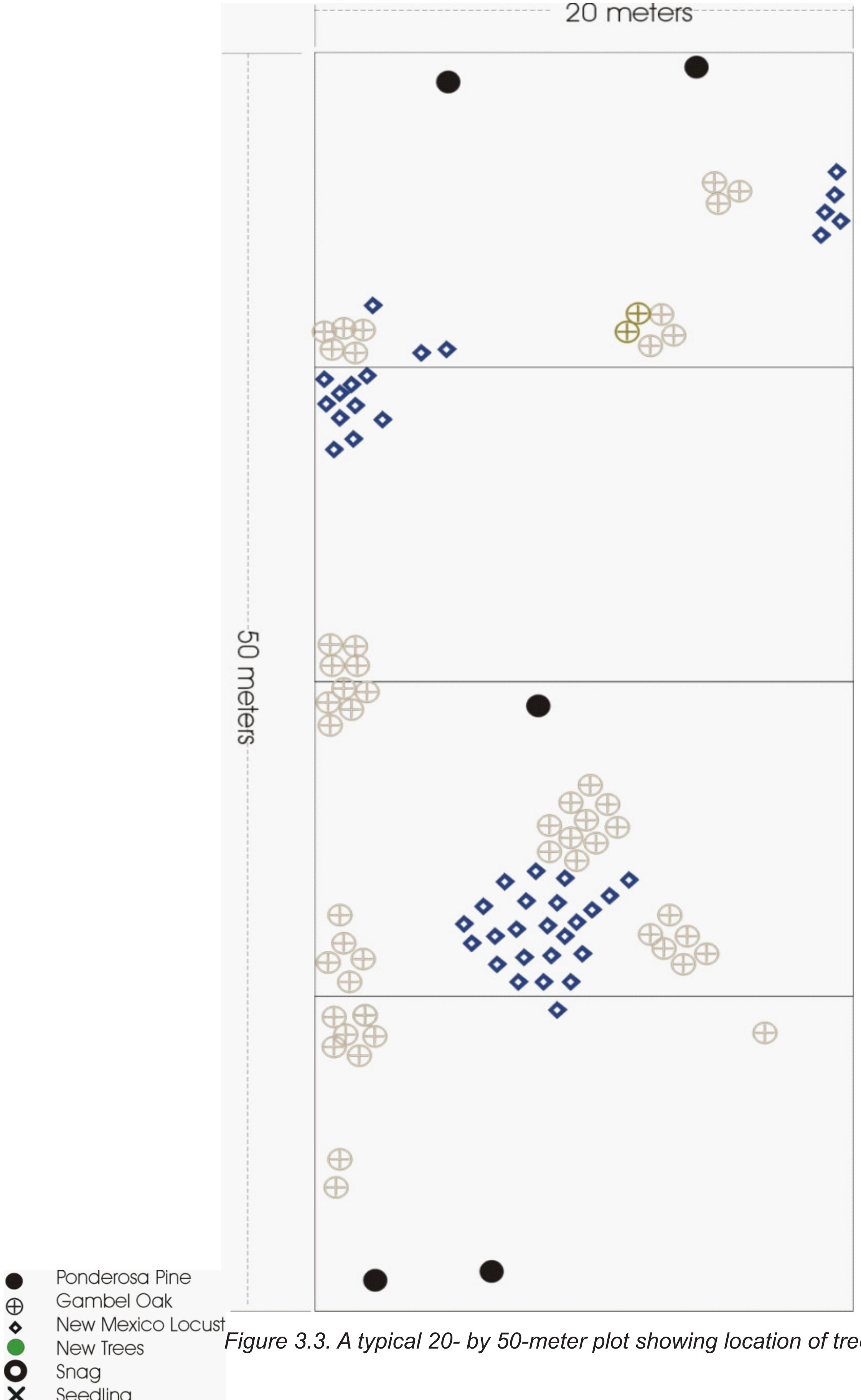


Figure 3.3. A typical 20- by 50-meter plot showing location of trees and shrubs

These plots were also used for mapping the tree and shrub location within each plot and trees were labeled with aluminum number tags. Each tree was measured with a dbh tape and that measurement recorded. This allowed us to determine which trees died and which survived.

Damage Assessment of Tree Species

Immediately after the fire in 1977, we developed a damage assessment criteria to examine the trees (Figure 3.4). This was done to determine viability of each tree class size and species.

Trees were divided into the following age classes:
<u>Seedlings:</u> less than one foot in height and less than one inch in diameter
<u>Sapling:</u> one to three feet in height and less than two inches in diameter
<u>Pole:</u> greater than three feet in height and four inches in diameter
<u>Mature:</u> four inches in diameter and greater

The following crown and trunk damage assessment classification was used.

<u>Class 1:</u> Over 75 percent of foliage green and alive
<u>Class 2:</u> More than 50 percent but less than 75 percent foliage green and alive
<u>Class 3:</u> More than 25 percent but less than 50 percent foliage green or alive
<u>Class 4:</u> Less than 25 percent of the foliage green and alive (little chance of survival)
<u>Class 5:</u> All foliage brown and tree considered dead
<u>Class 6:</u> All foliage consumed and tree dead

Trunk Damage

We also looked at the trunk damage and classified trunk damage in the following way:

The trunk was considered severely damaged if
a. confined to the first two feet
b. covering the first five feet
c. covering over five feet of trunk

The trunk was moderately scorched if cat faces formed in bark but bark not completely burned.

Trunk was lightly scorched or blackened if burned out new cat faces usually absent and bark structure generally well defined and easily visible.

Line Strips and Plots Through Time

Year of the Fire (1977)

In June 1977, the La Mesa Fire burned across 11 of the 13 previously examined sites. While the vegetation studies of previously burned areas had been completed, providing data to hypothesize the impact of wildfire and the nature of recovery, the La Mesa Fire, unfortunate as it was, turned the descriptive study and its hypotheses into an actual experiment. A re-examination of the study plots to determine varying degrees of damage and recovery response became imperative. Thus, Upper Alamo Crossing (1945), Bear Mesa (1950), Frijoles Rim (1960), and the respective controls were visited.

Attempts were made to re-examine the inner Frijoles Canyon plots, but because of the steepness of the terrain and lack of vegetation, it proved to be too dangerous. In addition, new line strips were run on the Escobas Mesa 1976 burn and an adjacent control, as well as an area adjacent to the 1960 Frijoles Rim burn that had been dated as probably not having burned since 1878 (99 years). In addition to measurement of species composition and size classes, a classification of the degree of foliage damage and trunk singeing was also done. Foliar damage was classified. Photographs were taken at the beginning of each transect and at various places along the transect.

The Year 1978

The first year after the fire, we repeated the vegetation studies on each of the plots and within the line strips. We mapped the location of trees, assessed mortality of trees, and did vegetation analysis in accordance with each methodology.

The Years 1985 and 1993

Vegetation studies were repeated both in 1985 and 1993. We relocated the transect and the elbs (right angles) as closely as possible and re-staked each site. We then collected data to determine species composition and density of trees per acre. The ex-

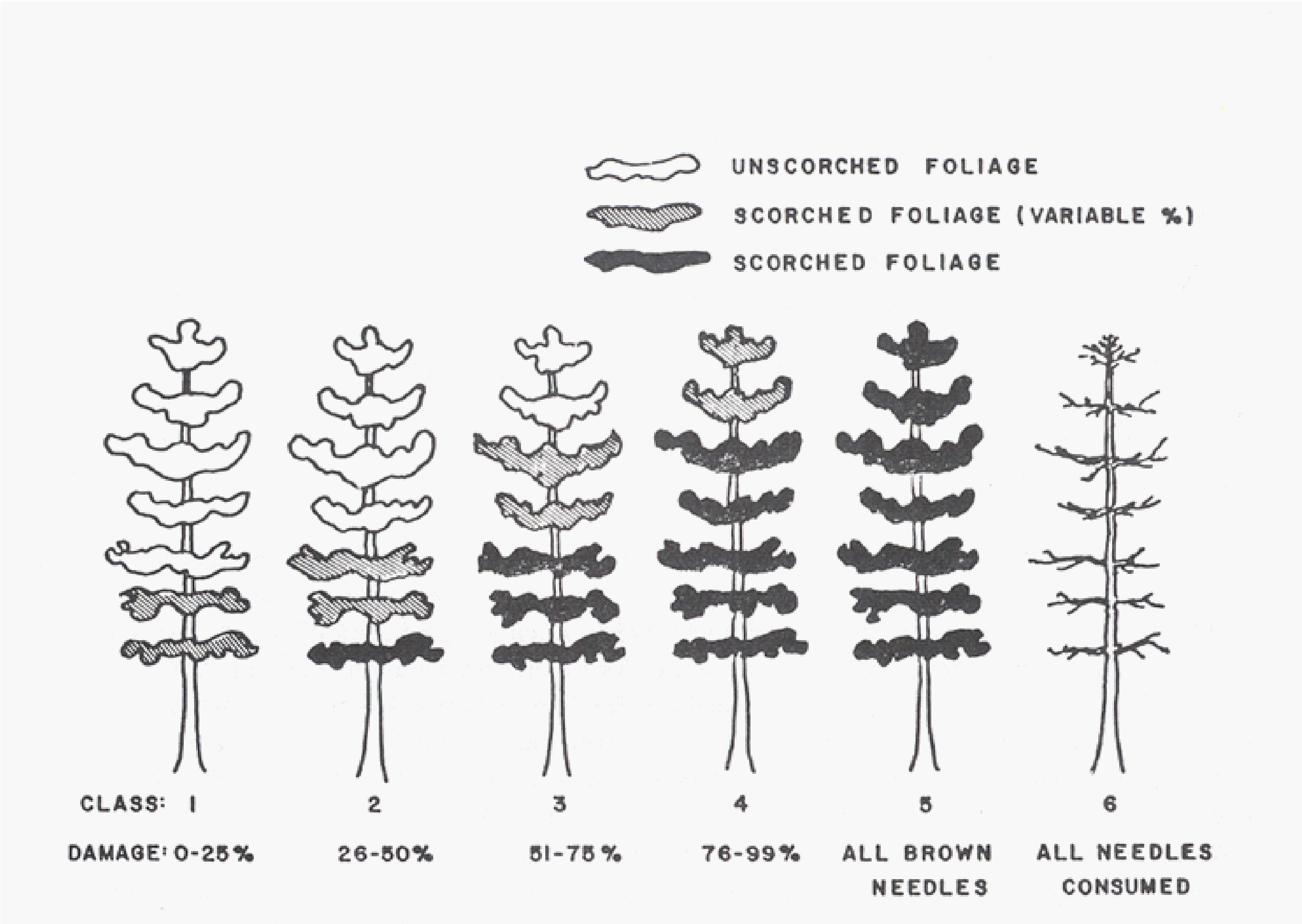


Figure 3.4. Crown Damage Classification after the 1977 La Mesa Fire

tent of mortality for the tagged trees was determined and photographs were taken in the same areas as in 1977 and 1978.

The Years 1985–1999
In subsequent years the plots within the ponderosa pine (Escobas Mesa, Burnt Mesa, and in TA-49) were revisited. We photographed each plot, located comparative pictures from photo files, used the Geographic Positioning System (GPS) to locate the plots for future reference, took data along the five lines, and mapped each site for tree and shrub location. Table 3.1 shows the type of information gathered for each area. The mixed conifer and piñon-juniper plots were not regularly revisited and in 1998–1999 only a portion of the plots could be relocated after 20 years.

The Year 2010
After an 11-year hiatus, personnel from BNM accompanied me to find the various plots on Burnt Mesa, Escobas Mesa, Frijoles Mesa, and Apache Springs.

We located all the plots on Burnt Mesa and Escobas Mesa. We could not find any of the plots in the Apache Springs area and only a portion of the plots on Frijoles Mesa.

The Year 2011
Repeat photography was done immediately after the Las Conchas Fire and 90 days later.

The Year 2012
Selected photos were taken on Burnt Mesa and Escobas Mesa and at Apache Springs.

Table 3.1 shows the activities through time within the various 20- by 50-meter plots.

3.3 Non-Vegetation Data

Fuel Loads (initial study only)
In addition to the site vegetation analysis, fuel loads were determined by collecting litter, duff, and debris less than three inches in diameter from quadrats along the line. The material was then separated into

Table 3.1. Data Collection in the 50- by 20-Meter Plots from 1977 to 2011

Plot	1977	1978	1985	1993	1998	1999	2002/2009	2010	2011	2012
Escobas Mesa (4 plots)	M, P, V	M, P, V	M, P ,V	M, P, V	M, P, V	M, P, V	P	M, P, V	M, P	P
Burnt Mesa (3 plots)	M, P, V	M, P, V	M, P, V	M, P, V	M, P, V	M, P, V	P	M, P, V	P	P
TA-49 (3 plots)	M, P, V	P, V	P	none	M, P, V	none	none	none	none	none
Frijoles Mesa (5 plots)	V	none	none	(2 plots) M, P	(2plots) V, P	none	none	P	none	none
Apache Springs (5 plots)	V	none	none	none	(2 plots) M, P	none	none	P	P	P

P = photography, M = mapping, V = vegetation fine fuel, litter, and duff less than one inch in diameter; sticks one to three inches in diameter, and standing herbaceous material. After drying, grams of weight were converted to tons per acre for each site.

Growth Rates (initial study only)
Growth rates of mature trees were determined by coring trees at random within the plot areas. Using standard dendrochronological techniques, the chronologies of selected cores were determined.

Fire Frequency (intitial study only)
Fire frequency was determined by collecting wedges of standing snags on Escobas Mesa and the north rim of Frijoles Canyon. Standing snags were used so that living trees would not be sacrificed. Since there was no way to cross-date, the numbers of annual rings between fire scars were counted. Other information was gained through samples collected by John Dieterich within and adjacent to the 1976 Escobas Mesa Fire. These were sent to the University of Arizona Tree Ring Laboratory for dating.

Photo Stations/Repeat Photography
Photo stations (see Figure 3.1) were established in a small fire that burned in 1975, Escobas Mesa 1975, and Alamo Canyon 1976. Two photo stations were placed in the Burnt Mesa Fire area, two in the Escobas Mesa Fire area, and three in the Alamo Canyon Fire area.

Photo stations were also established at the corners of each of the plots (see Figure 3.2). For the most part a wide-angle lens (28 mm) was used to obtain the widest coverage. Pictures were taken from one corner to the opposite corner (e.g., northwest to southeast). Pictures were repeated over time (see Table 3.1).

Mapping
Mapping from Aerial Photography
Aerial photo coverage of the La Mesa Fire area was obtained from three different government agencies (NPS, USFS, and LANL). The base map was composed of the Bland and Frijoles quadrangle 7.5 minute series at a scale of 124,000. Within each of the 50- by 20-meter plots, maps of tree location and the associated crown and trunk damage categories were recorded. Positive mylar prints were made with an 80 percent screening of the map lines. Using aerial stereo pairs of photographs at a scale of 1:36,000 and a Bausch and Lomb Stereo-Zoom Transfer Scope, necessary ground features not on the topographic map were temporarily filled in (i.e., roads and buildings). This information was used for transferring the fire data and deleted from the final map.

The LANL portion was mapped from stereo pairs of positive color photographs at a scale of 1:6000. These aerial photographs overlapped slightly into Bandelier. Most of the Bandelier portion was mapped from sets of color negatives of a scale 1:6000 taken on August 28, 1977. Unfortunately, the flights did not cover all the Bandelier area north of Frijoles Canyon. A third set for the USFS at a scale of 1:24,000 taken June 20, 1977, before the fire was completely under control, was used for the western section of the burn. It was in false-color infrared and was the most difficult to use for our purpose. Mapping details put on transparent overlay sheets using a Leitz Stereoscope were then transferred to the base map using a Model 55 Map-O-Graph provided by the NPS, University of New Mexico Remote Sensing Center.

We used the classification of categories of foliar damage—(1) 1 percent to 25 percent singeing, (2) 26 percent to 50 percent, (3) 51 percent to 75 percent, (4) 76 percent to 99 percent, (5) 100 percent, and (6) all needles completely consumed—and the appearance of the trees to map the areas of varying degrees of burn. Areas of complete needle combustion (class 6) and areas with trees having completely singed needles (class 5) were separately mapped. The balance of the areas that had trees in classes 1 to 4 were mapped together.

Geographic Information System
Before 1999, the location of the plots was placed on a map. However, by 1999, the GPS were available and each plot was re-located and recorded. That in-

formation was then placed on a map using the GIS (ARC Info).

3.4 Other Vegetation Analyses

Reseeding

The success of the reseeding effort was of interest. Two aspects were important—the species that germinated and the mortality of these species through time. On Escobas Mesa, two adjacent plots were initially examined to determine the success of the rehabilitation effort. Historically, plot 4 had been logged and had a foliar damage in classes 4 and 5; whereas, plot 3 was an unlogged area and had foliar damage in class 6. Seedlings were counted in 50 one-square-foot quadrats within each 20- by 50-meter plot. They were counted in the vicinity of herbaceous subplots but excluded in areas of root burnouts. Success of germination in percentage of average seeding rates was determined.

Measurement of Seedheads

Within the burn area, the seedheads of various grass species appeared to be more robust and vigorous than those outside the burned area. In order to substantiate this observation, seedheads of blue grama were collected within the burn and various non-burn areas and measured, and the measurements of 50 heads were averaged. These measurements were then compared.

Germinant Reforestation

A small study was initiated in July 1982 to determine the feasibility of using a germinant reforestation technique to establish ponderosa pine seedlings in areas devoid of trees as a result of the fire. A total of 1696 germinants were planted in six different days in late July and early August 1982.

Develice and Buchanan (1978) found the best time for planting germinants was when there was high humidity and a rain event occurred every three to four days. The peak rainy season was determined by looking at the Monument records. The planting window was set from late July to mid August based on rainfall events, seed availability, time needed to germinate seeds, and availability of personnel.

The site was selected based on easy accessibility, an area devoid of seed trees, and topographically level. The site selected was located south of State Route 4 and approximately one-quarter mile east of Ponderosa Campground.

Planting Plots

Within this area, 250 by 250 meters were delineated. The area was divided into 25-meter-square plots. Within each plot, four to five circular subplots measuring five meters in diameter were located. Each subplot was mapped on a master map so they could be more easily located at planting time. The subplots were placed so two logs and two stumps were available for planting.

Seed Germination

Seeds were obtained for zone 630 from the USFS Nursery in Albuquerque, New Mexico. Two different technqiues were used to germinate seeds: 1) planting flats with vermiculite and peat moss and 2) hamburger containers with vermiculite. Germination in the planting flats was slow and cumbersome, movement often breaking the radicles of the germinants. Germination in the hamburger container was more consistent and the container was less cumbersome in the field.

The seeds were soaked in three percent to five percent peroxide for two hours in preparation for planting. Styrofoam "Big Mac" containers obtained from McDonalds were used. (**Note:** In 1982 McDonalds used Styrofoam and they do not do that presently.) Vermiculite (100 cc) was placed in the bottom of the container and 3.2 grams, or approximately 100 seeds, were placed on the vermiculite and dusted lightly with the material. The lid was tightly closed and not opened for five days. A tent was constructed around the containers to keep the humidity at 75 percent. On the 6th day the germinants were found to have radical lengths of 35 to 70 millimeters and planting began on the 7th day.

Planting Germinants

Planting began at 0600 or sunrise and continued until the relative humidity fell below 68 percent. The germinants were planted by making a slit in the soil with a flat-bladed tool such as a putty knife (Figure 3.5). The germinant was quickly removed from the hamburger container and the radical placed in the slit. The radical was placed so the pink portion was at soil level and the white portion below. Another slit was made in the soil parallel to the planting hole and then the soil pressed against the germinant. After planting, a five-inch-tall vexar tube was pinned around the germinant.

Treatments were the following: Uncleared control were bare spots between herbaceous vegetation. Cleared sites consisted of an area 18 inches in diameter cleared of vegetation. Other germinants were planted next to logs and stumps.

Survival counts were made in September 1982 and August 1983 (Figure 3.6). From 1982 through 2010, periodic photographs were taken of the area.

Planting Two-Year-Old Trees
LANL wanted to develop a tree screen to prevent view of some of the facilities across Water Canyon. Therefore, the initiative to plant two-year-old trees was begun (Collins 1982). Figure 3.7 illustrates the difference between a germinated pine seed and two-year-old stock when planted.

Leaf Water Potential
In May 1980, five study sites were established adjacent to the plots established by Potter and Foxx in 1978 and 1979. Measurements of leaf water potential and soil moisture were performed periodically throughout the summer months. As the season progressed, measurements were only performed at two sites that were judged to be most similar in species composition, soil type, slope, and aspect.

Leaf water potential of the three grass species (slender wheatgrass, sheep fescue, and mountain muhly) was measured between 1200 and 1400 hours on sunny days (cloud cover less than 10% from 1000 to 1200 hours). The most recently emerged leaves were used for measurements. This was difficult to determine on sheep fescue so a different criterion was often used—selecting a leaf that was bright green, turgid, and of average or above average length. One leaf from each of five to 10 clumps of a species was cut with a razor blade and the xylem sap tension measured using a Scholander type pressure chamber (PMS Model 1000) (Scholander et al. 1965).

Within one day of the leaf water potential measurements, soil samples were taken at 10-, 20-, 30-, and 40-centimeter depths from each of the two sampling locations at each study site. The soil samples were weighed, dried at 105 ºC for 24 hours, and re-weighed, and the soil moisture as a percentage of the dry weight was calculated.

In September and October 1980, two specimens of each species were excavated using a modified monolith method (Bohm 1979). Each specimen was dug with an intact cylindrical soil block 30 centimeters in diameter and 30 centimeters in depth. The soil block was carefully wrapped and returned to the laboratory where it was supported on a heavy wire grid and the soil washed from the roots with a fine water jet. After most soil was removed, the root mass (still attached to the crown and shoot) was floated in many successive water baths, and debris and remaining soil removed by hand. The cleaned root-shoot system was spread on a sheet of white paper and photographed, then allowed to dry.

Scientific Nomenclature
Scientific names of plants have changed over the years; many plants have several common names. Names that were used in 1977 are no long considered up-to-date. We have tried to update the scientific names as much as possible. However, to assure the reader can extrapolate an old name to a new name, if we missed the name change in the text or tables, we have developed an annotated checklist (Appendix III).

Nomenclature has been checked using the US Department of Agriculture Plants database (http//:usda.plant.gov). This database has common names, scientific names, and symbols used in field notes. If there were further questions, the nomenclature was checked in Allred (2011), Flora Neomexicana, I:The Vascular Plants of New Mexico.

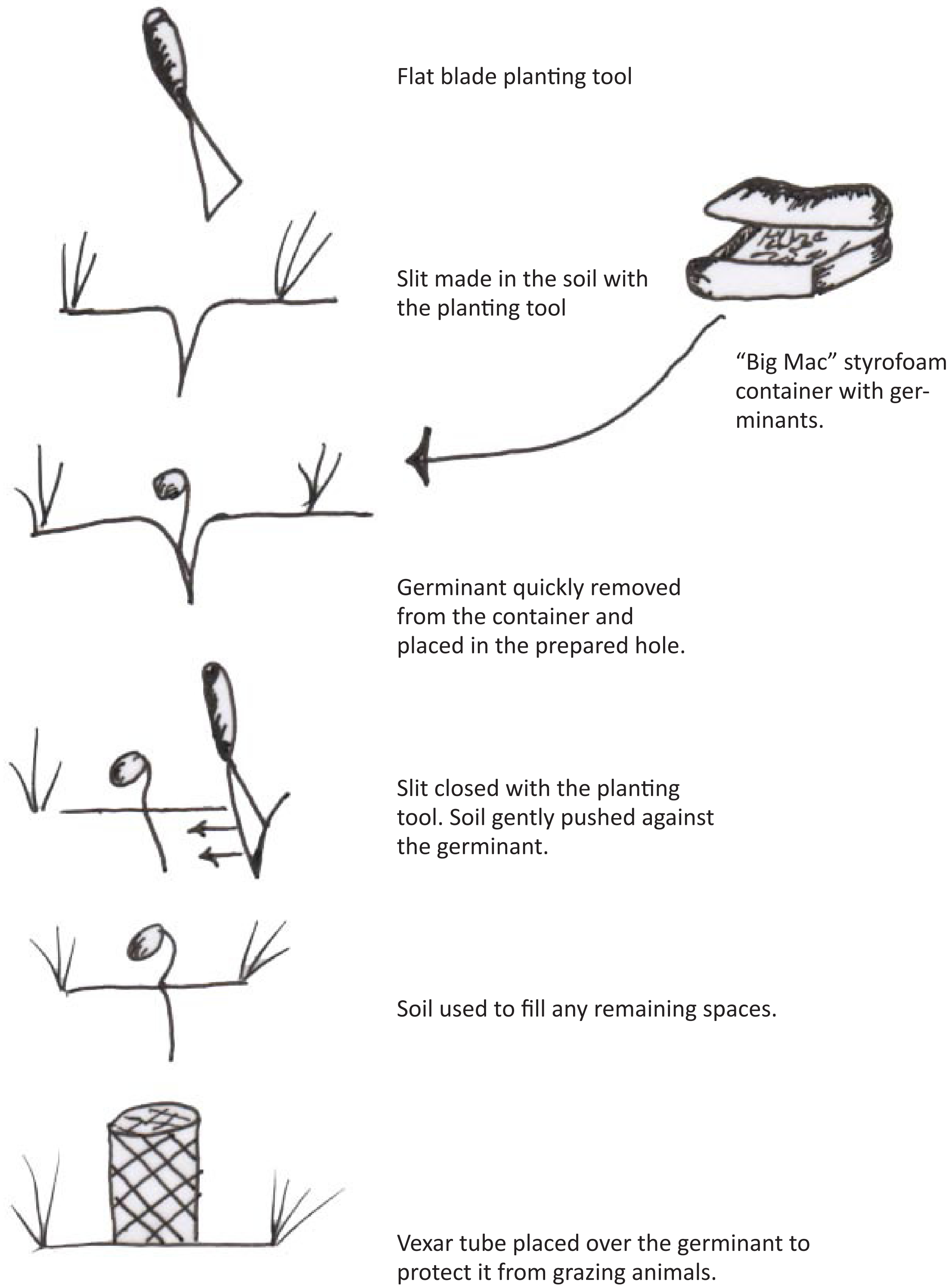


Figure 3.5. Planting method for germinants (Drawing by T.S. Foxx)

Figure 3.6. Recording survival information one year after planting germinated pine seedlings

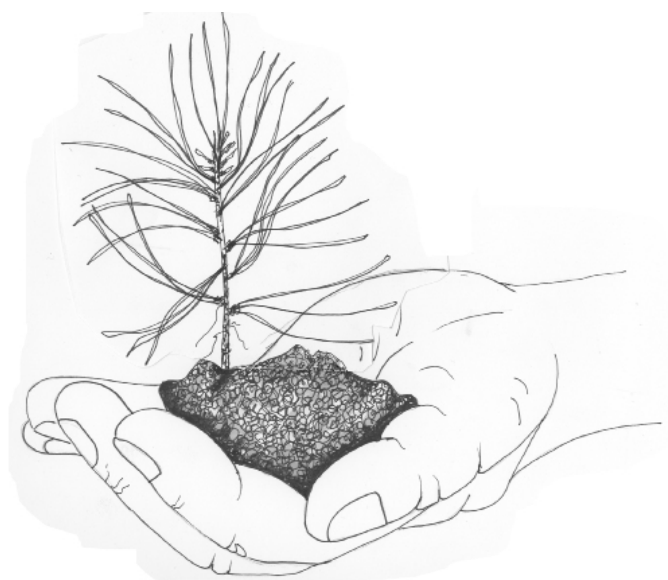


Figure 3.7. Comparison of germinated seed (top) versus the two-year-old stock (right) (Drawings by T.S. Foxx)

Literature Searches

Literature searches are far easier now than in 1977 and include reviewing scientific abstracts, literature databases, and tables of content from scientific journals, government publication lists, Dissertation abstracts, and other services. Many documents have now been entered on-line. One of the most extensive databases for literature related to fire is the Fire Effects Information System (FEIS) compiled by the Rocky Mountain Research Station, Missoula, Montana, and the Rocky Mountain Research Station, Fort Collins, Colorado. This database synthesizes scientific knowledge about fire effects on organisms in the US, including Alaska and Hawaii and was used extensively to check for more recent publications and reference accuracy (www.fs.fed.us/database/feis/).

4.0 DESCRIPTION AND RESULTS

All Plots

Sample areas were established in various areas of BNM before and after the La Mesa Fire. There were sample areas for ponderosa pine on Escobas and Burnt mesas, mixed conifer on Apache Springs, and piñon-juniper along State Route 4. The location of these plots can be seen in Figure 4.1. Each area was revisited periodically after the La Mesa Fire.

Ponderosa Pine

Pure stands of ponderosa pine extend from approximately 7000 to 8000 feet on the Pajarito Plateau. The 20- by 50-meter plots within the ponderosa pine vegetation type on Burnt Mesa and Escobas Mesa (Figure 4.1) were the most accessible and were followed periodically over the past 35 years: 1977, 1978, 1985, 1992, 1998, 2002, 2010, 2011, and 2012. After the fire, plots on Burnt Mesa and Escobas Mesa were established along the bird transects established by Roland Wauer before the La Mesa Fire.

Other plots were established on Burnt Mesa, within TA-49, at LANL. These were control plots for the seeding operation as the area was not reseeded. The TA-49 plots have only been visited occasionally during the past 35 years. In 1977, plots were located on maps, however, with the invention of GPS, locations were later refined and are included under each transect description.

4.1 Burnt Mesa

This area is a mesa that extends from Water Canyon to the edge of Cañon de los Frijoles (Figure 4.2).

The name Burnt Mesa may have been given to the mesa by government surveyors in the mid-1930s (Martin 1998). The mesa was originally part of the Ramon Vigil Grant and the AEC's holdings. It was transferred to BNM in December 1959 (LASL News 1963a, Martin 1998).

At one time, Burnt Mesa had two roads transecting the area (Figure 4.3). One is called Burnt Mesa Trail and is still in existence. The other is a fire road that went west to south. That road has not been maintained since the La Mesa Fire (Figure 4.4). The fire road was indistinguishable in 2010 and 2011.

Plot locations established along the fire road for the Burnt Mesa plots are on Figures 4.1 and 4.5.

Fire History

Before the area was burned by the La Mesa Fire, the mesa had a variety of stand types from open meadows to park-like and dense stands. Aerial photographs taken in 1958 show the openness of the mesa and the stand variety (Figure 4.6).

The origin of the meadow is in question since there are no available records of recent fires and no evidence of logging; however, pictures taken from Nake'muu on LANL in 1920 show the north rim of Water Canyon to be very open (Figure 4.7). This openness may have been due to past fire. From the few fire-scarred trees collected in 1976–1977, the fire frequency before 1900 was one fire every 19.3 years. Additonal information was gleaned from fire-scarred trees within the ponderosa pine areas of Burnt and Escobas mesas by Craig Allen (1989). From these fire-scarred trees, there is an indication that much of the area had not burned for 98 years before the La Mesa Fire (Table 4.1). (**Note:** Many of the tables in this section are multiple pages long. So, to maintain flow in this narrative, the tables are presented at the end of each plot description subsection.)

When the area was visited in 1976 before the La Mesa Fire, a meadow was near the entrance. A few snags were standing from a previous fire, drought, or insect damage.

The meadow was vegetated with numerous forbs, including Carruth sagewort, and grasses, including blue grama. The surrounding area had stands of ponderosa pine in various densities.

Figure 4.8 shows the area adjacent to the fire road in 1976. Note the density of the trees and the presence

Figure 4.1. Plot locations

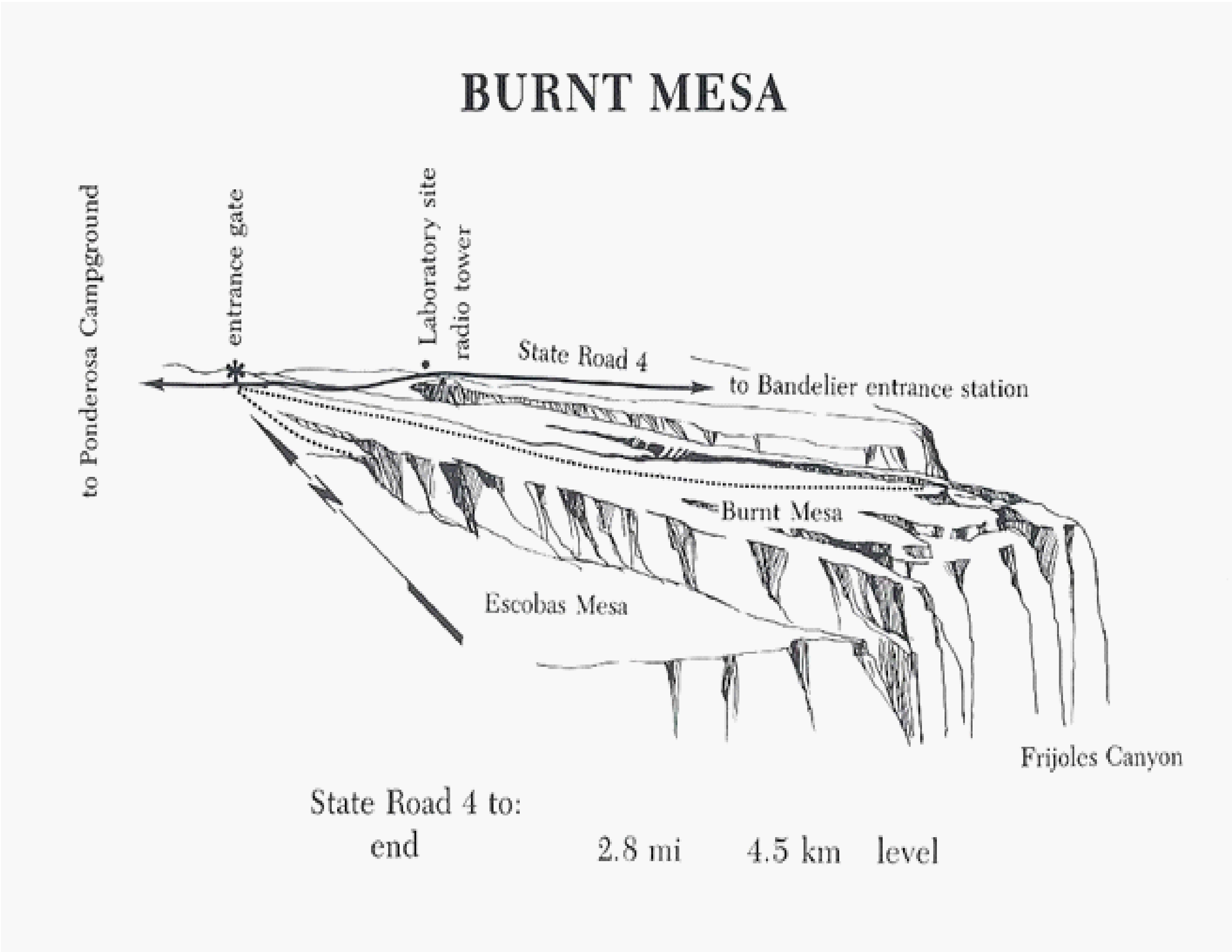


Figure 4.2. Location of Burnt Mesa and Escobas Mesa (by permission Dorothy Hoard, 1989)

Figure 4.3. Fire road on Burnt Mesa in 1978

Figure 4.4. Fire road on Burnt Mesa in 1998, 20 years later

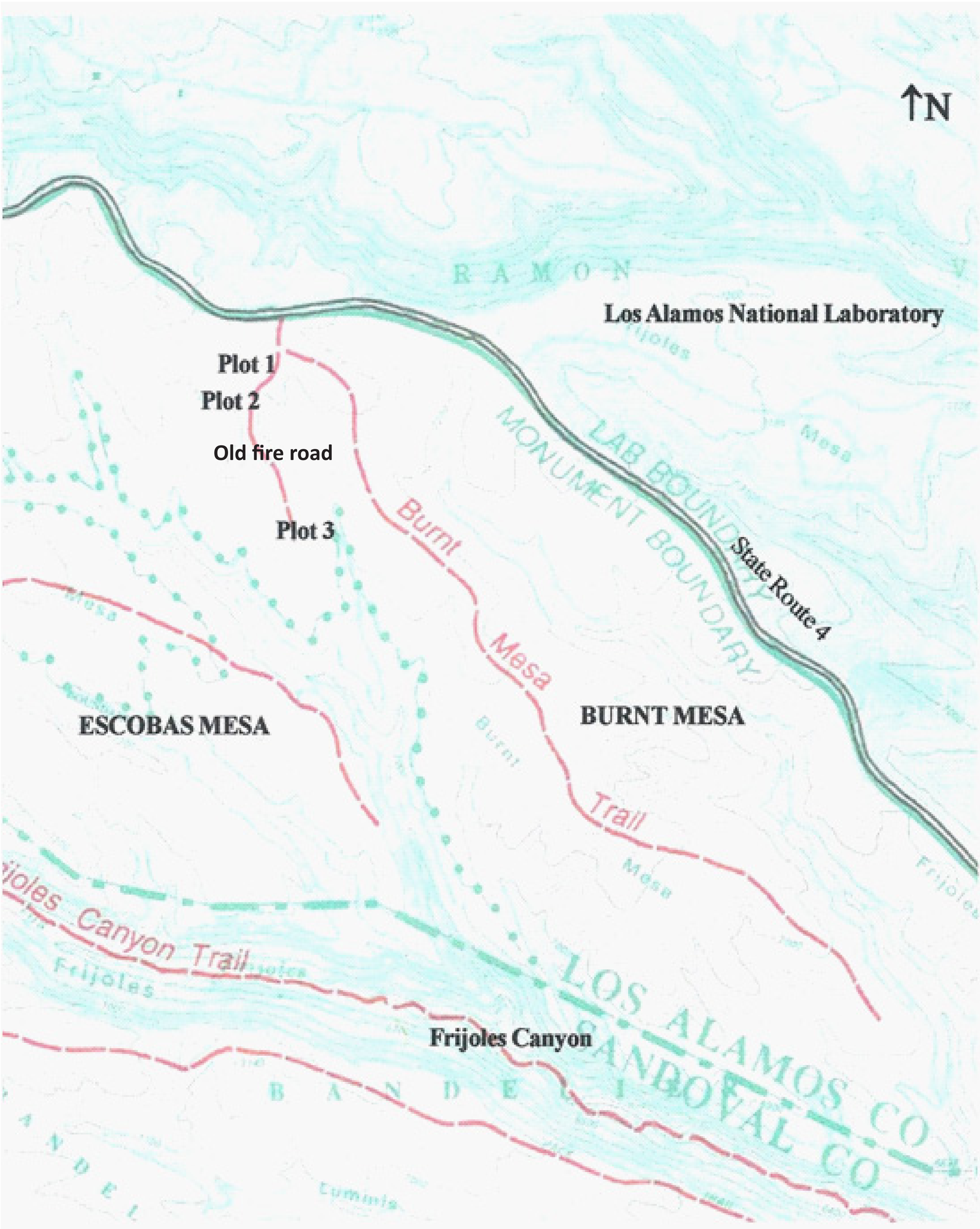


Figure 4.5. Location of the plots on Burnt Mesa

Figure 4.6. Burnt Mesa in 1958

Figure 4.7. Picture taken from Nake'muu, a ruin on the north side of Water Canyon (1920). The view is to the south side of the canyon toward Burnt Mesa. Note the lack of trees on the Burnt Mesa side in 1920. (Photograph courtesy of Los Alamos Historical Museum, Pond photograph.)

of a snag. Figure 4.9 shows that same snag, that survived the prescribed burn, after the Las Conchas Fire and the decreased density of trees after the La Mesa Fire and prescribed burn.

In 2011, we found two trees (Figure 4.10), scarred from a previous fire, adjacent to each other—one with a new fire scar and the other not. This shows the variability of scarring of trees in any particular fire.

Before the La Mesa Fire, there was a small fire on Burnt Mesa that was quickly extinguished. A photo station was set up and followed a couple years but no phytosociological data were taken.

Burnt Mesa burned July 18, 1977, when the rate of spread was estimated to be 38 chains per hour. The burn intensity throughout the mesa varied depending on the stand density. Dense stands were severely burned while the meadow was lightly burned. We first established plots approximately two months post-La Mesa Fire. The three plots—placed along the fire road—are a lightly burned area (the meadow), moderately burned area (adjacent to the meadow), and severely burned area (a dense stand). Figure 4.11 shows the relationship of each plot with the fire damage.

Burnt Mesa was burned by a prescribed fire in 1998. In the Las Conchas Fire, the plots were burned again from the backfire used to protect State Route 4 and LANL (Figure 4.12). Thus, since the La Mesa Fire, the area has burned twice at an interval of 21 and 13 years.

Data Collection

The plots on Burnt Mesa were visited eight times since 1977; some for data collection, others for photography. The sites were visited in the following years after the La Mesa Fire: 1977 post-La Mesa Fire; 1978, one year post-fire; 1985, eight years post-fire; 1992, 16 years post-fire. In 1998, a prescribed fire burned over the plot locations and reset the succession. Since 1998 the plots have been visited in 1998, 21 years post-fire but the year of the prescribed burn; 1999, one year post-prescribed fire; 2010, 12 years post-prescribed fire but 33 years post-La Mesa Fire. After the Las Conchas Fire, the plots were visted for purposes of photography 23 and 90 days post-fire.

Burnt Mesa 1

Burnt Mesa 1 is located in an open meadow 500 feet from the entrance gate to Burnt Mesa (see Figures 4.1 and 4.5). The meadow was considered to be lightly burned, evidenced by only charring of the surface litter and little effect on the above and below ground plant parts. The GPS coordinates are presented below.

Overstory Conditions

Within the meadow there were few mature trees. The density per acre was low, 4.0 mature trees per acre with a basal area of 0.9 square feet per acre. Most small trees of the area sustained damage to the crown but not extensive enough to kill them.

Understory Conditions

Within a short time after the fire (1977), this meadow was covered by luxuriant growth of grasses and

GPS coordinates for Burnt Mesa 1

Location	Y_Coordinates_27	X_Coordinates_27	Latitude	Longitude
BM-1-25N	3965351	379931	35.82680167	-106.32982761
BM-1-25 S	3965334	379940	35.82664501	-106.32972107
BM-1-NE	3965363	379952	35.82691197	-106.33006892
BM-1-NW	3965339	379909	35.82668642	-106.32947138
BM-1-SE	3965349	379963	35.82678759	-106.32947138
BM-1-SW	3965322	379920	35.82653680	-106.32994370

Figure 4.8. Taken in 1976 before the La Mesa Fire and setting up plots. Compare snag with pictures taken in September 2011 (Figure 4.9).

Figure 4.9. Snag seen in 1976 reduced by the La Mesa Fire, prescribed fire, and Las Conchas Fire. Note the thinning of the trees from 1977 to 2011.

Figure 4.10. Two trees near Plot 1. One was burned in the Las Conchas Fire and the other was not. Both were fire scarred from previous fires.

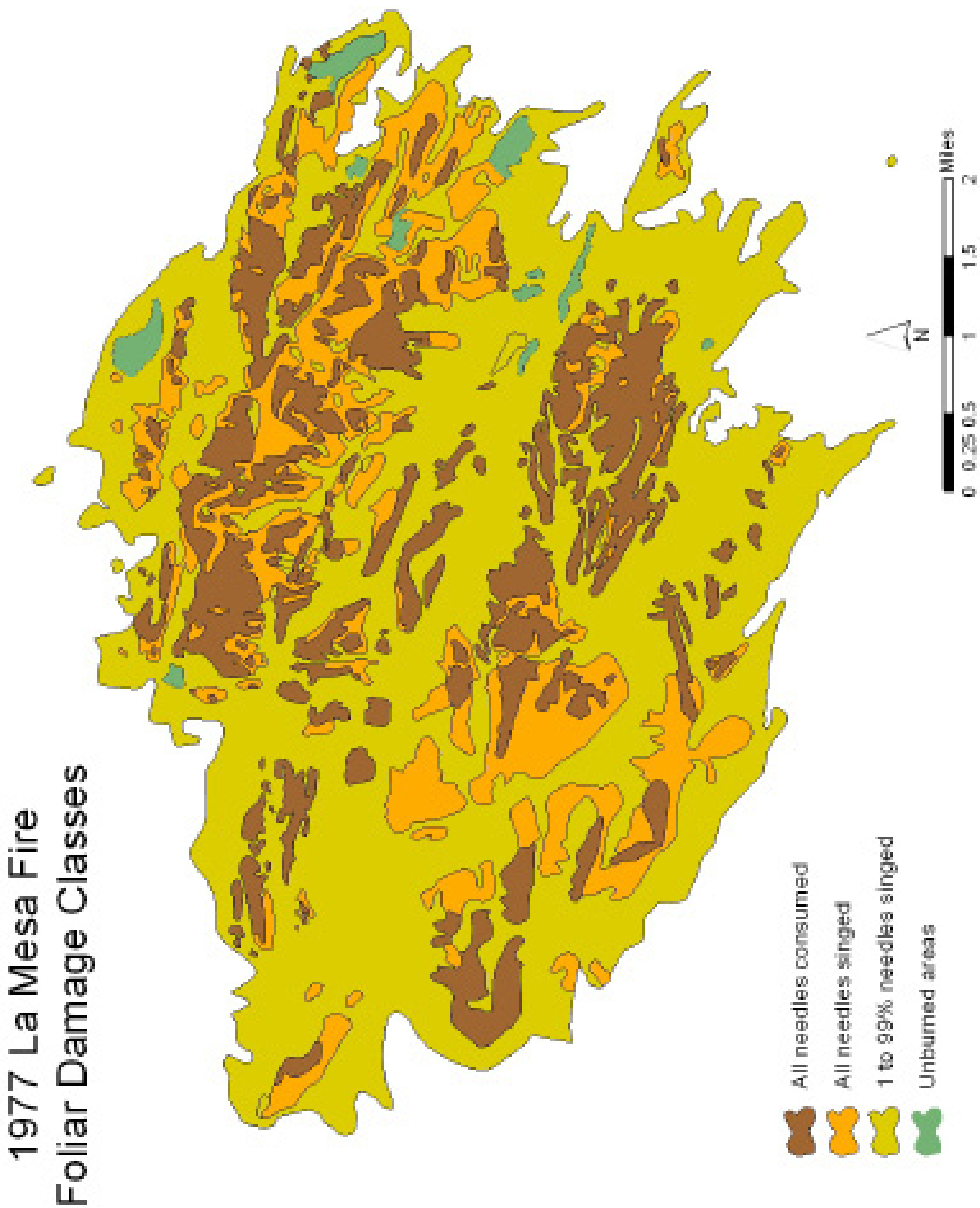


Figure 4.11. The severity mapping of the La Mesa Fire on Burnt Mesa

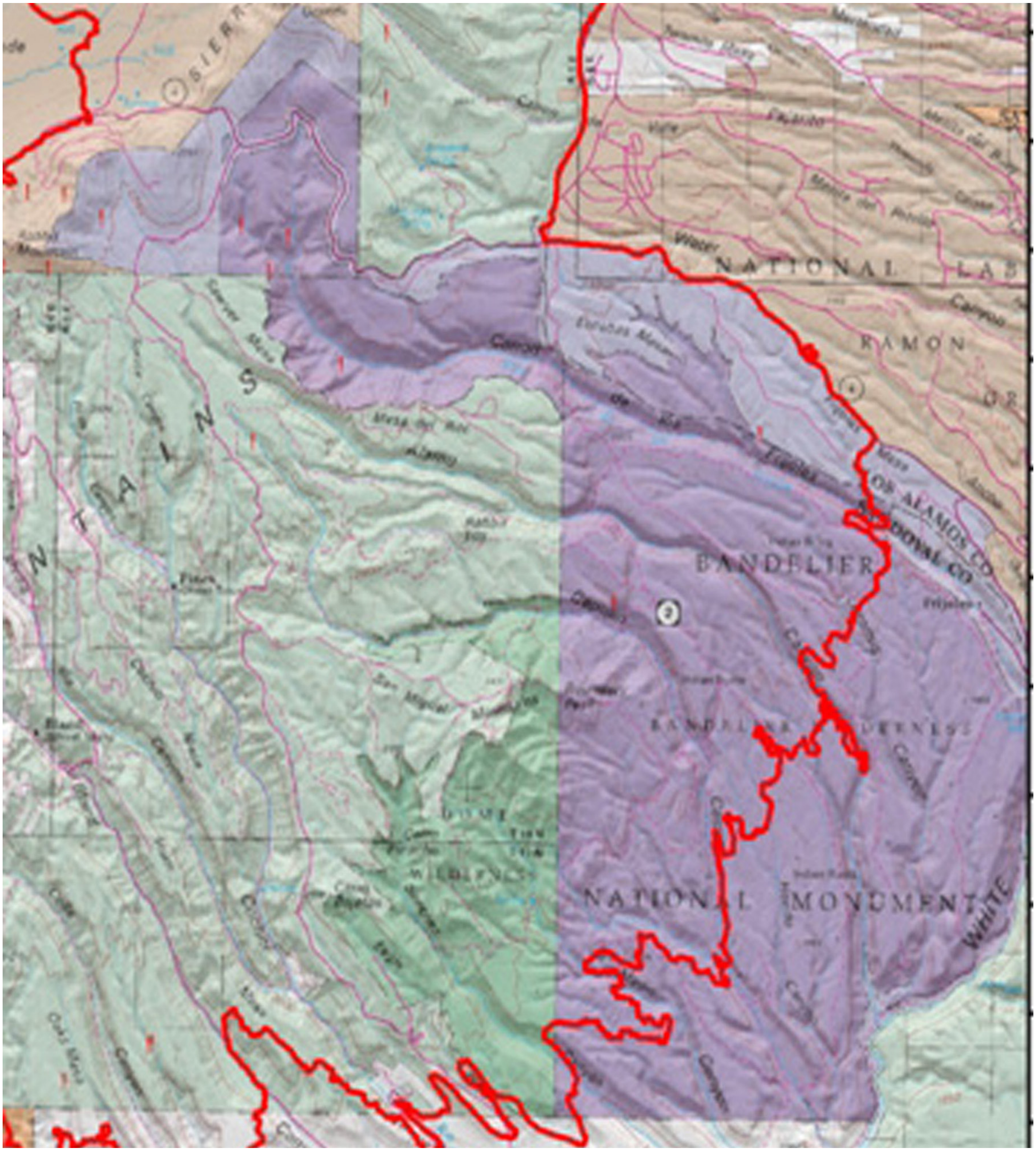


Figure 4.12. Las Conchas Fire boundaries in Bandelier

forbs. Seedheads of blue grama were extremely large, sometimes as much as one inch in length. Blue grama made over 60 percent of the total grass cover. There were patches of wild onion and 18 different species of forbs. Greenthread made up four percent of the total forb cover.

In 1998, before we returned to the plot, the area had been burned by a prescribed fire. The most striking aspect, again, was the cover of greenthread. It made up 36 percent of the total forb cover. But there was also an increase in Carruth sagewort and false tarragon. These two species made up 30 percent of the total forb cover. Greenthread seems to be stimulated by fire. Due to drought and other conditions, it appears that false tarragon is increasing. Table 4.2 presents the percent cover of grasses, forbs, and shrubs found in Burnt Mesa 1 through time.

Mapping and Photography

The meadow plot tree locations were not mapped through time as there were few trees. Comparative photographs were taken for the plot through time. The visual changes can be seen in Plate 4.1. Note the flush of growth of the various forbs and grasses taken post-La Mesa, prescribed fire, and Las Conchas. These changes can be seen in 1977, 1998, and 2011.

Soon after the La Mesa Fire

August 18, 1977, two months post-fire (F2-4)

Plate 4.1. *Comparative photographs taken from the northeast corner of Burnt Mesa 1 looking along the 50-meter line from 1977 through 2011.* *(Continued on the next page)*

June 4, 1998

August 1998

Plate 4.1. *Comparative photographs taken from the northeast corner of Burnt Mesa 1 looking along the 50-meter line from 1977 through 2011 (continued)*

April 2009 before summer greening

2010

July 2011, 23 days after Las Conchas Fire

September 2011, 90 days after Las Conchas Fire

Table 4.1. Fire History of Burnt Mesa Based on Datable Dendrochonological Samples Collected by Potter and Foxx (Potter and Foxx 1984, Foxx and Potter 1978)

Sample	Severity	Fire Dates	Year Interval	Interval	Years Since Last Fire
1	Severe	1797–1806 1806–1822 1822–1900	9 16 78	34.3	77
2	Severe	1797–1806 1795–1847 1847–1858	9 41 11	20.3	119
3	Severe	1806–1814 1814–1822 1822–1842 1842–1870 1870–1878	9 8 20 28 8	14.6	99
7	Severe	1806–1814 1814–1822 1822–1830 1830–1870 1870–1878	8 8 8 40 8	14.4	99
Intervals			19.4 years		98.5

Table 4.2. Percent Cover of Species Found in Burnt Mesa 1 Through Time

Species Name	1977*	1992	1998	2010	Years Occurred
Grass					
Native Grass					
Bouteloua gracilis	8.76	23.82	2.0	19.72	4
Carex spp.	0.3				1
Elymus elymoides	4.68			0.26	2
Festuca octoflora		0.04			1
Hilaria jamesii	0.1				1
Koleria macrantha				2.62	1
Muhlenbergia montana				0.78	1
Poa spp.		0.1	0.4	0.4	3
Schizachyrium scoparium		0.48		0.3	2
Unidentified Grass	0.75	1.2			2
Total Native Grass Cover	**14.59**	**25.64**	**2.4**	**24.08**	
Seeded Grass					
Festuca ovina		1.4			1
Introduced Grass					
Bromus tectorum		0.06		0.1	2
Total Introduced Grass Cover					
Total Grass Cover	**14.59**	**27.10**	**2.4**	**24.18**	
Total Grass Species	**5**	**7**	**2**	**7**	
Forbs					
Allium cernuum	0.1	0.14	0.1		3
Artemisia carruthii	6.22	2.8	4.08	0.7	3
Artemisia dracunculus		0.36	3.44		2
Bahia dissecta	0.02			0.12	2
Castilleja integra	1.06	0.22			2
Chenopodium graveolens	0.02				1
Cirsium spp.	0.06	0.2	0.5		3
Cryptantha jamesii		0.1			1
Erigeron spp.				1.0	1
Erigeron divergens		0.46		0.1	2
Erigeron flagellaris		0.58	1.52		2
Euphorbia serpyllifolia	3.0		0.11		2
Gaura coccinea	0.5		0.02		2
Heterotheca villosa	1.32	1.26	1.6	0.38	4
Hymenoxys richardsonii				0.6	1
Lotus wrightii		0.12			1
Lupinus caudatus	0.46	1.4	1.16		3
Medicago sativa			0.04		1

Species Name	**1977***	**1992**	**1998**	**2010**	**Years Occurred**
Forbs (cont.)					
Orthocarpus purpureo-albus		0.12		0.08	2
Penstemon spp.	0.04				1
Physalis foetens var. *neomexicana*	0.1		0.1		2
Plantago purshii		0.26			1
Polygonum aviculare		0.02			1
Potentilla spp.	0.72		3.22		2
Thelesperma trifidum	0.64	1.38	9.02	1.36	4
Tragopogon dubius	0.1				1
Vicia americana	0.1	0.28	0.04		3
Verbascum thapsum	0.2	0.06			2
Unidentified Forb	0.9		0.08		2
Total Forb Cover	**15.56**	**9.76**	**25.03**	**4.34**	**4**
Total Forb Species	**18**	**17**	**15**	**8**	
TOTAL FOLIAR COVER	**30.15**	**36.86**	**27.43**	**28.52**	
Bare soil	69.85	62.24	65.22	6.14	
Litter	0.9	0.9	7.14	34.78	
Gravel				36.18	

*Data for 1978 and 1985 not available.

Burnt Mesa 2

Plot Location and Condition

Burnt Mesa 2 is southwest of Burnt Mesa 1 and was placed in an open stand of ponderosa pine at the edge of the meadow (see Figures 4.1 and 4.5). The t-pole is located in the southeast corner next to a large tree. We classified the site as moderately burned with a mean fire damage of 4.8, many of the trees maintaining at least one-quarter of the crown. The GPS coordinates are presented below.

Overstory Conditions

Some girdling of the trees was apparent immediately after the La Mesa Fire. The fire consumed the foliage of many of the trees from 50 percent to 25 percent, twigs and litter layer, and some of the duff, rotten wood, and smaller-diameter woody debris. Small saplings in the area were noted to be sprouting from the terminal buds soon after the fire. The density of the trees in 1977 was 44 per acre and by 2010 there were only eight trees per acre in this area (Table 4.3). Maps of the density and location of the trees through time are shown in Plate 4.2.

After the Las Conchas Fire, remaining trees were variously charred and scorched (Plate 4.3). Tree number 1 was more seriously charred at the base and the canopy slightly singed and was surrounded by oak in 2010. Tree number 2 was surrounded by oak at the base and was not as seriously charred in the Las Conchas Fire. Figure 4.13 shows the reduction in tree cover from 1977 through 2010.

Understory Conditions

In 1977, we noted large patches of wild onion in the more severely burned areas where the ground was denuded. In this plot the cover of grasses was greater than that of the forbs (3.2% grasses and 0.7% forbs). However, after the 1998 prescribed fire, the percent of grass cover was reduced (5.4%) and the cover of forbs was increased (16.3%). Figure 4.14 presents changes in grass cover through time.

There was a distinct difference in the number of forb species in the plot through time (Figure 4.15). In 1977, there were only five forb species. In all other years there were over 20 species. Cover for each species was less than one percent. Four different species were recorded for all five years. Those species included wild onion, Carruth sagewort, lupine, and American vetch. Other species, including golden aster, common fleabane, groundsel, and greenthread, were recorded as being present four out of the five years. Table 4.4 presents the percent cover of grasses, forbs, and shrubs found in Burnt Mesa 2 through time.

Conditions after the 1998 Prescribed Fire

After the 1998 prescribed burn, cover for Carruth sagewort, false tarragon, golden aster, lupine, and greenthread increased. Most striking from 1998 to 2010 was the increase in false tarragon (Figure 4.16) and spreading fleabane. Both of these species are drought tolerant. From 1992 to 2010 the litter remained stable but the vegetative cover increased. For that reason the percent litter cover decreased as the plant biomass increased (Figure 4.17).

Conditions after the Las Conchas Fire

No data were taken immediately after the Las Conchas Fire but photographs were taken of each plot. Two sets of photographs were taken after the fire—

GPS coordinates for Burnt Mesa 2

Identification	Y_Coordinates_27	X_Coordinates_27	Latitude	Longitude
BM-2-12.5-E	3965289	379861	35.82623161	-106.33059514
BM-2-25 W	3965305	379846	35.82637503	-106.33081038
BM-2 NE	3965322	3798770	35.82653177	-106.33049388
BM-2-NW	3965328	379849	35.82658038	-106.33072682
BM-2-SE	3965328	379849	35.82658038	-106.33064358
BM-2-SW	3965283	379836	35.81970362	-106.33086663

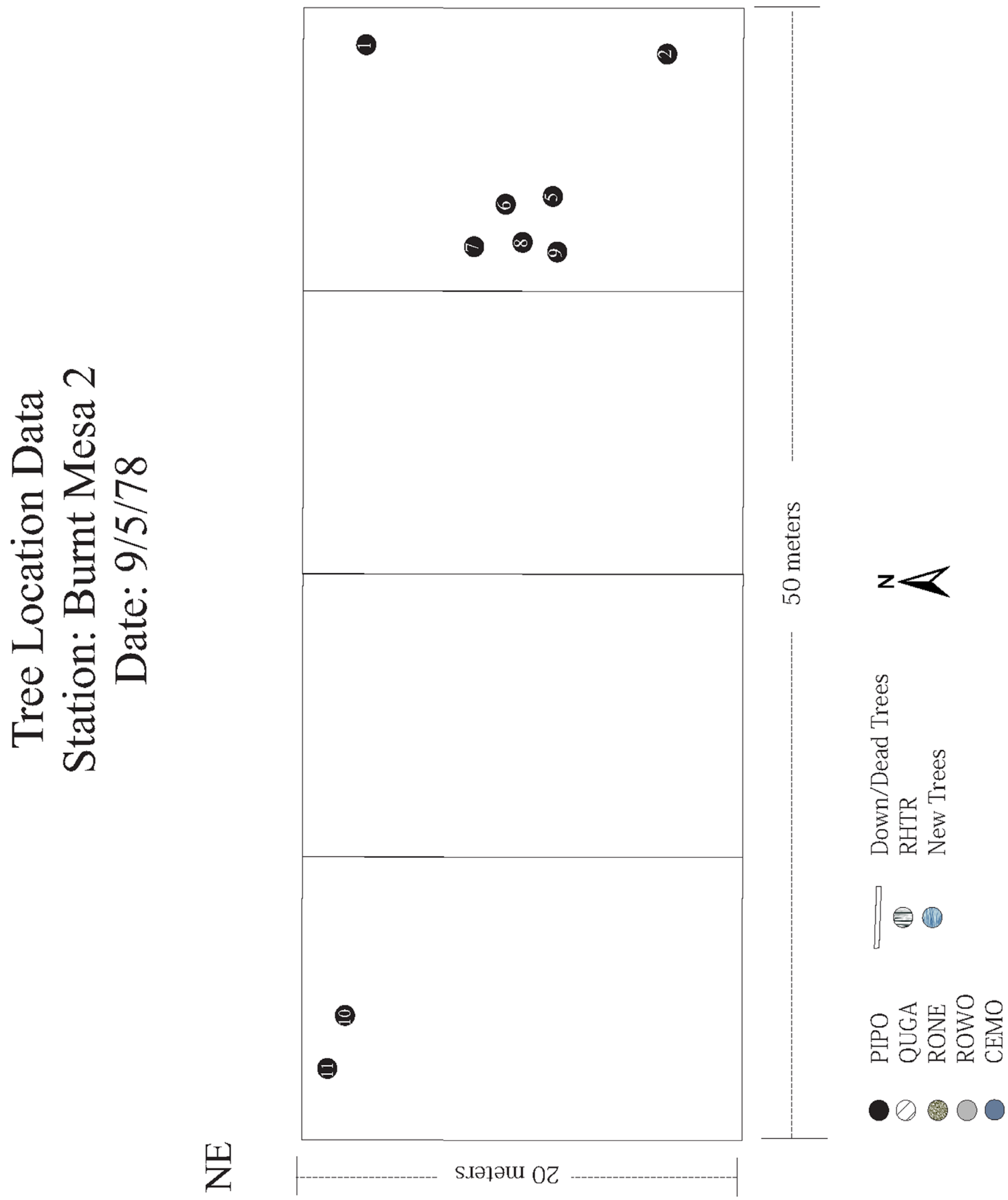


Plate 4.2. *Maps of the density and location of the trees through time for Burnt Mesa 2 (continued on the next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

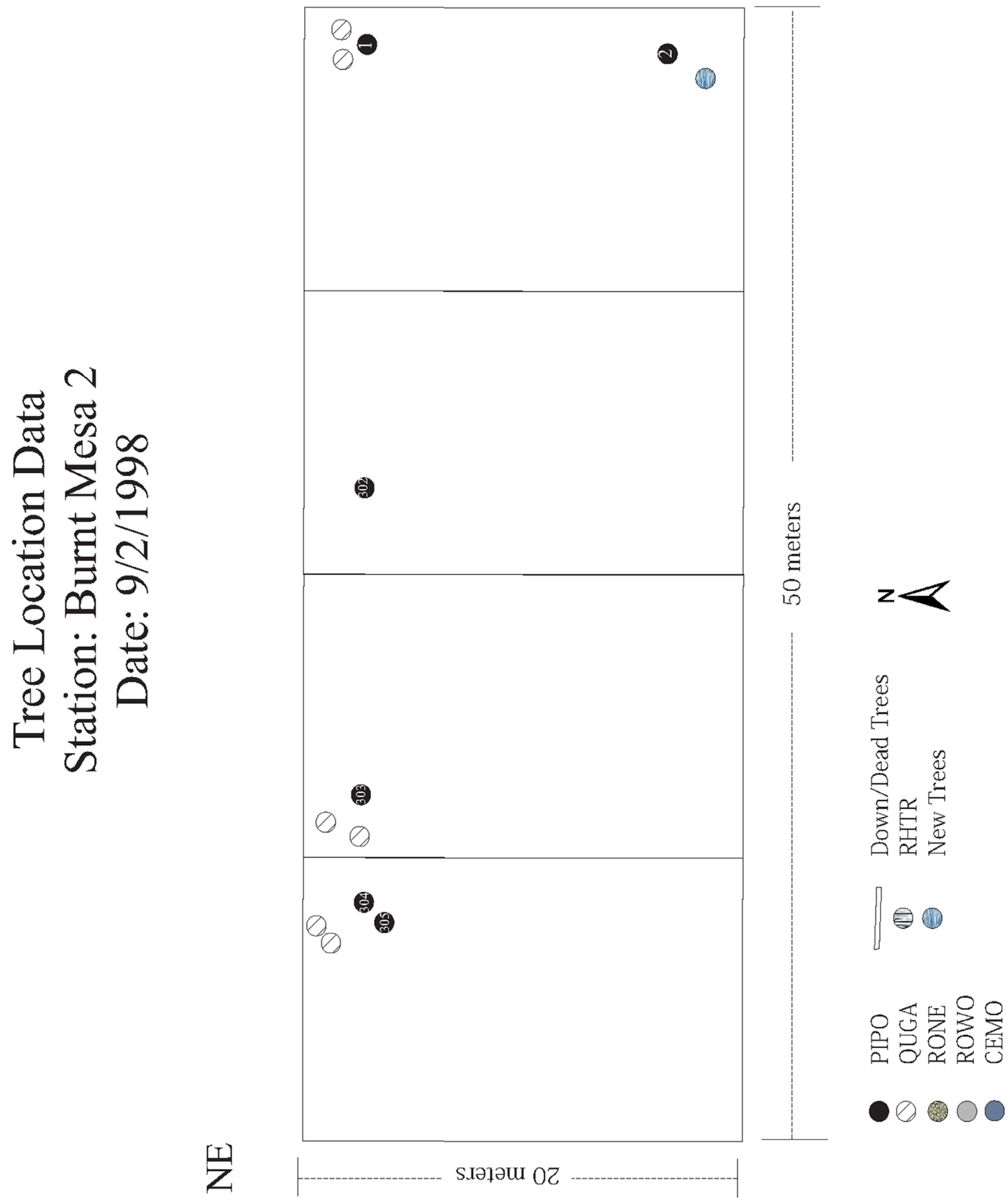


Plate 4.2. *Maps of the density and location of the trees through time for Burnt Mesa 2* *(continued on next page)*

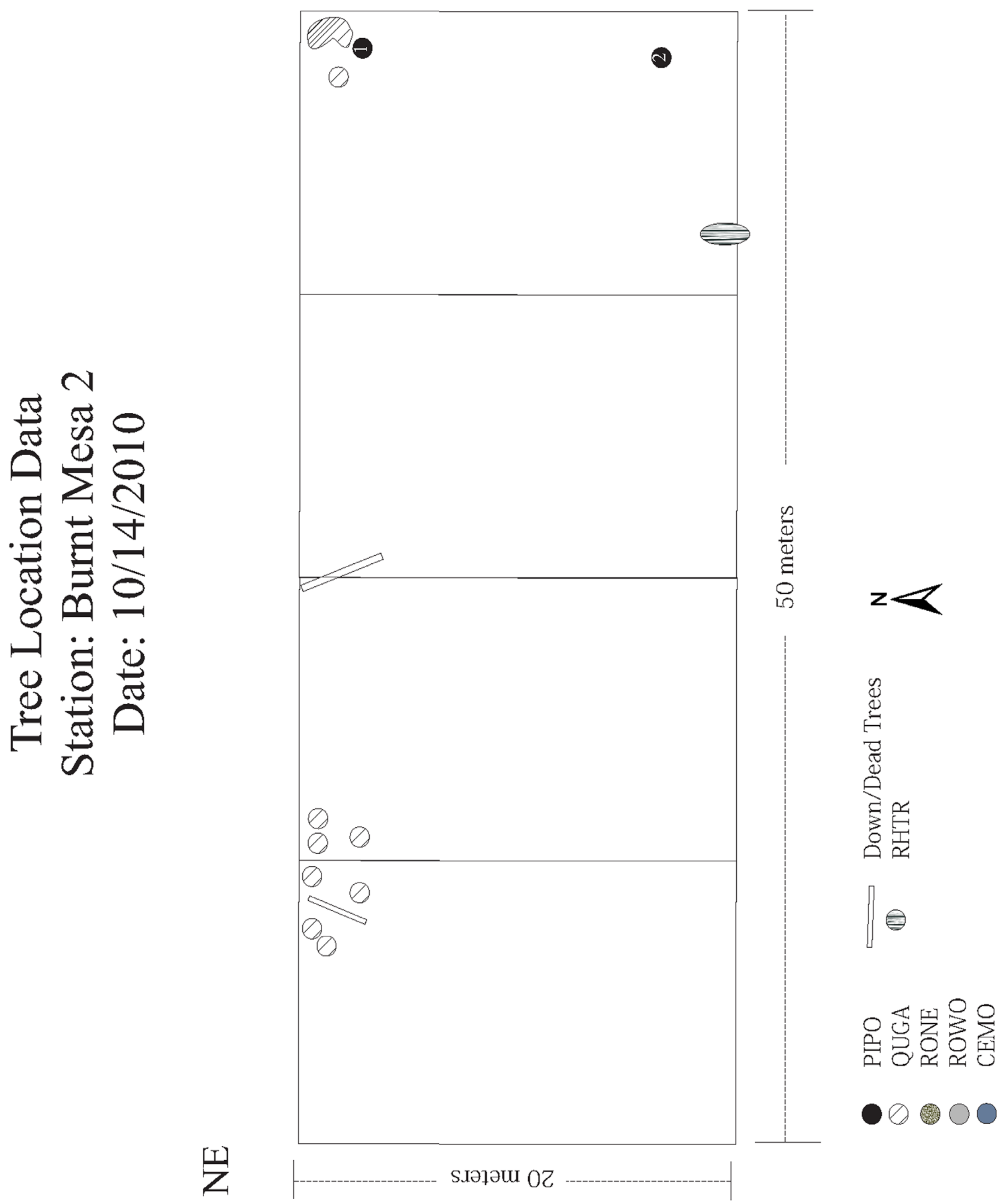
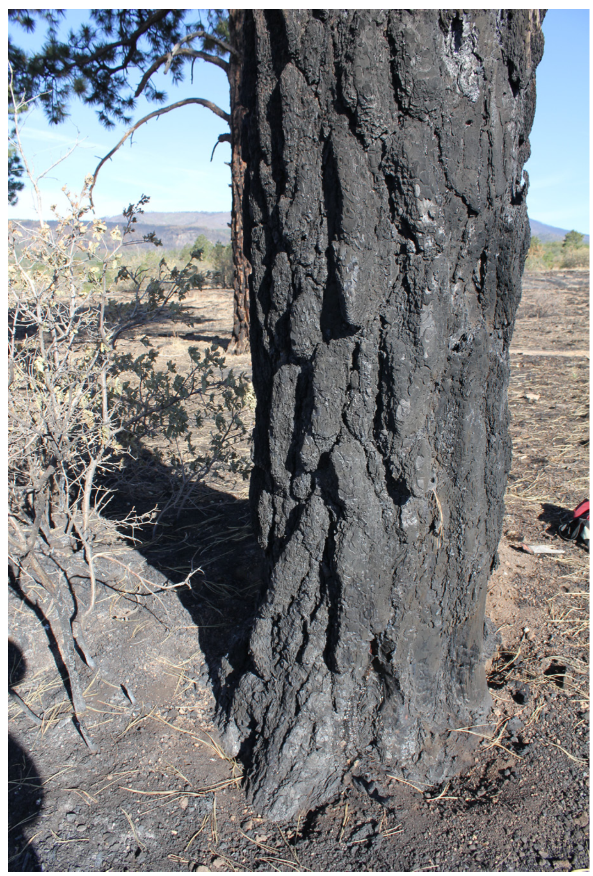


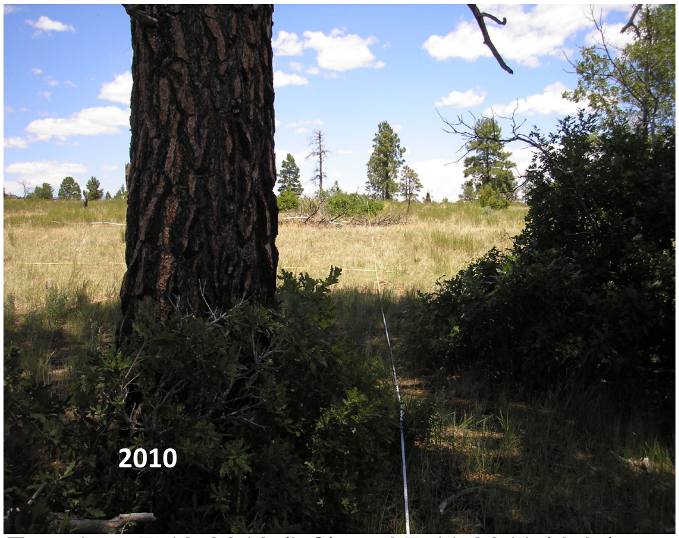
Plate 4.2. *(continued) Maps of the density and location of the trees through time for Burnt Mesa 2*

Plate 4.3. *Selected comparative photos of Burnt Mesa 2 (continued next page)*

The two remaining trees present in the plot in 2011 after the Las Conchas Fire



Condition of tree 1 after the Las Conchas Fire on north side (left) and south side (right).



Tree 1 on 7-12-2010 (left) and 7-11-2011 (right) southeast corner looking north. Note the amount of oak at the base in the 2010 picture.

The east side of Burnt Mesa 2 looking west August 1977, one and a half months after La Mesa Fire. Note the density of the trees. (F2-3)

The east side of Burnt Mesa 2 looking west July 2010. The vista has opened up from the loss of trees over the 35 years since the La Mesa Fire.

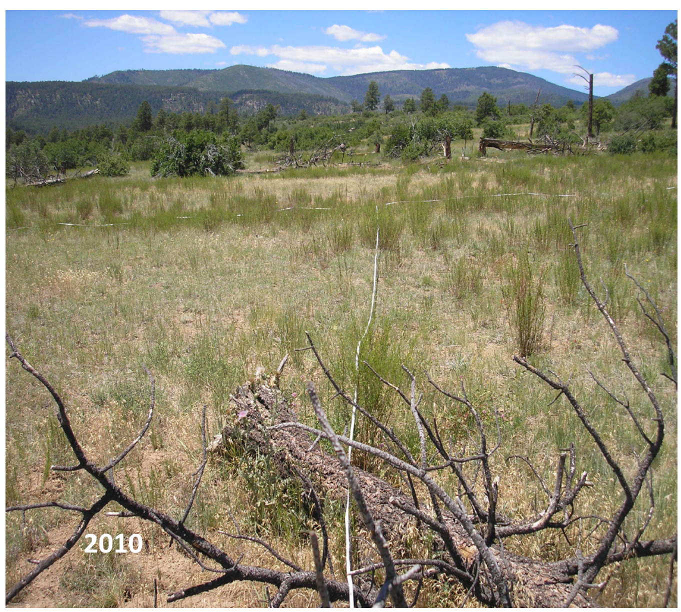


Plate 4.3. *(continued)*

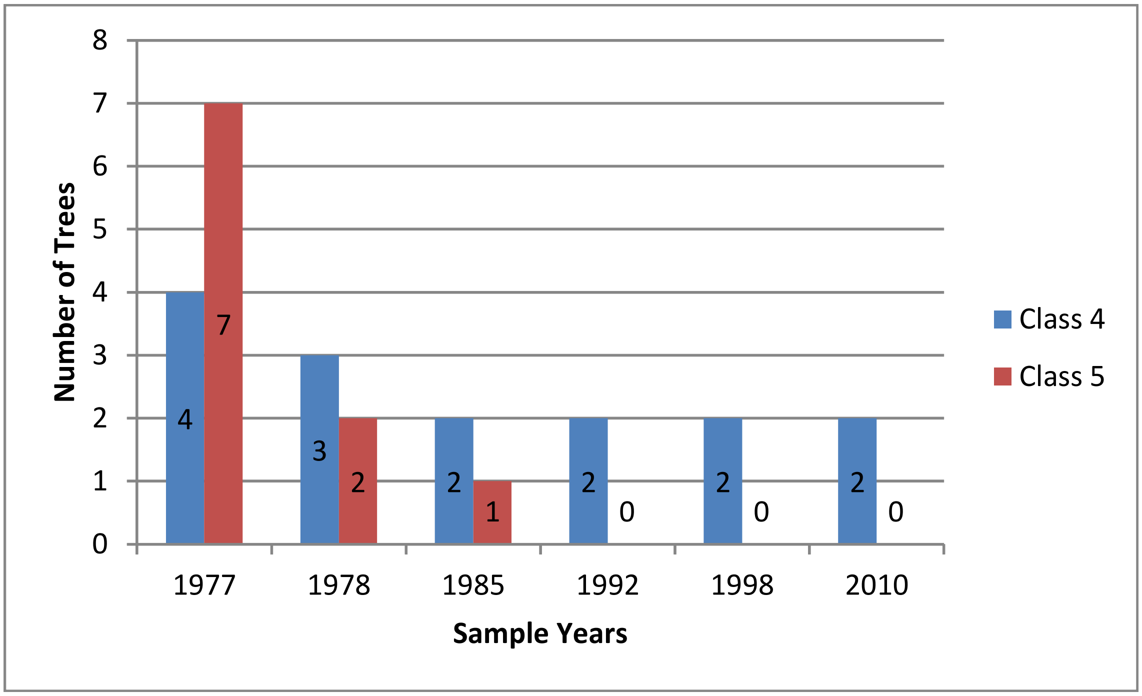


Figure 4.13. Tree mortality from 1977 through 2010 for Burnt Mesa 2

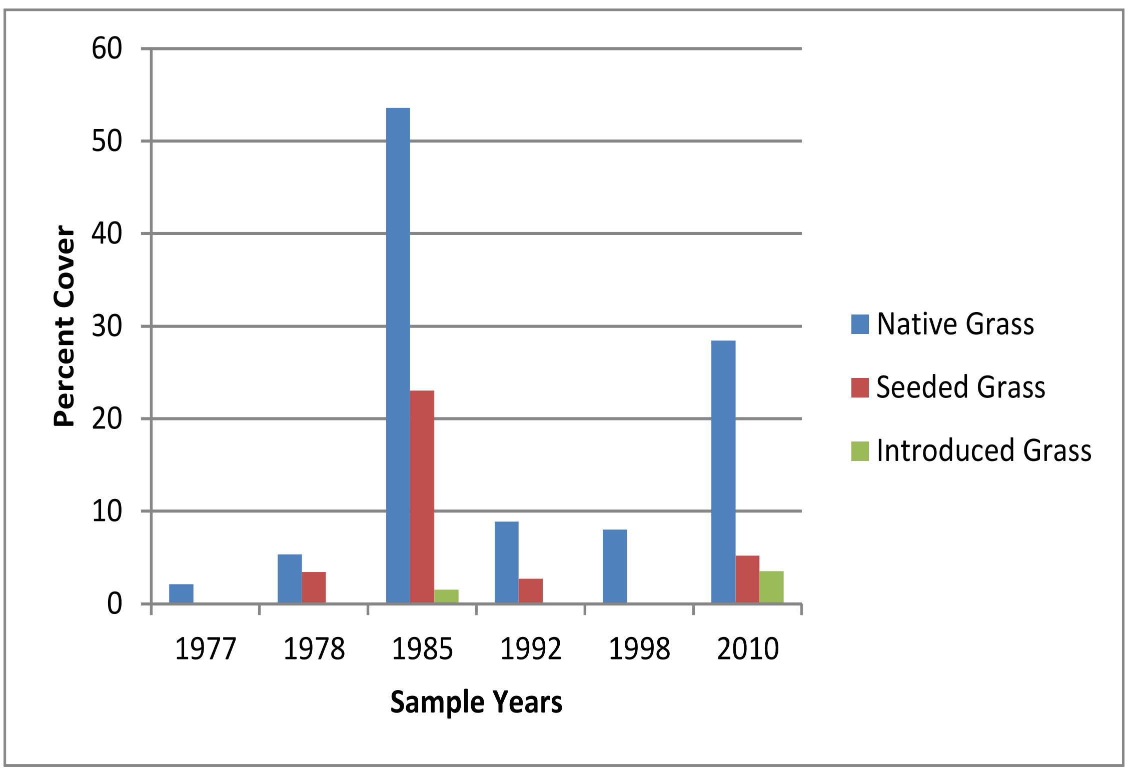


Figure 4.14. Changes in grass cover through time (1977 through 2010)

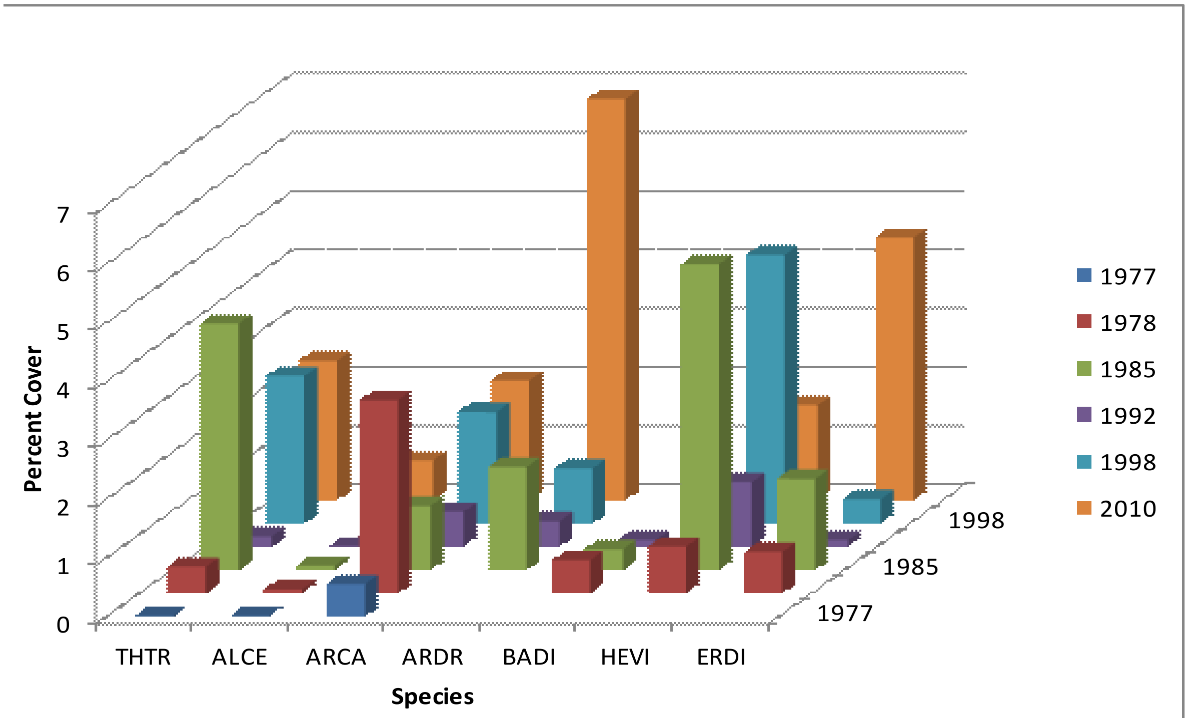


Figure 4.15. Cover of common forbs through time (1977 through 2010)
(THTR = Thelesperma trifidum*, ALCE* = Allium cernuum*, ARCA* = Artemisia carruthii*,*
ARDR = Artemisia dracunculus*, BADI* = Bahia dissecta*, HEVI* = Heterotheca villosa*,*
ERDI = Erigeron divergens*)*

Figure 4.16. Increase in false tarragon since 1998

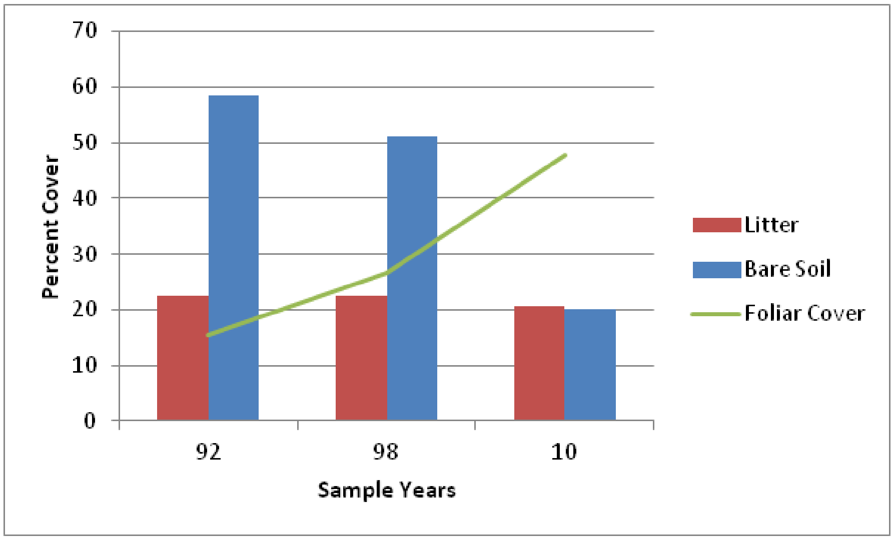


Figure 4.17. Comparison of the litter and forb cover from before the prescribed fire and 12 years after the fire

one 23 days post-fire (Figure 4.18) and one 90 days post-fire (Figure 4.19). Most striking was the increase in biomass from July to late September. Blue grama was revitalized by the fire (Figure 4.20).

Mapping and Photography
The moderately burned plot was mapped through time (see Plate 4.2). Selected matching scenes are presented in Plates 4.3 (above), 4.4, and 4.5. A complete set of matching photos for this plot is available at BNM.

Figure 4.18. Burnt Mesa 2 southeast corner looking along the 50-meter line within 23 days after the Las Conchas Fire

Figure 4.19. Burnt Mesa 2, southeast corner looking along the 50-meter line in late September (90 days post-fire). Note the increase in cover. Visually the cover was composed of blue grama and patches of forbs, such as fetid goosefoot, redroot pigweed, and New Mexico groundcherry.

Figure 4.20. Blue grama was revitalized after the Las Conchas Fire.

Southeast corner looking northeast 9-5-78 (1586) (F2-3). Note the stand of slender wheatgrass that was planted.

Southeast corner looking along 50-meter line to northeast 6-30-92 (F2-4).

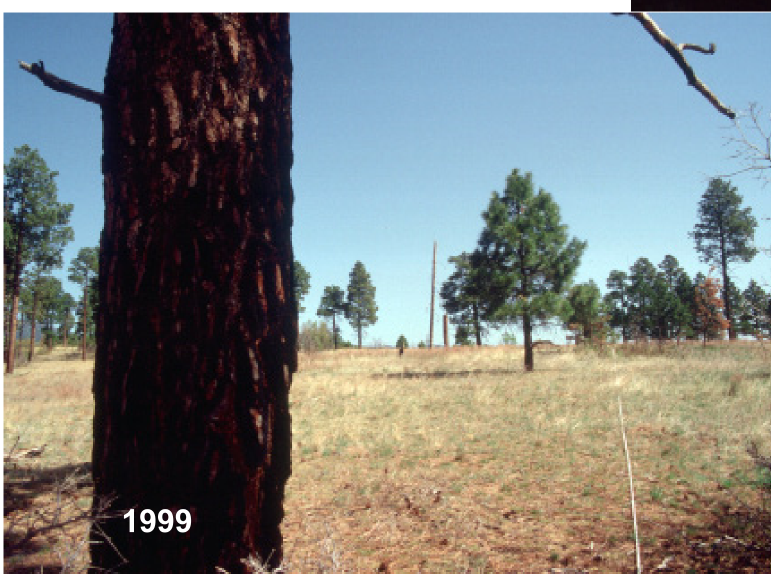
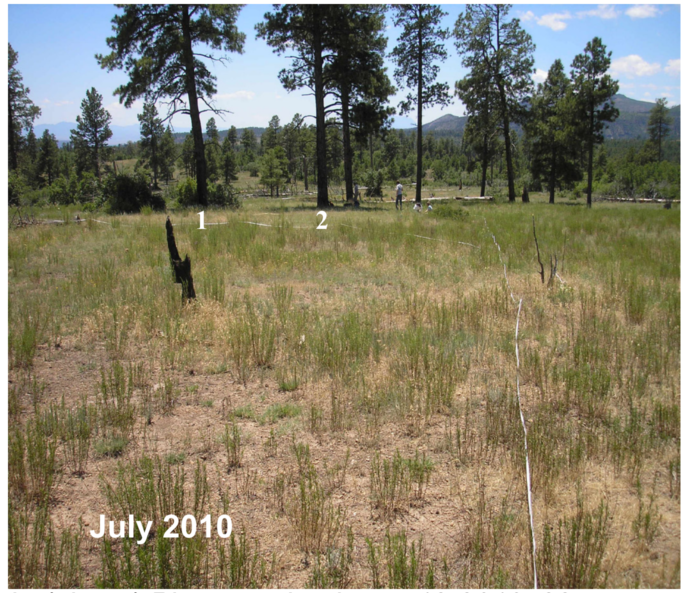


***Plate 4.4.** These pictures show the conversion from stands of slender wheatgrass in 1978 to the emergence of small trees in 1992 and 1999 on Burnt Mesa 2. By 2010 this small tree was dead and the area was devoid of reproductive stock.*

a. Photograph taken 1978, one year after the La Mesa Fire. Note trees 1 and 2 and density of surrounding forested area. Also note the stump remnant in the mid-ground.



b. (above) Photograph taken 7-12-2010, 33 years post-La Mesa Fire, and 12 years post-prescribed fire. Note the extensive amount of false tarragon.

c. (left) Photograph taken 7-11-2011 after the Las Conchas Fire. Note the log remnant still stands.

Plate 4.5. *Changes in tree density through time*

d. (right) Photograph taken 9-24-2011, approximately 90 days after the Las Conchas Fire. Although there were several patches of redroot pigweed, there was also an abundance of blue grama.

Table 4.3. Status of Trees in Burnt Mesa 2

Tree Number	Foliar Damage	1977	1978	1985	1992	2010
98						
1	4	23.2	23.2	23.3	25.0	Alive
2	4	21.9	22.9	22.2	22.7	Alive
3	5	11.6	Dead	Dead	Dead	
4	5	1.0	Dead	Dead	Dead	
5	5	1.0	Dead	Dead	Dead	
6	5	3.2	4.0	3.2	Dead	
7	5	1.0	1.0	Dead	Dead	
8	5	1.0	Dead	Dead	Dead	
9	5	1.0	Dead	Dead	Dead	
10	4	16	16.0	Dead	Dead	
11	4	12	Dead	Dead	Dead	
Total		92.9	67.1	48.7	47.7	
Total Trees Alive		11	5	3	2	
Average		8.4	13.4	16.2	23.9	
Trees/acre		44	20	12	8	

Table 4.4. Percent Cover of Species Found in Burnt Mesa 2 Through Time							
Species Name	**1977**	**1978**	**1985**	**1992**	**1998**	**2010**	**Years Occurred**
Grass							
Native Grass							
Aristida purpureum					0.60		1
Bromus spp.		0.50	0.92				2
Carex spp.	0.04						1
Festuca octoflora			0.04				1
Hilaria jamesii				0.32			1
Koeleria macrantha			2.10				1
Lycrus phleoides						1.04	1
Schizachyrium scoparium				0.10		0.20	2
Poa spp.		0.11		1.82	1.30		3
Pascopyrum smithii		0.30	12.82	0.52		0.50	4
Muhlenbergia montana		0.23	22.62	2.00	2.40		4
Sitanion hystrix			0.40	0.14		0.03	3
Bouteloua gracilis	0.10	4.20	14.68	3.96	3.72	25.86	6
Unidentified grass	1.96					0.8	2
Total Native Grass Cover	**2.10**	**5.34**	**53.58**	**8.86**	**8.02**	**28.43**	
Seeded Grass							
Elymus trachycaulum		2.39	15.28	1.22		5.18	4
Festuca ovina		1.03	7.74	1.5	0.10		4
Total Seeded Grass Cover		**3.42**	**23.02**	**2.72**	**0.10**	**5.18**	
Introduced Grass							
Bromus tectorum			1.54			3.52	2
Total Introduced Grass			**1.54**			**3.52**	
Total Grass Cover	**2.10**	**8.76**	**78.14**	**11.58**	**8.12**	**37.13**	
Total Grass Species	**3**	**7**	**10**	**9**	**5**	**7**	
Forbs							
Allium cernuum	0.02	0.07	0.08	0.02	0.04	0.68	6
Artemisia carruthii	0.56	3.30	1.10	0.60	1.90	2.04	6
Artemisia dracunculus			1.76	0.44	0.94	6.84	4
Asclepias spp.		0.10		0.02		0.60	3
Astragalus canadensis		0.01					1
Bahia dissecta		0.57	0.36	0.12		0.16	4
Castilleja integra			0.86	0.02		0.20	3
Cerastium arvense					0.1		1
Chenopodium album/fremontii		0.75	0.06			0.40	3
Chenopodium graveolens					0.12		1

Species Name	**1977**	**1978**	**1985**	**1992**	**1998**	**2010**	**Years Occurred**
Forbs (cont.)							
Cirsium spp.	0.02	0.11	0.74	0.78	1.32		2
Cryptantha fendleri					0.16		1
Erigeron divergens		0.71	1.56	0.12	0.42	4.48	5
Erigeron flagellaris				0.34	0.20		2
Erysimum capitatum			0.10				1
Euphorbia serpyllifolia					0.01		1
Gaura coccinea			0.04		0.02		2
Geranium caespitosum		0.10	0.10				2
Heterotheca villosa		0.80	5.22	1.11	4.58	1.62	5
Hymenoxys richardsonii			0.20	0.10		0.20	3
Lappula spp.			0.02				1
Liatris punctata					0.60		1
Linum neomexicanum		0.54		0.02			2
Lithospermun multiflorum			0.02				1
Lotus wrightii					0.10		1
Lupinus caudatus	0.04	2.40	2.20	2.00	4.50		5
Lupinus kingii						0.80	1
Penstemon secundiflorus			1.20				1
Phacelia corrugata					0.50		1
Physalis foetens var. *neomexicana*	0.02	1.90					2
Plantago spp.				0.02		0.02	2
Polygonum convolvulus			0.33				1
Potentilla spp.					0.10		1
Oenothera spp.			0.26				1
Orthocarpus purpureo-albus		0.26				0.30	2
Oxybaphus linearis		0.10			0.02		2
Senecio spp.			0.10	0.10			2
Spheralcea coccinea						0.30	1
Taraxicum officinale					0.10		1
Thelesperma trifidum	0.02	0.46	4.20	0.18	2.52	2.38	6
Townsendia incana			0.80		0.1	0.2	3
Tragopogon dubius			0.30	0.02			2
Trifolium repens			0.40	0.50			2
Vicia americana			0.18	0.08	0.10	0.06	4
Verbascum thapsum			0.20		0.72		2

Species Name	**1977**	**1978**	**1985**	**1992**	**1998**	**2010**	**Years Occurred**
Forbs (cont.)							
Unidentified forb						0.6	1
Total Forb Cover	**0.68**	**12.18**	**22.39**	**6.59**	**19.17**	**21.88**	
Total Number Forb Species	**6**	**16**	**25**	**19**	**23**	**18**	
Shrubs							
Quercus spp.		0.61	0.40				2
Total Shrub Cover		**0.61**	**0.44**				
Total Shrub Species		1	1				
TOTAL FOLIAR COVER	**2.78**	**21.55**	**100.97**	**18.17**	**27.29**	**59.01**	
Bare Soil	97.22	81.90		57.88	52.66	28.19	
Litter				22.56	19.94	28.20	
Rock						0.28	
Wood						5.10	

Burnt Mesa 3

Burnt Mesa 3 is approximately one mile from the gate to Burnt Mesa (see Figures 4.1 and 4.5). To locate the plot, go southwest from Burnt Mesa 2 along the mesa about three quarters of a mile. The plot is located to the north side. The plot sits with the 50-meter side oriented north to south and the 20-meter side oriented east to west. The fire crowned in this location and all the trees were severely burned as evidenced by complete loss of crown and intense charring of the trees. The GPS locations for this plot are presented below.

Overstory Conditions

In 2010, this was an open meadow that had an abundance of false tarragon and very few reproductive trees.

Before the La Mesa Fire, this site had over 300 trees per acre with an average dbh of 7.49 inches. Four trees had a diameter of 12 inches dbh and above. In 1977, most of the trees had no needles and only seven trees of the 148 trees in the plot had brown needles. Essentially, all trees within the plot were dead after the La Mesa Fire (Figure 4.21). Sixty percent of the trees within the plot were eight inches in diameter or smaller. No trees were followed up in this site after 1977. A few seedlings were noted by 1992 but by 2010 none of these were alive. Maps of the density and location of the trees through time are shown in Plate 4.6.

Understory Conditions

The changes in the understory were remarkable from sample year to sample year. The first year there was considerable needle fall from the trees. In early 1978 the slender wheatgrass had sprouted and by fall had abundant cover. Most of the trees had fallen by 1985 and then the dominant grass became little bluestem (Figure 4.22). Little bluestem persisted until in 2010 we noted a shift to *Artemisia dracunculus* and *Bromus tectorum.* Until 1985, the dominant grasses were slender wheatgrass and sheep fescue, which were in the seed mix. By 2010, the seeded grasses had essentially disappeared except for *Muhlenbergia wrightii* (Figure 4.23). By 2010, the dominant grasses were mountain muhly, little bluestem, and cheatgrass. There was little or no blue grama.

The forb percentages changed through time. In 1998, after the prescribed fire, *Bahia dissecta* increased and then dropped off by 2010 (Figures 4.24 and 4.25). This species appears to respond to disturbance and seeds may be stimulated to germinate by fire. Other species that were seen to increase by 2010 were Carruth sagewort and false tarragon. Table 4.5 presents the percent cover of grasses, forbs, and shrubs found in Burnt Mesa 3 through time.

Conditions after the 1998 Prescribed Fire

After the 1998 prescribed burn, the most striking change from 1998 to 2010 was the increase in false tarragon. Areas that had been dominated by

GPS coordinates for Burnt Mesa 3

Identification	Y_Coordinates_27	X_Coordinates_27	Latitude	Longitude
B3-12.5E	3964561	380096	35.81970362	-10632787999
B3-12.5W	3964566	380076	35.81985315	-106.32808476
B325E	3964575	380095	35.81982507	-106.32811837
B3-37.5e	3964591	380092	35.81992080	-106.32792223
B3-37.5W	3964591	380075	35.81996581	-106.32811837
B3-NE	3964602	380093	35.82006639	-106.32721787
B3-NW	39764602	380072	35.82006320	-106.32815022
B3-SE	3964551	380101	35.819608983	-106.32782299
B3-SW	3964552	380082	35.81962072	-106.32803229

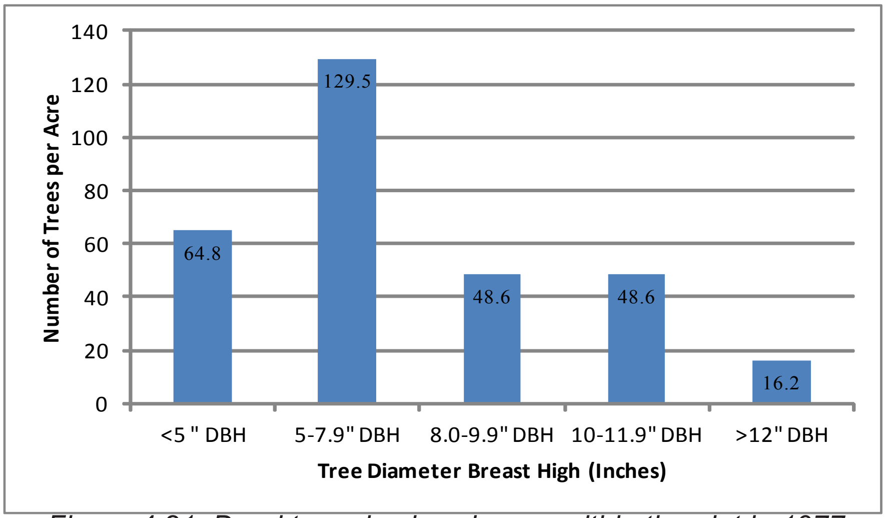


Figure 4.21. Dead trees in size classes within the plot in 1977

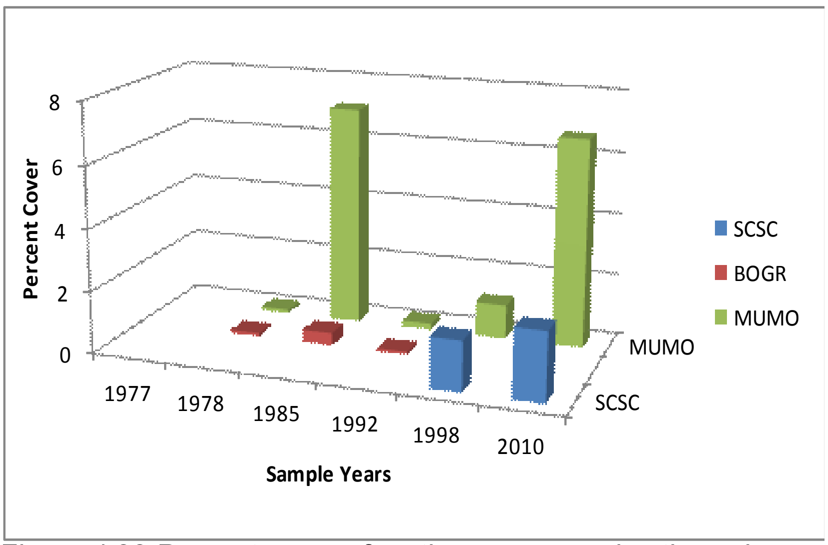


*Figure 4.22 Percent cover of native grass species through time. (*SCSC = Schizachryrium scoparium, *BOGR* = Bouteloua gracilis, *MUMO* = Muhlenbergia montana*)*

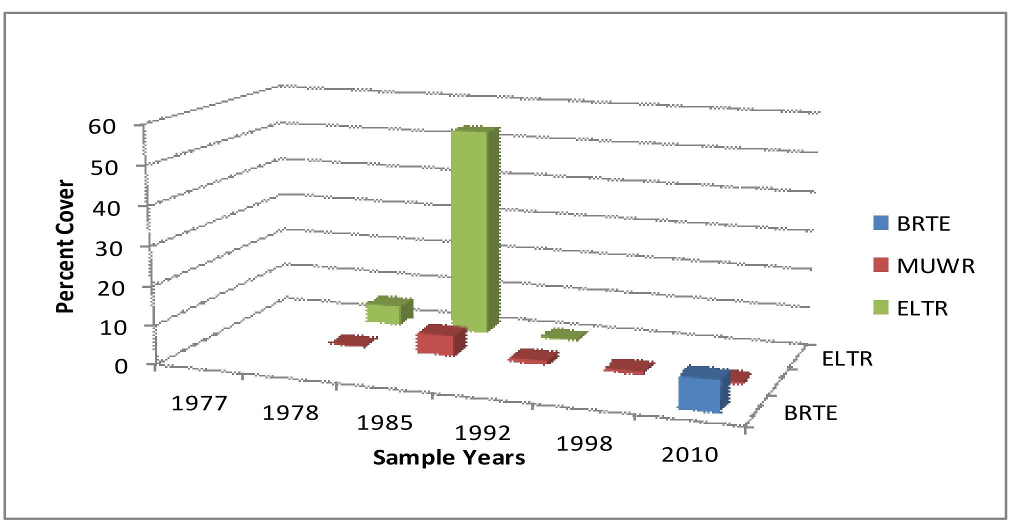


Figure 4.23 Percent cover of seeded and introduced grass (BRTE = Bromus tectorum, *ELTR* = Elymus trachycaulus, *MUWR* = Muhlenbergia wrightii*)*

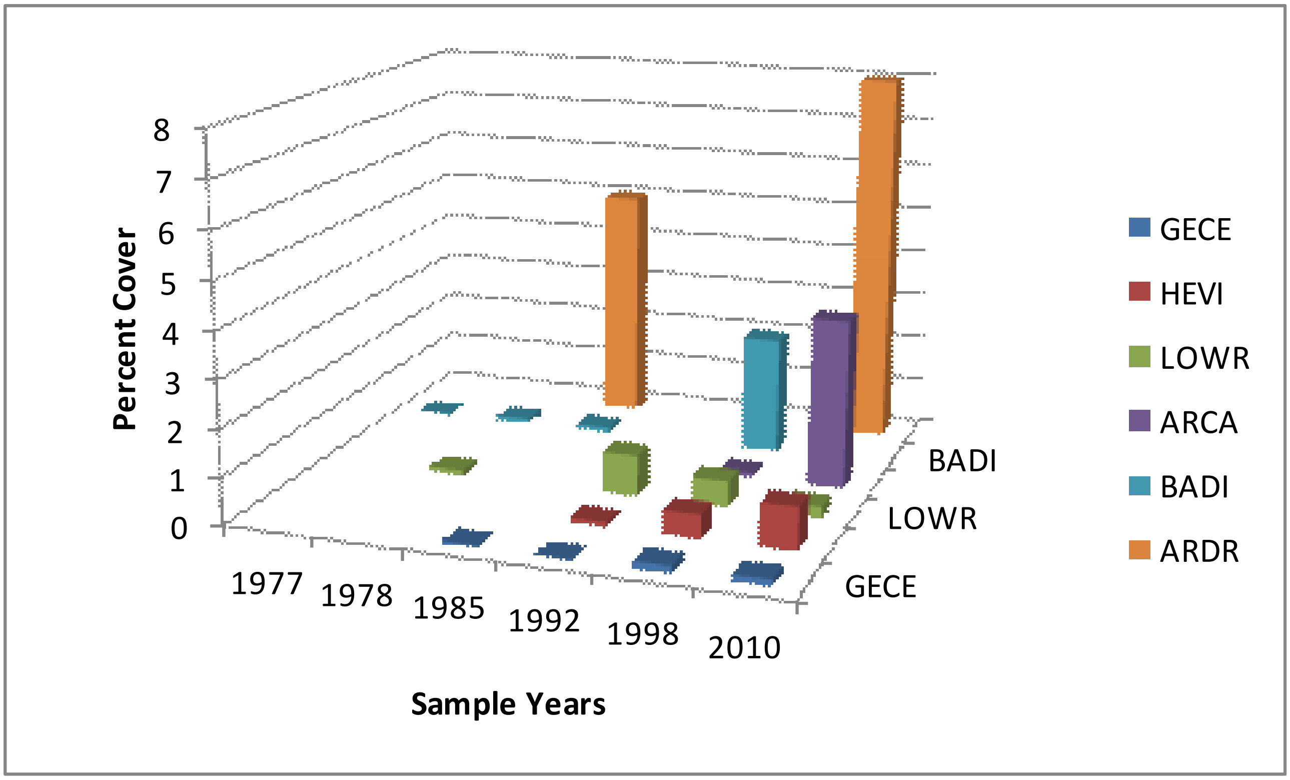


Figure 4.24. Diversity of species through time (GECE = Geranium caespitosum*, HEVI =* Heterotheca villosa*, LOWR =* Lotus wrightii*, ARCA = Artemisia carruthii, BADI = Bahia dissecta, ARDR = Artemisia dracunculus)*

Figure 4.25. Dense patches of Bahia dissecta *after the prescribed fire on Burnt Mesa 3*

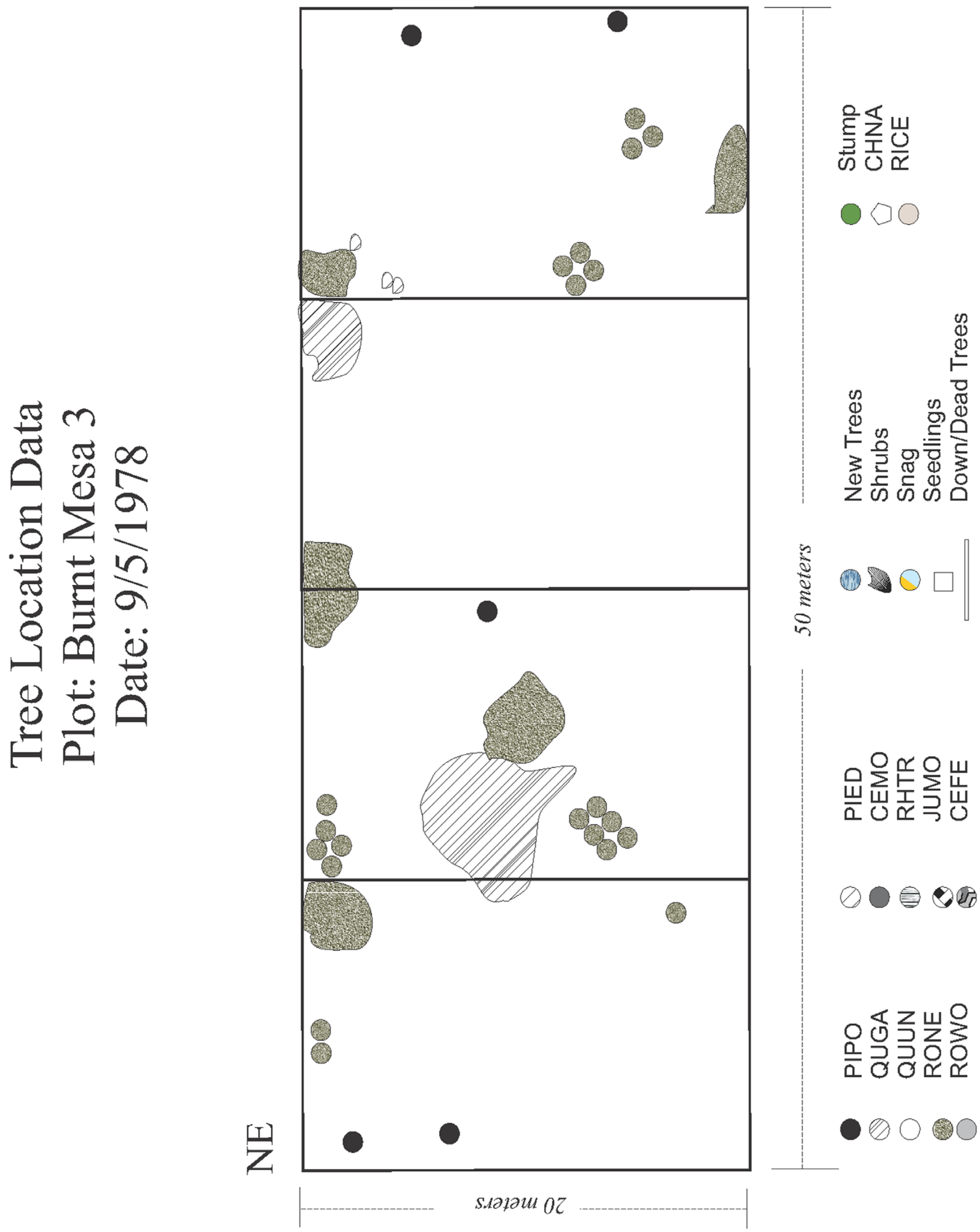


Plate 4.6. *Maps of the density and location of the trees through time for Burnt Mesa 3. Note the increase of density of shrubs. (Continued on next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

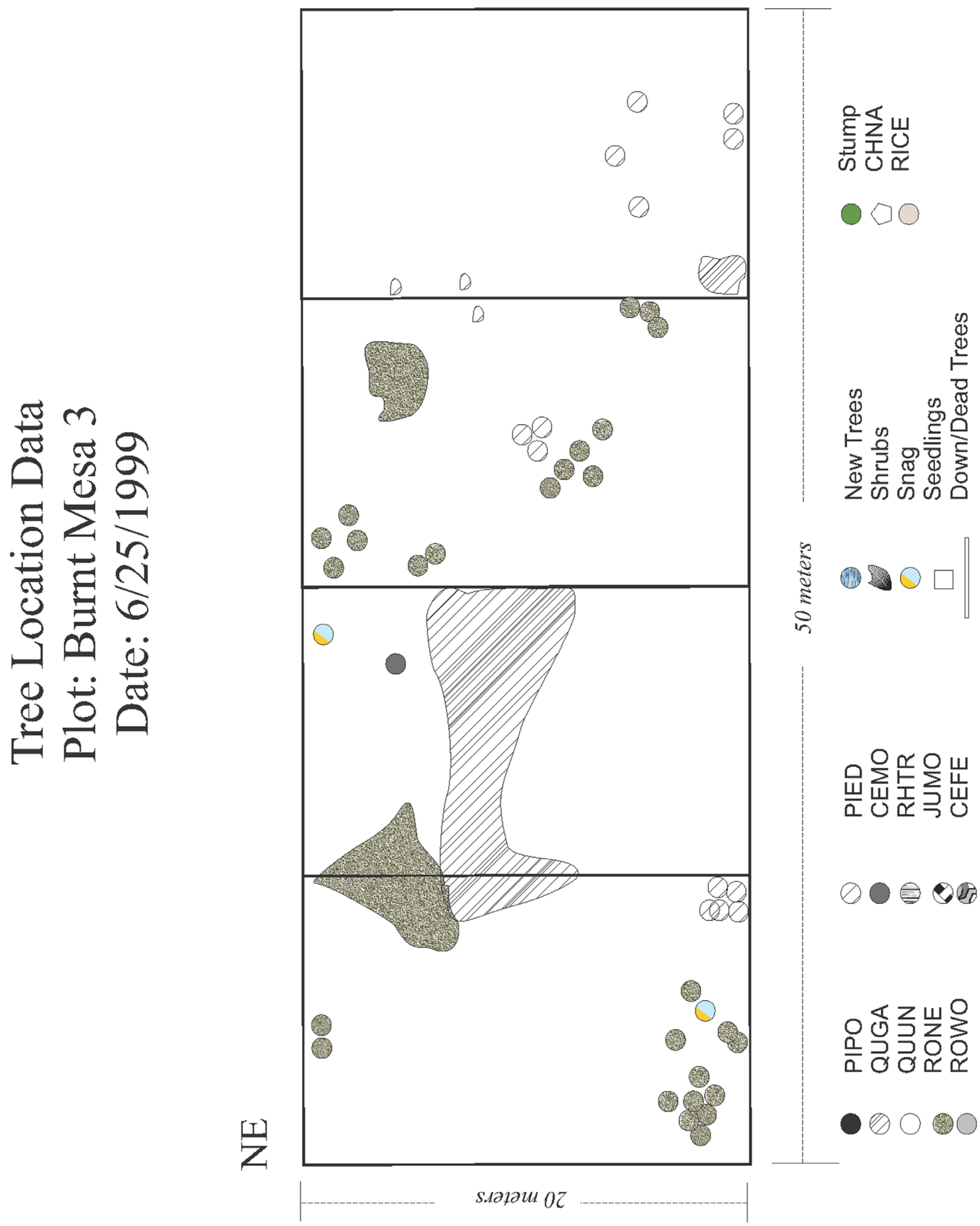


Plate 4.6. *Maps of the density and location of the trees through time for Burnt Mesa 3. Note the increase of density of shrubs.* *(Continued on next page)*

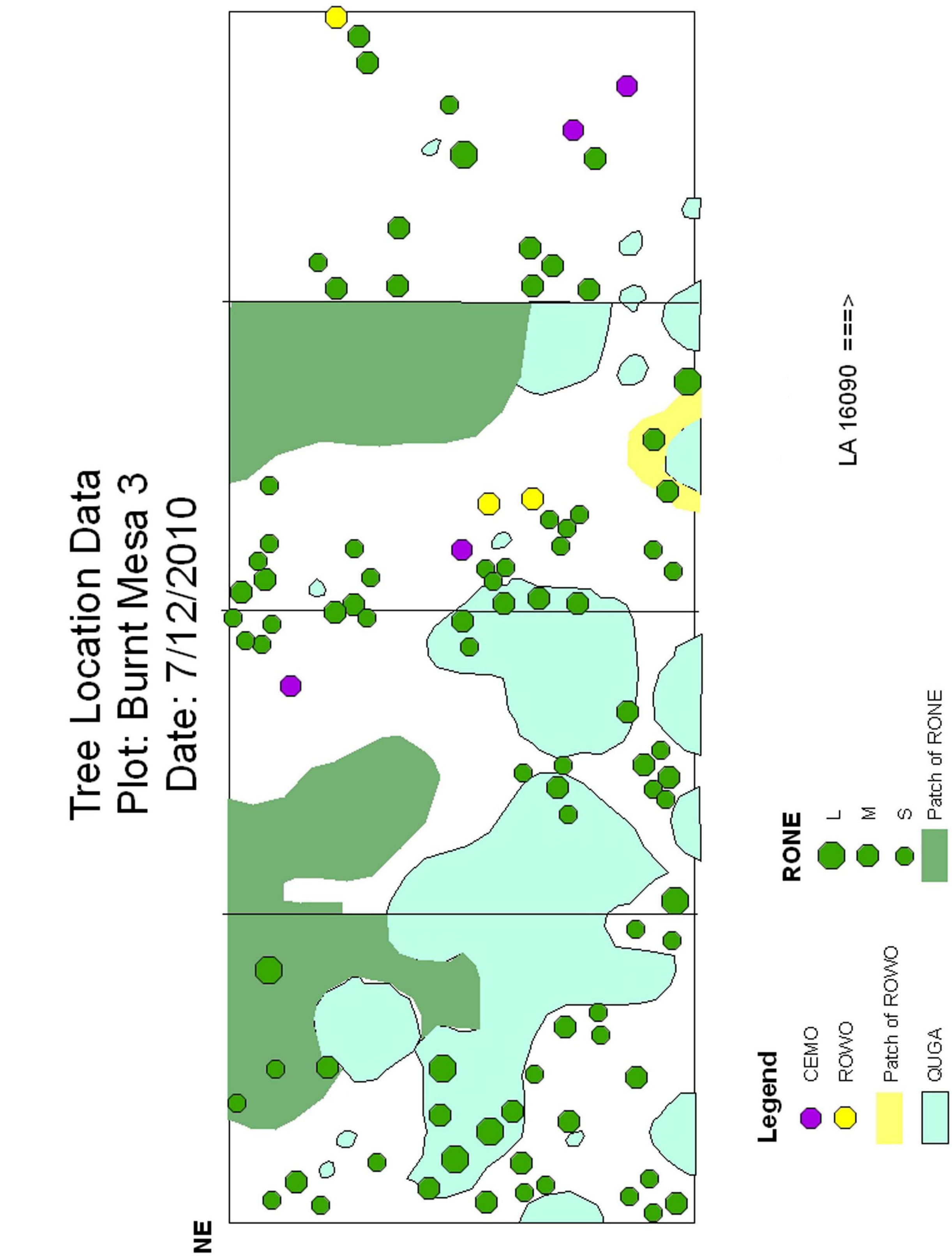


Plate 4.6. *Maps of the density and location of the trees through time for Burnt Mesa 3. Note the increase of density of shrubs. (Continued)*

little bluestem were now dominated by *Artemisia dracunculus*. Cheatgrass also appeared in the plots where there had been none before. From 1992 to 2010, vegetative cover increased and bare soil and litter decreased.

Conditions after the Las Conchas Fire

No data were taken immediately after the Las Conchas Fire, but photographs were taken of each plot. Two sets of photographs were taken after the fire—one 23 days post-fire and one 90 days post-fire.

Most striking was the increase in biomass from July to late September (Figure 4.26). Species noted were fetid goosefoot, redroot pigweed, dayflower, New Mexico groundcherry, and other species. Oak, New Mexico locust, and other shrubs were sprouting.

Mapping and Photography

The severely burned plot was mapped through time (see Plate 4.6). Selected matching scenes are seen in Plate 4.7. A complete set of matching photos for this plot is available at BNM.

Figure 4.26. Plant coverage at 90 days post-Las Conchas Fire on Burnt Mesa 3

Plate 4.7. *Selected matching scenes of Burnt Mesa 3 over time*

Northeast corner diagonal to the southwest 8-23-1977 (858) (F2-2)

Northeast corner diagonal to southwest 9-5-78 (1550) (F2-2)

Northeast corner diagonal to the southwest 8-30-98 (F2-2)

Northeast corner diagonal to southwest 7/11/10 (4969)

Northeast corner diagonal to southwest 7/19/2011 (4969)

Northeast corner diagonal to southwest 10-1-2011 (5308)

Table 4.5. Percent Cover of Species Found at Burnt Mesa 3 Through Time

Species Name	1977	1978	1985	1992	1998	2010	Years of Occurrence
Grass							
Native Grass							
Agropyron spp.					0.60	7.96	2
Andropogon gerardii					0.70		1
Blepharoneuron tricholepis					0.10		1
Bouteloua gracilis		0.10	0.40		0.30	0.60	4
Bromus spp.		0.23					1
Carex spp.		0.01			0.40	1.30	3
Cyperus fendleri					0.04		1
Festuca octoflora					0.04		1
Koeleria cristata			0.10			1.26	2
Muhlenbergia montana		0.10	7.10	0.20	1.10	6.70	5
Pascopyrum smithii		0.10	2.20		0.84		3
Schizachyrium scoparium					1.60	2.20	2
Sporobolus spp.						0.10	1
Unidentified grass	0.08						1
Total Native Grass Cover	**0.08**	**0.54**	**9.8**	**0.2**	**5.72**	**20.12**	
Seeded Grass							
Elymus trachycaulus		5.00	53.24	0.30			3
Festuca ovina		1.06	21.56	20.00	0.90		4
Muhlenbergia wrightii		0.29	5.28	1.10	0.80	0.60	5
Total Seeded Grass Cover		**6.35**	**80.08**	**21.40**	**1.70**	**0.60**	
Introduced Grass							
Bromus inermis						0.04	1
Bromus tectorum						7.98	1
Total Introduced Grass Cover						**8.02**	
Total Grass Cover	**0.08**	**6.89**	**89.88**	**21.60**	**7.32**	**28.74**	
Total Grass Species	**2**	**8**	**7**	**4**	**12**	**10**	
Forbs							
Achillea millefolium var. *occidentalis*			0.58				1
Allium cernuum	0.06		T			0.16	3
Antennaria parvifolia				0.10			1
Artemisia carruthii					0.10	3.60	2
Artemisia dracunculus			5.00			8.00	2
Bahia dissecta	0.02	0.10	0.10		2.50		4
Chenopodium album			T				1

Species Name	1977	1978	1985	1992	1998	2010	Occurrence
Forbs (cont.)							
Cirsium undulatum				0.30	1.90		2
Commelina dianthifolia		0.96					1
Convolvulus arvensis		0.58					1
Cryptantha jamesii					0.20		1
Erigeron divergens		0.04				0.72	2
Erigeron flagellaris					0.20		1
Eriogonum spp.			0.02				1
Erysium capitatum			0.02				1
Euphorbia serpyllifolia	0.08	0.52			0.04		3
Fragaria americana						0.08	1
Geranium caespitosum			0.04		0.12	0.14	3
Heterotheca villosa				0.10	0.50	0.90	3
Hymenoxys argentea						0.80	1
Hymenoxys richardsonii					0.26		1
Ipomopsis aggregata			0.10		0.22	0.20	3
Liatris punctata					0.20		1
Linum neomexicanum						0.60	1
Lithospermun multiflorum					0.15		1
Lotus wrightii		0.10		0.10	0.55	0.24	4
Lupinus caudatus			T		2.30		2
Lupinus kingii						0.40	1
Mentzelia pumila			0.96		0.25		2
Oenothera spp.			0.38				1
Oxybaphus lineraris					0.01		1
Orthocarpus spp.						0.16	1
Penstemon spp.						0.06	1
Physalis foetens var. *neo-mexicana*	0.01						1
Senecio spp.				0.30			1
Thelesperma trifidum					0.52		1
Tragopogon dubius			T				2
Verbascum thapsum			0.20		1.20		3
Unidentified forb						0.30	2
Total Forb Cover	**0.17**	**2.30**	**7.40**	**0.90**	**11.22**	**16.36**	
Total Forb Species	**4**	**6**	**14**	**5**	**28**	**15**	

Species Name	1977	1978	1985	1992	1998	2010	Years of Occurrence
Shrubs							
Quercus spp.			2.30	0.90	11.00	21.30	4
Ceanothus fendleri			2.00	0.30			2
Robinia neomexicana				9.00	12.2	13.60	3
Rosa woodsii				0.33		0.10	2
Total Shrub Cover			**4.30**	**10.53**	**23.20**	**35.00**	
Total Shrub Species	**0**	**0**	**2**	**4**	**2**	**3**	
TOTAL FOLIAR COVER	**0.25**	**9.19**	**101.58**	**32.49**	**41.84**	**80.10**	
Bare Soil	99.75	90.81	0	67.51	46.20	15.61	
Rock/Gravel						17.56	
Litter					11.68	41.7	
T = in plot but not measurable							

4.2 Escobas Mesa

Escobas Mesa is located west of Burnt Mesa and extends from the rim of Water Canyon to Frijoles Canyon. Ponderosa Campground and the trail to upper Frijoles Canyon are on Escobas Mesa. Craig Martin (1998) points out that escobas means "broom," which is derived from escobar, "to sweep." The mesa has both little bluestem and big bluestem (Figure 4.27). These bunch grasses were used by homesteaders and the puebloan peoples as brooms, thus the name for the mesa (Curtin 1965).

Aerial photographs and maps indicate that by at least 1943 there were roads that extended from State Route 4 to the rim of Frijoles Canyon near the present location of the Upper Crossing Trail. Another road appears to go out Escobas Mesa and may have been used during the logging operations or perhaps to fight fires. By 1963, the road is described as "terrible to impossible." Access to Upper Crossing is described as "follow the old road, keeping to the right at several dim forks." The Escobas Mesa plots are along the first of these forks (Figure 4.28).

Figure 4.27. Big bluestem—a bunch grass used for brooms

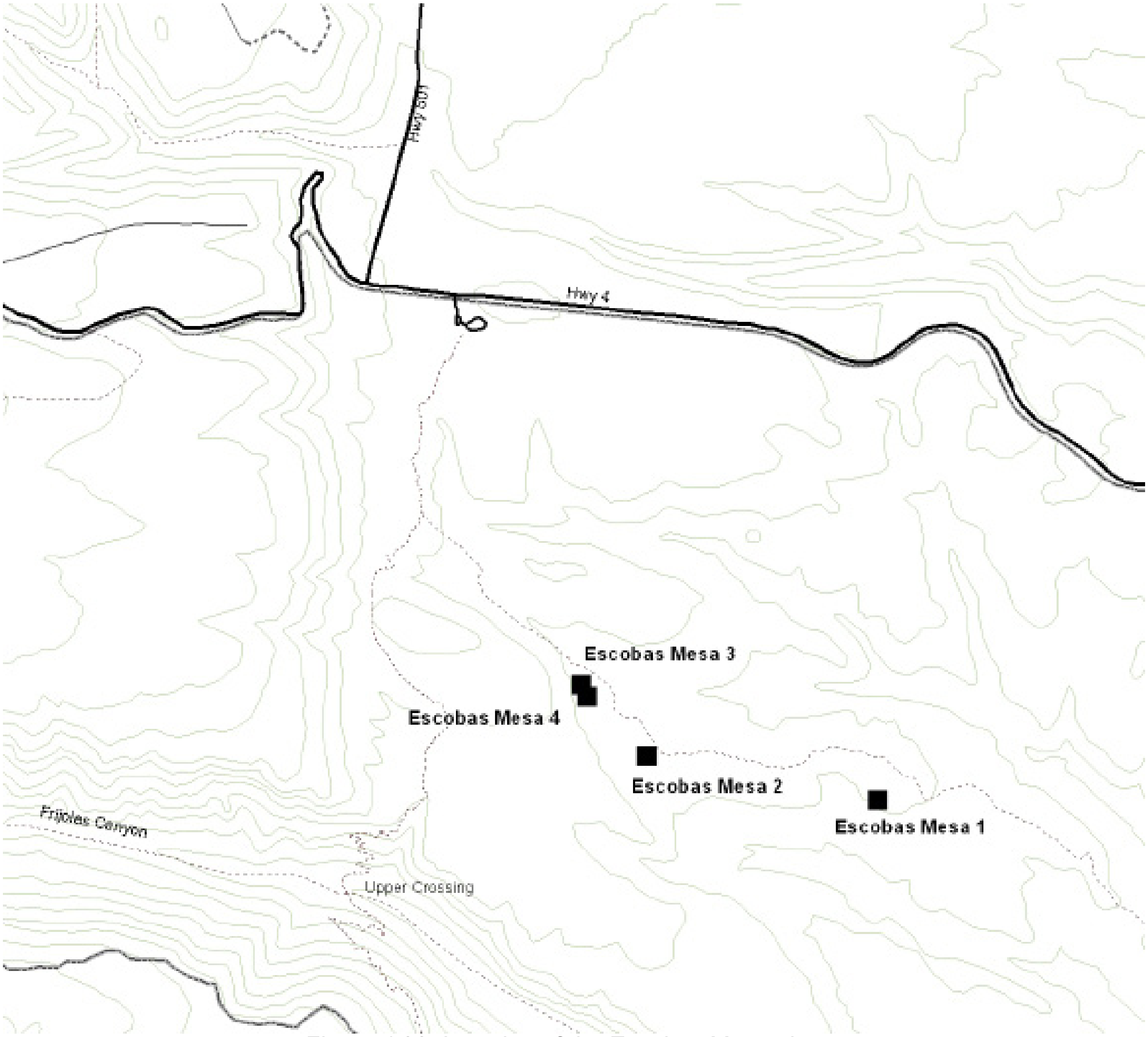


Figure 4.28. Location of the Escobas Mesa plots

The mesa at one time was part of the Ramon Vigil Grant and was part of a land exchange between BNM and the AEC in the early 60s. After transfer of the property to the Park Service, Upper Crossing Trail was improved. An article in the Los Alamos Scientific Laboratory news describes the removal of a large number of trees because of beetle kill (LASL News 1963b). There is evidence of logging in the early part of the century, probably at the time of Buckman (Foxx and Potter 1978). The logging during the late part of the 19th century and early part of the 20th century primarily targeted large trees. Nevertheless, a 1958 aerial map shows dense stands of ponderosa pine (Figure 4.29). Compare the changes through time in aerial maps (1965, 1977, 1986, 1991) (Plate 4.8). Note the comparison of the pre-fire forest with the post-La Mesa Fire conditions.

Studies by Foxx and Potter (1978) and Allen (1989) indicate that there were frequent fires on the mesa before 1893, but the last major fire appears to have burned during the late part of the 19th century. Figure 4.30 presents data from a 340-year-old tree collected by Allen from Escobas Mesa. This tree had a very long fire history ranging from 1637 to 1977. The fire scar dates on this tree were compared with other samples collected by Foxx and Potter with fire history beginning in 1797. From 1797 to 1893 there were frequent fires, as evidenced by multiple samples with the same fire scar dates. The average time between fire scars for the 340-year-old tree was 11.2 years (Table 4.6). This compared to a sample of trees collected by Foxx and Potter at Escobas Mesa 4 with an average time between fire scars as 13.5 years. After 1893 there were few fires before the La Mesa Fire. This indicates most of Escobas Mesa had not burned for over 50 to 80 years since 1900.

Burning on Escobas Mesa during the 1977 fire was variable depending on factors such as terrain, presence of previously burned areas, and logging. The area burned between 1100 and 2200 hours July 18, 1977, when the predicted rate of spread was 38 chains per hour. The entire Escobas Mesa study area was burned again by a prescribed fire June 16, 1998.

We visited the plots in 1997 and again in 1998 approximately two months after the prescribed fire. Then in 2010, we returned to these plots and reassessed the vegetation. GPS locations were taken for each plot. Four plots were established on Escobas Mesa—E1 (moderately burned), E2 (lightly burned), E3 (severely burned), and E4 (lightly burned and logged).

Escobas Mesa 1

Escobas Mesa 1 was established in an area that was considered moderately burned by examination of the foliar damage of the tree crowns. The site was dominated by ponderosa pine ranging from five to 21 inches in diameter. The plot was about 50 yards from the fire road and adjacent to an open meadow. The site is adjacent to an archaeological ruin (number 16083). GPS coordinates are presented below.

GPS coordinates for Escobas Mesa 1

Plot Identification	Y-Coordinates_27	X_Coordinates_27	Latitude	Longitude
E1-12.5E (side)	3964407	378899	35.81816512	-106.34110898
E1-12.5W (side)	3964409	378887	35.81817904	-106.34123521
E1-25E (side)	3964416	378903	35.81824609	-106.34106170
E1-25W (side)	3964422	378887	35.81830317	-106.34123982
E1-NE (corner)	3964438	378916	35.81844474	-106.34091821
E1-NW (corner)	3964445	378899	35.81850383	-106.34111132
E1-SE (corner)	3964400	378895	35.81809781	-106.34114251
E1-SW (corner)	3964401	378877	35.81810628	-106.34134811

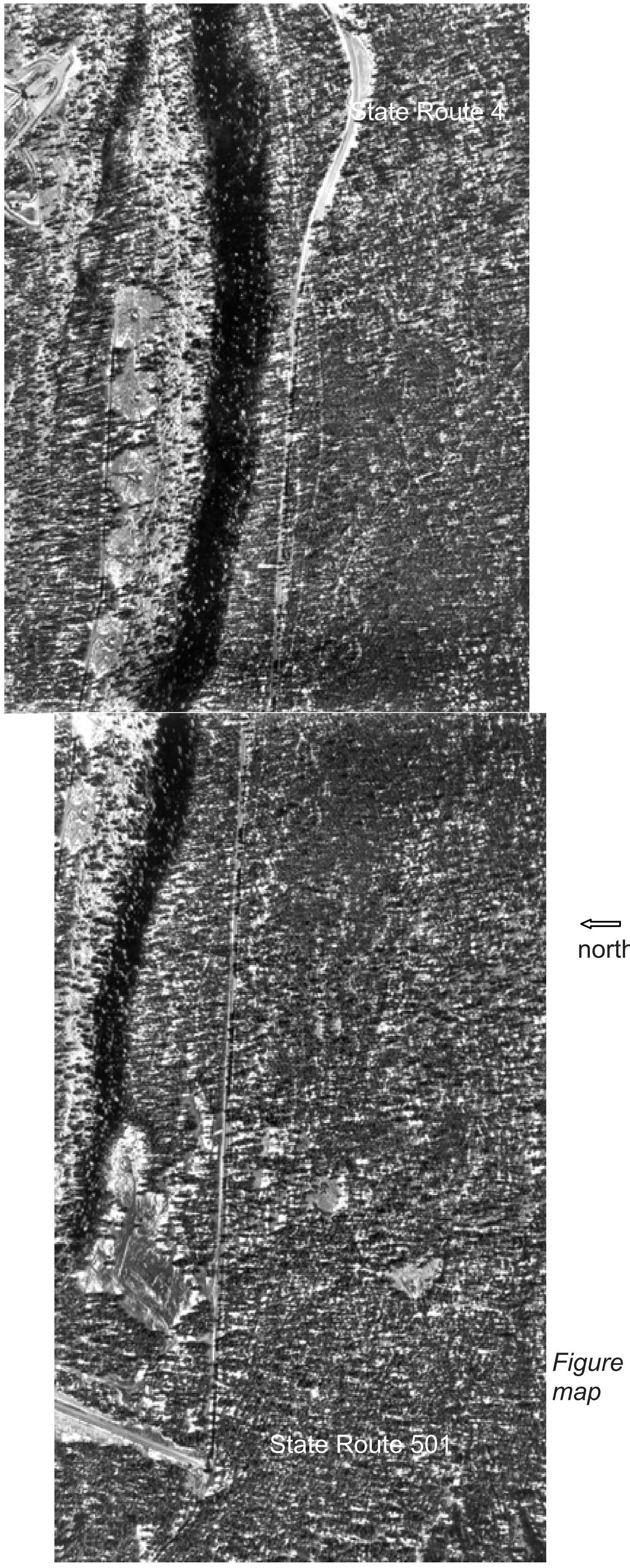
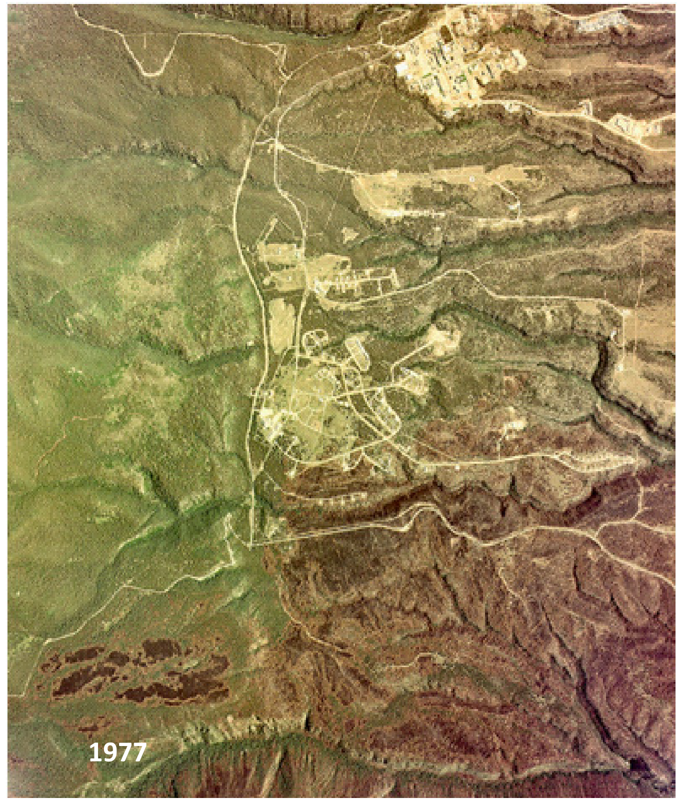
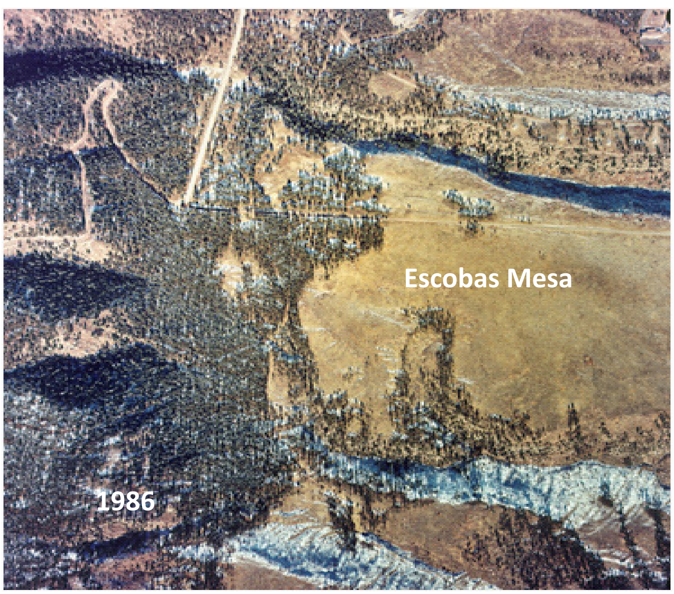


Figure 4.29. 1958 aerial map

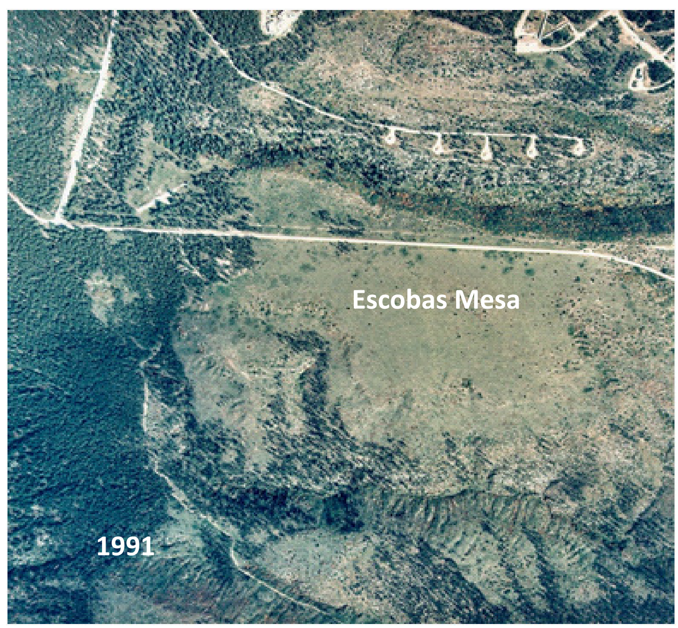
1965 (ER-16394-1965-LANL)



1977 (ER-17740-1977-LANL)



1986 (ER-17944-1986-LANL)



1991 (ER-18065-1991-LANL)

⇧
north

Plate 4.8. *Aerial photographs of Escobas Mesa through time (continued on next page)*

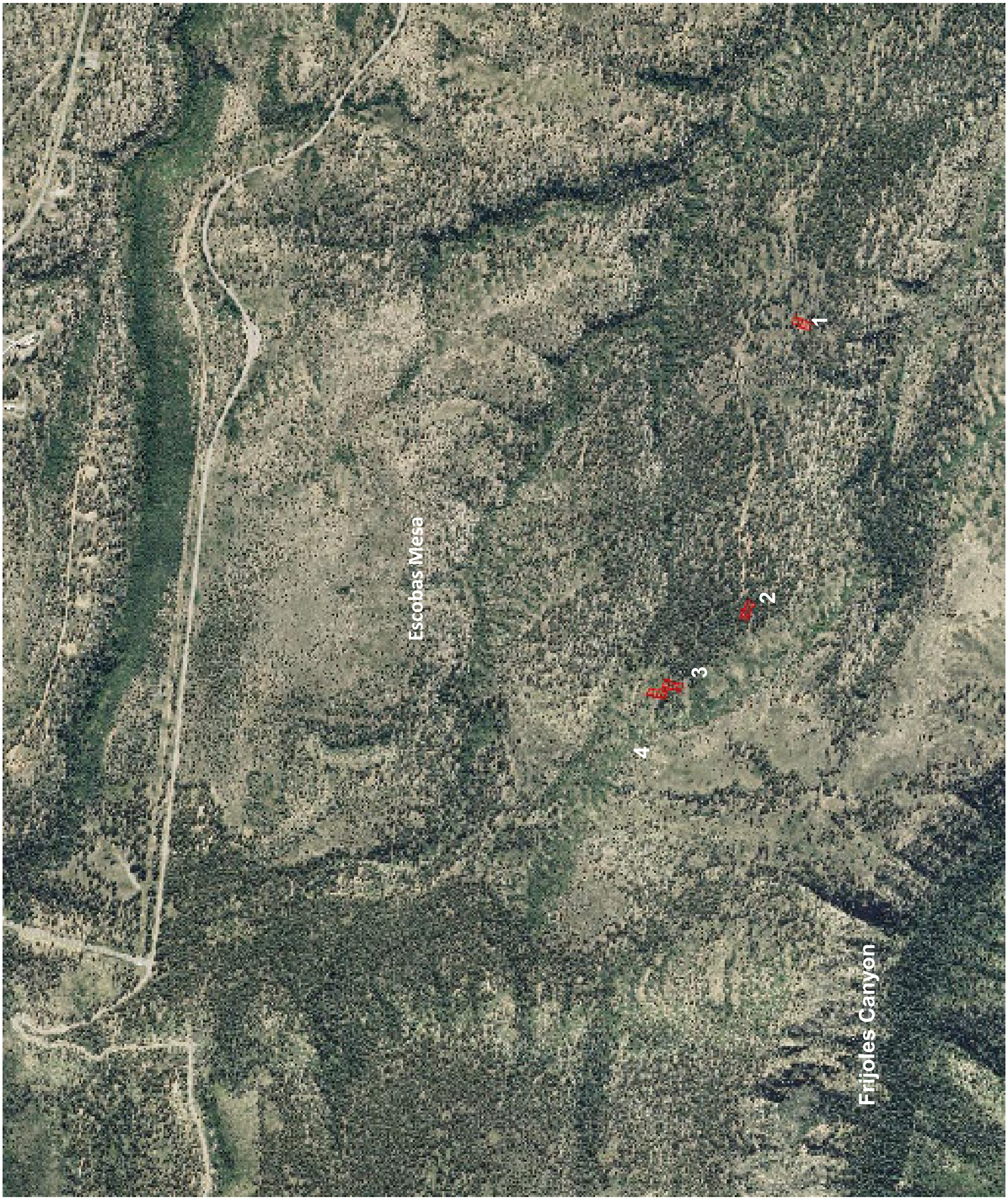


Plate 4.8. *Aerial photographs of Escobas Mesa through time (continued)*

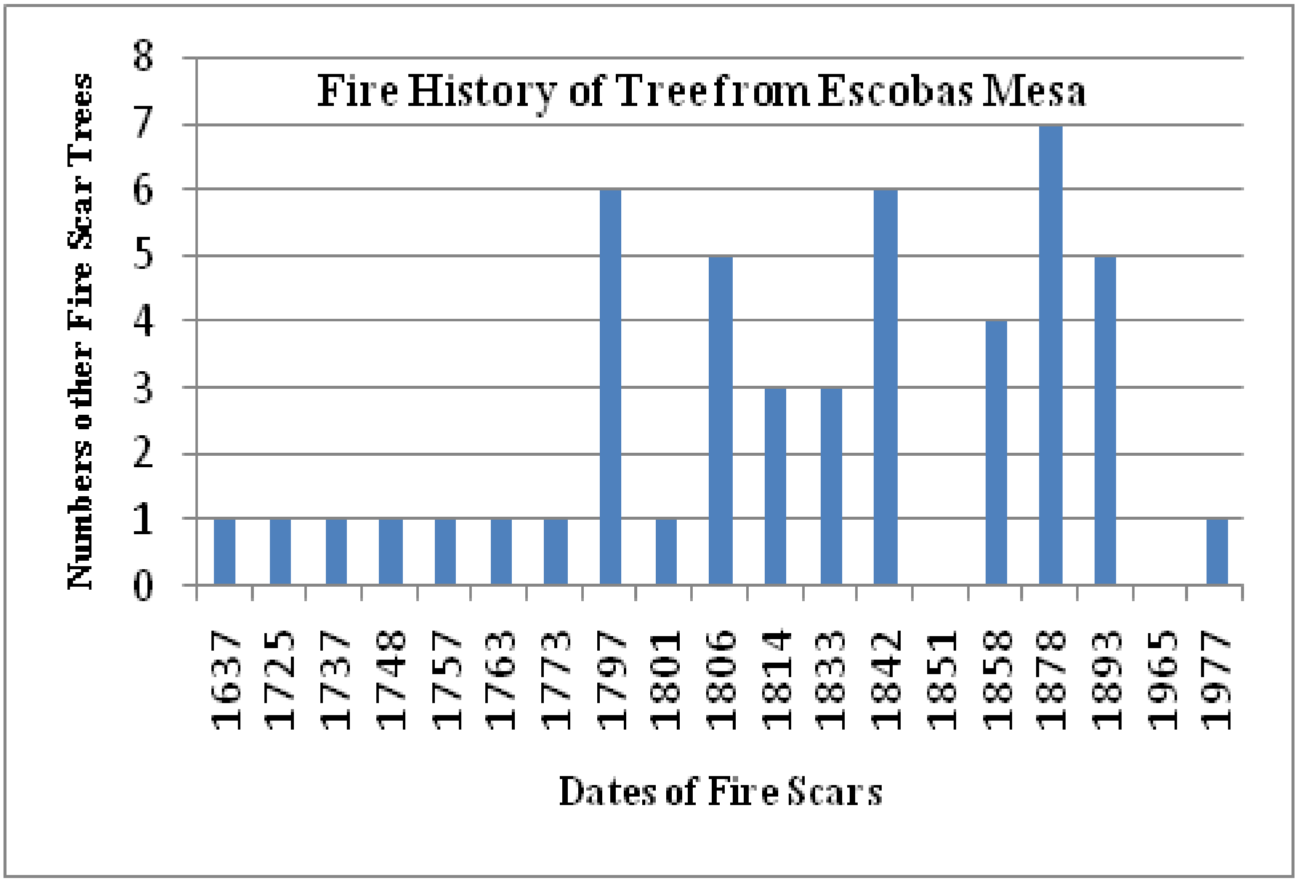


Figure 4.30. Fire history of a ponderosa pine from Escobas Mesa. Dates on X-axis are fire history from one 340-year-old tree. Blue bars are numbers of other sampled trees with fire scars in the same year.

The origin of the meadow adjacent to this plot is unknown, however, it should be noted that the species composition seemed to be one of disturbed soil because it included large numbers of weedy species such as *Sitanion hystrix, Amaranthus retroflexus, Verbascum thapsus*, and *Lycurus phleoides*. This was not true of the meadow near Escobas Mesa 2. There are several archaeological sites in the area and a fire or logging road that extended beyond the plot location. The meadow was nearly indistinguishable in 1999 as many of the small trees were approaching four inches in diameter making the meadow appear like an open stand of ponderosa pine (Figure 4.31).

Overstory Conditions

This plot had 77 trees in 1977 (312 trees per acre). The mean fire damage for this plot in 1977 was 5.4 with an average dbh of 5.7 inches (Table 4.7). The average diameter of mature trees (over four inches dbh) was 8.6. All trees with diameters less than eight inches dbh had died. The density of the mature trees went from 72 trees per acre in 1977 to 28 trees per acre in 1992. The density of the mature trees went from 73 trees per acre in 1977 to 40 trees per acre in 2010. Seedling trees in this area sustained high degrees of foliar damage in 1977, but sprouting from leaf buds was noted (Figure 4.32). These seedling trees had a good degree of recovery by 1978 but were damaged by animal use. They were still alive in 2010.

A comparison of the amount of foliar damage and size class in 1977 is shown in Figure 4.33. From 1977 to 2010 there were only 13 percent of the mature trees still living. Those trees had an average diameter of 13.6 inches. Only 56 percent of the original 18 living trees were alive in 2010.

Understory Conditions

Comparison of percent cover of all species for all sample years is found in Table 4.8.

Figure 4.31. Trees in the meadow adjacent to Escobas Mesa 1

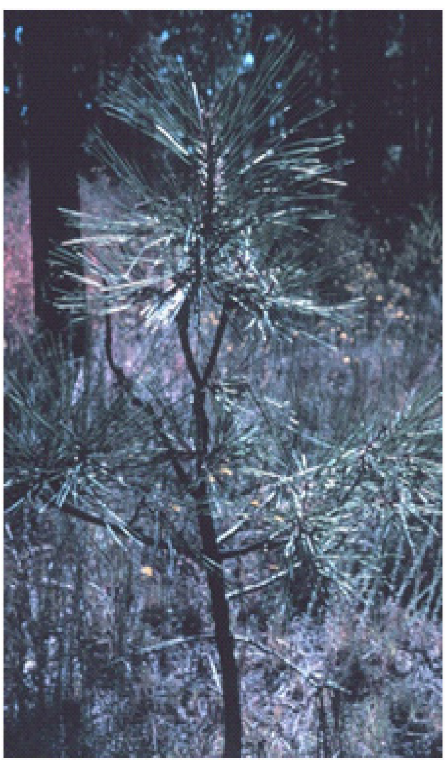


Figure 4.32. Small tree recovered in 1985

Grasses dominated this site. In 1978 to 1998 grasses had a 20 percent to 25 percent higher cover than forbs. However, in 2010, cover of forbs was about seven percent higher than grasses. In 1985, the seeded grass (slender wheatgrass) had higher percent cover than native grasses but by 1998 and 2010, the seeded grasses had a lower percent cover than did native grasses. The native grasses that dominated the site in 2010 included pine dropseed, blue grama, and mountain muhly. Additionally, small stands of big bluestem were found on the perimeter of the site. Big bluestem was producing large seedheads by the fall of 1977. Figures 4.34 and 4.35 show the changes in cover for seeded grasses: sheep fescue (FEOV) and slender wheatgrass (AGTR) and native grasses, respectively.

Forb species had lower percent cover from 1977 to 1998 than the grasses (Figure 4.36). Only in 2010 was the forb cover substantial. Table 4.8 provides information about cover for Escobas Mesa 1. Wild onion (ALCE), golden aster (CHFO), and Potentilla spp. (POXX) were recorded six of the six

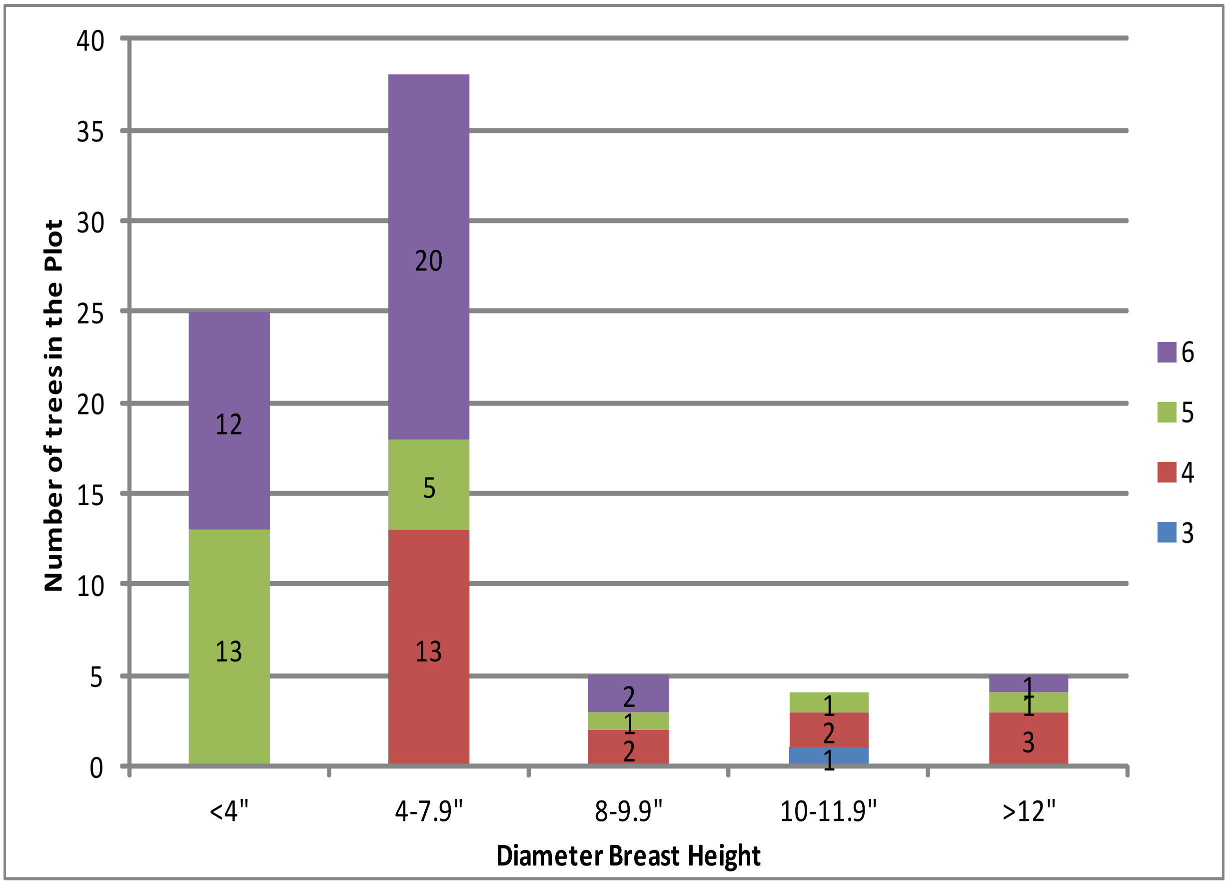


Figure 4.33. Survival of trees as related to size class (dbh inches) and foliar damage class. (Class 6 = no needles, Class 5 = all brown needles, Class 4 = 25% crown intact, Class 3 = 50% crown intact)

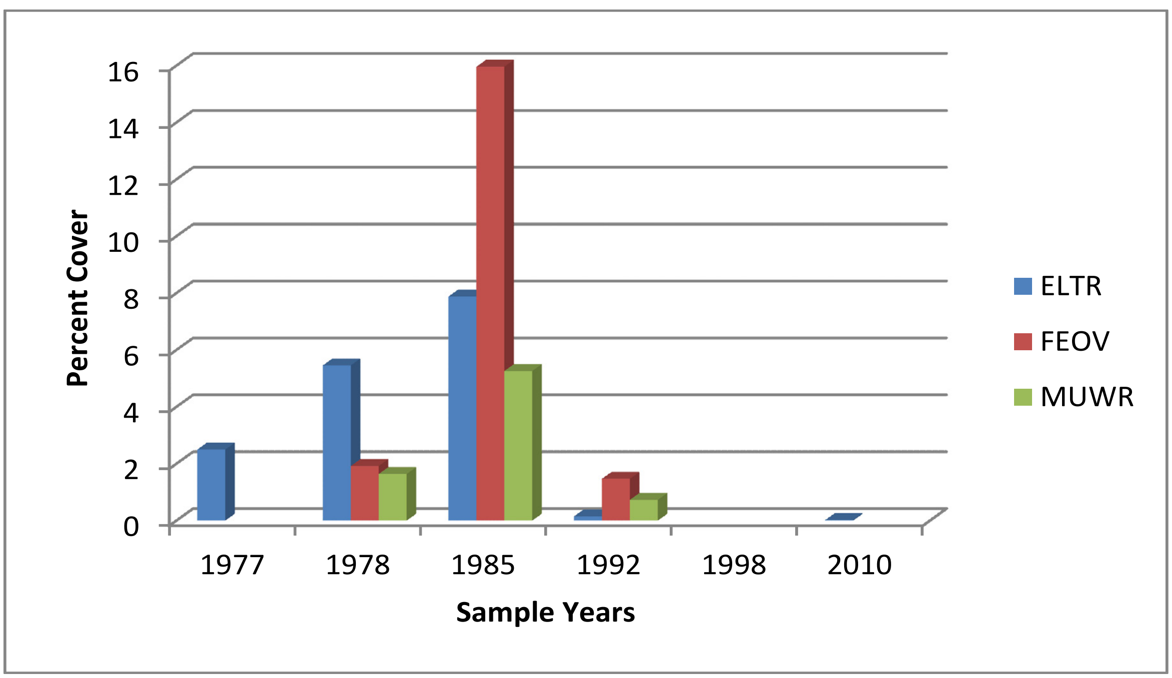


Figure 4.34. Seeded grass cover through time

(ELTR = Elymus trachycaulus, *FEOV* = Festuca ovina, *MUWR* = Muhlenbergia wrightii*)*

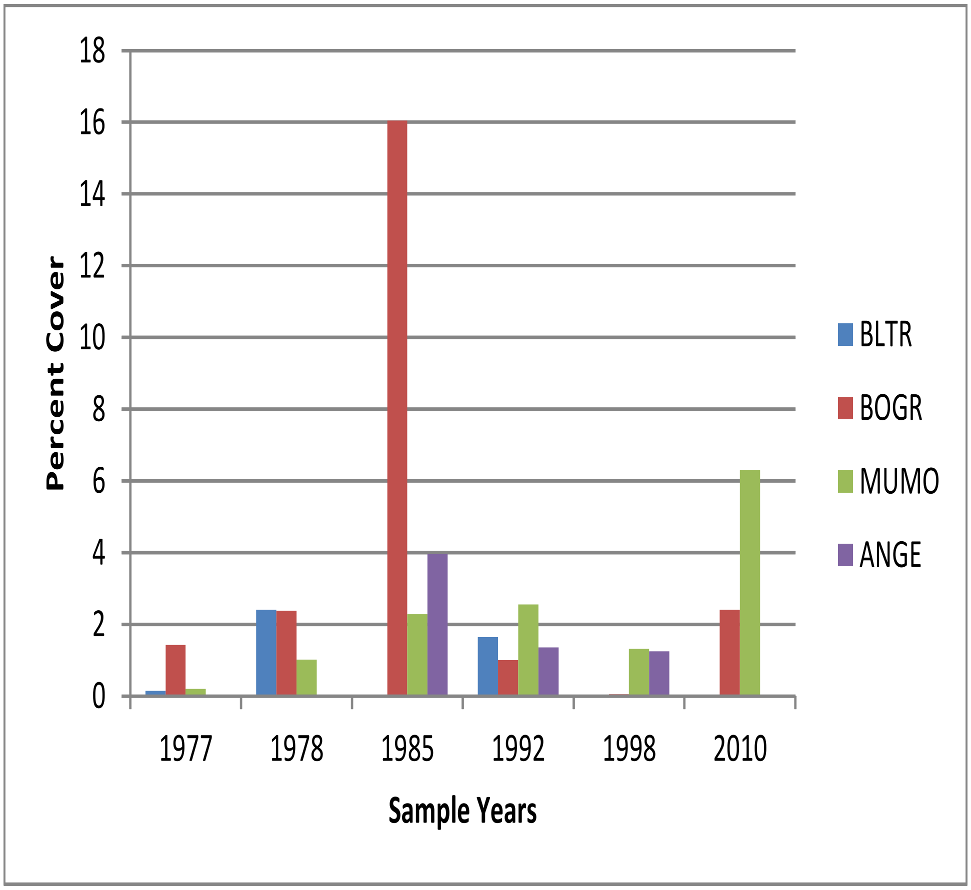


Figure 4.35. Native grass cover through time (MUMO = Muhlenbergia montana*, BOGR* = Bouteloua gracilis*, ANGE* = Andropogon gerardii*, BLTR* = Blepharoneuron tricholepis*)*

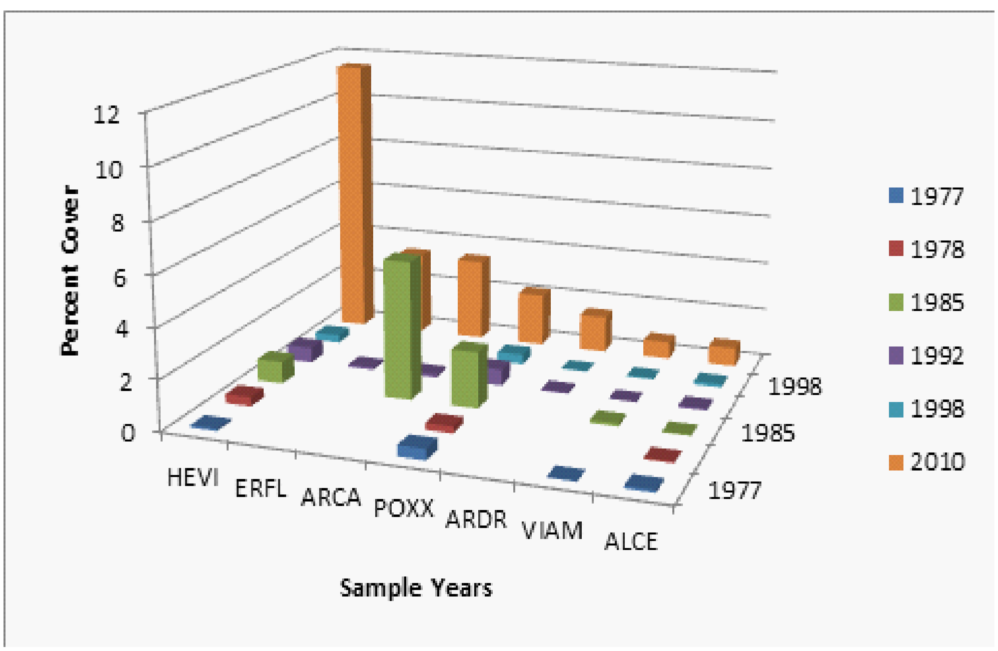


Figure 4.36. Common forb cover through time (ALCE = Allium cernuum*, ARCA* = Artemisia carruthii*, ARDR* = Artemisia dracunculus*, HEVI*= Heterotheca villosa*, ERFL* = Erigeron flagellaris*, POXX* = Potentilla *spp., VIAM* = Vicia americana

years sampled. Common fleabane (ERDI), puccoon (LIMU), and American vetch (VIAM) were recorded four out of five years.

Conditions after the 1998 Prescribed Burn

The first three sampling years only the amount of bare soil was estimated. However, in 1992, we began to estimate litter, cryptogams, and rock. Figure 4.37 shows the relationship of bare soil to the vegetation cover. Note that in 1998 there was a reduction of vegetation and an increase in bare soil. The prior sample year, 1992, there had been a reduction of bare soil due to increased litter, which was reduced by the prescribed fire. At the time we sampled, there was also a reduction of foliage cover, but the foliage may not have had sufficient time to recover at the time of our sampling. Litter was reduced 25 percent and foliage increased. Figure 4.38 compares the bare soil with the total forb and grass cover for the plot.

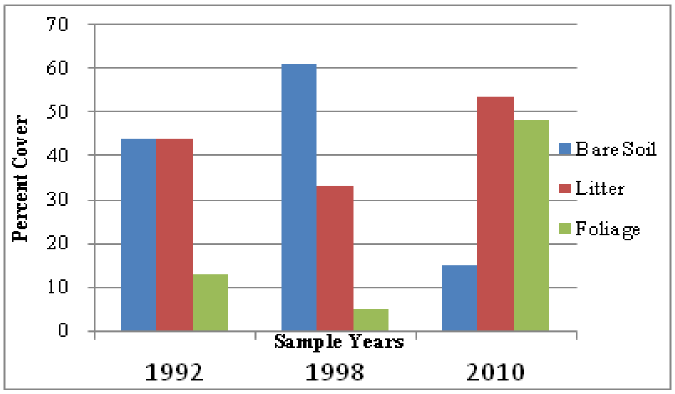


Figure 4.37. Comparison of litter, bare soil, and forb cover through time

Mapping and Photography

Visual changes and changes in the stand characteristics can be seen in Plates 4.9 and 4.10.

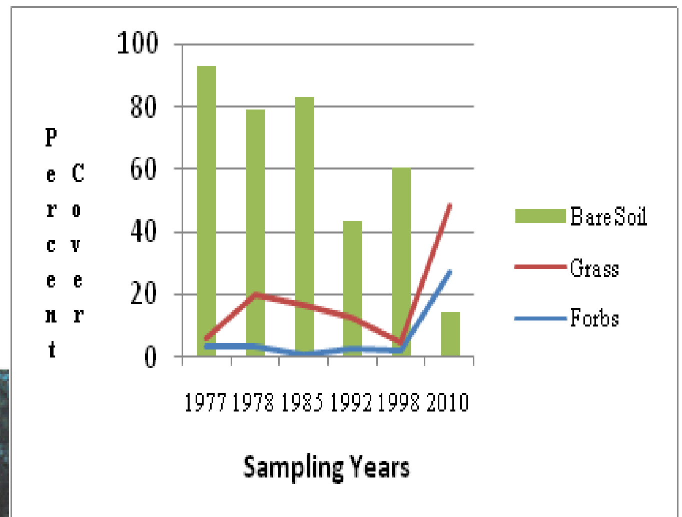
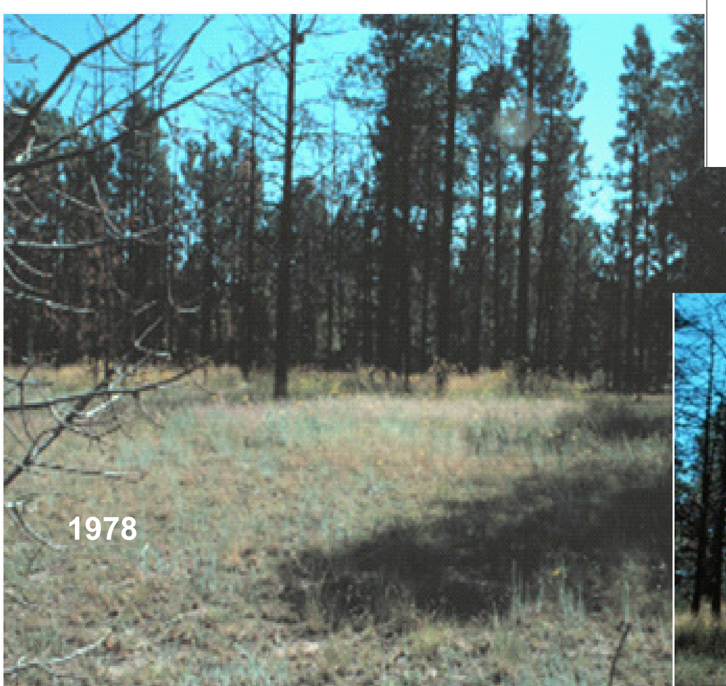


Figure 4.38. Comparison of bare soil, grass, and forb cover through time



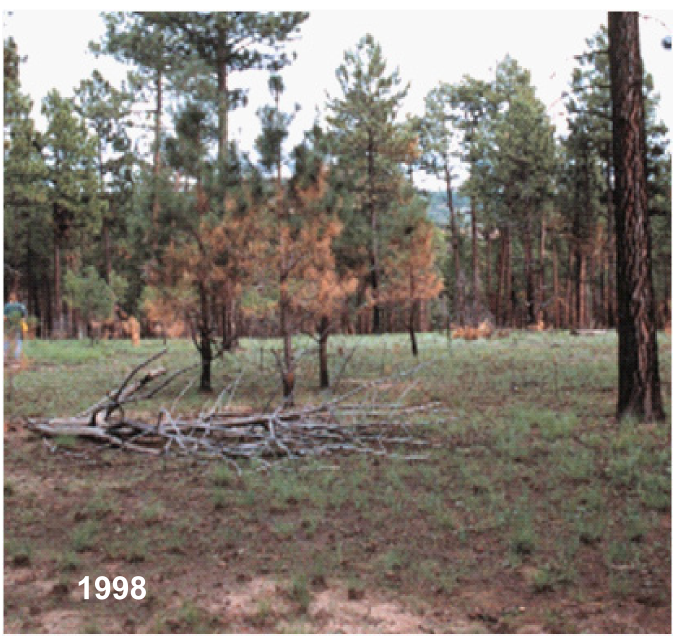
1978; northwest to southeast

1999; northwest to southeast

Plate 4.9. *Escobas Mesa 1 through time (continued on the next page)*

2002; northwest to southeast

1978; northwest corner looking southeast



1998; northeast to southeast after prescribed burn

1978; southwest to northeast

1978; southeast corner looking northwest

Plate 4.9. *(continued)*

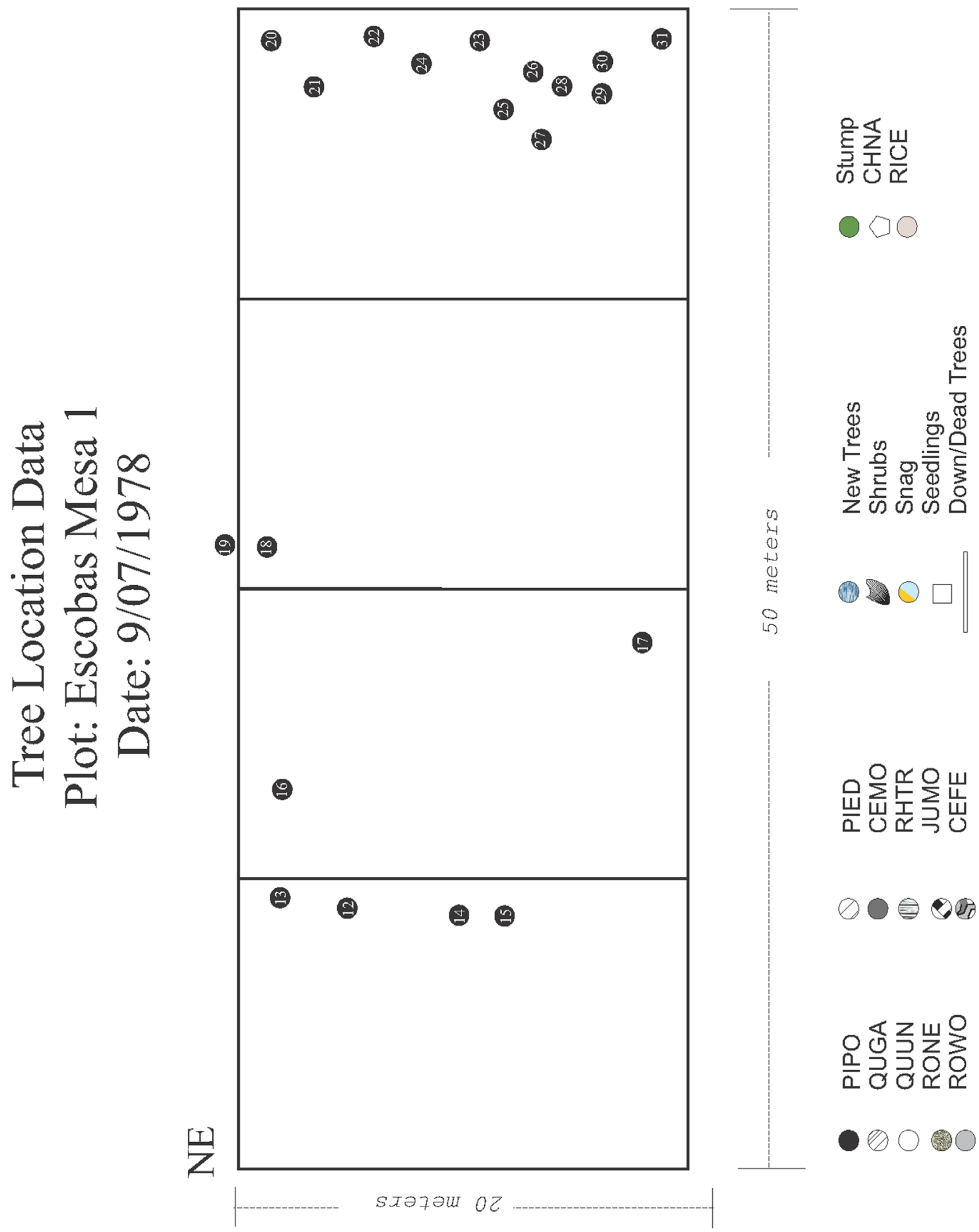


Plate 4.10. *Tree location data for Escobas Mesa 1 (continued on next page)*

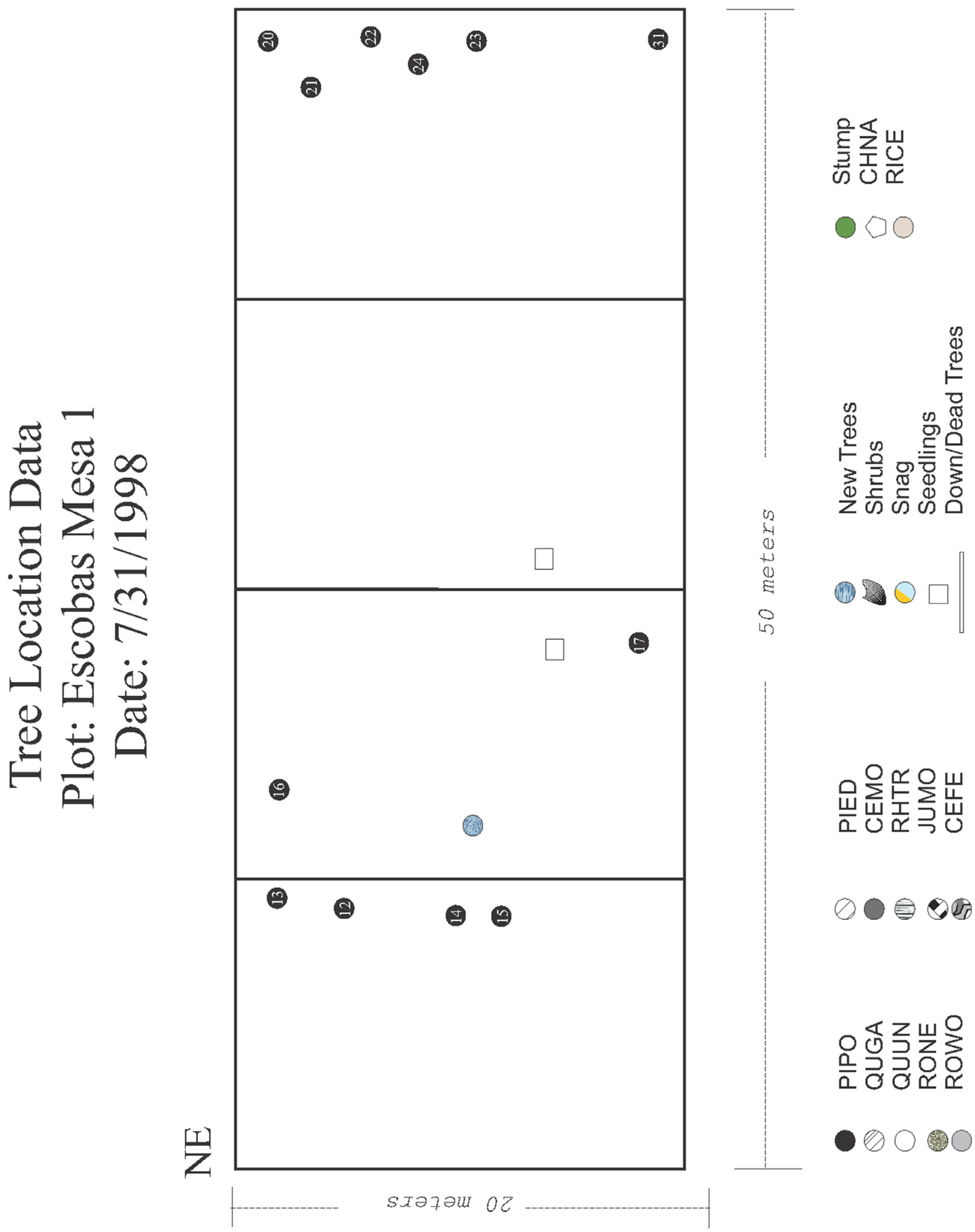


Plate 4.10. *Tree location data for Escobas Mesa 1 (continued on next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

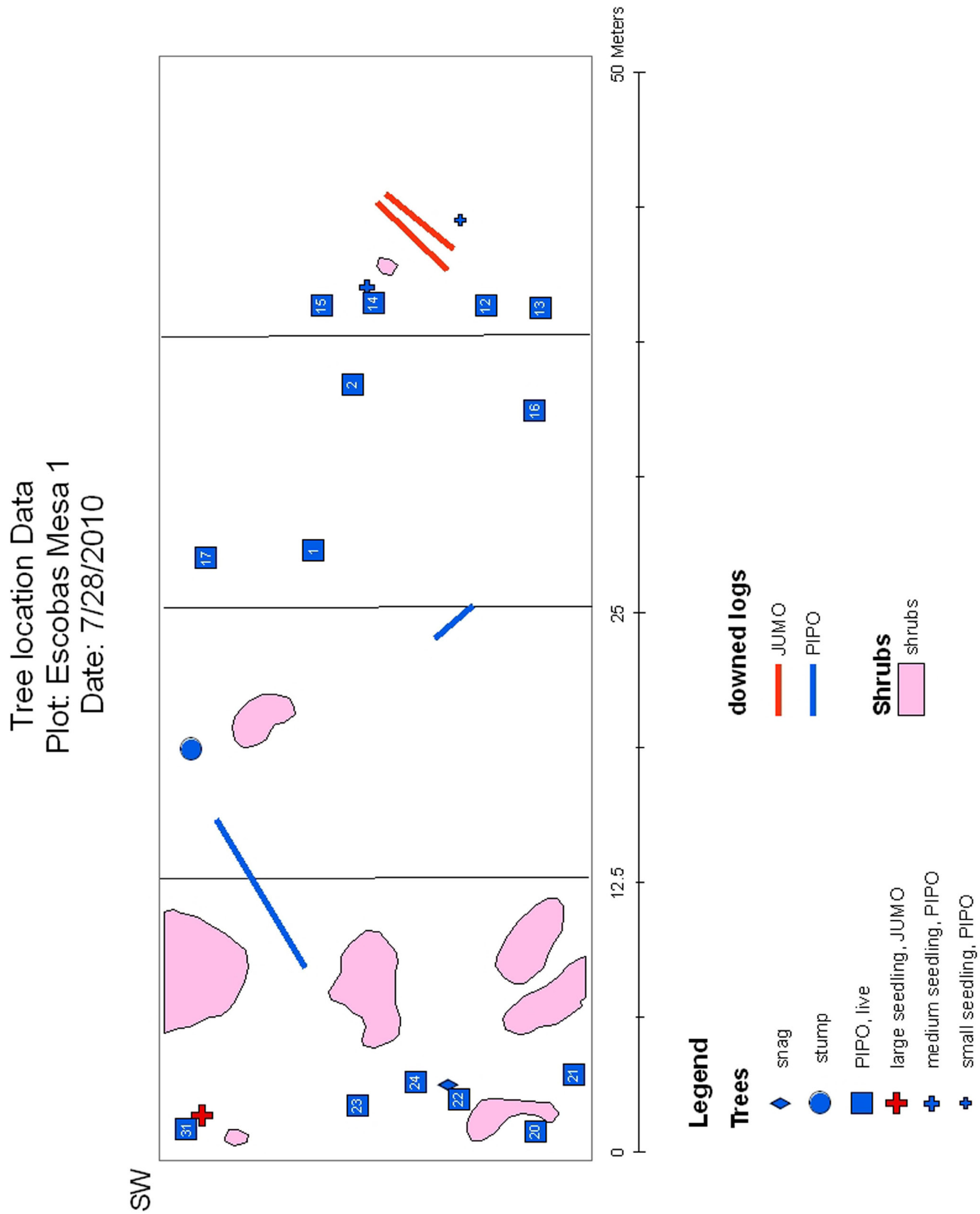


Plate 4.10. *Tree location data for Escobas Mesa 1 (continued)*

Table 4.6. Fire Scar Data for a 340-Year-Old Tree on Escobas Mesa

	Fire Scar Date	Years Between Fire Scars	Average Years Between Scars
Center	1637		
First Fire Scar	1637–1725	88	
	1725–1737	12	
	1737–1748	11	
	1748–1757	9	
	1757–1763	6	
	1763–1773	10	
	1773–1797	24	
	1797–1801	4	
	1801–1806	5	
	1806–1814	8	
	1814–1833	19	
	1833–1842	9	
	1842–1851	9	
	1851–1858	7	
	1858–1878	20	
	1878–1893	15	11.2 years
	1893–1965	72	
	1965–1977	12	42 years

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

Table 4.7. Size and Mortality of Trees within Escobas Mesa 1 Through Time

Foliar Damage	Fo-liar class	1977	1977 Basal Area	1978 DBH	1985 DBH	1992 DBH	1998 DBH	1977-1998 growth	2010 DHB	1977-2010 growth	2010 Basal Area
Mature											
20	3	6.6	0.24	6.6	7.5	8.9	9.5	3.9	10.1	3.5	0.56
24	3	10.1	0.56	10.2	11.3	NR	14.4	4.3	14.4	4.3	1.13
12	4	11.0	0.66	11.0	12.5	15.9	17.2	6.2	17.19	6.9	1.61
13	4	21.0	2.41	21.2	21.3	21.8	22.0	1.0	21.6	0.6	2.54
16	4	8.6	0.40	8.6	10.1	12.9	14.3	5.7	15.4	6.8	1.29
17	4	9.9	0.53	9.7	10.3	NR	14.6	5.8	15.7	5.8	1.34
18	4	18.2	1.81	18.3	Dead	Dead	Dead	Dead	Dead		
19	4	8.1	0.36	7.8	7.8	10.4	Dead	Dead	Dead		
21	4	6.3	0.22	6.3	ND	ND	8.2	2.3	8.6	2.3	0.40
22	4	5.7	0.18	5.8	6.8	8.2	8.6	.7	9.7	4	0.51
23	4	5.5	0.16	5.5	ND	ND	8.5	3.0	8.9	3.4	0.43
25	4	6.9	0.26	6.9	6.9	6.9	8.2		Dead	Dead	Dead
26	4	4.9	0.13	4.9	Dead	Dead	Dead	Dead	Dead	Dead	Dead
27	4	4.9	0.13	4.7	Dead	Dead	Dead	Dead	Dead	Dead	Dead
28	4	4.8	0.13	4.2	Dead	Dead	Dead	Dead	Dead	Dead	Dead
29	4	4.9	0.13	4.2	Dead	Dead	Dead	Dead	Dead	Dead	Dead
30	4	5.0	0.14	5.0	Dead	Dead	Dead	Dead	Dead	Dead	Dead
31	4	12.8	0.89	12.7	ND	ND	14.3	1.3	14.1	1.3	1.08
		18		18	12	12	11		10		
Total Basal			9.33								10.91
Trees/acre alive		18 (73/acre)		73	49	49	40		40		
Total Growth Inches								3.4		3.9	
Total Trees Class 4-5 dead 1977		39 (158/acre)									
Total Trees Class 6 1977		20 (81/acre)									
Total Trees/Acre		312 trees/acre							40		

Table 4.8. Escobas Mesa 1 Comparison of Percent Cover for Species Noted from 1977 to 2010

Species Name	1977	1978	1985	1992	1998	2010	No. Years
Grass							
Native Grass							
Andropogon gerardii			3.96	1.36	1.25		3
Aristida purpurea	0.10	0.82	0.18			1.20	4
Blepharoneuron tricholepis	0.14	2.45		1.64			3
Bouteloua gracilis	1.43	2.37	16.04	1.00	0.05	2.40	6
Bromus tectorum			0.02		0.01	1.96	3
Carex spp.	0.22	1.47		0.98	0.06	1.66	5
Elymus elymoides		0.09	0.10	0.07		4.50	4
Festuca octoflora						0.14	1
Koeleria cristata				0.09		1.50	2
Muhlenbergia asperifolia							1
Muhlenbergia montana	0.2	1.01	2.28	2.56	1.31	6.30	6
Muhlenbergia spp.						0.50	1
Pascopyrum smithii			.18				
Poa spp.					0.49	.22	
Sporobolus spp.				0.02			1
Sporobolus cryptandrus							1
Schizchyrium scoparium						0.60	1
Unidentified grass					.31	0.10	2
Total Native Grass	**2.09**	**8.21**	**22.76**	**7.72**	**3.48**	**21.08**	
Seeded grass							
Elymus trachycaulus	2.50	5.46	7.88	0.15		0.02	5
Festuca ovina		1.92	15.96	1.47			3
Muhlenbergia wrightii		1.64	5.26	0.73		0.50	4
Total Seeded Grass	**2.5**	**9.02**	**29.01**	**2.35**		**0.52**	
Introduced grass							
Bromus tectorum			0.02		0.01	1.96	3
Total Introduced Grass Cover			**0.02**		**0.01**	**1.96**	
Total Grass Cover	**4.59**	**17.23**	**51.79**	**10.07**	**3.49**	**23.56**	
Number Grass Species	**6**	**9**	**11**	**11**	**8**	**15**	
Forbs							
Allium cernuum	0.1	0.06	0.04	0.09	0.14	0.76	6
Antennaria spp.			2.10				1
Artemisia spp.	1.02	1.18					2
Artemisia carruthii			5.56	0.13		3.38	3
Artemisia dracunculus				0.05	0.03	1.50	3
Bahia dissecta	0.34	0.37		0.02		0.40	4

Forbs (cont.)							
Calliandra conferta				0.15			1
Castilleja integra	0.02		0.64				2
Chenopodium album		0.18					1
Chenopodium graveolens	0.94				0.21	0.02	3
Cirsium spp.				0.09			1
Cirsium neomexicanum					0.02		1
Erigeron divergens	0.02	0.28	0.08	0.05		0.76	5
Erigeron flagellaris				0.11		3.40	2
Euphorbia serpyllifolia	0.54				0.13		2
Gaura coccinea					0.09		1
Heterotheca villosa	0.1	0.37	0.90	0.62	0.33	11.5	6
Hymenoxys acaulis		0.01					1
Hymenoxys argentea			0.36	0.02		0.22	3
Hymenoxys richardsonii			0.10				1
Linum neomexicanum				0.05			1
Lithospermum multiflorum	0.02	0.28	0.04	0.02	0.05		5
Lotus wrightii				0.02	0.05		2
Lupinus caudatus			0.02	0.49	0.05	0.24	4
Mirabilis linearis					0.01		1
Orthocarpus purpureo-albus					0.01		1
Penstemon spp.			0.10			0.20	2
Petalostemum candidum	0.06						1
Plantago purshii				0.04		0.24	2
Polygonum sawatchense						.4	1
Potentilla spp.	0.44	0.27	2.26	0.67	0.40	2.16	6
Senecio spp.			0.02				1
Taraxicum officinale						0.10	1
Vicia americana	0.02		0.12	0.02	0.05	0.70	5
Unknown forb	0.12			0.02		.28	3
Total Forb Cover	**3.74**	**3.00**	**12.34**	**2.66**	**1.57**	**26.26**	
Total Forb Species	**13**	**9**	**14**	**18**	**14**	**16**	
TOTAL FOLIAR COVER	**8.33**	**20.23**	**64.13**	**12.73**	**5.06**	**49.82**	
Bare soil	91.67	79.77	35.87	43.85	61.03	14.86	
Litter				44.05	33.08	53.58	
Rock					0.25	0.20	
Wood						7.10	
Shit						0.64	
Moss/Cryp				2.0		3.90	
Soil Crust					0.30		

Escobas Mesa 2

Escobas Mesa 2 is accessed by the Upper Crossing Trail and branch fire road and is west of Escobas Mesa 1 and south of the road approximately one mile from the junction of the fire road and the Upper Crossing Trail (see Figure 4.1). Archaeological site 16106 is within the boundaries of the plot. GPS coordinates are presented below.

The plot was a dense stand of pine next to an open meadow and had burned three times in the past 20 years: 1976 Escobas Mesa Fire, 1977 La Mesa Fire, 1998 prescribed burn. After the 1976 fire we found fuel loadings to be 1.3 tons per acre. After the La Mesa Fire, foliar damage was from classes 1 through 4. The plot was lightly burned, likely because fuels had been reduced in the 1976 Escobas Mesa Fire.

Overstory Conditions

In 1977, there were 152 trees in the plot, 81 were alive. Based on this, the tree density in the area was 526 total trees per acre with an average diameter of 5.7 inches. The mean fire damage was 4.3. In 1977, there were 81 trees with an average diameter of 5.6 inches and a mean fire damage of 3.8. No trees died the first year after the fire but by 1985 the density had been reduced to 308 trees per acre. Only one large tree (17-in. dbh) died; most of the mortality occurred in trees with dbh less than six inches. By 2010 the density was reduced to 194 trees per acre. Fifty-nine percent of the trees alive in 1977 were alive in 2010, 33 years later. Table 4.9 presents size and mortality of trees through time.

A comparison of the amount of foliar damage with the survival of the trees through time is found in Figure 4.39. Within the plot no trees had less than 25 percent of the crown damaged.

We visited the site in 2012 after the 2011 Las Conchas Fire. In 2010, the mapping of the plot revealed a considerable amount of downfall. In 2012, we noted the reduction in litter and downed logs as well as trees that had not survived after that fire. The information can be seen in Plate 4.11, which compares the reduction in tree density through time.

Understory Conditions

Comparison of the percent cover for all species for all sample years is found in Table 4.10. The cover of individual forbs remained about the same through time, although the numbers of species increased from one in 1977 to 17 in 1998. Only *Chenopodium graveolens* increased after the 1998 prescribed fire. Carruth sagewort was recorded four out of the six years. Grass cover increased from 1977 to 1985 but decreased in 1992 and 1998, increasing again by 2010. Grass cover was dominated by sheep fescue and mountain muhly. In 1998, mountain muhly had the highest cover and was recorded six out of six years. Figure 4.40 shows the grass cover through time. Figure 4.41 shows the most common forbs and the cover distribution from 1977 through 2010.

Conditions after the 1998 Prescribed Fire

Cover was low for both the forbs and grasses. Beginning in 1992, we began to separate out the non-vegetation cover into litter and bare soil (Figure 4.42). There was a high percent of litter before the prescribed fire, a reduction of litter from the prescribed fire, and a buildup of litter over the 12 years since the prescribed fire. The litter cover in 1992 was 95.4 percent and in 1998 38.1 percent. This litter was pine needles and a few logs. After the prescribed fire, *Chenopodium graveolens* was found where soil was denuded and made up 56 percent of all the forb cover. It was surprising to see an increase in foliar cover after the prescribed burn. The reduction of litter by 60 percent could have provided better growing conditions.

Mapping and Photography

The lightly burned plot was mapped through time (see Plate 4.11) and visual changes and changes in the stand characteristics can be seen in Plate 4.12.

GPS coordinates for Escobas Mesa 2

Plot Identification	Y_Coordinates_27	X_Coordinates_27	Latitude	Longitude
E2-NE (corner)	3964574	378132	0.000000	0.0000
E2-NW (corner)	3964591	378080	0	0
E2-SE (corner)	3964557	378126	0	0
E2-SW (corner)	3964576	378083	0	0

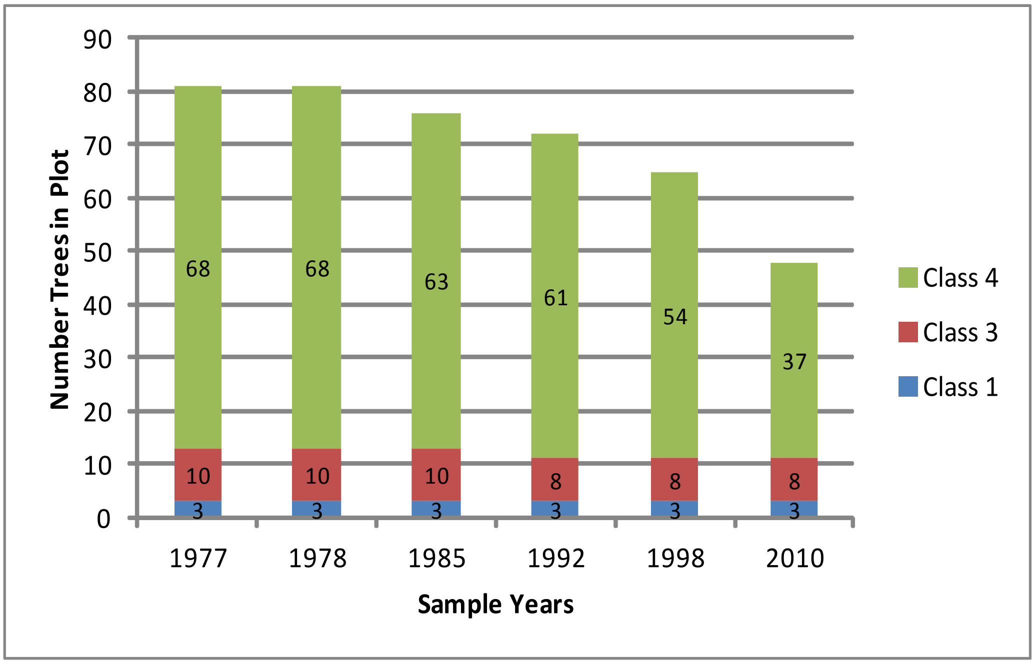


Figure 4.39. Survival of trees as related to foliar damage at Escobas Mesa 2

(Class 4 = 25% of crown intact, Class 3 = 50% of crown intact, Class 1 = no scorching)

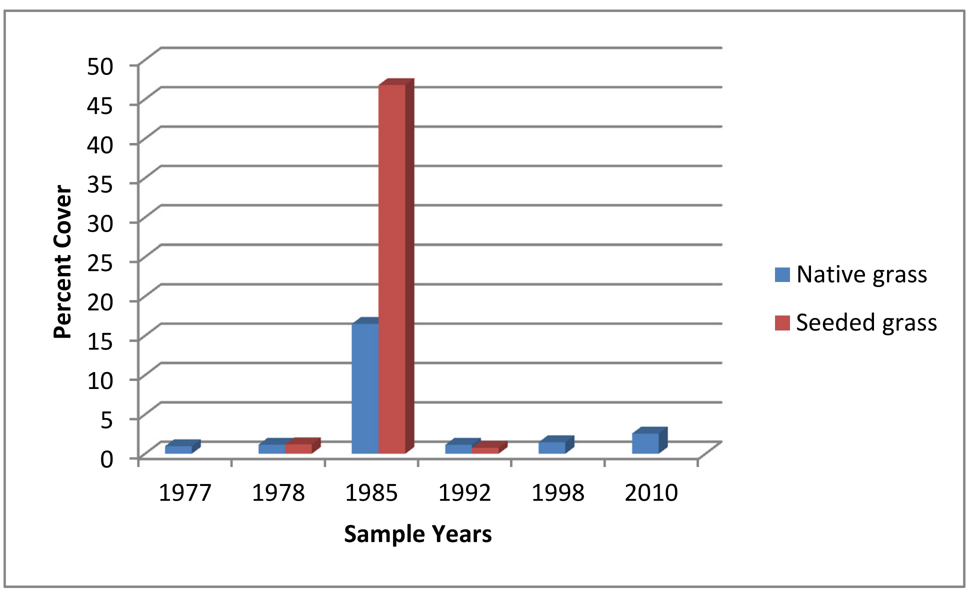


Figure 4.40. Grass cover through time on Escobas Mesa 2

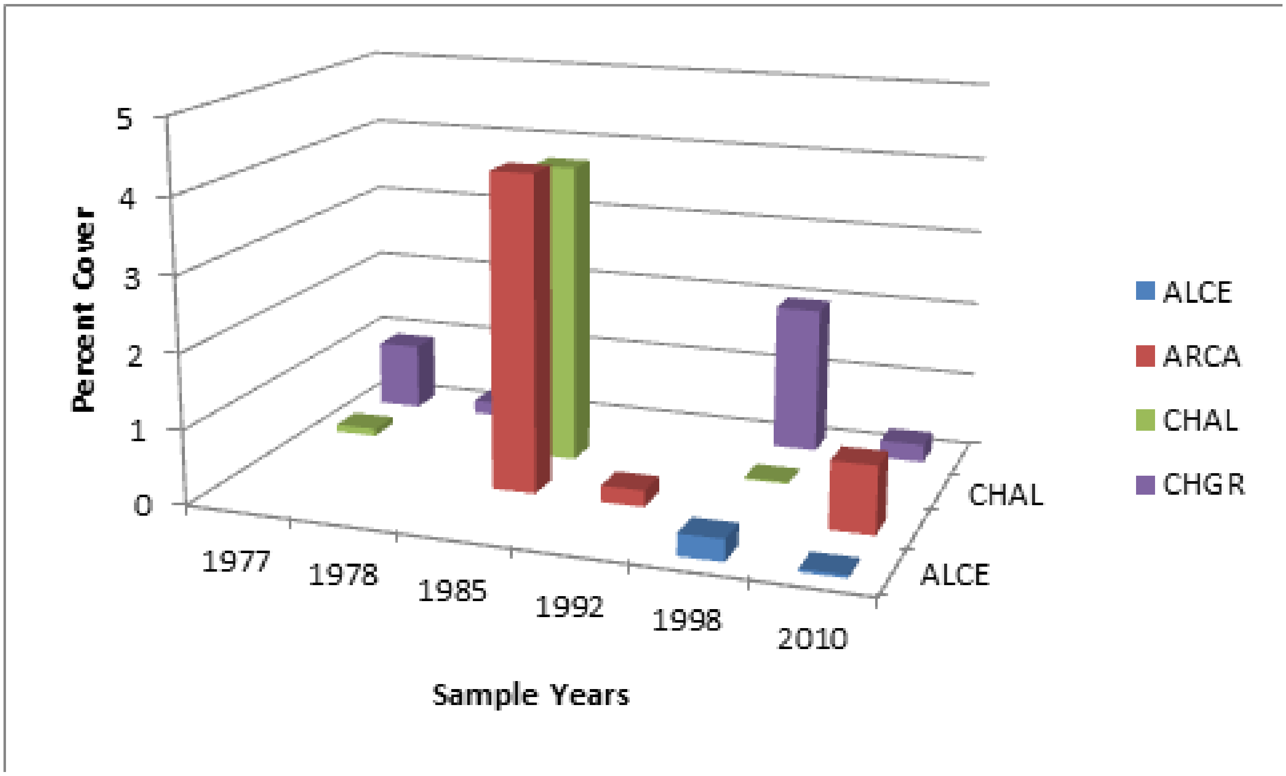


Figure 4.41. Common forb species found in Escobas Mesa 2 (ARCA = Artemisia carruthii, ALCE = Allium cernuum, CHAL=Chenopodium album, CHGR = Chenopodium graveolens,

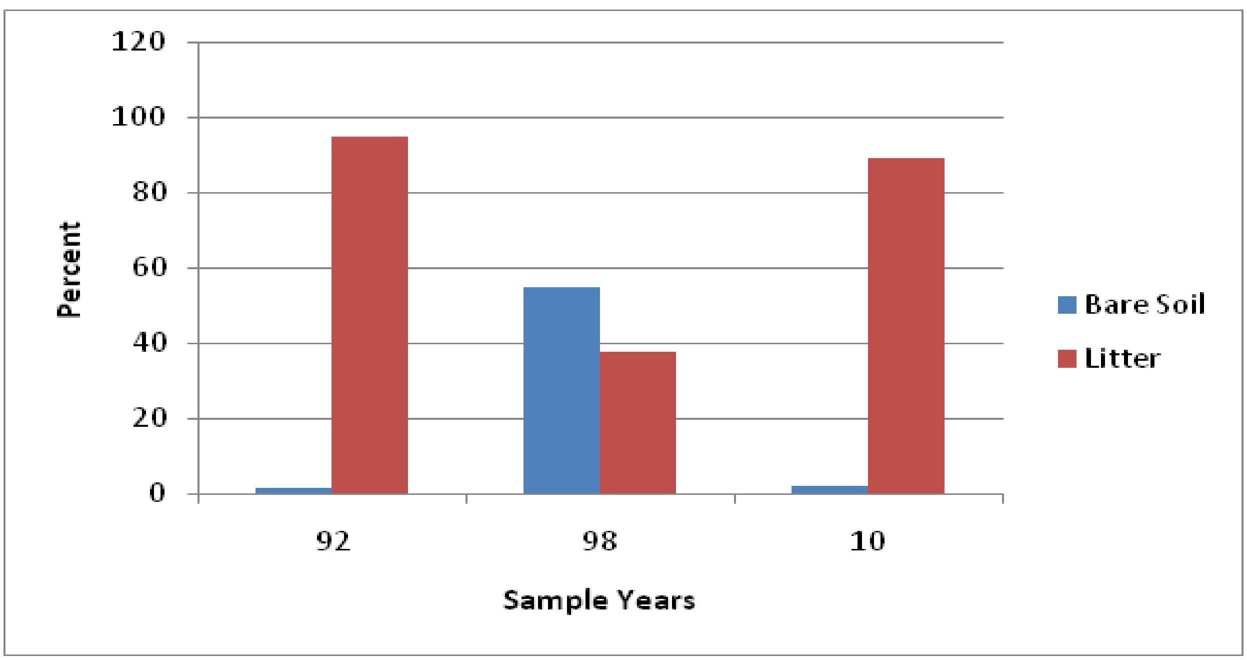


Figure 4.42. Comparison of bare soil and litter for Escobas Mesa 2

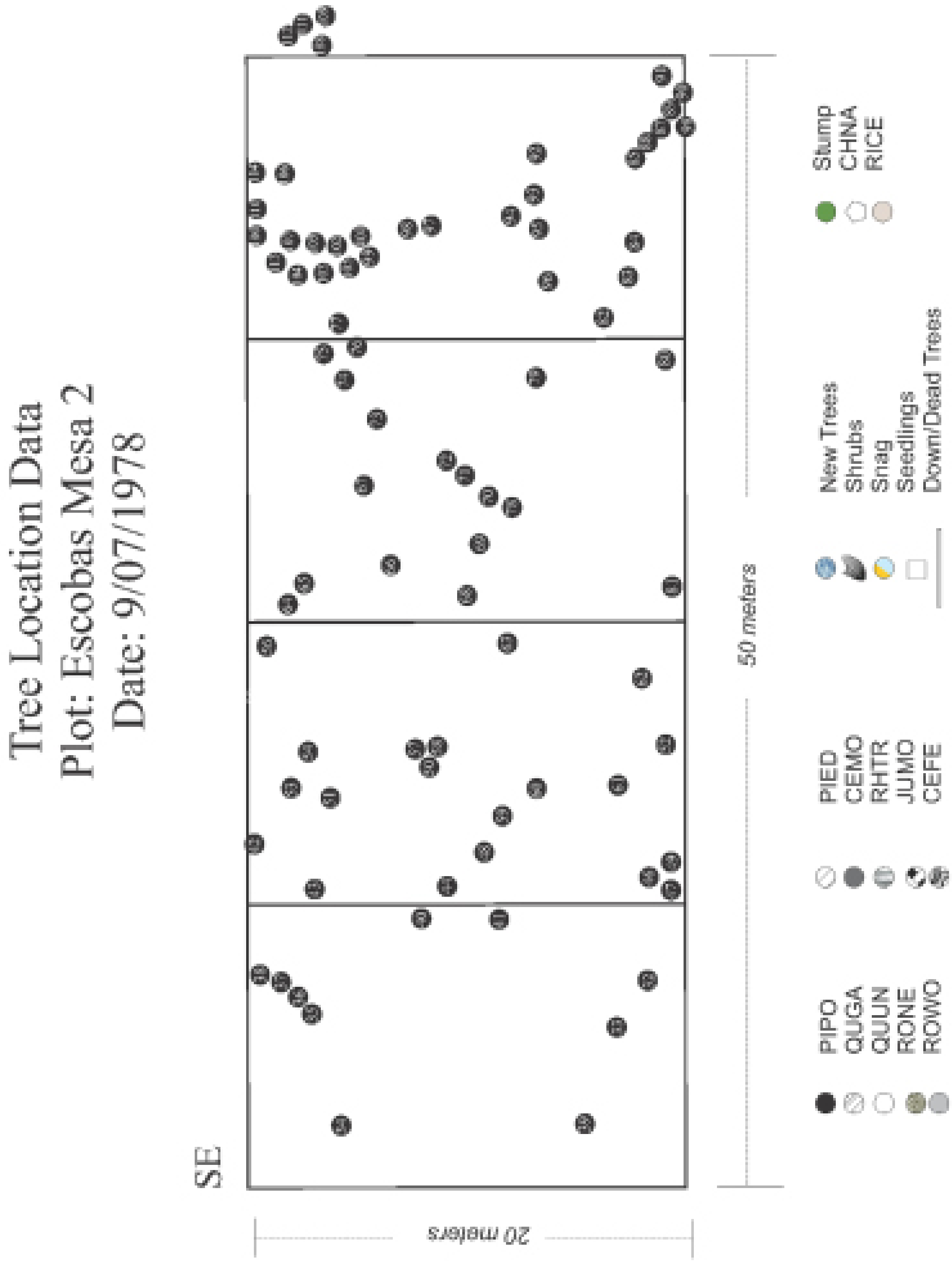


Plate 4.11. *Tree location data for Escobas Mesa 2 (continued on next page)*

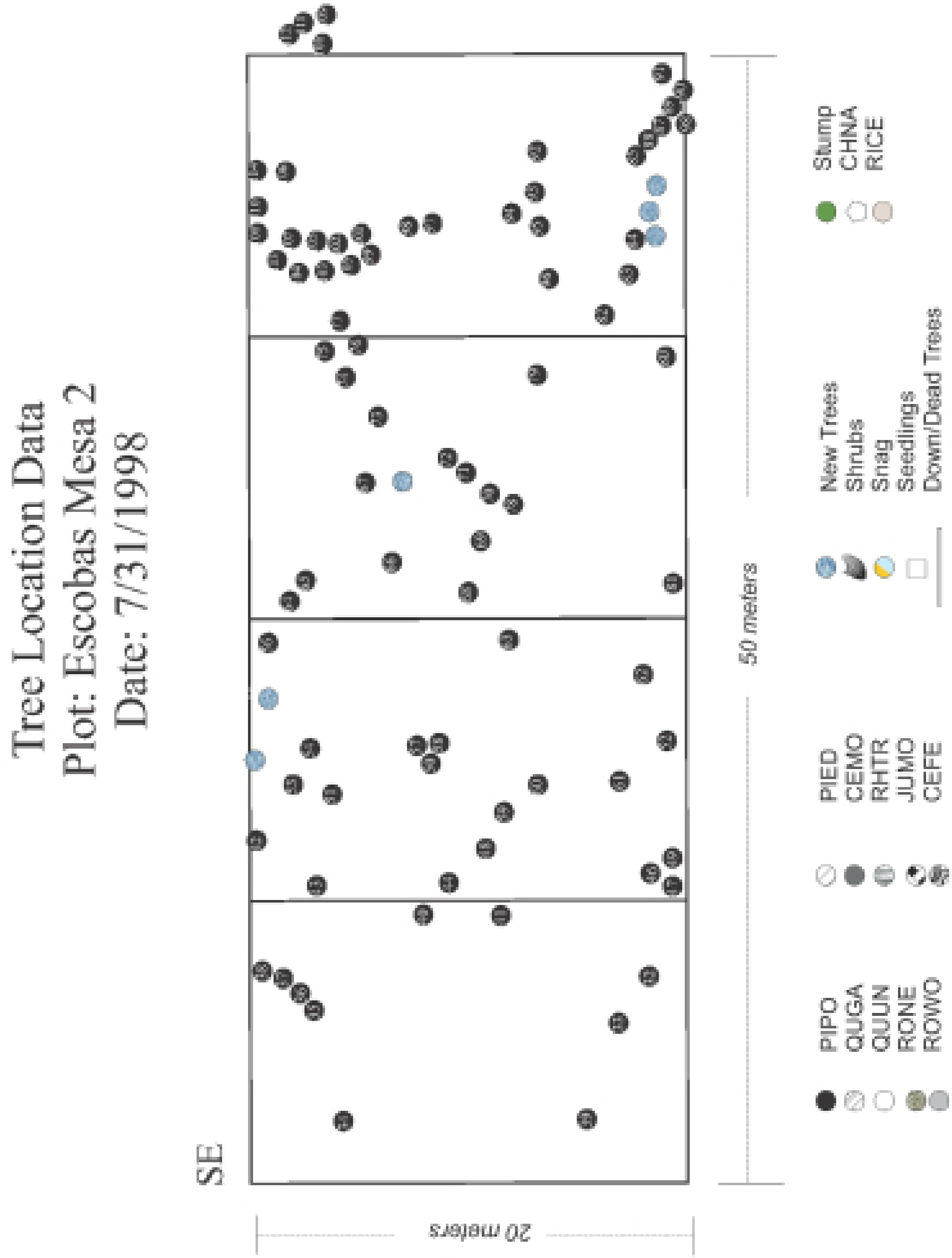


Plate 4.11. *Tree location data for Escobas Mesa 2 (continued on next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma*), PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

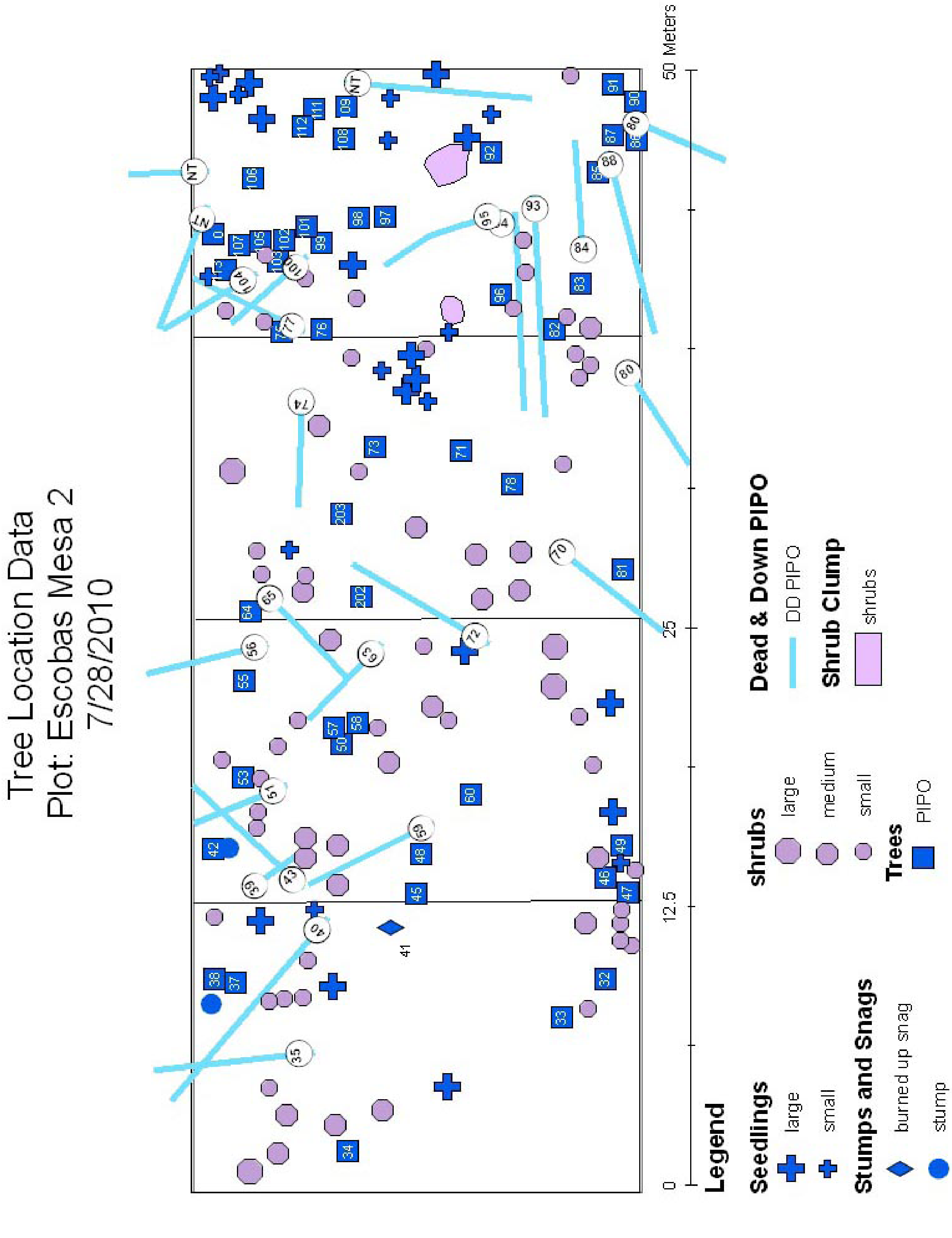


Plate 4.11. *Tree location data for Escobas Mesa 2 (continued on next page)*

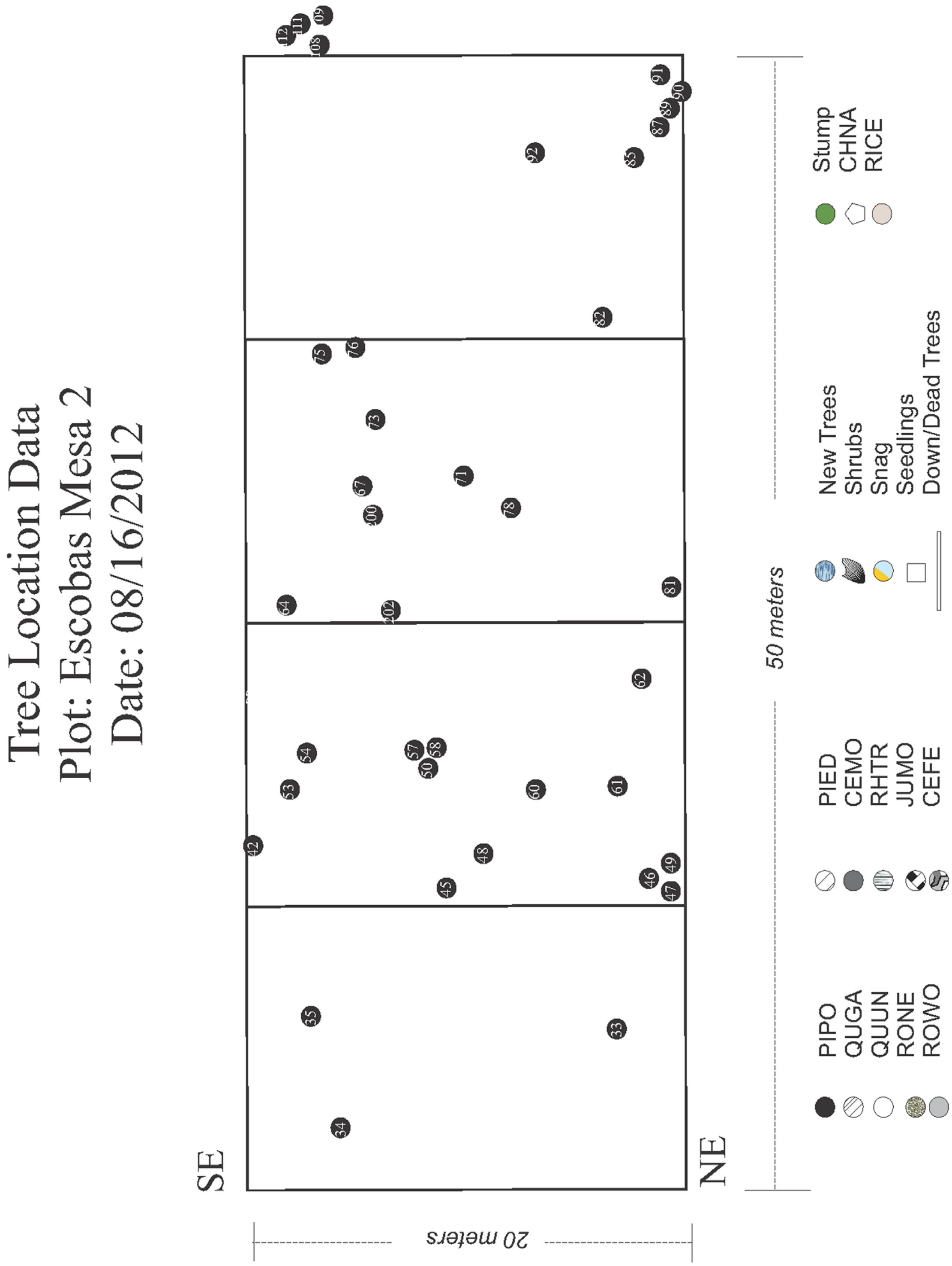


Plate 4.11. *Tree location data for Escobas Mesa 2 (this diagram after the La Conchas Fire)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

Note the reduction of the downed woody litter from 2010 to 2012 after the Las Conchas Fire (2011).

Plate 4.12. *Escobas Mesa 2 through time*

Table 4.9. Size and Mortality of Trees within Escobas Mesa 2 Through Time

	Foli-age Class	1977 DBH	Basal Area 1977	1978 DBH	1985 DBH	1992 DBH	1998 DBH	77-98 Growth	2010 DBH	Basal Area 2010	77-10 Growth
34	1	15.1	1.24	15.2	16.5	18.2	18.6	3.5	19.9	2.16	4.8
37	1	10.5	0.60	11.0	12.4	14	14.4	3.8	15.2	1.26	4.7
38	1	9.9	0.53	10.1	10.8	11.5	11.7	1.8	12.1	0.80	2.2
Number	3	3		3	3	3	3		3		
33	3	15.5	1.31	15.5	16.8	17.9	18.9	3.6	19.3	2.03	3.8
35	3	13.9	1.05	13.9	14.7	15.9	15.9	2.0	16.7	1.52	2.8
41	3	9.4	0.48	9	8.9	Dead	Dead	Dead	Dead	Dead	Dead
64	3	10.4	0.59	10.5	11.4	12.3	12.8	2.4	12.4	0.84	2
69	3	15.8	1.36	16	16.3	Dead	Dead	Dead	Dead	Dead	Dead
73	3	9.9	0.53	9.7	11.3	12.9	13.7	3.8	15.1	1.24	5.2
75	3	8.3	0.38	8.3	8.3	10	10.5	2.2	11	0.66	2.7
76	3	8.4	0.38	8.4	8.4	10.3	10.8	2.4	11.3	0.70	2.9
101	3	7.7	0.32	7.6	8.2	8.7	9.1	1.4	9.4	0.48	1.7
112	3	6.4	0.22	6.2	6.5	6.8	7	0.6	7.4	0.30	1.0
Number	10	10		10	10	8	8		8		
32	4	12	0.79	11.5	12.3	13	13.5	1.5	13.8	1.04	1.8
36	4	7.4	0.30	7.2	7.8	8.6	8.5	1.1	Dead	Dead	Dead
39	4	6.6	0.24	6.6	6.6	9.6	Dead	Dead	Dead	Dead	Dead
40	4	12.5	0.85	12.1	12.4	13.2	Dead	Dead	Dead	Dead	Dead
42	4	9.9	0.53	9.6	10.9	12	12.5	2.6	13.1	0.94	3.2
43	4	7.4	0.30	7.4	7.1	9	Dead	Dead	Dead	Dead	Dead
44	4	5.8	0.18	5.7	Dead	Dead	Dead	Dead	Dead	Dead	Dead
46	4	10.7	0.62	10.8	11.4	12.3	12.7	4.2	15.4	1.29	4.7
47	4	6.9	0.26	7.4	7.7	8.1	8.4	1.5	8.5	0.39	1.6
48	4	7.5	0.31	7.5	8.4	9.8	ND	0	9.5	0.49	2.0
49	4	8.4	0.38	8.3	8.8	9.8	10.1	1.7	10.8	0.64	2.4
50	4	8.2	0.37	8.2	8.3	9.9	10	1.8	9.8	0.52	1.6
51	4	7.1	0.27	7.1	7.4	8	7.9	0.8	Dead	Dead	Dead
52	4	4.0	0.09	4.1	Dead	Dead	Dead	Dead	Dead	Dead	Dead
53	4	6.2	0.21	6.3	7.1	9.3	7.6	1.4	7.9	0.34	1.7
54	4	6.9	0.26	6.6	7.1	7.5	7.5	0.6	7.4	0.30	0.5
55	4	8.2	0.37	8	8.9	9.4	9.6	1.4	10.3	0.58	2.1
56	4	6.4	0.22	7.5	7.8	7.9	8	1.6	Dead	Dead	Dead
57	4	10.0	0.55	9.2	10.5	11.7	11.9	1.9	13.3	0.96	3.3
58	4	5.9	0.19	6	6.7	7.5	6.1	0.2	7.7	0.32	1.8
59	4	5.1	0.14	5.2	5.5	6	6	0.9	Dead	Dead	Dead
60	4	7.4	0.30	7.2	7.8	9.8	9.6	2.2	10.5	0.60	3.1
61	4	6.8	0.25	6.7	7.5	8.6	9.1	2.3	9.6	0.50	2.8

	Foli-age Class	1977 DBH	Basal Area 1977	1978 DBH	1985 DBH	1992 DBH	1998 DBH	77-98 Growth	2010 DBH	Basal Area 2010	77-98 Growth
62	4	5.5	0.16	6.6	7.4	Dead	Dead	Dead	Dead	Dead	Dead
63	4	5.0	0.14	5.1	5.2	5.5	5.3	0.3	Dead	Dead	Dead
65	4	6.1	0.20	5.8	6.0	6.2	6.3	0.2	Dead	Dead	Dead
66	4	3.8	0.08	4.0	4.2	4.9	Dead	Dead	Dead	Dead	Dead
67	4	4.0	0.09	4.0	Dead	Dead	Dead	Dead	Dead	Dead	Dead
68	4	17.4	1.65	17.2	17.4	Dead	Dead	Dead	Dead	Dead	Dead
70	4	3.5	0.07	3.5	3.7	4.3	4.7	1.2	Dead	Dead	Dead
71	4	4.4	0.11	4.3	4.8	5.8	6.4	2.0	6.7	0.80	0.3
72	4	3.0	0.05	3.0	3.2	3.5	3.9	0.9	Dead	Dead	Dead
74	4	2.8	0.04	2.8	3.8	4.3	4.6	1.8	Dead	Dead	Dead
77	4	3.9	0.08	4.0	4.5	5.0	5.0	1.1	Dead	Dead	Dead
78	4	4.6	0.12	4.6	5.4	6.8	7.3	2.7	7.9	0.34	3.3
79	4	4.6	0.12	4.6	Dead	Dead	Dead	0	Dead	Dead	Dead
80	4	2.1	0.02	3.0	4	5.1	5.6	3.5	Dead	Dead	Dead
81	4	3.5	0.07	3.5	4.1	5.2	5.6	2.1	6.0	0.20	2.5
82	4	10.4	0.59	10.5	11.6	13.4	13.9	3.5	14.9	1.21	4.5
83	4	5.8	0.18	5.6	6.1	6.6	6.7	0.9	6.7	0.24	0.9
84	4	5.3	0.15	5.3	5.3	5.4	5.6	0.3	Dead	Dead	Dead
85	4	8.8	0.42	8.8	9.4	10.4	10.7	1.9	11.1	0.67	2.3
86	4	6.7	0.24	6.8	7.3	7.8	7.7	1.0	8.0	0.35	1.3
87	4	7.3	0.29	7.2	8.1	9.4	9.8	2.5	10.8	0.64	3.5
88	4	5.8	0.18	5.8	6.1	6.4	6.4	0.6	Dead	Dead	Dead
89	4	7.3	0.29	7.3	8.0	8.4	8.5	1.2	Dead	Dead	Dead
90	4	6.2	0.21	6.2	6.5	7.5	7.4	1.2	7.4	0.30	1.2
91	4	6.3	0.22	6.2	6.7	7.5	7.5	1.2	8.6	0.40	2.3
92	4	9.0	0.44	10.4	11.1	12.1	ND	ND	13.5	0.99	4.5
93	4	5.8	0.18	5.8	5.7	5.9	Dead	Dead	Dead	Dead	Dead
94	4	7.2	0.28	7.2	7.8	8.7	Dead	Dead	Dead	Dead	Dead
95	4	4.3	0.10	4.3	4.4	4.4	Dead	Dead	Dead	Dead	Dead
96	4	4.9	0.13	4.8	5.2	9.5	6.4	1.5	6.1	0.20	1.2
97	4	8.0	0.35	8.0	8.4	8.8	8.9	0.9	8.8	0.42	0.8
98	4	9.5	0.49	9.5	10.1	11	11.5	2.0	12.1	0.80	2.6
99	4	5.8	0.18	5.9	6.2	6.5	6.7	0.9	7.1	0.27	1.3
100	4	4.7	0.12	4.7	5.7	4.9	5.0	0.3	Dead	Dead	Dead
102	4	7.9	0.34	7.9	8.8	9.9	10.5	2.6	11.2	0.68	3.3
103	4	4.5	0.11	5.2	5.3	5.8	5.9	1.4	Dead	Dead	Dead
104	4	5.7	0.18	5.6	5.9	6.2	6.5	0.8	Dead	Dead	Dead
105	4	8.3	0.38	8.4	8.9	9.6	10.1	1.8	10.2	0.57	1.9

	Foli-age Class	1977 DBH	Basal Area 1977	1978 DBH	1985 DBH	1992 DBH	1998 DBH	77-98 Growth	2010 DBH	Basal Area 2010	77-10 Growth
106	4	6.5	0.23	5.5	6.1	6.2	6.5	0.4	6.5	0.23	Dead
107	4	8.6	0.40	8.5	9.0	9.5	9.8	1.2	9.9	0.53	1.3
108	4	5.8	0.18	5.7	6.2	6.8	7.2	1.4	7.5	0.31	1.7
109	4	6.8	0.25	6.8	7.3	8	8.2	1.4	9.1	0.45	2.3
110	4	4.1	0.09	4.2	Dead	Dead	Dead	Dead	Dead	Dead	Dead
111	4	8	0.35	7.95	8.9	9.6	10.0	2.0	10.8	0.64	2.8
113	4	7.1	0.27	6.9	7.5	8	8.3	1.2	8.4	0.38	1.3
Number		81		81	76	72	65		48		
Basal Area			27.85							32.55	
Average growth-Live Trees (Inches)											2.36
Total Trees/ Acre 1977		526			308	292	263		194		

Table 4.10. Escobas Mesa 2 Percent Cover from 1977 to 2010

Species Name	1977	1978	1985	1992	1998	2010	No. of years
Grass							
Native grass							
Andropogon gerardii	0.1						1
Blepharoneuron tricholepis		0.09					1
Bouteloua gracilis					0.10		2
Carex spp.			1.3			0.32	2
Koeleria cristata						0.9	1
Muhlenbergia montana	0.84	1.06	13.6	1.13	1.26	0.56	6
Elymus elymoides	0.02		0.6	T		0.78	4
Pascopyrum smithii			1.0				
Sporobolus cryptandrus					0.10		1
Unid grass						0.04	1
Total Native Grass Cover	**0.96**	**1.15**	**16.50**	**1.13**	**1.46**	**2.60**	
Seeded grass							
Elymus trachycaulus			17.02				1
Festuca oviana		1.19	27.62	0.76			3
Muhlenbergia wrightii			2.16				1
Total seeded grass		**1.19**	**46.8**	**0.76**	**0**	**0**	
Total Grass Cover	**0.96**	**2.34**	**63.3**	**1.89**	**1.46**	**2.60**	
Total Grass Species	3	3	7	3	3	5	
Forbs							
Allium cernuum					.29	0.04	2
Antennaria parvifolia				0.02			1
Artemisia spp.	0.02						1
Artemisia carruthii			4.2	0.22		0.90	3
Aster spp.						0.20	1
Cheilanthes feei						0.66	1
Chenopodium spp.						0.66	1
Chenopodium album	0.1		4.0		.02		3
Chenopodium graveolens	0.9	0.18			1.97	0.24	4
Erigeron divergens						0.06	1
Euphorbia serpyllifolia					0.03		1
Hieracium spp.						.02	1
Linum neomexicanum					0.02		1
Lithospermum multiflorum					0.12		1
Lotus wrightii					0.30	.2	2

Species Name	1977	1978	1985	1992	1998	2010	No Years
Forbs (cont.)							
Penstemon secundiflorus				0.02			1
Pinus ponderosa			0.01				1
Potentilla spp.					0.36		1
Thermopsis pinetorum	0.10			0.09			2
Vicia americana					0.05		1
Unknown forb			0.03		0.31		2
Total Forb Cover	**1.12**	**0.18**	**4.64**	**.35**	**3.47**	**2.98**	
Total Forbs Species	**4**	**1**	**4**	**4**	**10**	**9**	
Shrubs							
Quercus gambelii				0.09			1
Robinia neomexicana				0.02			1
Total Shrub Cover				**0.11**			
Total Shrub Species	0	0	0	2	0	0	
TOTAL FOLIAR COVER	**2.08**	**2.52**	**67.84**	**2.35**	**4.93**	**5.58**	
Bare soil	97.92	97.48	32.16		55.35	2.28	
Litter				95.4	38.11	89.70	
Rock						0.14	
Moss				0.45	2.20		
Soil Crust					1.04		

Escobas Mesa 3

Escobas Mesa 3 is the closest plot after taking the Escobas Mesa fire road. The site is north facing and on a shallow escarpment (see Figure 4.1). The t-pole marking the site is to the northwest edge of the plot. Adjacent to Escobas Mesa 3 is Escobas Mesa 4. Escobas Mesa 3 was set up immediately after the fire and is directly adjacent to Escobas Mesa 4. Escobas Mesa 4 was established only after we observed a considerable difference in the immediate recovery of the area. Escobas Mesa 3 was a doghair stand and the adjacent plot, Escobas Mesa 4, was an open stand of larger pines. There was evidence that Escobas Mesa 4 had been logged in the early part of the 20th century. After the La Mesa Fire, soils within Escobas Mesa 3 were denuded and burned almost to mineral soil; whereas, the soils in Escobas Mesa 4 were protected by a needle mulch from the singed trees. GPS coordinates for Escobas Mesa 3 are presented below.

Overstory Conditions

This plot was a dense plot of ponderosa pine, a doghair stand, of over 800 trees per acre at the time of the fire (Figures 4.43 and 4.44). Of 221 trees in the plot, only 12 were alive after the fire, reducing the live trees per acre to 49. The mean fire damage of the 12 living trees was 4.7 with an average diameter of the original 12 trees of 11.1 inches. By 2010 all of the trees had died except two. These were in the quadrant closest to Escobas Mesa 4 and were large diameter (Table 4.11) The density of the mature trees was 404 trees per acre and 121 trees in the pole and sapling class. This was the highest density per acre of any of the plots sampled. Most all of the mature trees and saplings died, with the exception of a couple large trees on the edge of the plot closest to Escobas Mesa 4. These remaining trees had an average diameter of over 18 inches in 1998. The density was reduced 99 percent. Plate 4.13 presents tree location data for Escobas Mesa 3 through time.

In 1992, there were a number of small seedlings, particularly on the end of the plot closest to Escobas Mesa 4 where there were seed trees. The seedlings were given 300 numbers and can be seen on Table 4.12. There was evidence of browse and rubbing on these small trees. Most of the trees were severely scorched in 1998 and few were apparent in 2010. In 1992, there were 144 seedlings per acre based on the data from the plot. Plate 4.14 presents a visual comparison of loss of trees after 1978. Only the large-diameter trees survived over time.

Understory Conditions

A comparison of all species recorded for all sample years can be found in Table 4.13.

Nine grass species were found in this plot, including three of the seeded species—sheep fescue, slender wheatgrass, and spiked muhly. There was an increase in sheep fescue from 1978 to 1992 and then a reduction of cover from 1998 to 2010 (Figure 4.45). By 2010 87 percent of the grass cover was native grasses of mountain muhly, little bluestem, and *Poa* species. In 1985, 97 percent of the grasses recorded for the site were seeded. Grass cover increased from 1977 through 1992 and decreased substantially in 1998 at the time of the prescribed fire and then increased again in 2010.

The cover of individual forbs remained about the same through time, although the numbers of species increased from 0 in 1977 to 17 in 2010. Forb species were not consistent from year to year. No forb

GPS coordinates for Escobas Mesa 3

Location	Y_Coordinate_27	X_Coordinate_27	Latitude	Longitude
Escobas Mesa 1 NE	3964841	377892	0	0
Escobas Mesa 2 NW	3964797	377865	0	0
Escobas Mesa 3 SE	3964793	377884	0	0
Escobas Mesa 4 SW	3964797	377884	0	0

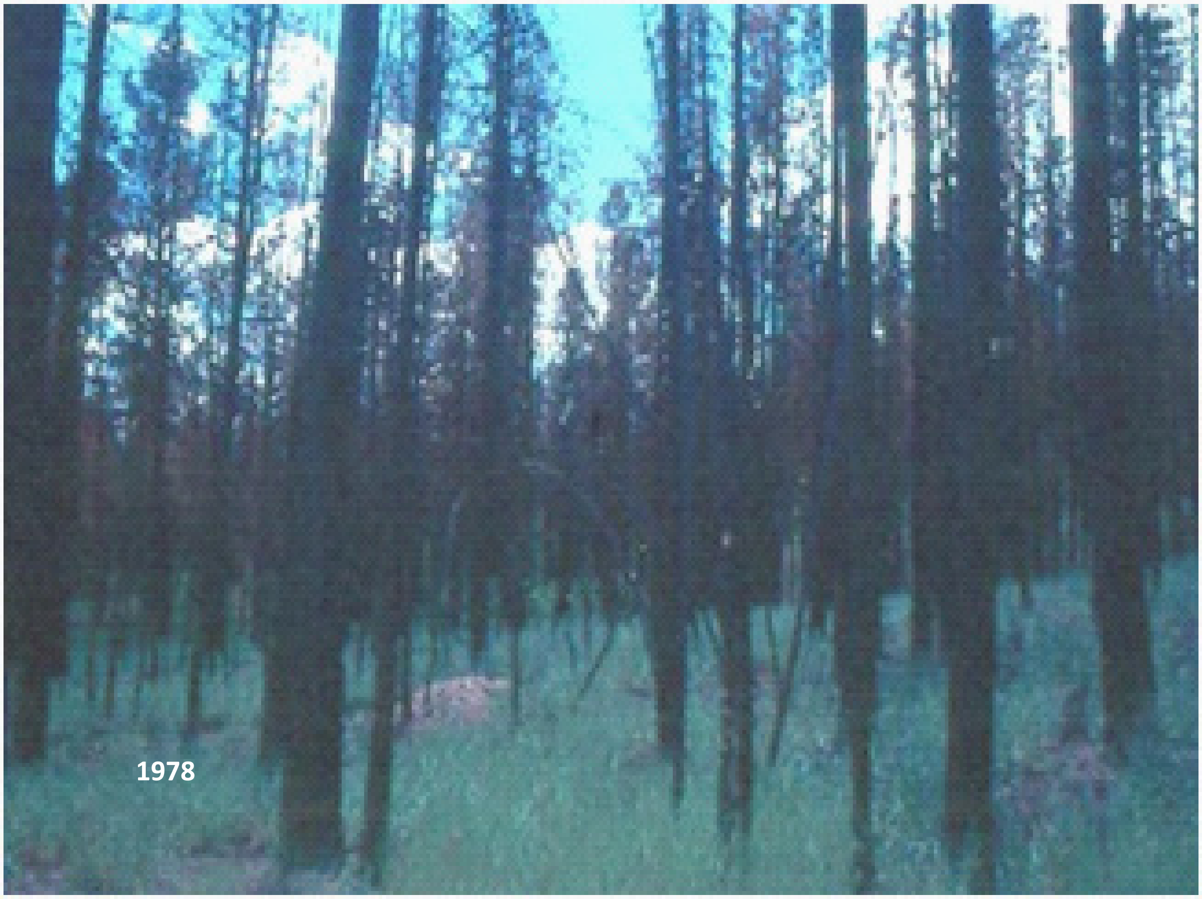


Figure 4.43. Doghair stand at Escobas Mesa 3, 1978

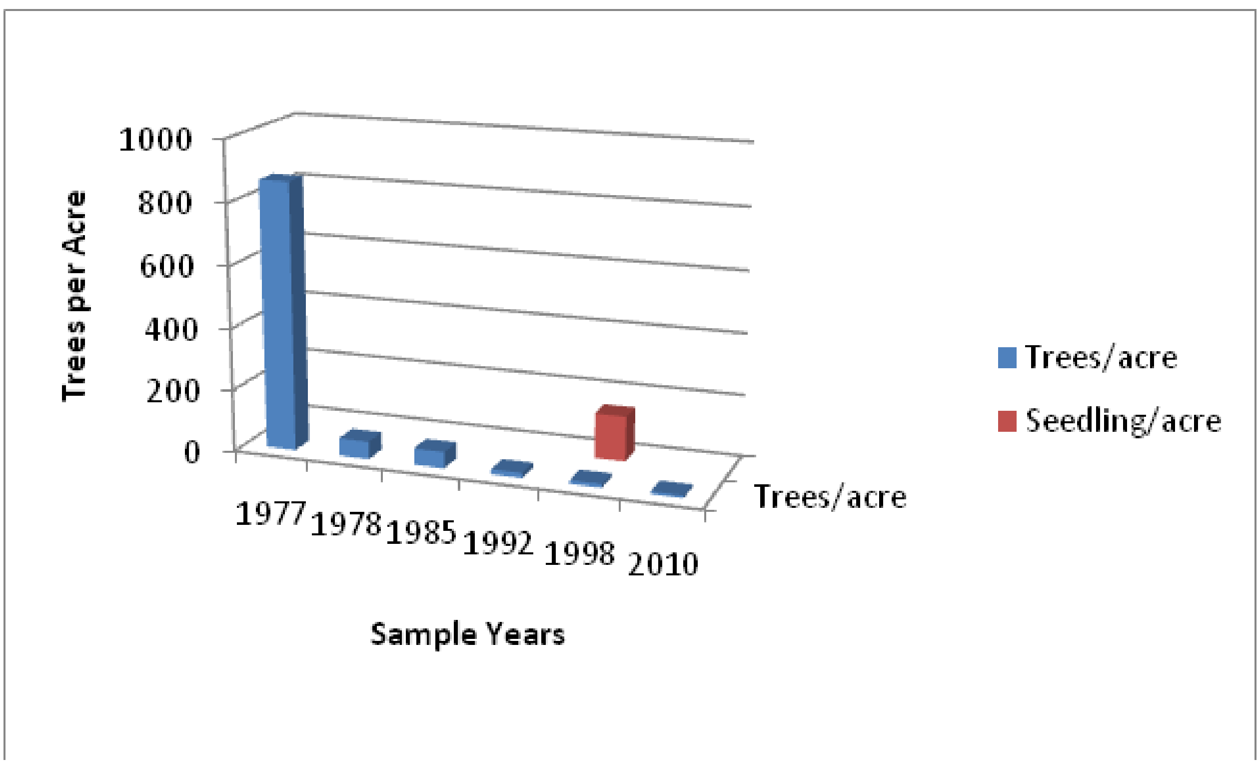


Figure 4.44. Stand characteristics of Escobas Mesa 3 before and after the La Mesa Fire

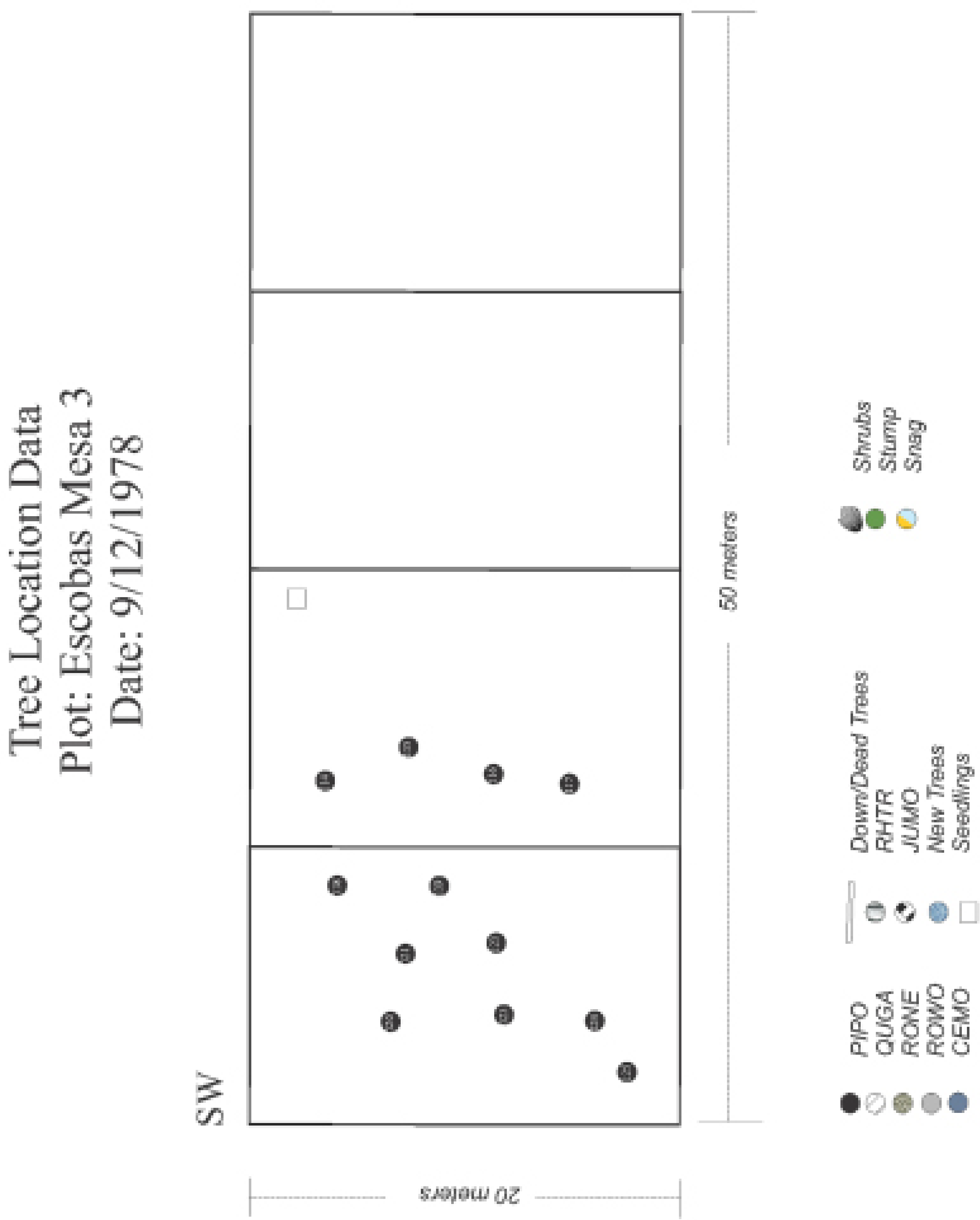


Plate 4.13. *Tree location data for Escobas Mesa 3 (continued on the next page)*

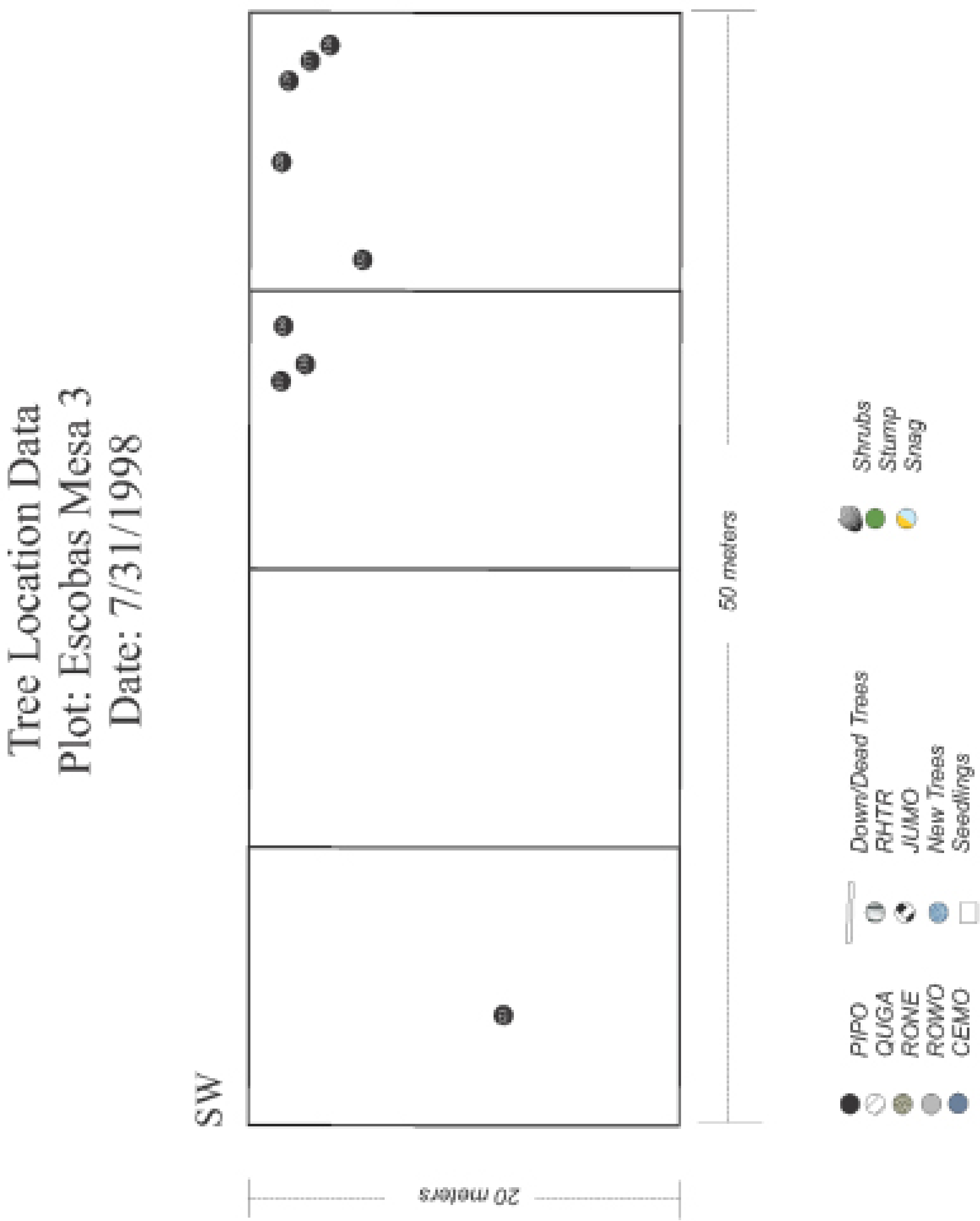


Plate 4.13. *Tree location data for Escobas Mesa 3 (continued on the next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

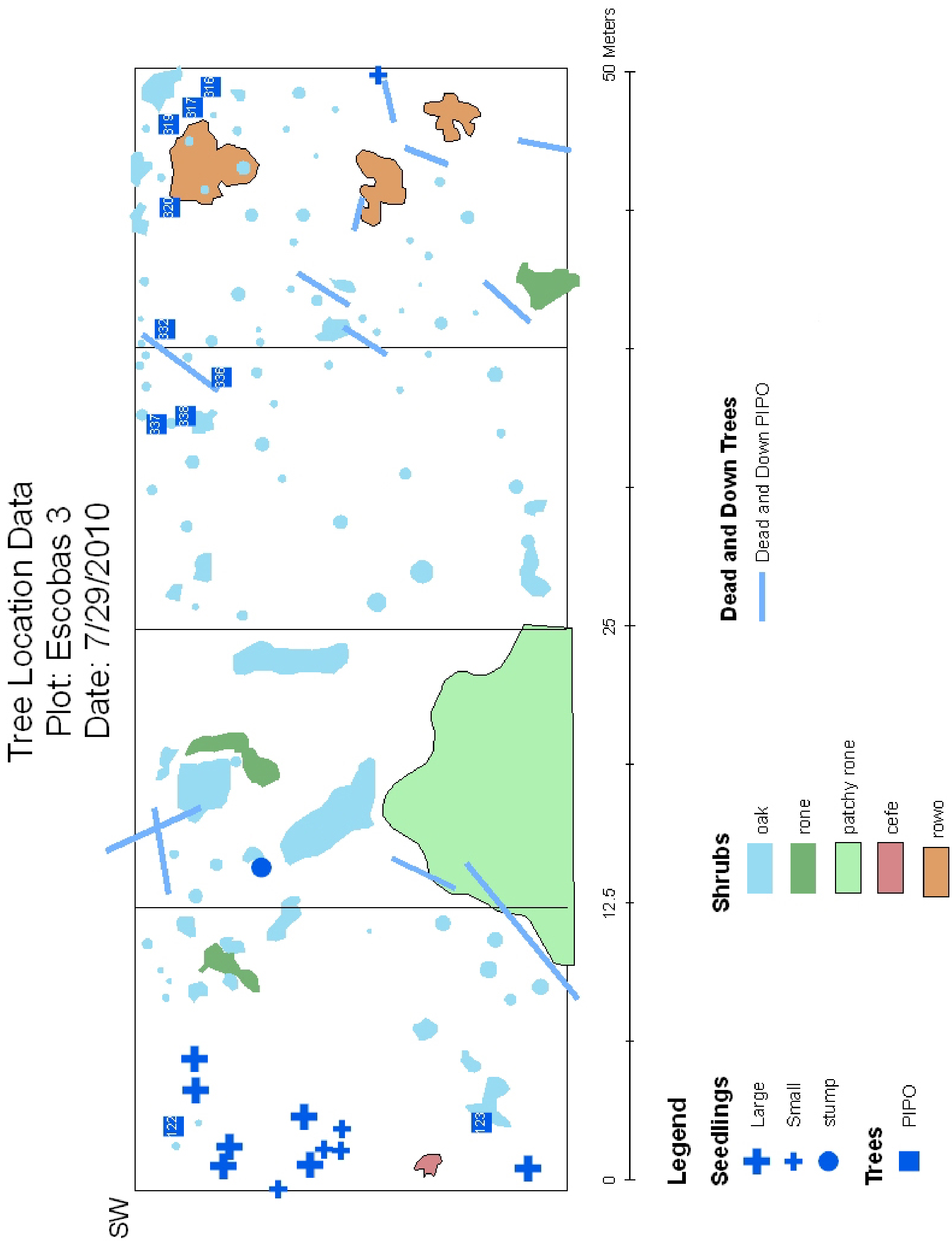


Plate 4.13. *Tree location data for Escobas Mesa 3 (continued)*

1992, showing the seedling trees and New Mexico locust

1998, after the prescribed fire; note the condition of the seedling trees.

1999, the trees had died.

Plate 4.14. *Escobas Mesa 3 through time*

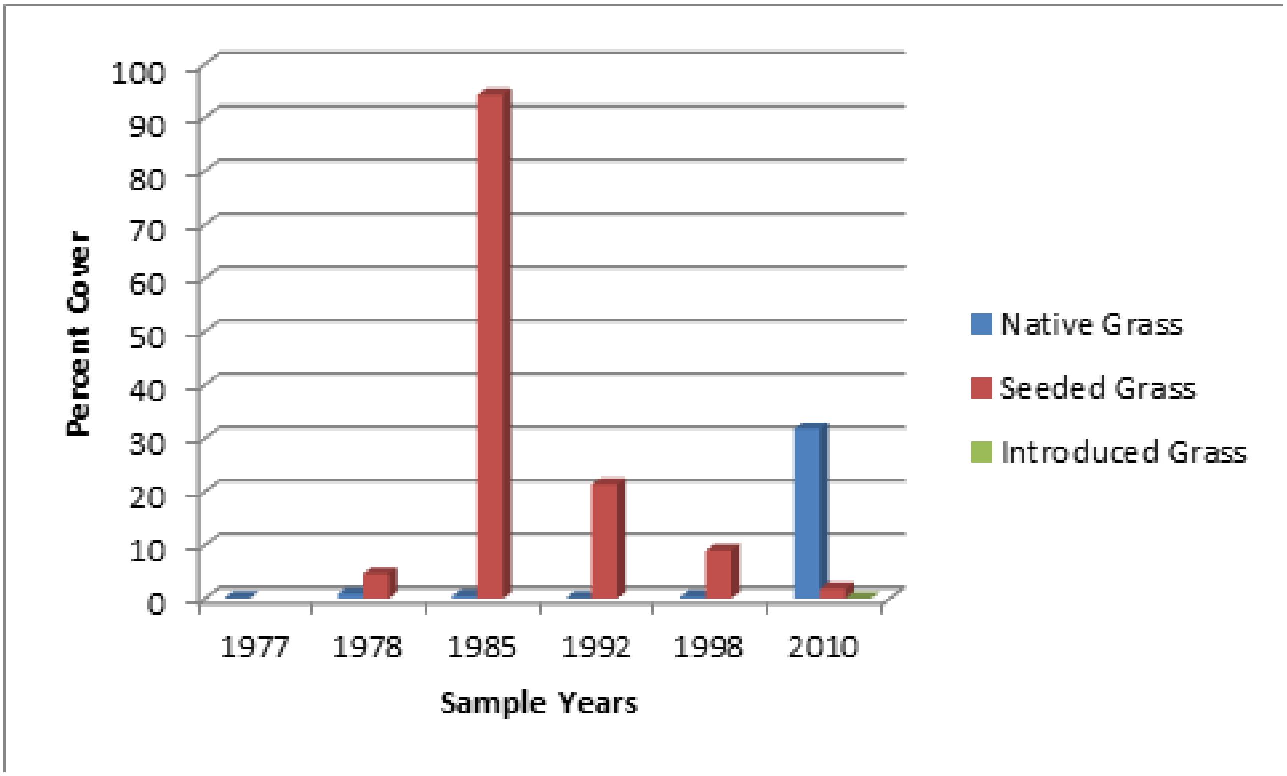


Figure 4.45. Grass cover through time, 1977 to 2010 (Seeded grass = Elymus trachycaulus, Festuca ovina*,* Muhlenbergia wrightii*; Introduced grass* = Bromus tectorum*)*

species were recorded in all sample years. By 2010, Carruth sagewort and false tarragon were quite common and had the highest percent cover (Figure 4.46).

Conditions after the 1998 Prescribed Fire

This plot did not appear to have reduction of litter after the prescribed fire. The site had a number of small trees that had singed needles that produced needle-fall and may account for the lack of reduction in the fuels. This is the only site that did not have a reduction in litter although there was an increase in bare soil (Figure 4.47).

Mapping and Photography

The severely burned plot was mapped through time (see Plate 4.13) and visual changes and changes in the stand characteristics can be seen above in Plate 4.14.

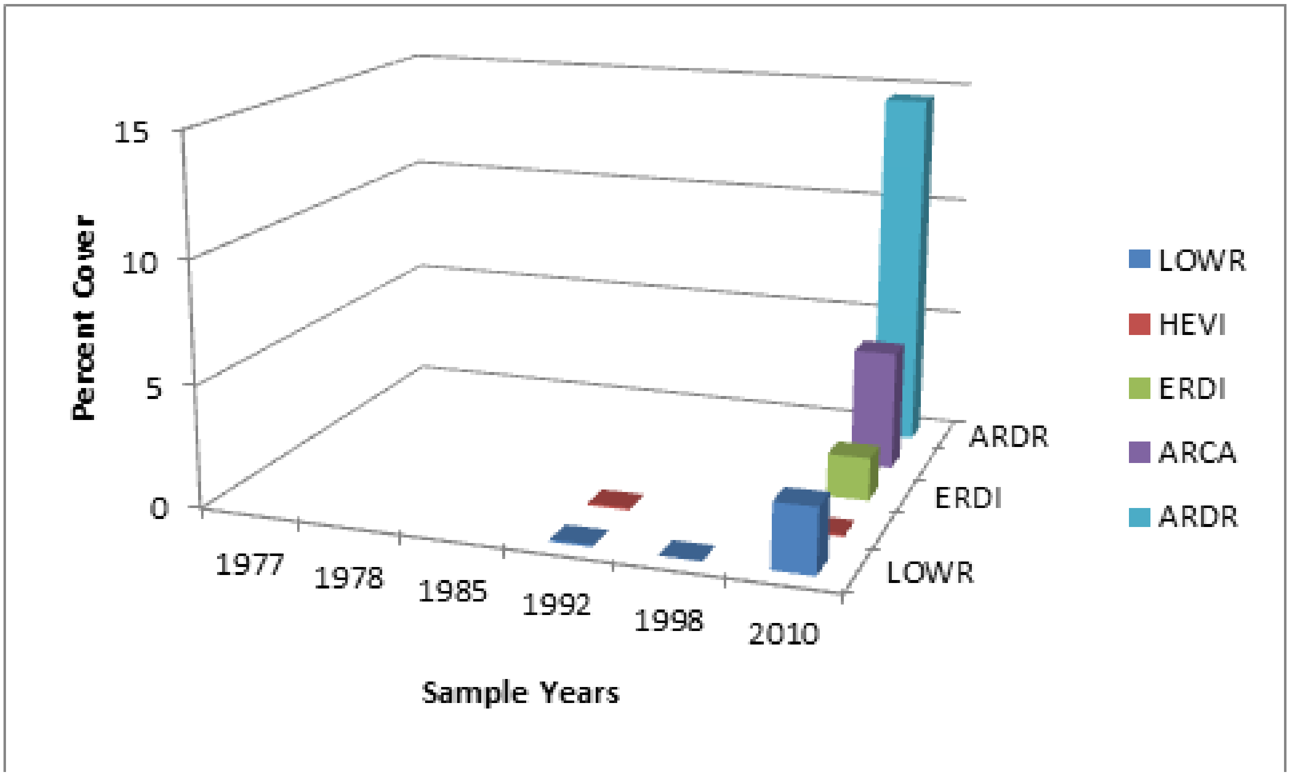


Figure 4.46. Common forb species found in Escobas Mesa 3, 1977 to 2010

(*ARCA* = Artemisia carruthii, *ARDR* = Artemisia dracunculus, *ERDI* = Erigeron divergens, *LOWR* = Lotus wrightii, *HEVI* = Heterotheca villosa)

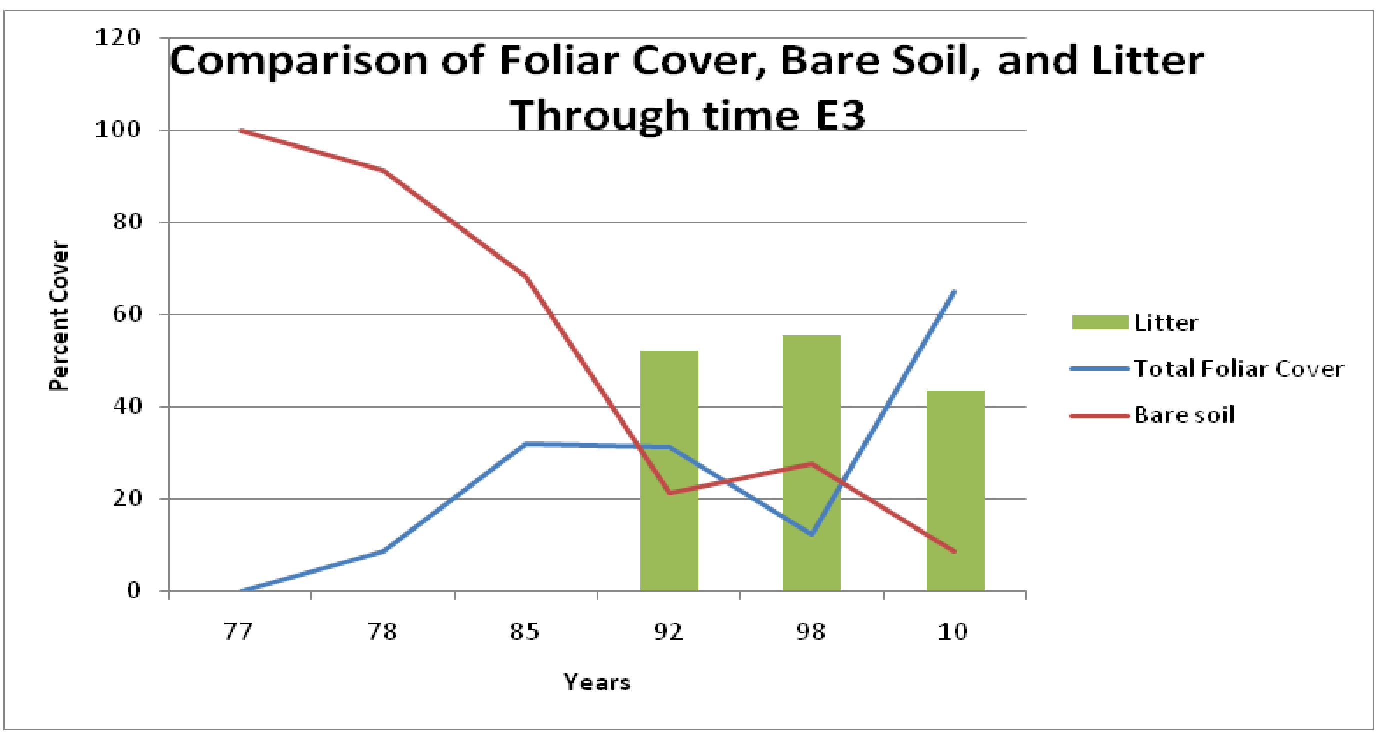


Figure 4.47. Comparison of foliar cover, bare soil, and litter for Escobas Mesa 3

Table 4.11. Size and Mortality of Living Trees within Escobas Mesa 3 from 1977 to 1998

Tree Number	Foliar Damage	1977	1978	1985	1992	1998	2010	
1998								
2010								
114	5	12.0	11.8	Dead	Dead	Dead	Dead	
115	5	7.8	7.8	Dead	Dead	Dead	Dead	
116	5	10.5	10.8	Dead	Dead	Dead	Dead	
117	5	11.8	11.8	11.8	Dead	Dead	Dead	
118	5	14.3	14.1	Dead	Dead	Dead	Dead	
119	5	9.8	9.8	Dead	Dead	Dead	Dead	
120	5	10.9	11.2	Dead	Dead	Dead	Dead	
121	4	7.1	8.8	Dead	Dead	Dead	Dead	
122	4	19.2	19.1	19.4	Dead	Dead	Dead	
123	5	15.3	14.8	15.6	17.5	18.7		3.4
124	4	7.1	7.1	8.9	10.2	Dead	Dead	
125	4	8.2	8.2	Dead	Dead	Dead	Dead	
Total	52	134.0	135.3	55.7	27.7	18.7		
Number alive		12	12	4	2	2		
1								
Average	4.3	11.1	11.3	13.9	13.8	18.7		
Living Trees per acre	16	16	16	12	8	4		

Table 4.12. Seedling Trees Present on Escobas Mesa 3 in 1992

Tree Number	Diameter	Height Feet	Animal Activity
310	1.2	6 .0	
311	1.5	6.0	
312			Browse
313	1.0	4.0	
314	1.0	3.0	
315	1.0	3.0	
316	1.0	4.0	
317	1.0	2.5	
318	1.0	3.0	
319	1.0	3.0	
320	2.2	25	
321	1.0	3.6	
322	1.5	5.0	
323	1.0	3.0	
324	2.0	5.0	
325	1.0	4.0	
326	1.0	3.6	
327	1.8	7.0	Browse/rub
328	1.9	7.0	
329	1.0	6.0	Browse/rub
330	1.0	4.6	
331	1.0	6.0	
332	1.0	4.0	
333	1.0	3.6	Browse/rub
334	2.0	5.0	
335	1.0	3.0	
336	2.0	3.0	
337	1.0	3.5	
338	1.0	5.5	
339	1.0	3.0	
340	1.0	3.0	
341	1.0	4.0	
342	1.0	4.0	
343	1.0	6.0	browse
344	1.0	5.0	
345	2.0	5.0	
346	1.0	3.0	

Table 4.13. Escobas Mesa 3 Percent Cover of Species from 1977 to 2010

Species Name	1977	1978	1985	1992	1998	2010	Number of years
Grass							
Native Grass							
Agropyron spp.						8.50	1
Blepharoneuron tricholepis		0.05					1
Bouteloua gracilis						1.10	1
Bromus tectorum						0.08	1
Carex spp.	0.02	0.10	0.23				3
Elymus elymoides						0.06	1
Muhlenbergia spp.						2.38	1
Muhlenbergia montana		0.58		0.18	0.40	13.60	4
Pascopyrum smithii		0.20	0.10				2
Poa spp.			0.20			3.80	2
Schizchyrium scoparium						2.30	1
Unidentified grass	0.11						1
Total Native Grass	**0.13**	**0.93**	**0.53**	**0.18**	**0.40**	**31.82**	
Seeded Grass							
Elymus trachycaulus		2.05	15.98	0.29			3
Fetuca ovina		2.54	74.26	20.0	5.45	1.88	5
Muhlenbergia wrightii		0.07	4.04	1.09	3.53		4
Total Seeded Grass		**4.66**	**94.28**	**21.38**	**8.98**	**1.88**	
Introduced Grass							
Bromus tectorum						0.08	1
Total Introduced Grass						**0.08**	
Total Grass Cover	**0.13**	**5.59**	**94.81**	**21.56**	**9.38**	**33.78**	
Total Grass Species	2	7	6	4	3	10	
Forbs							
Achillea lanulosa					0.05	0.20	2
Antennaria parvifolia				0.09	0.13		2
Artemisia carruthii						4.88	1
Artemisia dracunculus						14.60	1
Artemisia ludoviciana						0.30	1
Bahia dissecta						0.08	1
Brickellia spp.				0.09			1
Cheilanthes feei					0.03		1
Chenopodium spp.						0.12	1
Chenopodium graveolens	0.01	0.10					
Cirsium neomexicanum				0.29			1
Cirsium undulatum					0.66		1

Species Name	1977	1978	1985	1992	1998	2010	Number of Years
Forb (cont.)							
Erigeron divergens						1.76	1
Erigeron flagellaris					0.23		1
Euphorbia serpyllifolia					0.01		1
Heterotheca villosa				0.09		0.08	2
Ipomopsis aggregata						0.08	1
Lactuca serriolata						0.06	1
Lithospermum multiflorum					0.01		1
Lotus wrightii				0.09	0.01	2.64	3
Polygonum spp.					0.05		1
Senecio spp.			0.1	0.33	0.05		3
Taraxaum officinale						0.20	1
Tragopogon spp.			0.06				1
Verbascum thapsus					0.63	0.78	2
Vicia americana				0.02			1
Viguera multiflora						0.26	1
Unknown forb					0.01	0.54	2
Total Forb Cover	**0.01**	**0.1**	**0.16**	**1.0**	**1.87**	**26.58**	
Total Forb Species	**1**	**1**	**2**	**7**	**12**	**15**	
Shrubs							
Ceanothus fendleri			0.14	0.27	0.06		3
Rosa spp.		0.02	0.28	0.36			3
Quercus gambelii		0.03	0.32	0.91		2.0	3
Robinia neomexicana		0.02	0.02	9.00	1.03	8.64	5
Juniperus monosperma				.02			
Total Shrub Cover	**0**	**0.07**	**0.76**	**10.56**	**1.09**	**10.64**	
TOTAL FOLIAR COVER	**0.14**	**5.76**	**95.73**	**33.12**	**12.34**	**71**	
Bare Soil	**99.90**	**94.24**	**4.27**	**21.10**	**27.70**	**8.56**	
Litter				52.30	55.95	43.72	
Rock					3.98	15.38	
Soil Crust				2.45	0.11	5.14	

Escobas Mesa 4

Escobas Mesa 4 is southeast of Escobas Mesa 3 in an area that, from all indications, was logged 50 to 60 years ago. The gentle slope faces west toward Escobas Mesa 3. This plot was not established immediately after the fire but later when we saw a definite contrast in recovery in this previously logged area. GPS coordinates are presented below.

Overstory Conditions

Adjacent to Escobas Mesa 4, John Dieterich had collected a sample from a stump for dendrochronological studies (Figure 4.48) (Dieterich 1976). From the condition of the stump, he estimated that the area was logged 50 to 60 years ago. The Timber Management Plan for the Los Alamos Working Circle indicates that the first management plan for the area was drawn up in 1923, but timber had been harvested without a plan since 1894 by Buckman. Most of the logging done in the Los Alamos area (town site and vicinity) during 1923–1931 was used by the Ranch School for building logs, poles, and cordwood. The Ramon Vigil Grant included this area on Escobas Mesa and was logged by Buckman.

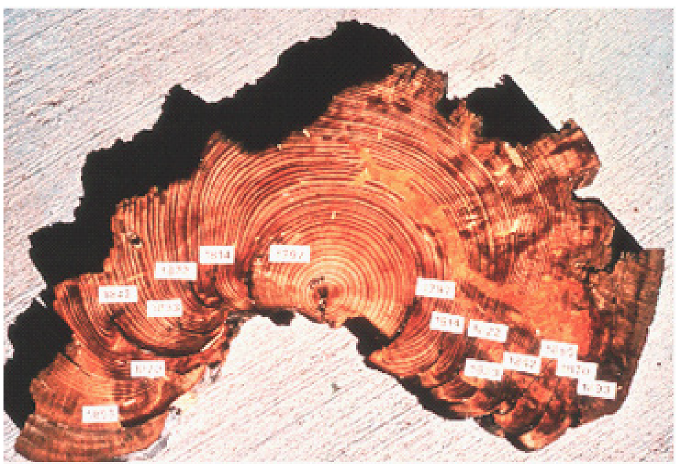


Figure 4.48. Cross section taken from a logged stump near Escobas Mesa 4

There is some indication that logging in the immediate area of the origin of the La Mesa Fire was done to furnish timbers for the railroad that supplied the town of Buckman. Mr. Pickens indicated that logging was done after 1927 in the Ramon Vigil Grant area and what logging was being done was in conjunction with homesteading—particularly clearing of fields and building of homes. Monthly reports to the Southwest Monuments Association indicate some logging was done for the purpose of supplying vigas for the lodges in Frijoles Canyon during the early 1930s on the Ramon Vigil Grant, but areas were not specified.

The logging history of this site was known because of the cross section, which was from a logged stump. Further fire history is not known. Because of the previous history, the area was open with large trees. Adjacent was a severely burned area where Escobas Mesa 3 had been established. Soon after the fire, the recovery of grass in the previously logged area was striking as compared to the adjacent Escobas Mesa 3. For that reason we set up a fourth plot on the mesa, Escobas Mesa 4, as a comparison to the severely burned Escobas Mesa 3.

The comparison of the two adjacent areas was obvious (Figures 4.49 and 4.50). In Escobas Mesa 3, which had over 800 trees per acre, trees had burned severely. The average diameter of the trees was 4.7 inches. There were only 14 trees alive (57 trees per acre) with an average severity class of 5.8. Escobas Mesa 4 had 300 trees per acre; the average diameter was 8.1 inches. There were 30 trees alive (221 trees per acre) with an average foliar damage of 4.6.

In 2010, Escobas Mesa 3 was a meadowed area with forbs and shrubs and only two trees alive, mostly in the area directly adjacent to Escobas Mesa 4. Both trees are of a large diameter (25.1 and 18.7 inches dbh). In the Escobas Mesa 4 plot there are

GPS coordinates for Escobas Mesa 4

Location	Y_Coordinate_27	X_Coordinate_27	Latitude	Longitude
E4 NE	3964798	377914	0	0
E4 NW	3964803	377895	0	0
E4 SE	3964750	377901	0	0
E4 SW	3964754	377881	0	0

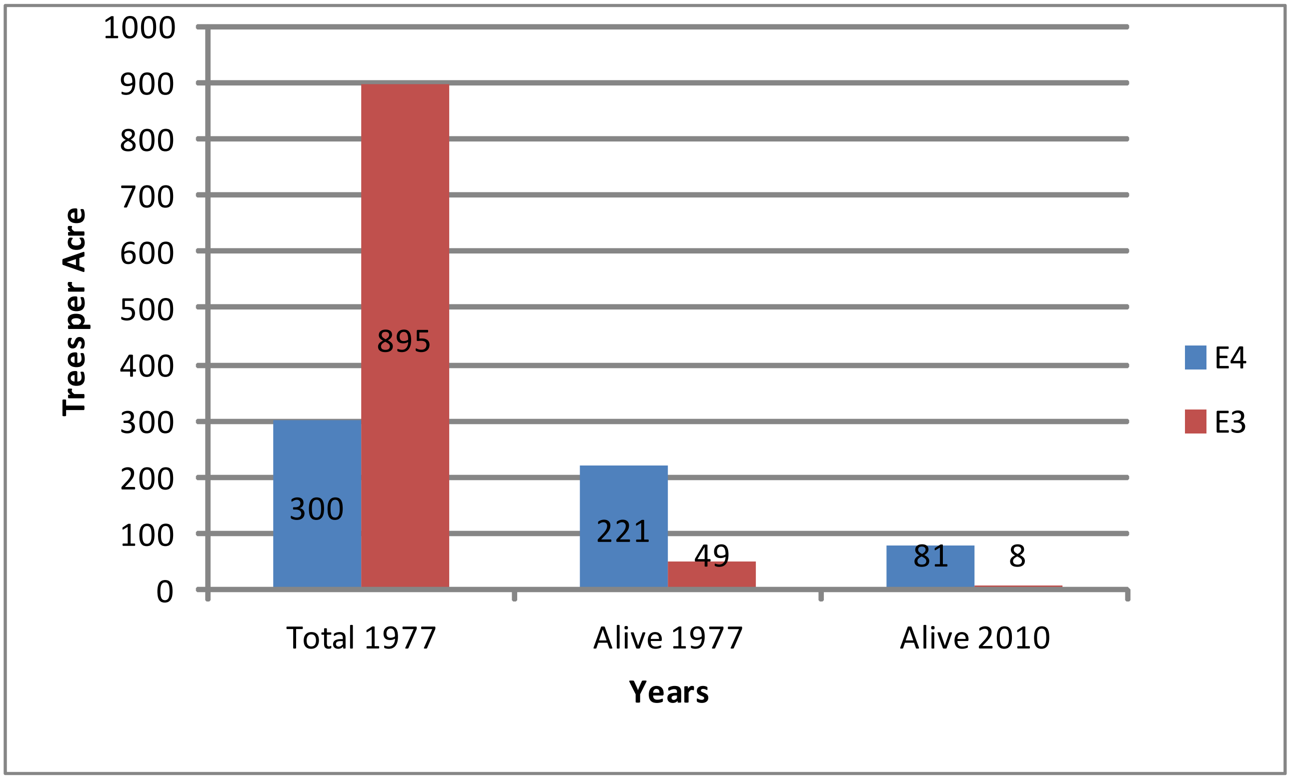


Figure 4.49 Comparison of Escobas Mesa 3 and Escobas Mesa 4 tree density (in acres) at the time of the La Mesa Fire and the number of trees alive in 2010

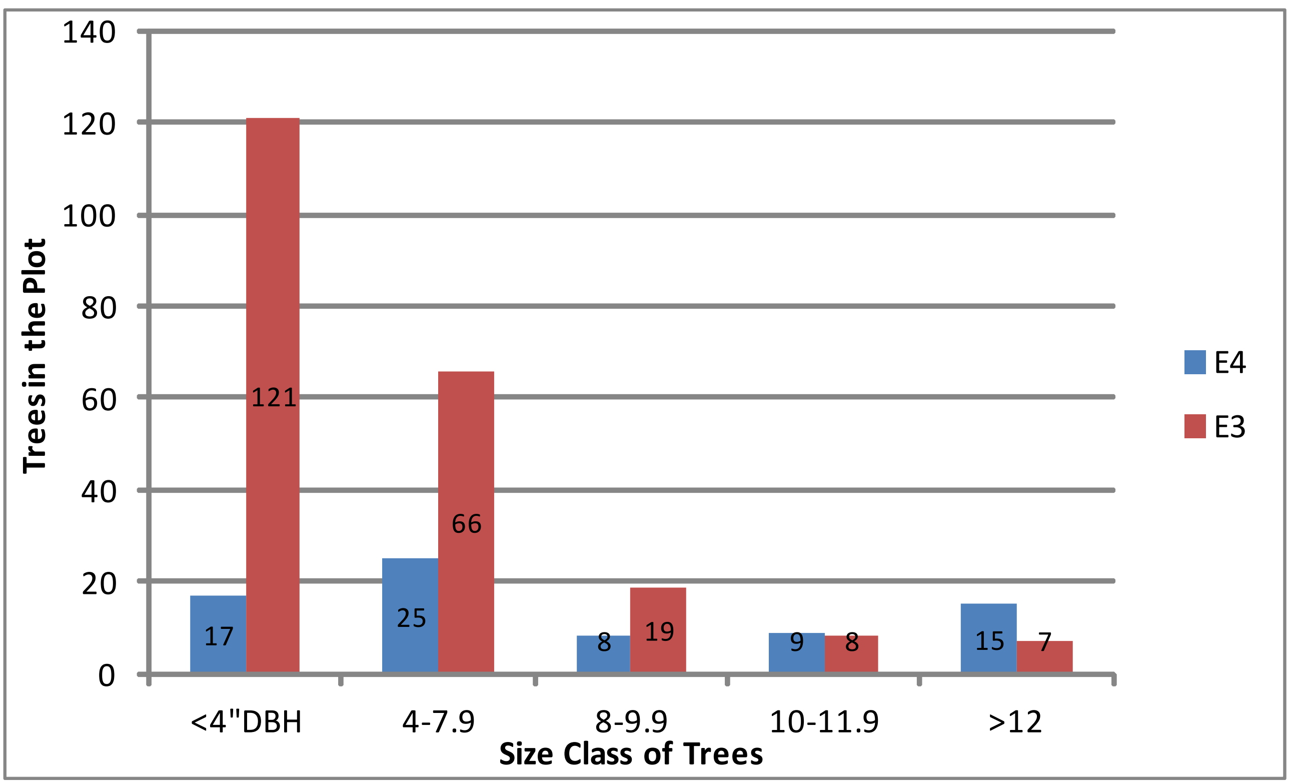


Figure 4.50 Comparison of the size class of trees within Escobas Mesa 3 (E3) and Escobas Mesa 4 (E4) in 1977 at the time of the La Mesa Fire

20 trees alive. The diameter of the trees range from 9.4 inches to 27 inches with an average diameter of 15.7 inches. Most of the trees that died in Escobas Mesa 4 were in the quadrant of the plot adjacent to the severely burned Escobas Mesa 3 and were of small size classes.

After the Las Conchas Fire we returned and found only one tree had died since 2010. That tree had broken off and died. No data were taken.

Table 4.14 presents size and mortality of trees within Escobas Mesa 4. Table 4.15 shows seedlings found at Escobas Mesa 4 in 1992 and their status in 1998. Plate 4.15 presents maps of the distribution of trees within the plot beginning in 1978 and subsequently through time.

Understory Conditions

The seeded grasses dominated this site until 2010. In 2010, mountain muhly had a higher cover than did sheep fescue (Figure 4.51). Grass cover was highest in 1978 and 1985 when slender wheatgrass and sheep fescue were dominant. Sheep fescue seems to be the dominant grass on this plot as it was recorded four out the five years.

The cover of individual forbs remained about the same through time as did the total number of species (Figure 4.52). No species increased after the prescribed fire. Table 4.16 presents a comparison of percent cover for all species from 1977 to 2010.

Conditions after the 1998 Prescribed Fire

There was a 29 percent reduction in litter at this site (Figure 4.53). This included needles and the many logs that dominated the site from tree fall. Vegetation cover increased after the prescribed fire.

Mapping and Photography

The moderately burned/logged plot was mapped through time (see Plate 4.15) and visual changes and changes in the stand characteristics can be seen in Plate 4.16.

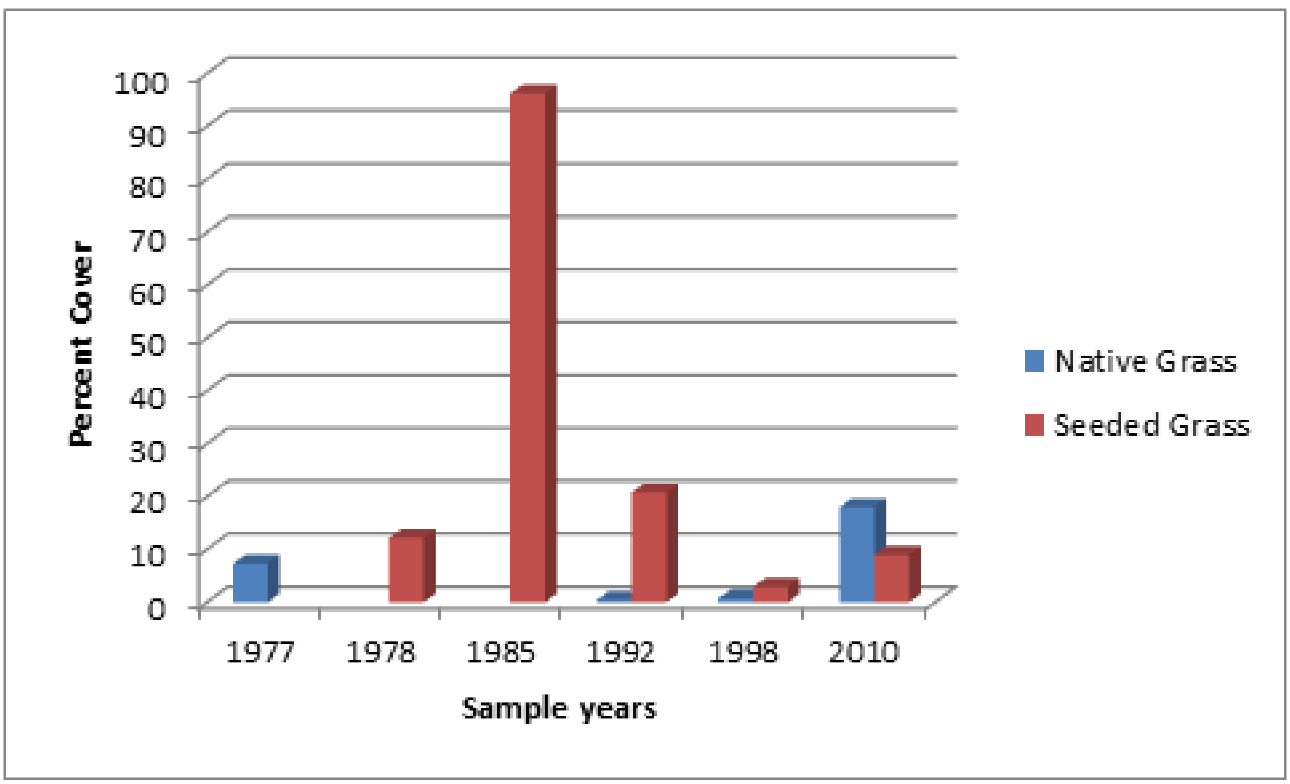


Figure 4.51. Comparison of seeded and native grass cover from 1977 to 2010

(Seeded grasses include Elymus trachycaulus*,* Festuca ovina*,* Muhlenbergia wrightii*)*

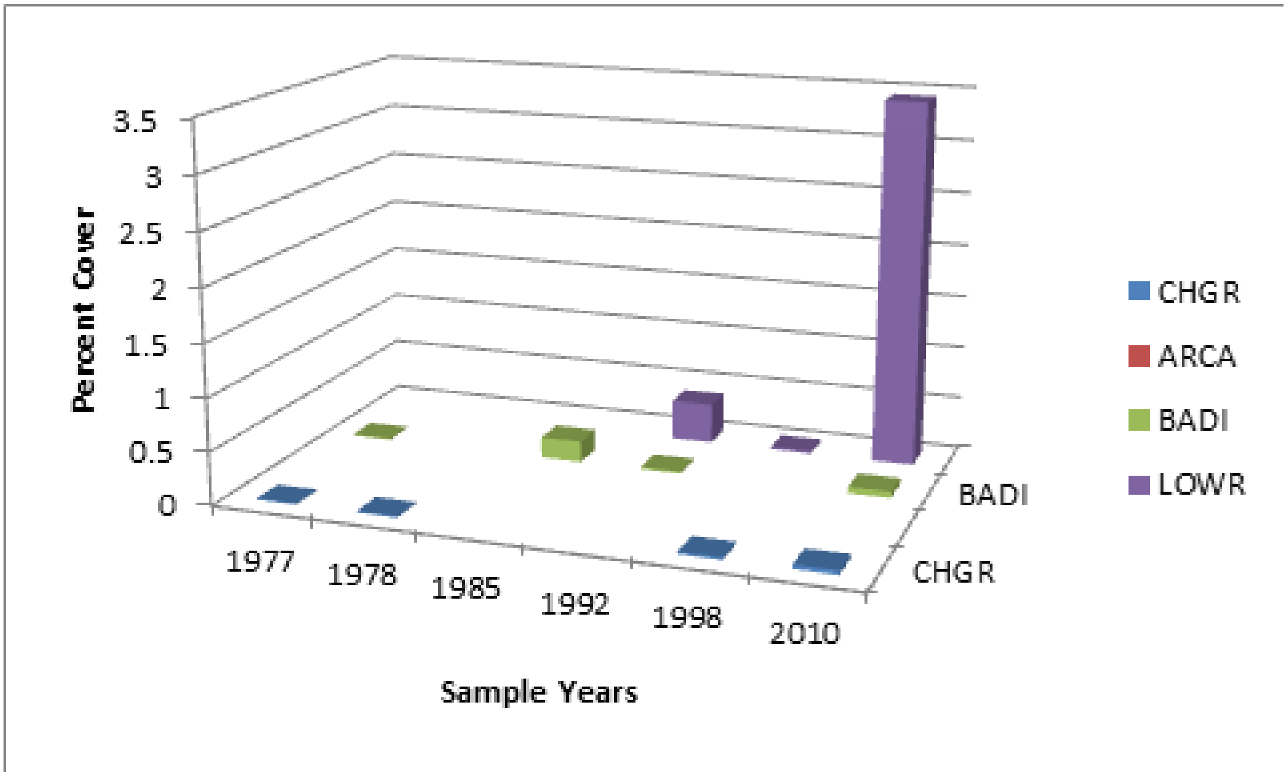


Figure 4.52. Common forbs in Escobas Mesa 4 through time, 1977 to 2010
(BADI = Bahia dissecta, *CHGR* = Chenopodium graveolens, *LOWR* = Lotus wrightii,
ARCA = Artemisia carruthii*)*

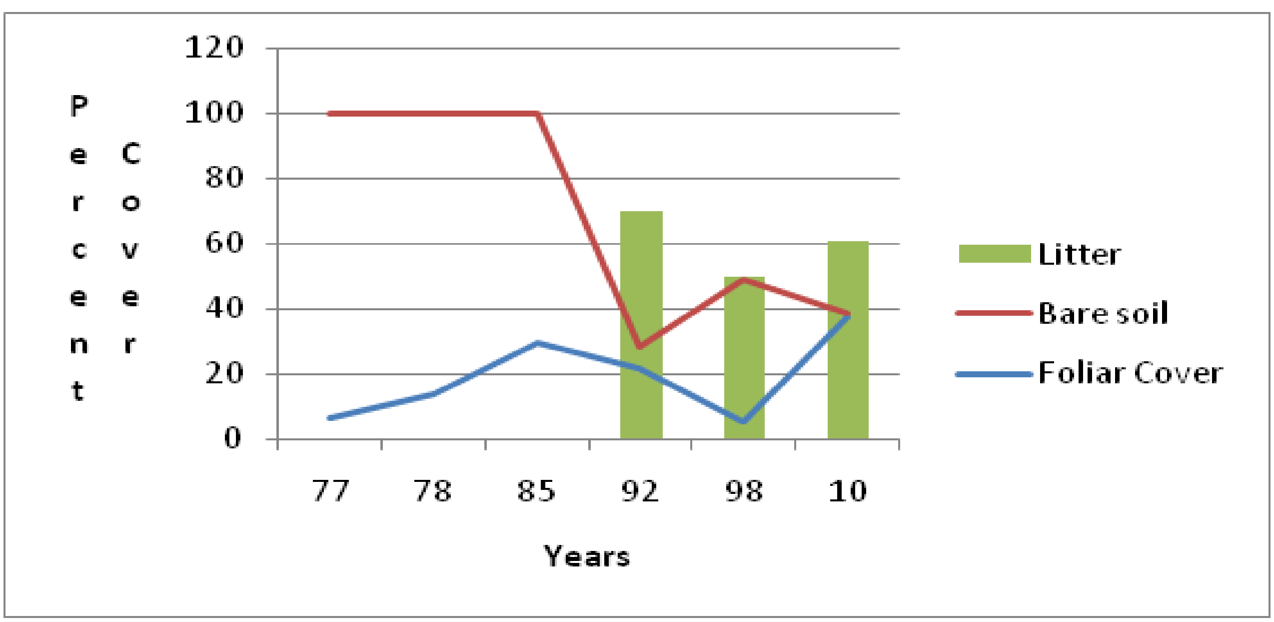


Figure 4.53. Comparison of bare soil, foliar cover, and litter for Escobas Mesa 4

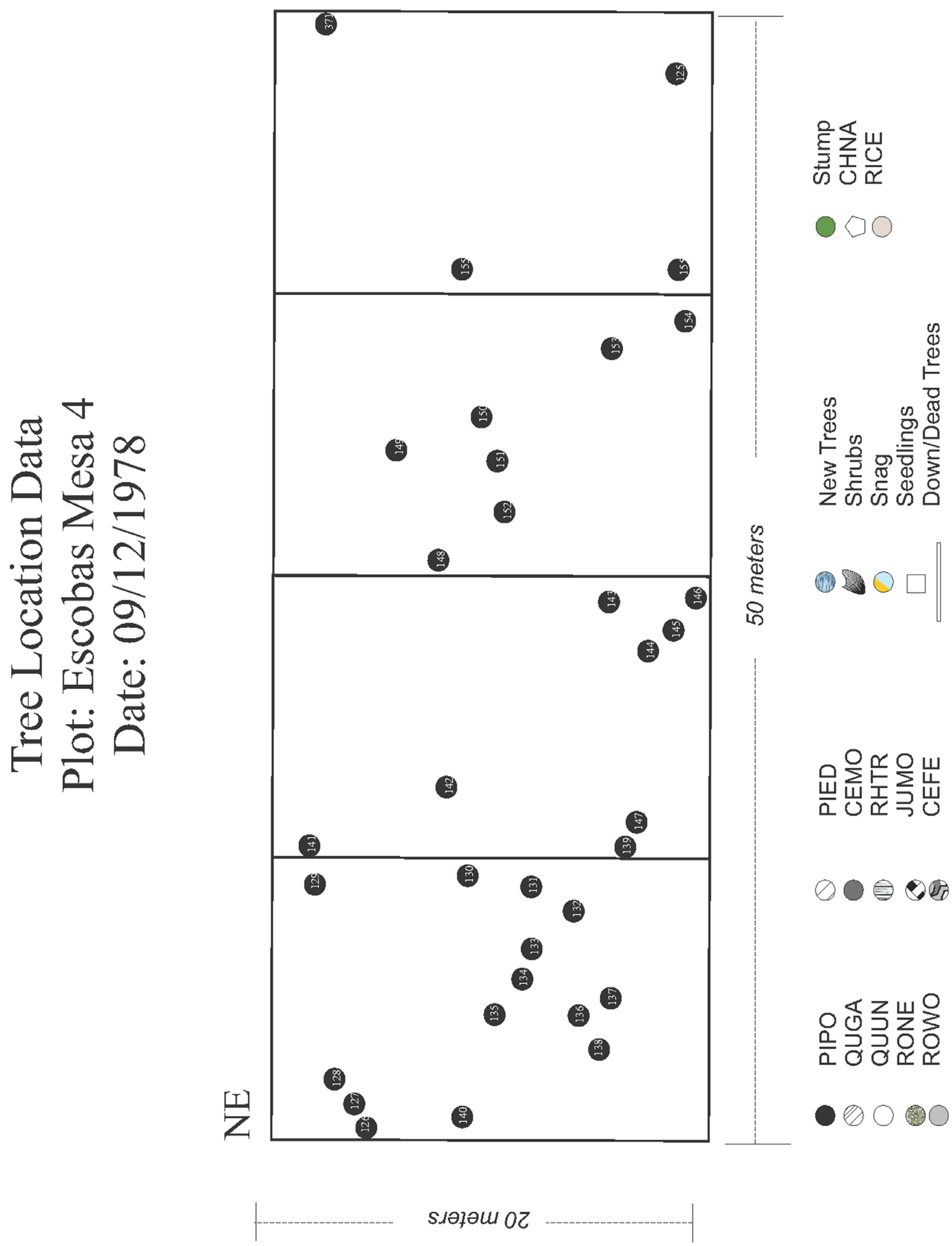


Plate 4.15. *Tree location data for Escobas Mesa 4 (continued on the next page)*

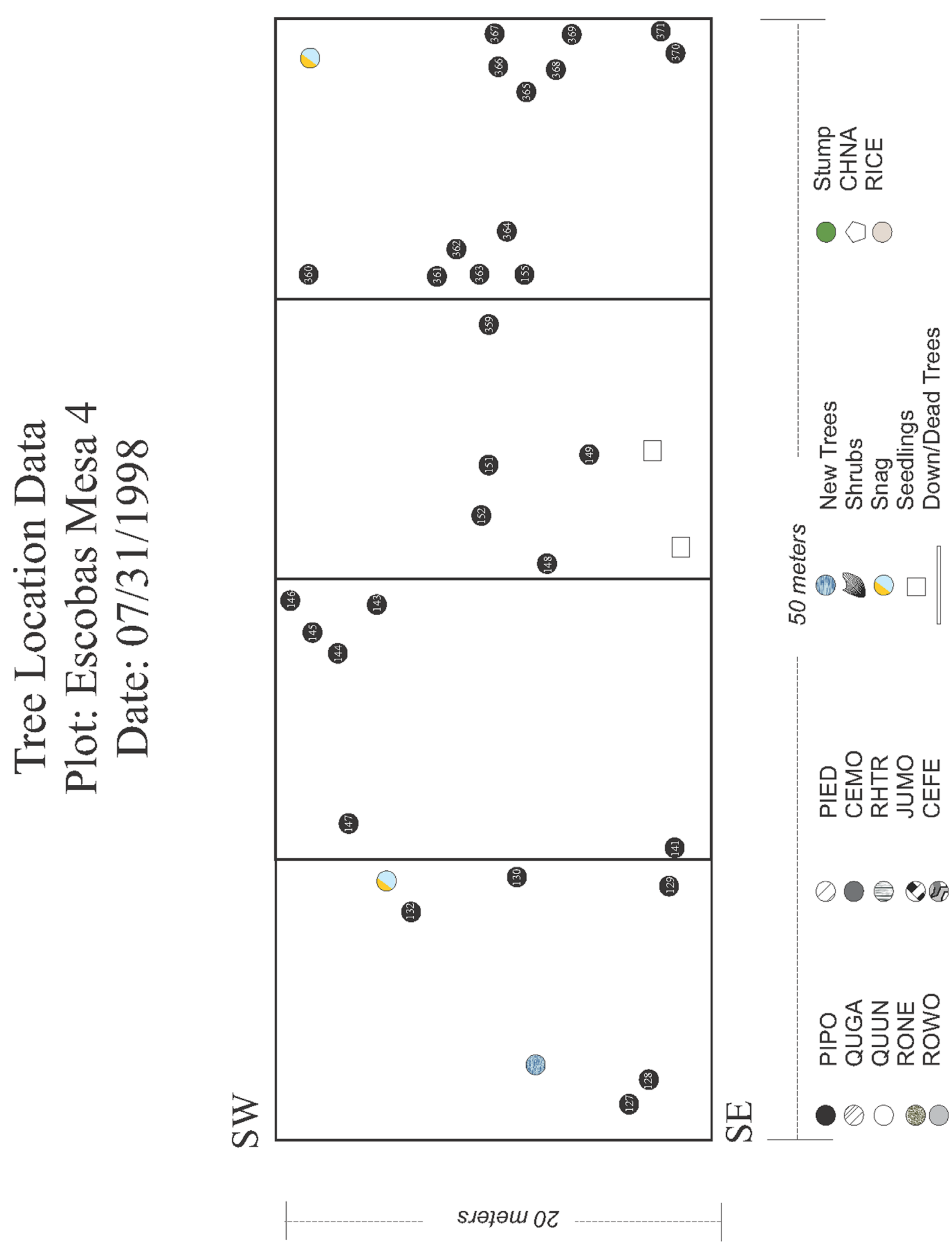


Plate 4.15. *Tree location data for Escobas Mesa 4 (continued on the next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

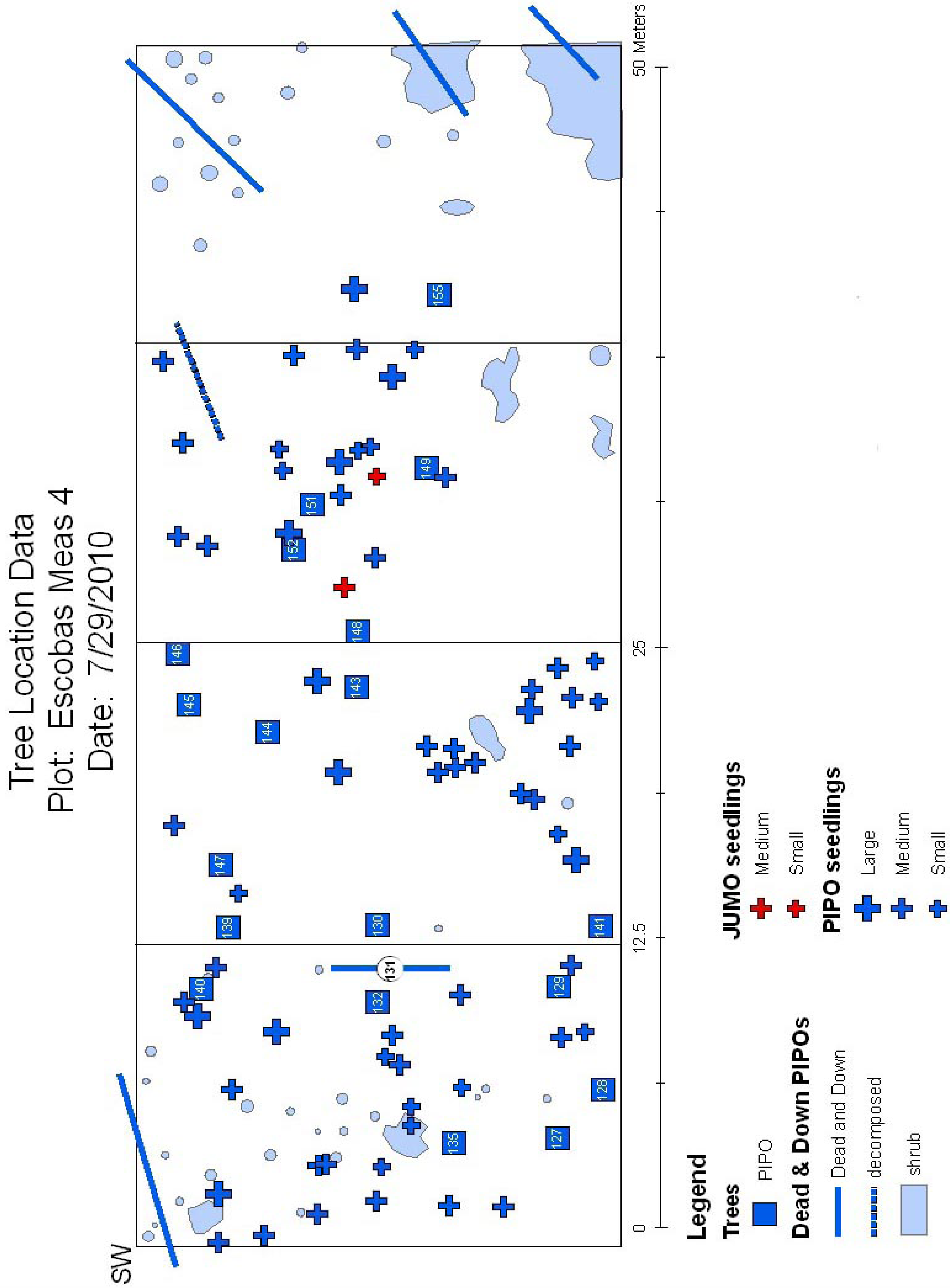


Plate 4.15. *Tree location data for Escobas Mesa 4 (continued)*

Plate 4.16. *Escobas Mesa 4 through time*

Table 4.14. Size and Mortality of Trees within Escobas Mesa 4 Through Time

Tree Number		1977 DBH (inches)	Basal Area 1977	1978 DBH (inches)	1985 DBH (inches)	1992 DBH (inches)	1998 DBH (inches)	2010 DBH (inches)	Basal Area 2010	77-2010 Growth (inches)
145	3	16.8	1.54	15.9	16.7	18.0	18.6	19.1	1.99	2.3
146	3	15.9	1.38	15.9	16.4	17.9	18.6	19.5	2.07	3.6
152	3	14.2	1.10	13.0	13.0	14.1	14.6	14.6	1.16	0.4
155	3	23.1	2.91	23.1	23.5	25.4	25.9	27.3	4.06	4.2
126	4	9.1	0.45	9.5	Dead	Dead	Dead	Dead	Dead	Dead
127	4	11.5	0.72	11.3	11.9	13.6	15	16.5	1.48	5.0
128	4	10.1	0.56	10.5	11.0	11.3	12.3	12.2	.81	2.1
129	4	16.5	1.48	16.7	17.3	17.8	18.8	18.9	1.95	2.4
130	4	12.6	0.87	12.6	12.6	14.0	14.7	15.3	1.28	2.7
131	4	11.1	0.67	12.6	11.9	12.6	12.6	13.0	.92	1.9
132	4	13.2	0.95	13.0	13	14.7	15.5	16.2	1.43	3
133	4	9.5	0.49	9.5	Dead	Dead	Dead	Dead	Dead	Dead
134	4	7.9	0.34	8.9	Dead	Dead	Dead	Dead	Dead	Dead
135	4	8.3	0.38	8.3	8.5	9.3	ND	10	.55	1.7
136	4	8.5	0.39	8.2	Dead	Dead	Dead	Dead	Dead	Dead
137	4	8.6	0.40	8.5	Dead	Dead	Dead	Dead	Dead	Dead
138	4	7.7	0.32	7.7	Dead	Dead	Dead	Dead	Dead	Dead
139	4	12.5	0.85	12.0	12.2	12.5	ND	13.2	.95	0.7
140	4	15.3	1.28	15.0	15.3	ND	ND	17.7	1.71	2.4
141	4	9.9	0.44	8.7	9.0	ND	ND	9.4	.48	0.4
143	4	13.0	0.92	13.5	14.5	15.5	ND	15.8	1.36	2.8
144	4	11.6	0.73	11.2	11.7	12.5	ND	13.2	.95	1.6
147	4	14.6	1.16	13.9	14.3	14.9	ND	15.7	1.34	1.1
148	4	13.4	0.98	13.3	14.4	17.9	ND	16.6	1.50	3.2
149	4	10.5	0.60	10.5	10.5	11.0	12.5	13.1	.94	2.6
150	4	11.8	0.76	10.0	Dead	Dead	Dead	Dead	Dead	Dead
151	4	12.9	0.91	13.0	13.2	14.8	15.5	16.4	1.47	3.5
153	4	10.3	0.58	9.7	Dead	Dead	Dead	Dead	Dead	Dead
154	4	11.3	0.70	11.3	Dead	Dead	Dead	Dead	Dead	dead

Tree Number		1977 DBH (inches)	Basal Area 1977	1978 DBH (inches)	1985 DBH (inches)	1992 DBH (inches)	1998 DBH (inches)	2010 DBH (inches)	Basal Area 2010	77-2010 Growth (inches)
142	5	6.5	0.23	6.9	Dead	Dead	Dead	Dead	Dead	Dead
Total		357.3	25.10	354.2	270.9	267.8	194.6	313.7	28.41	47.6
Total number live Trees		30 (121/ acre)		30	20	20	20	20 (81/ acre)		20
Average DBH		11.9						15.7		
Total Trees dead 1977		44 (178 / acre)								
Avg. Foliar Class 1977	4.6 (alive 3.9)									

Table 4.15. Escobas Mesa 4 Seedlings Found in 1992 and Status in 1998

Tree Number	1998
348	Dead
349	Dead
350	Dead
351	Dead
352	Dead
353	Dead
354	Dead
355	Dead
356	Dead
357	Dead
358	Dead
359	
360	
361	
362	
363	
363	
364	
365	
366	
367	
368	
369	
370	
371	

Table 4.16. Escobas Mesa 4 Comparison of Percent Cover for all Species from 1977 to 2010

Species Name	1977	1978	1985	1992	1998	2010	No. years
Grass							
Native Grass							
Agropyron spp.				0.29		0.6	2
Andropogon gerardii	0.02						1
Carex spp.	1.99						1
Elymus elymoides						3.08	1
Koeleria cristata						2.40	1
Muhlenbergia spp.						0.14	1
Muhlenbergia montana				0.18	0.64	7.02	3
Pascopyrum smithii					0.10		1
Poa spp.						0.24	1
Schizchyrium scoparium						3.90	1
Sporobolus spp.						0.40	1
Unidentified grass	5.30					0.22	2
Total Native Grass Cover	**7.31**	**0**	**0**	**0.47**	**0.74**	**18.00**	
Seeded grass							
Elymus trachycaulus		4.28	8.98	0.78		0.60	4
Festuca ovina		7.88	85.83	19.9	2.88	8.94	5
Muhlenbergia wrightii			0.4	0.09			2
Total Seeded Grass		**12.16**	**95.21**	**20.77**	**2.88**	**9.54**	
Total Grass Cover	**7.31**	**12.16**	**95.21**	**21.24**	**3.62**	**27.54**	
Total Grass Species	**3**	**2**	**3**	**5**	**3**	**11**	
Forbs							
Allium cernuum	0.05						1
Antennaria parvifolia				0.02	0.10	0.10	3
Artemisia carruthii						.88	1
Bahia dissecta	0.01		0.02	0.02		0.06	4
Cerastium arvense						0.06	1
Chenopodium						0.04	1
Chenopodium album	0.06						1
Chenopodium graveolens	0.01	0.01			0.02	0.04	4
Descurania spp.						0.40	1
Erigeron divergens		0.01				0.56	2
Geranium caespitosum			0.04	0.09			2
Ipomopsis aggregata						0.12	1
Linum neomexicanum	0.01				0.10		2
Lithospermum multiflorum			0.16	0.07			2

Species	1977	1978	1985	1992	1998	2010	No. years
Forbs (cont.)							
Lotus wrightii				0.38	0.02	3.44	3
Lupinus caudatus			0.1				1
Lupinus kingii				0.02			1
Penstemon spp.						0.10	1
Taraxicum officinale						0.20	1
Verbascum thapsus						0.56	1
Viguiera multiflora						1.46	1
Vicia americana						0.28	1
Unknown forbs						1.34	1
Total Forb Cover	**0.14**	**0.02**	**0.32**	**0.60**	**0.44**	**9.64**	
Total Forb Species	**5**	**2**	**4**	**6**	**4**	**16**	
Shrubs							
Ceanothus fendleri				0.36			1
Pinus ponderosa seedling			T	0.11			2
Robinia neomexicana				0.09	0.87		2
Total Shrub				**0.56**	**0.87**		
Total Shrub Species			**1**	**0**	**1**		
TOTAL FOLIAR COVER	**7.45**	**12.18**	**95.53**	**22.40**	**4.93**	**37.18**	
Bare soil	93.40	86.00		6.60	43.29	1.10	
Litter				70.40	50.80	77.26	
Rock						4.00	
Wood						1.46	
Soil Crust				1.0	1.00	1.92	

4.3 Los Alamos National Laboratory TA-49

After the fire, BNM participated in a project with the USFS to seed grasses by helicopter. All of the burned area of the Monument was to be seeded. None of the LANL lands that had been burned were to be re-seeded. In 1978, it was decided that plots should be placed in the unseeded area of TA-49 for long-term observation about the differences between a seeded and unseeded area.

TA-49 is located on the south rim of Water Canyon north of State Route 4 (Figure 4.54). It is within the restricted area of LANL and includes the recently constructed helicopter pads. These facilities did not exist in 1977-78 when the plots were established. Bandelier is on the south side of State Route 4.

Three 20- by 50-meter plots were established in TA-49, in 1978. All the plots were in high-severity burn with all trees in class 5 (brown needles) or 6 (no needles). In addition to the severe burning of the overstory, the duff layer and some downed woody fuels were consumed and soil heating was evident. The TA-49 plots were not seeded, but some sites got seed blow-over from BNM over-flights. Unfortunately, the original intention to have them as unseeded controls did not occur as all the plots by 1985 showed large amounts of seeded slender wheatgrass and Wright's muhlenbergia.

Although the plots were established in 1978, they were not re-visited at the same frequency as the Burnt and Escobas mesas plots. However, the plots were revisited in 1978, 1985, 1993, and 1998. Archived raw data were found for 1978, 1985, and 1998. The raw data from 1993 were not relocated but were included from previous tables. The GPS coordinates for the plots are presented below.

Los Alamos National Laboratory TA-49 Plot 1

Plot 1 was located on the south side of the fire/utility road (see Figure 4.54) in an area of high-severity burn. The fire crowned and all the trees did not survive the fire. This plot was on the west side of the main road into TA-49. The 50-meter side was set north/south and the 20-meter side east/west. There was a mound to the north of the plot. There was disturbance in the area from the roads.

Overstory Conditions

This plot had ponderosa pine and one-seed juniper (Figure 4.55). The average dbh was 7.4 inches for the mature trees and 284 trees per acre with dbh greater than four inches. The site also supported 144 trees that had a dbh less than four inches, with a total tree density of 428 trees per acre (Table 4.17). Trees were not followed because all were determined to be dead in the 1978 survey. In addition there were 16 one-seed juniper trees per acre.

Understory Conditions

Apparent blow-over from the seeding of Bandelier resulted in substantial cover of slender wheatgrass in 1985 (Figure 4.56). Table 4.18 shows the percent cover for the species found within the plot. There was a shift from mostly forbs in 1978 to dominance of slender wheatgrass and other grasses in 1985 and by 1998 the shift was back to forbs (Figure 4.57). By 1998, the seeded grass, slender wheatgrass, was not found, but native grasses had increased (Figure 4.58).

Once the seeded grasses were outcompeted by native grasses, there was an increase in forb species. Forbs such as false tarragon, a drought-tolerant species, and other weedy species are seen to increase over time (Figure 4.59).

GPS coordinates for the three TA-49 plots

Location	Eastling	Northing
TA-49-1	381425	3965665
TA-49-2	381491	3965693
TA-49-3	381661	3965616

Figure 4.54. Aerial photograph taken November 1958 (12,200 ft) showing area of TA-49. All plots are between Water Canyon and the TA-49 main road and to the left of the TA-49 utility road. (1372MCSAUSAF AF58-25-5 Roll 2)

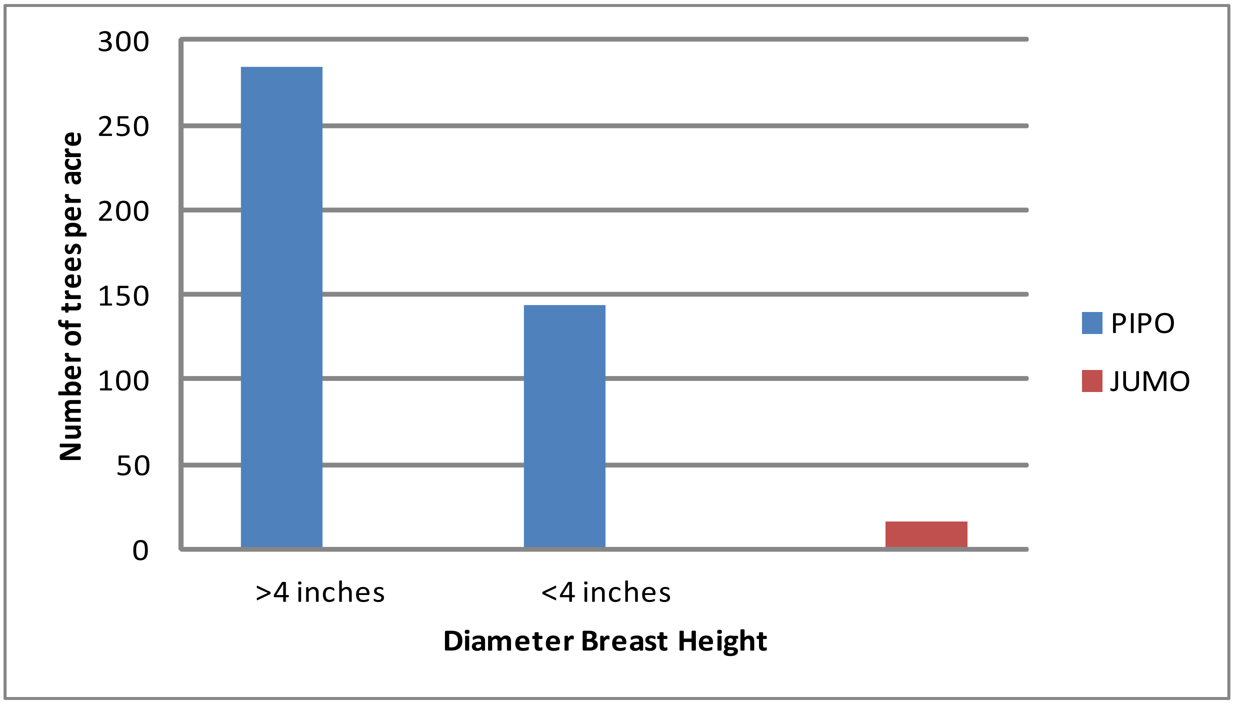


Figure 4.55. Tree sizes and density in TA-49 Plot 1, 1978
(PIPO = Pinus ponderosa*, JUMO* = Juniperus monosperma*)*

Figure 4.56. Slender wheatgrass, a seeded grass, was abundant at TA-49.

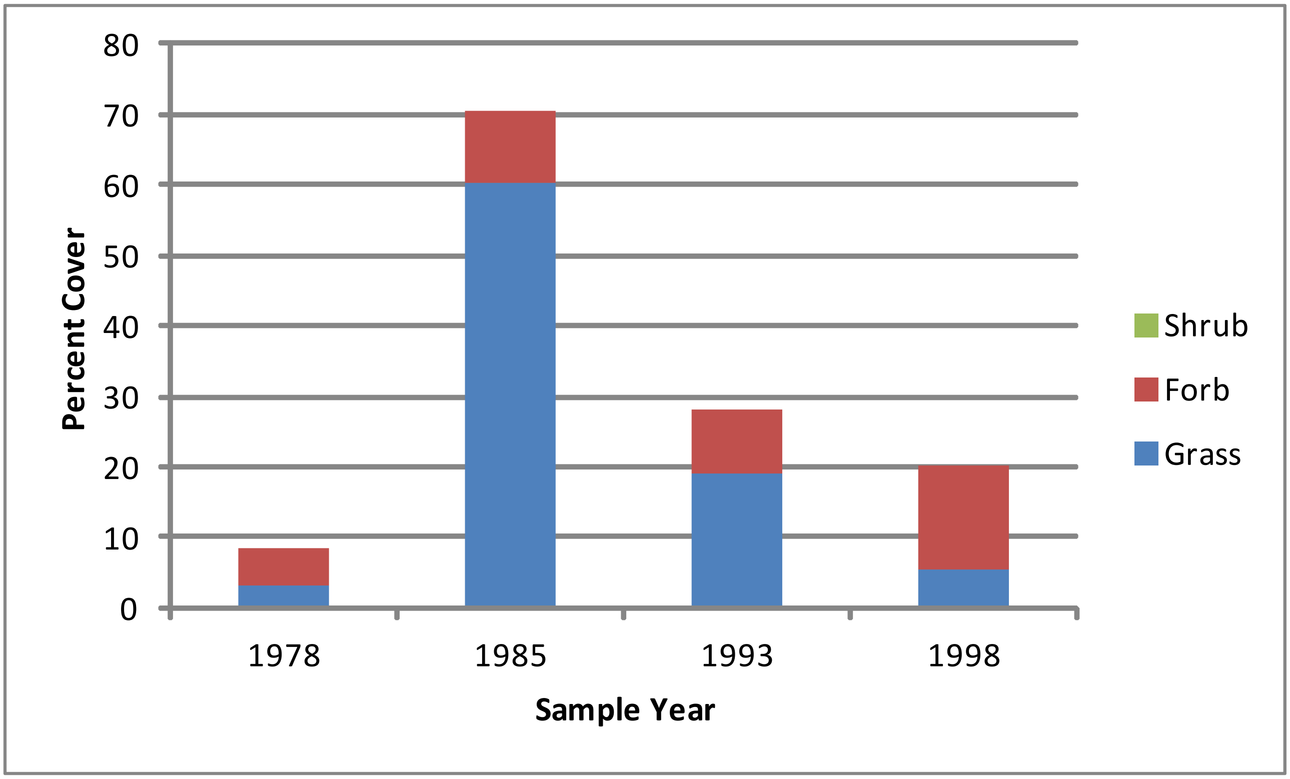


Figure 4.57. Shift of cover of grasses and forbs 1978 to 1998

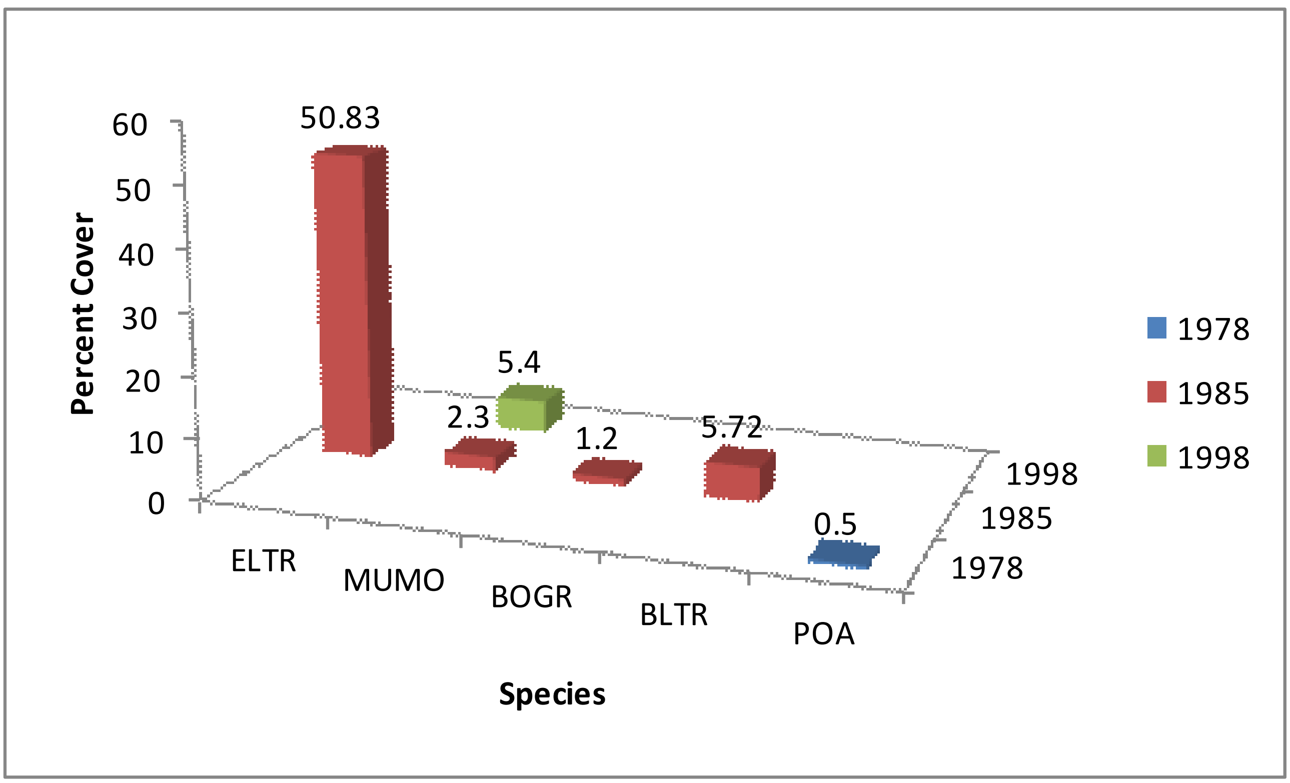


Figure 4.58. Distribution of seeded and native grass species through time
(ELTR = Elymus trachycaulus, *MUMO* = Muhlenbergia montana, *BOGR* = Bouteloua gracilis, *BLTR* = Blepharoneuron tricholepis, *POA* = Poa *spp.)*

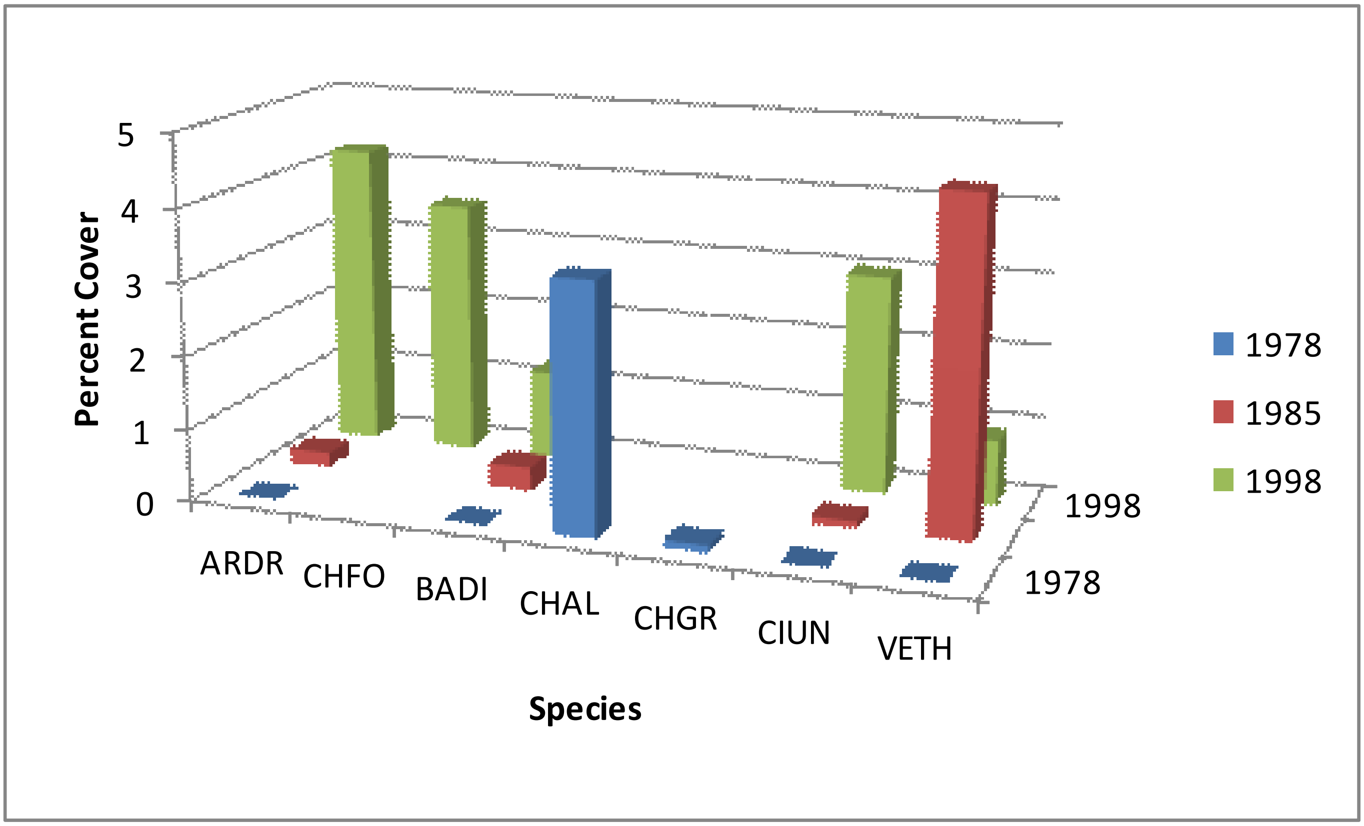


Figure 4.59. Distribution of forb species with high importance values through time
(ARDR = Artemisia dracunculus*, CHFO* = Chrysopsis foliosa*, BADI* = Bahia dissecta*, CHAL* = Chenopodium album*, CIUN* = Cirsium undulatum*, VETH* = Verbascum thapsus*)*

Table 4.17. Size and Density of Trees within TA-49 Plot 1

Species	DBH >4"	DBH<4"	Juniper	Species	DBH >4"	DBH<4"	Juniper
				PIPO	4.7		
PIPO		2.0			6.5		
	5.2					3.9	
	5.9					3.5	
	5.4					2.9	
	7.4					3.1	
	4.6					2.5	
		2.0			4.1		
	9.1	1.8				2.7	
		3.8				3.5	
		3.1				1.0	
		3.6				1.0	
	6.5			JUMO			2
		3.4					
	8.6			PIPO	11.0		
		1.8			7.3		
		3.0				1.0	
	4.8					2.8	
	6.4				9.6		
	4.4					2.4	
		3.2				1.0	
		3.3				1.0	
	24.4				5.8		
		3.2			10.1		
	5.4				7.0		
	9.0				11.0		
	5.4				4.2		
	6.9				4.0		
	6.7				9.3		
		3.3			4.3		
	4.5				6.3		
	7.4				5.0		
JUMO			6.9		10.5		
PIPO	5.4				9.3		
	7.2				5.0		
		3.3			9.1		
		1.0			11.0		
	4.2					1.0	
	6.1			JUMO		3.2	2-1
	7.9						1.0
	7.5						1.0
	4.7				395.7	68.1	2.8
	6.5						

Table 4.18. Percent Cover and Relative Cover of Species in TA-49 Plot 1

	1977	1985	1998	
SPECIES	**% Cover**	**% Cover**	**% Cover**	
	Grass			
Native Grass				
Aristida divaricata		0.32		1
Blepharoneuron tricholepis		5.72		1
Bouteloua gracilis		1.20		1
Carex spp.	3.05			1
Koeleria cristata			0.10	1
Muhlenbergia montana		2.30	5.14	2
Poa spp.	0.50			1
Total Native Grass Cover	**3.55**	**9.54**	**5.24**	
Seeded Grass				
Elymus trachycaulus		50.83		1
Total Seeded Grass		**50.83**		
Total Grass Cover	**3.55**	**60.37**	**5.24**	
Total Grass Species	**2**	**5**	**2**	
	Forbs			
Artemisia carruthii		0.82	1.40	2
Artemisia dracunculus		0.20	4.22	2
Bahia dissecta		0.32	1.22	2
Chenopodium album	3.40			1
Chenopodium graveolens	0.10			1
Cirsium undulatum		0.10	3.00	2
Erigeron divergens	0.60			1
Euphorbia	0.05			1
Haplopappus spp.	0.05			1
Heterotheca villosa			3.52	1
Hymenoxys richardsonii		1.00	5.20	2
Guterrezia microcephala	0.05	0.40		2
Lotus wrightii			0.20	1
Lupinus caudatus		0.10		1
Lithospermum multiflorum		0.14		1
Petalostemum spp.	0.04			1
Physalis neomexicana	1.03			1
Polygonum spp.		0.12		1
Tragopogon dubius		1.90		1
Taraxacum officinale		0.32		1
Verbascum thapsus		4.54	0.90	2
Vicia americana		0.20		1
Unidentified forb		0.30		1
Total Forb Cover	**5.32**	**9.96**	**14.96**	

Species	% Cover	% Cover	% Cover	
Shrubs				
Juniperus monosperma			0.20	1
Quercus gambelli		2.78		1
Quercus undulata	3.62	8.49		2
Robinia neomexicana			0.30	1
Ribes cernuum		0.50		1
Total Shrub Cover	**3.62**	**11.77**	**0.50**	
TOTAL FOLIAR COVER	**12.49**	**82.60**	**25.40**	
Bare soil	87.51	17.40	12.59	
Litter			62.01	

Los Alamos National Laboratory TA-49 Plot 2
This plot was located on the south side of the fire road and west side of the main road. The area was severely burned. Shrubs such as Gambel's oak and wax currant were found on the site by 1998. Slender wheatgrass dominated in 1985, indicating blow-over from the seeding of Bandelier (Figure 4.60).

Understory Conditions
Table 4.19 shows the percent cover for the species found within the plot. Change in percent cover of grasses, forbs, and shrubs through time indicate a shift from 1978 to 1998 (Figure 4.61). In 1978, forbs dominated but the cover was only 2.5 percent. By 1998 cover had increased to nearly 30 percent and the grass cover had decreased to little over seven percent from the high in 1985. The seeded grasses dominated until 1993 and then the native grasses became more abundant (Figure 4.62). The primary shift in the forb species (Figure 4.63) seemed to be from early annual successional species, such as lambsquarter, fetid goosefoot, and wild chrysanthemum, to perennial species, such as sagewort and false tarragon. The increase in false tarragon and thistle seems to be related to drought and has been seen in other plots. There was shrub growth by 1998.

Overstory Conditions
Table 4.20 shows the measurements of the trees in 1978 in Plot 2. There were 256 mature trees per acre (over 4-in. dbh) and 280 trees per acre of trees less than four inches in diameter (Figure 4.64). The total trees per acre was 536. The average diameter of the mature trees was 5.71 inches and the poles 2.7 inches dbh (Figure 4.65). Ponderosa pine was the only tree species identified in the plot.

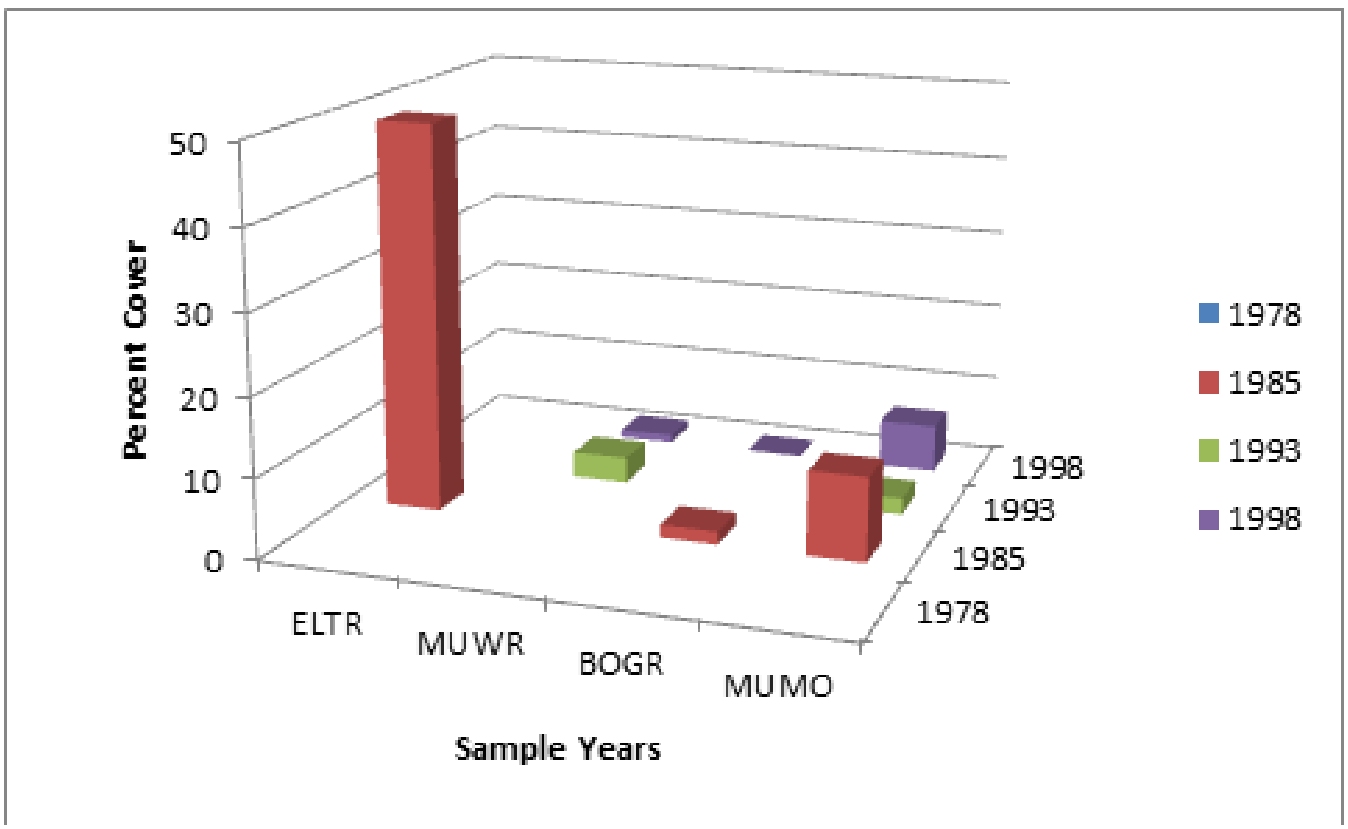


Figure 4.60. The change in grass species over time from seeded species to native species (ELTR = Elymus trachycaulus*, MUWR =* Muhlenbergia wrightii*, BOGR =* Bouteloua gracilis*, MUMO =* Muhlenbergia montana*)*

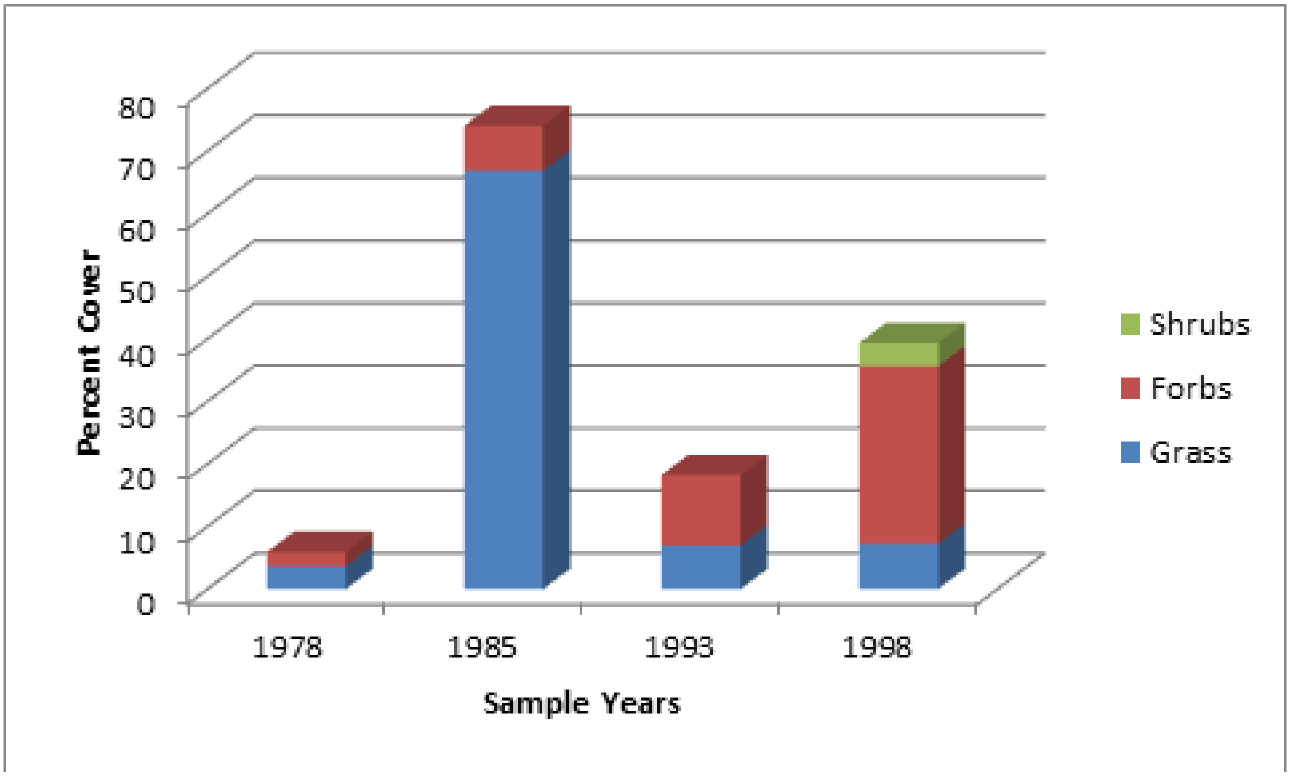


Figure 4.61. The change in percent cover of grass, forbs, and shrubs over the 20 years of study

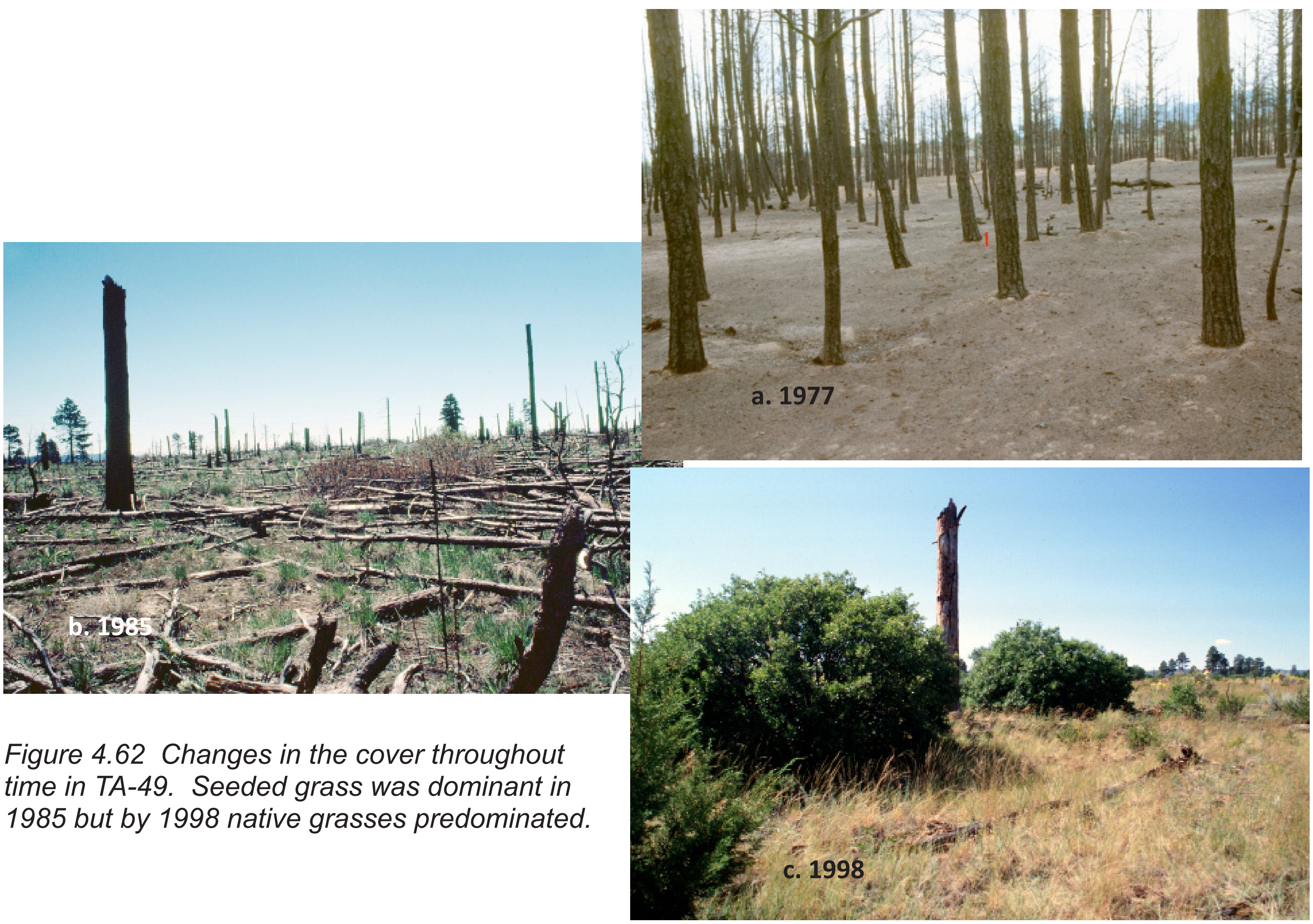


Figure 4.62 Changes in the cover throughout time in TA-49. Seeded grass was dominant in 1985 but by 1998 native grasses predominated.

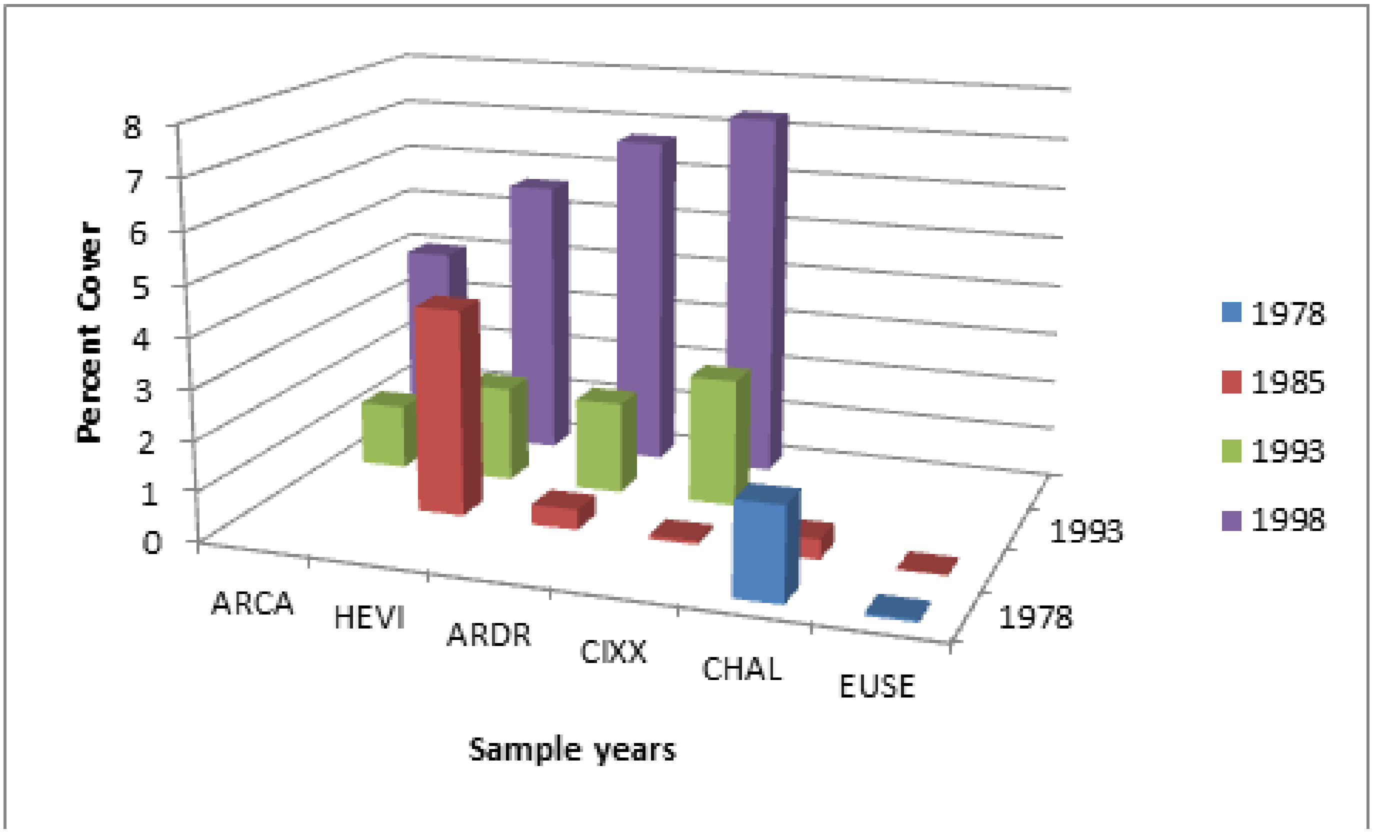


Figure 4.63. The change in selected dominant forb cover over time (CHAL = Chenopodium album*, EUSE*= Ephorbia serpyllifolia*, HEVI* = Heterotheca villosa*, ARCA* = Artemisia carruthii*, ARDR* = Artemisia dracunculus*, CIXX* = Cirsium *spp.)*

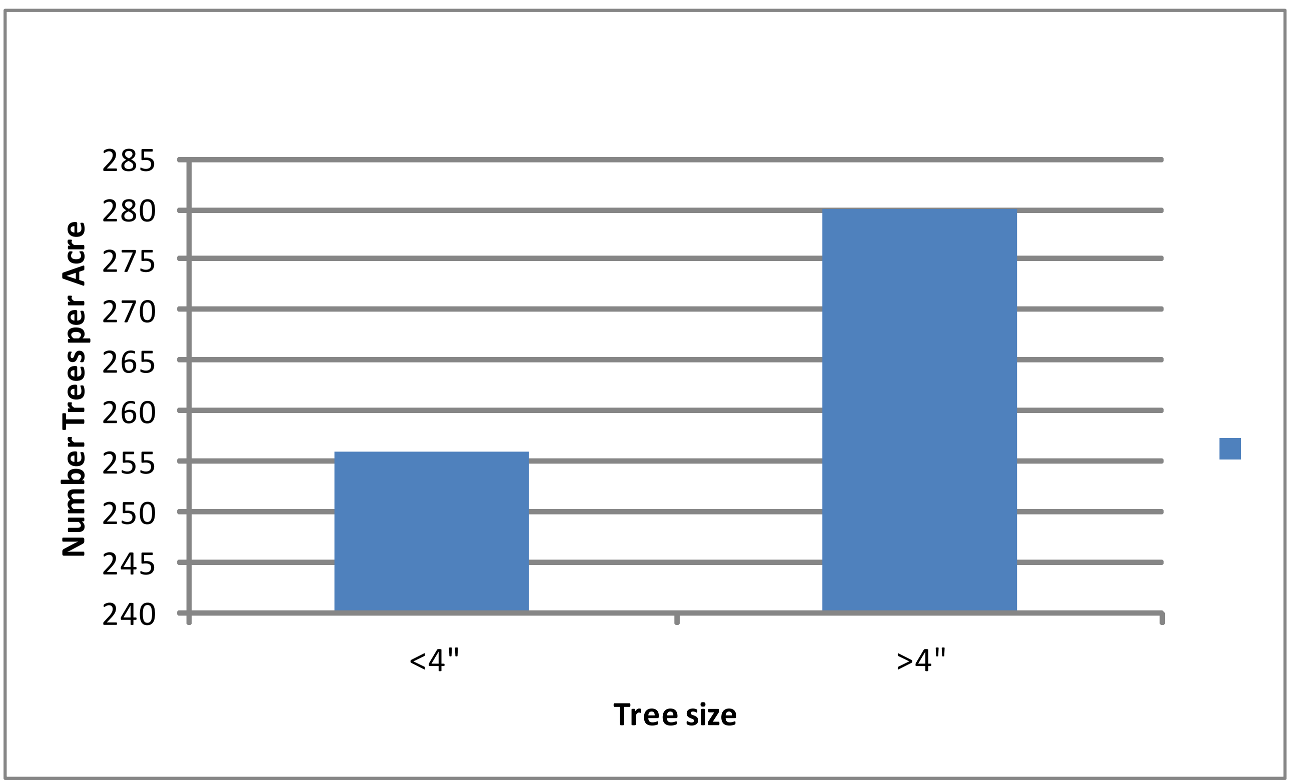


Figure 4.64. The density of trees within TA-49 Plot 2

Figure 4.65. The doghair stands of ponderosa pine that were within the area of TA-49

Table 4.19. Percent Cover of Species in TA-49 Plot 2 Through Time

Species Name	1978	1985	1993	1998	Years of Occurrence
Grass					
Native Grass					
Blepharoneuron tricholepis				0.10	1
Bouteloua gracilis		1.65		0.06	2
Elymus elymoides		0.20	0.65		2
Koeleria cristata			1.0		1
Muhlenbergia montana		10.6	2.09	6.1	3
Panicum spp.	0.03				1
Pascopyrum smithii		5.54			1
Total Native Grass	**0.03**	**17.99**	**3.74**	**6.26**	
Seeded Grass					
Elymus trachycaulus		48.86			1
Muhlenbergia wrightii			3.27	1.00	2
Total Seeded Grass	**0.03**	**48.86**	**3.27**	**1.00**	
Total Grass Cover	**.03**	**66.85**	**7.01**	**7.26**	
Total Grass Species	**1**	**5**	**4**	**3**	

Species	1978	1985	1993	1998	No. Years
Forbs					
Allium cernuum				0.10	1
Artemisia spp.			0.73		1
Artemisia carruthii			1.29	4.00	2
Artemisia dracunculus			1.84	6.70	2
Bahia dissecta			0.40	0.52	2
Chenopodium album	1.85	0.40			2
Chenopodium graveolens	0.55				1
Heterotheca villosa		4.13	1.91	5.60	3
Cirsium spp.		0.08	2.55	7.32	3
Conyza canadensis			0.09		1
Cryptantha jamesii				0.02	1
Cyperus spp.			0.02		1
Erigeron divergens		0.02	0.64		2
Euphorbia spp.	0.05				1
Geranium caespitosum			0.09	0.10	2
Gutierrezia sarothrae		0.27	0.09		2
Hymenoxys richardsonii		1.81	0.09	0.10	3
Lupinus spp.		0.02			1
Oenothera spp.				0.3	1
Petalostemum purpureum			0.18		1
Potentilla spp.		0.07	0.27	0.40	3
Polygonum spp.		0.05			1
Solidago spp.			0.09	2.90	2
Taraxacum officinale			0.09		1
Tetradymia spp.			0.09		1
Tragopogon dubius		0.22	0.09		2
Vicia americana		0.04	0.11	0.22	3
Verbascum thapsus			0.56	0.08	2
Unknown Forb	0.05	0.04			2
Total Forbs Cover	**2.17**	**7.17**	**11.22**	**28.36**	
Total Forb Species	**4**	**12**	**20**	**14**	
Shrubs					
Quercus gambelli				2.50	1
Ribes cereum				1.20	1
Total Shrub Cover				**3.70**	
Total Shrub Species	**0**	**0**	**0**	**2**	
TOTAL FOLIAR COVER	**2.20**	**74.02**	**18.23**	**39.26**	
Bare soil	97.32	26.00	24.25	10.90	
Litter			53.13	48.72	
Soil crust			2.36		

Table 4.20. Sizes and Density of Trees in TA-49 Plot 2

Species	>4" DBH	<4" DBH	Species	>4" DBH	<4"DBH	Species	>4"DBH	<4"DBH
PIPO		3.3	PIPO		4.5	PIPO	4.0	
	7.0	3.5			4.0		4.9	
	4.5				7.2		5.9	
	4.4	2.5			4.9		6.5	
	4				4.0		4.0	3.8
	4.4				5.0		5.0	
		3.0			6.9			
		3.6				1.0	6.6	1.0
		3.5				2.0	5.3	
	4.2					2.0		3.5
	5.0	2.5			9.3	2.5	5.3	
		3.9			7.5			3.8
		3.1				1.0	6.2	2.0
		3.4			5.2			
		2.2			4.0			2.8
		3.1			8.1		4.6	
		3.4			8.1			2.0
		2.2			5.0		23.4	3.9
		3.1			7.0			
		2.0				3.7		3.7
	4.4				4.1		8.4	
		3.8				3.1		3.6
	5.9					3.1	4.3	2.0
	5.8					1.0		2.5
		2.5			5.5			2.5
		3.6				2.0		2.5
	5.0				4.5			1.0
	5.1					2.0		2.0
	6.6					2.0		1.0
		3.5				1.0		3.0
	5.1	2.9				3.0		2.8
	7.2					2.0		3.0
		3.1			5.5			
		2.4				2.0		
		3.5			4.7		4.6	2.4
		1.0			4.1		4.5	
	7.4					3.9		2.2
	5.5					3.9	4.6	
	4.6				5.2			
	4.8				4.3		**366**	**186**
	7.5					3.0	**No. Trees**	**64/70**
		3.2			5.3		**AV. DBH**	**5.71/2.7**
	5.0					3.8		
	4.5				6.4			
		2.8				1.0		

Los Alamos National Laboratory TA-49 Plot 3
This plot was across the entrance road to TA-49. Like all the other TA-49 plots the trees within the plot died; however, no archived data were located to determine the density. Blow-over from the Bandelier seeding effort affected this plot also. In 1985, slender wheatgrass dominated the area (Figure 4.66). There were no trees to follow-up on these plots. Table 4.21 shows the percent cover of the species identified on this plot. Figure 4.67 shows the percent cover of grass and forb species through time. This area was not part of the prescribed burn at BNM.

Understory Conditions
Figure 4.68 shows the change in percent cover through time by phenology. In 1978, forbs dominated but the cover was only 4.73 percent. By 1998 cover had increased to nearly 12 percent and the grass cover had decreased to little over 2.7 percent from the high in 1985 of 62.02 pecent. The seeded grasses dominated until 1993 and then the native grasses became more abundant (see Figure 4.66).

The primary shift in the forb species seemed to be from early annual successional species such as lambsquarter, fetid goosefoot, and wild chrysanthemum, to perennial species such as sagewort and false tarragon. The increase in false tarragon and thistle seems to be related to drought and has been seen in other plots (see Figure 4.66).

Overstory Conditions
No archived information was found on trees in Plot 3. The area was similar to the tree density in Plot 1 and all trees died.

General Observations
There was a definite shift in species density from 1978 to 1998 (Plate 4.17). Although the area had not been seeded, blow-over apparently happened at the time of seeding. By 1985 all of the plots had a substantial cover of slender wheatgrass, a seeded species. By 1993, most of the seeded grasses had disappeared and native grasses were more dominant.

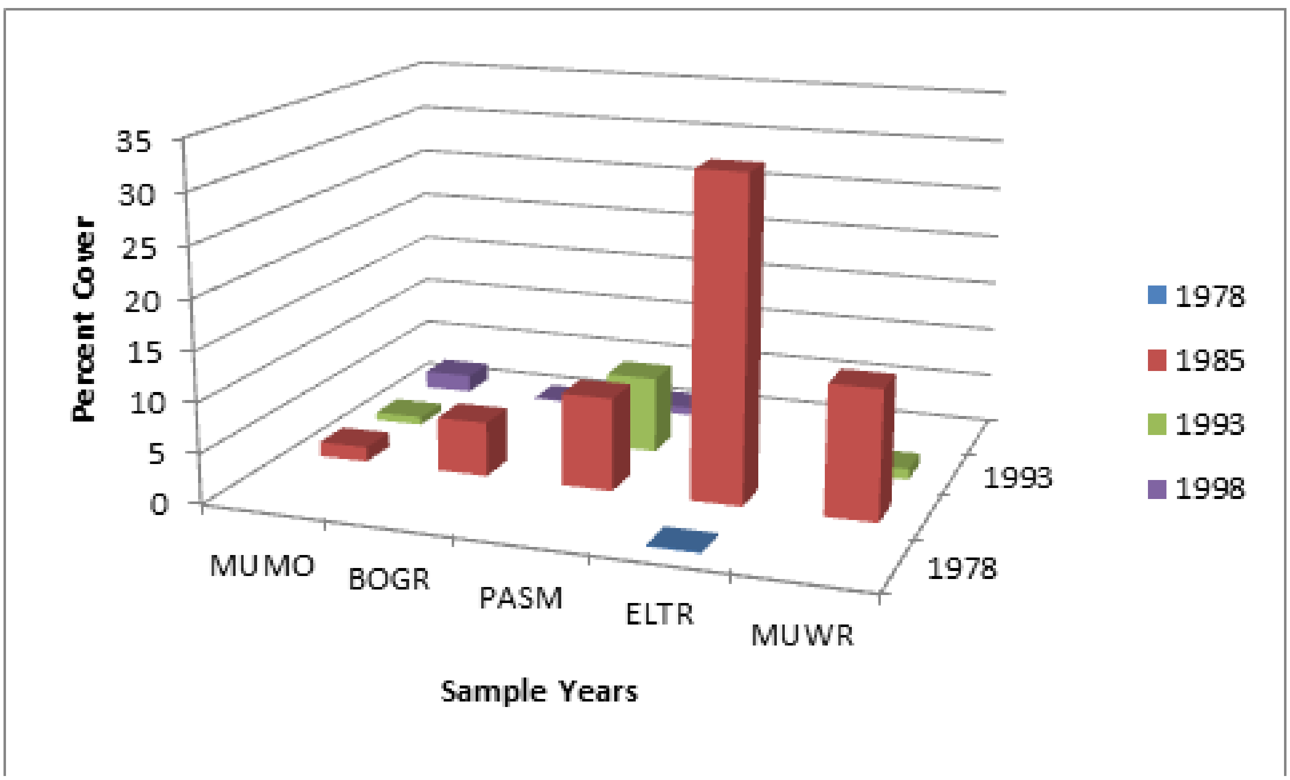


Figure 4.66. The change in percent cover of grass species over time from seeded species to native species (ELTR = Elymus trachycaulum, MUWR = Muhlenbergia wrightii, BOGR = Bouteloua gracilis, MUMO = Muhlenbergia montana, PASM= *Pascopyrum smithii)*

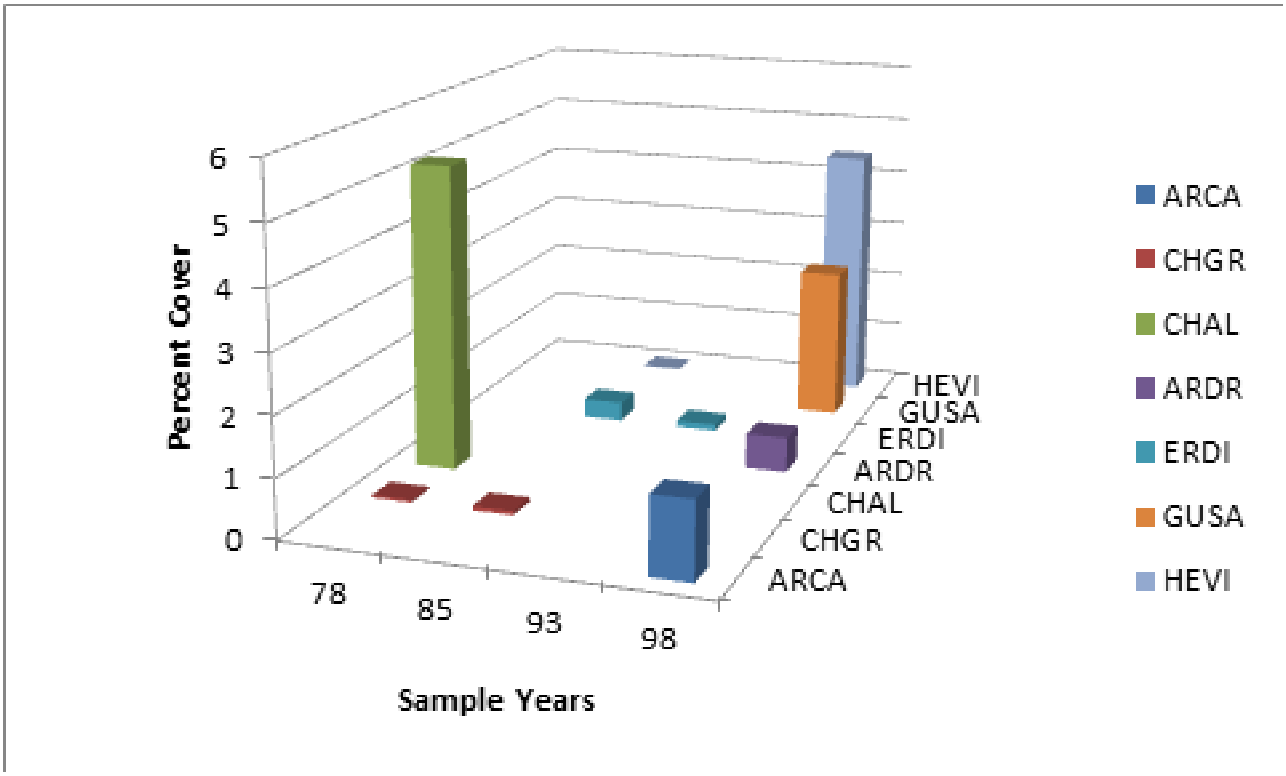


Figure 4.67. The change in selected forb cover over time. CHAL= Chenopodium album, CHGR=Chenopodium graveolens, ARCA=Artemisia carruthii, ARDR Artemesia dracunculus, HEVI=Heterotheca villosa, GUSA=Guterrezia sarothrae, ERDI=Erigeron divergens

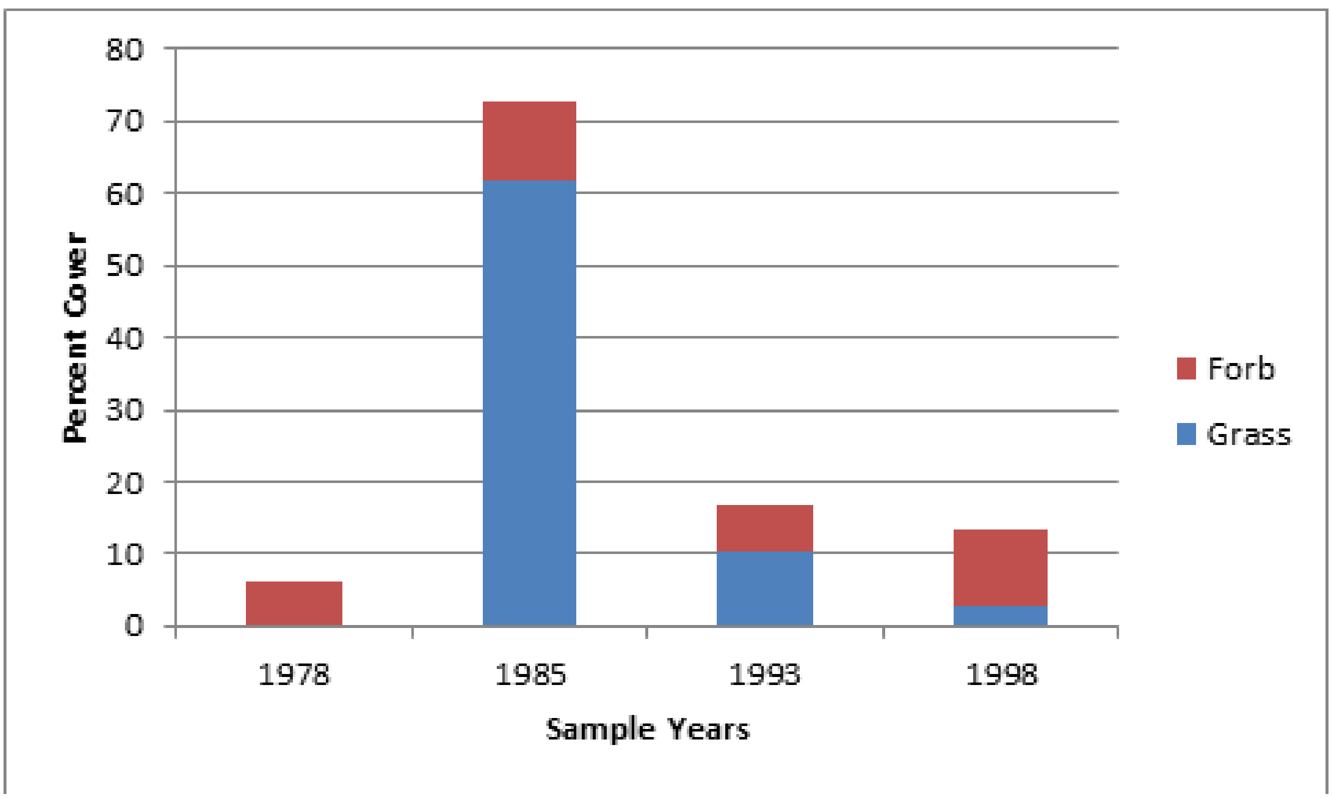


Figure 4.68. The change in percent cover by phenology over the 20 years of study

TA-49 had a large number of trees per acre that burned severely.

Early successional species were first found within the plots at TA-49.

Although the area was not purposefully seeded, the area is adjacent to Bandelier and blow-over contaminated the site.

Plate 4.17. *LANL TA-49 plots through time (continued on next page)*

Plate 4.17 *(continued)*

By 1985 nearly all the trees had fallen. A few snags remained.

Aerial photo taken in 1983 showing the few trees standing on the mesas.

By 1998 in some areas shrub growth was apparent, particularly oak.

The area of TA-49 had a high density of trees before the fire—greater than 400 trees per acre—and, there fore, the fire was severe. No trees survived in the plots. Tree data were found only for Plots 1 and 2, but 3 was similar (Figure 4.69). Plot 1 had a few one-seed junipers, but plot 2 was wholly ponderosa pine. Plot 1 had a larger grouping of trees with more trees in the mature size class and an average diameter 7.1 inches dbh. Plot 2 had doghair stands with many small trees and an average diameter of 5.7 inches dbh. No trees were greater than 9.3 inches dbh.

Early species presence were mostly those that are early successional and are within the soilbank. Species such as fetid goosefoot disappear after the secondary successional species begin to grow. Species like false tarragon and other drought-tolerant species increased over time. *Bromus tectorum* was noted in one plot by 1998.

By 1985 all the trees had fallen and the area became meadowed. Some reproduction and development of shrubs was seen. Visual images of the changes in this area are seen above in Plate 4.17.

Maps were done for the three plots (Plate 4.18) in 1993 and 1998. Only two 1998 maps could be found in the archives.

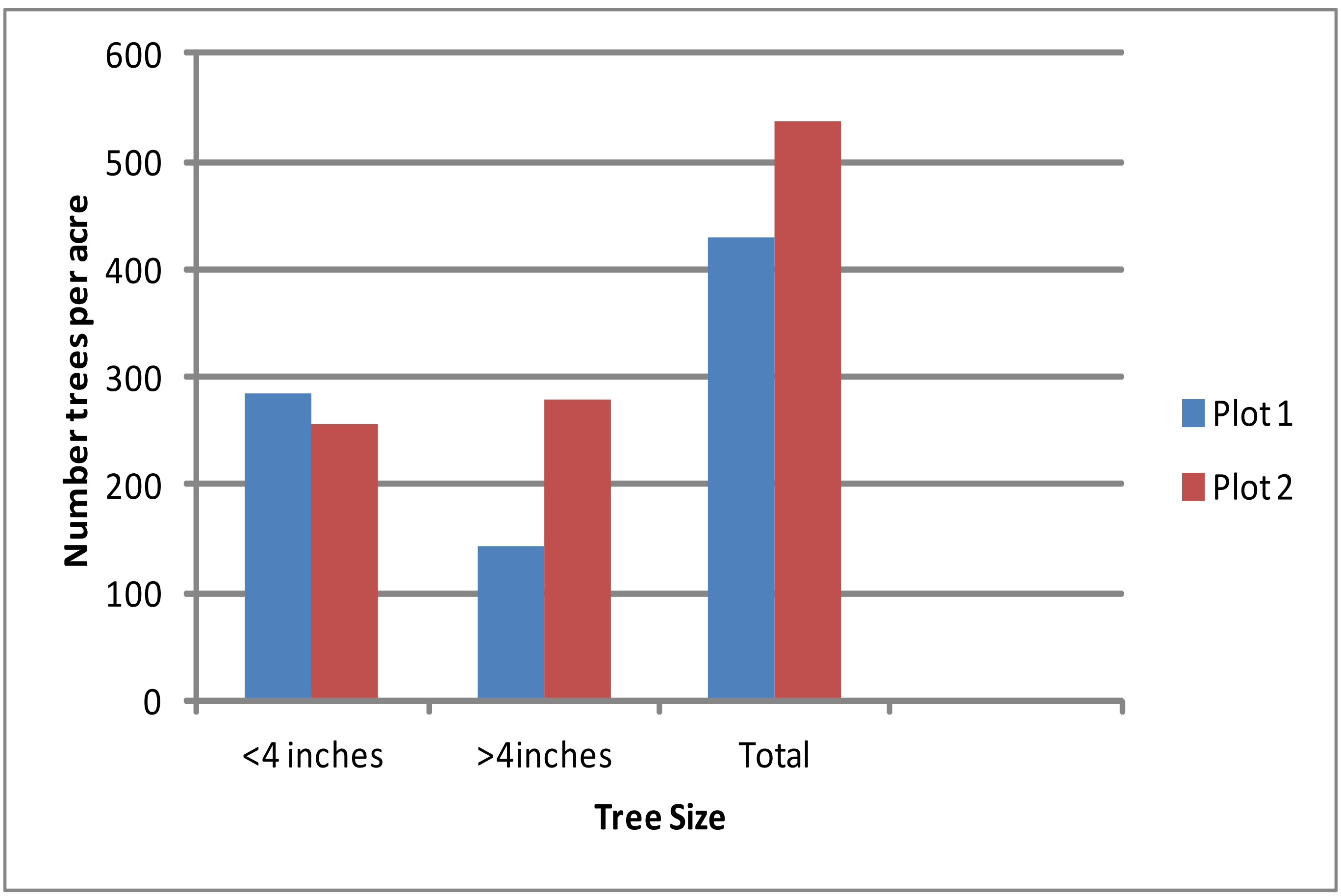
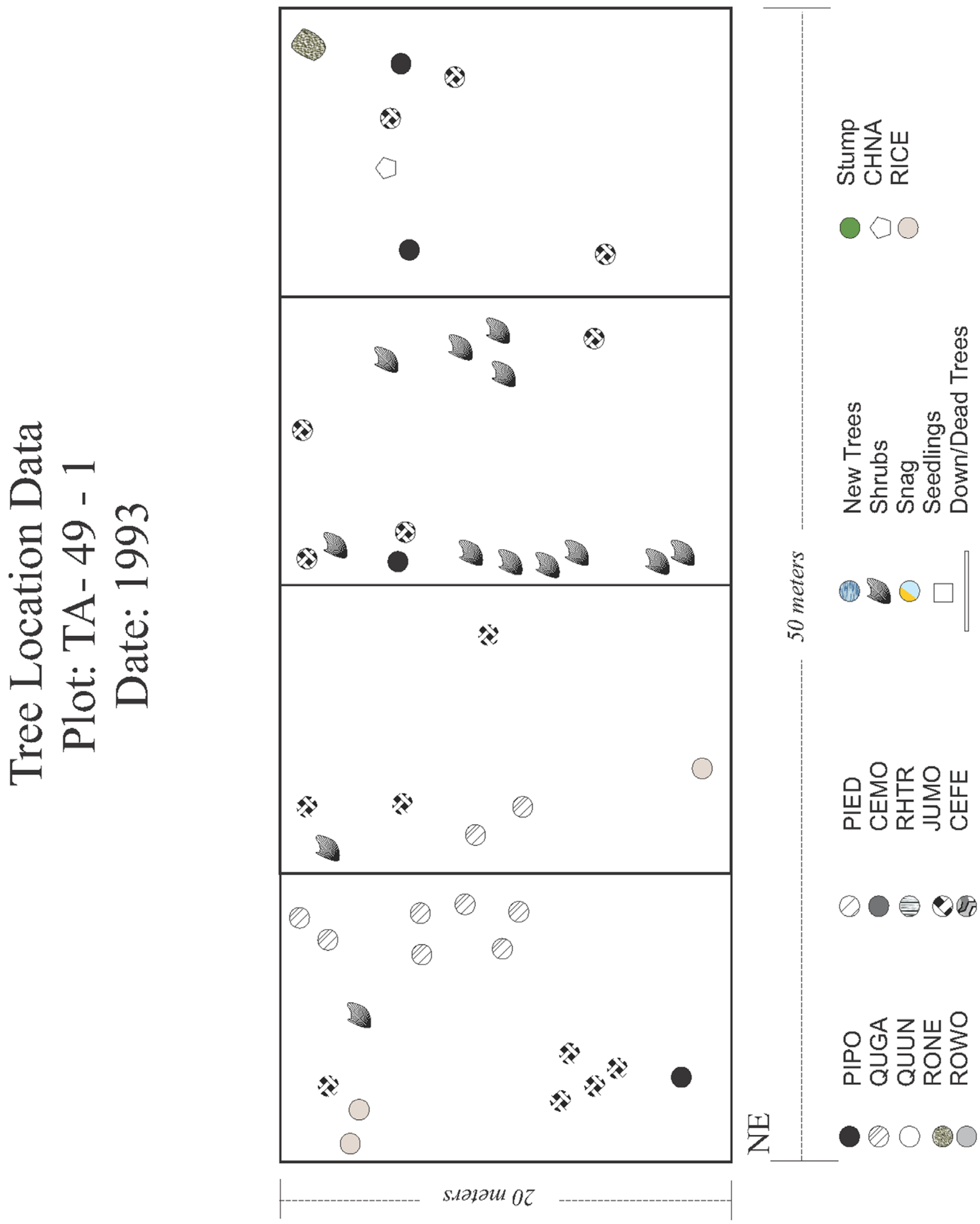
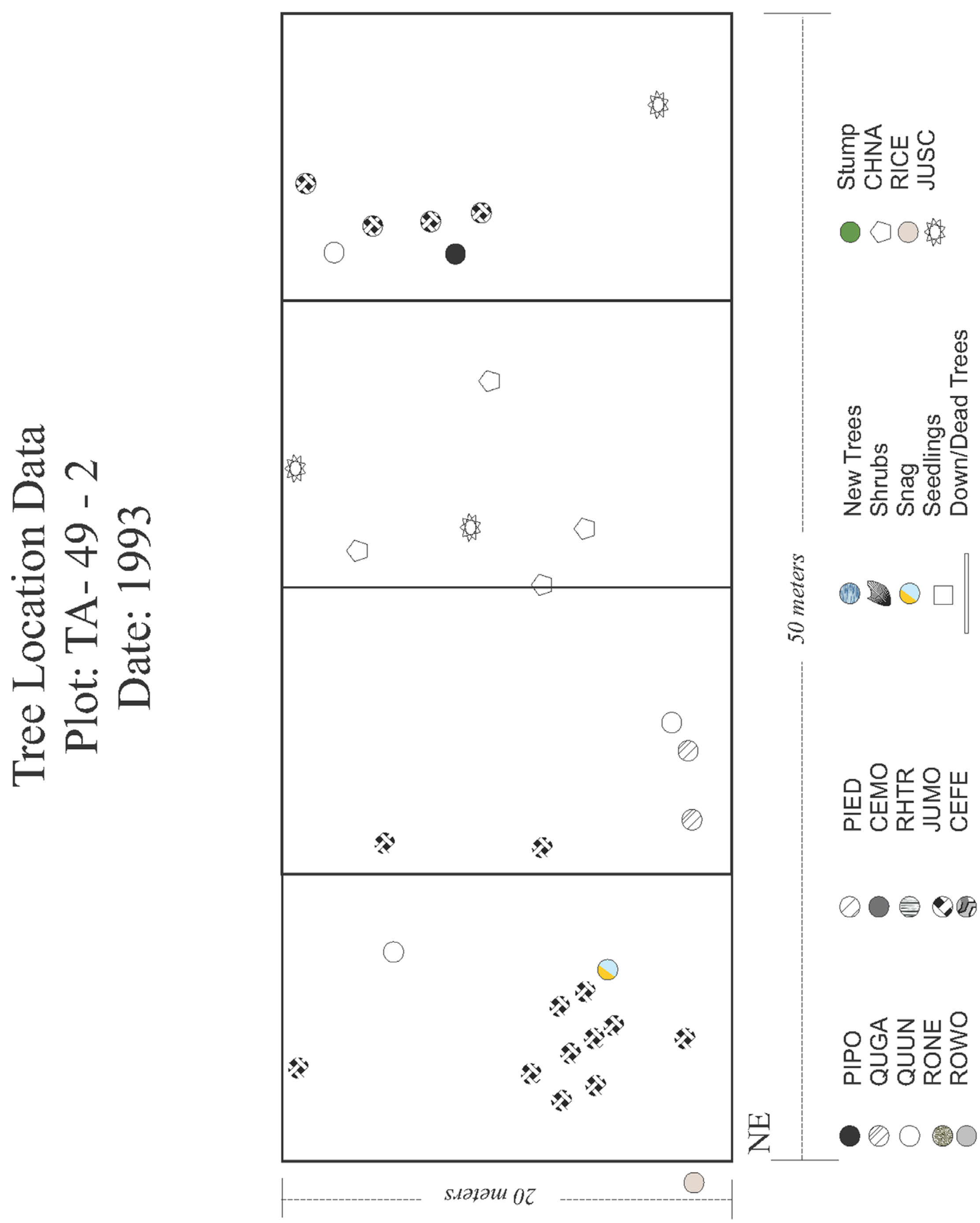


Figure 4.69. Comparison of the tree sizes and density in Plot 1 and Plot 2 of TA-49



Plot 1, 1993

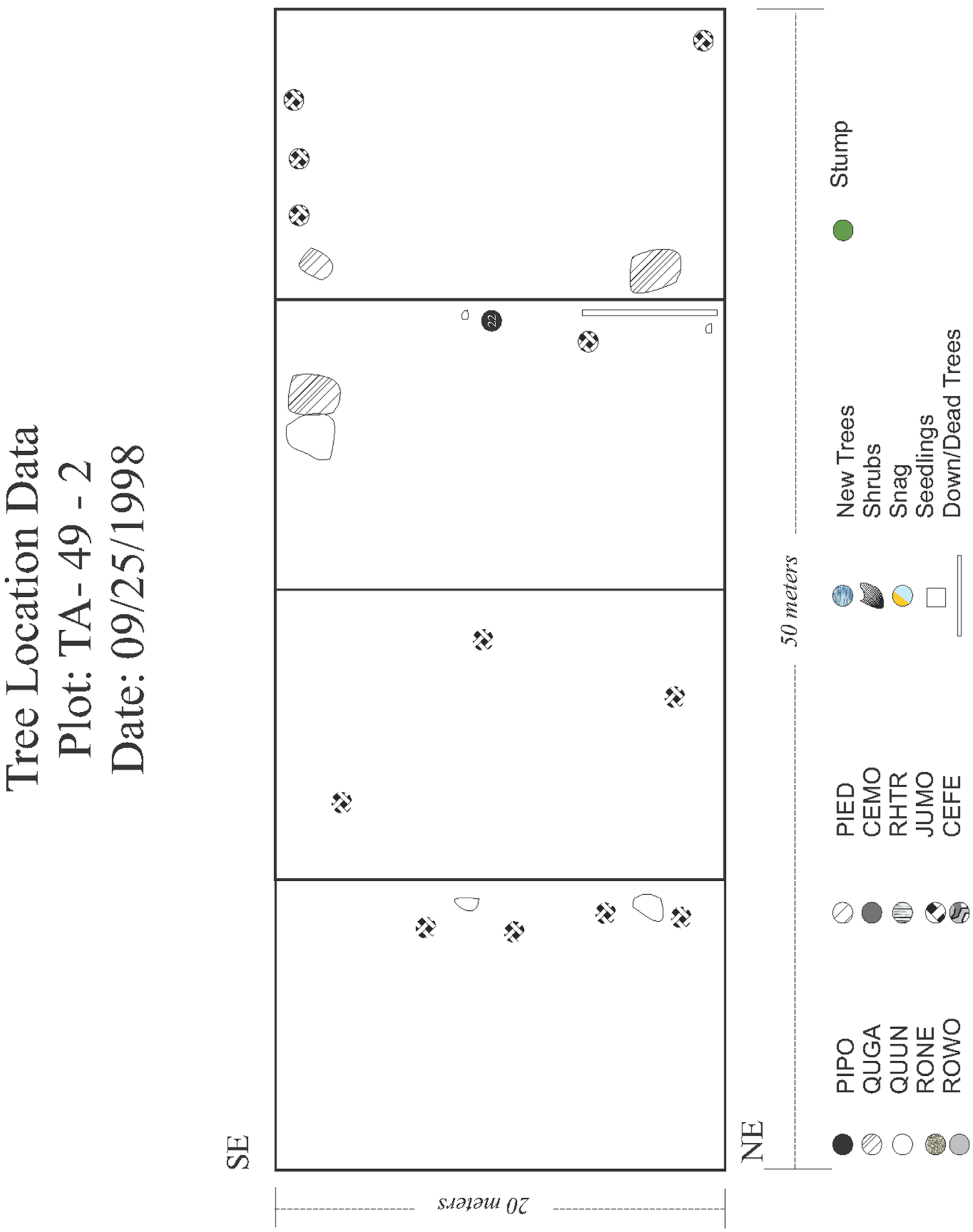
Plate 4.18. *Vegetation maps of tree and shrub locations for plots 1 and 2 (continued on next page)*



Plot 2, 1993

Plate 4.18. *Vegetation maps of tree and shrub locations for plots 1 and 2* *(continued on next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*



Plot 2, 1998

***Plate 4.18** (continued)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

Table 4.21. Cover of Species in TA-49 Plot 3 Through Time

Species Name	1978	1985	1993	1998	Years Occurred
		Grass			
Native Grass					
Bouteloua gracilis		5.44		0.1	2
Koeleria cristata			0.64		1
Muhlenbergia montana		1.48	0.82	1.8	3
Poa spp.		0.92			1
Pascopyrum smithii		9.25	7.64	0.8	3
Unidentifed grass	0.06				1
Total Native Grass	**0.06**	**17.09**	**9.1**	**2.7**	
Seeded Grass					
Elymus trachycaulus	0.10	31.94			2
Muhlenbergia wrightii		12.88	1.09		2
Total Seeded Grass	**0.10**	**44.82**	**1.09**		
Introduced Grass					
Bromus tectorum		0.05			1
Total Grass Cover	**0.16**	**61.96**	**10.19**	**2.70**	
		Forbs			
Artemisia carruthii				1.30	1
Artemisia dracunculus		0.74		0.6	2
Bahia dissecta	5.2				1
Chenopdium graveolens		0.01			1
Chenopodium album	0.4	0.07			2
Chryptantha jamesii		0.33			1
Cirsium spp.		1.22			1
Conyza canadensis	0.06				1
Dalea purpurea	0.4	0.02			2
Euphorbia serpyllifolia			0.11		1
Guterrieza sarothrae			0.73		1
Heterotheca villosa			4.00		1
Hymenoxys richardsonii		2.93	0.73		2
Linum neomexicanum	0.1	4.44	0.02		3
Polygonum avicularae			0.02		1
Potentilla spp.		0.05	0.18		2
Thelesperma trifidum			0.11		1
Tragopogon dubius		0.08	0.18		2
Verbascum thapsum		0.49			1
Vicia americana		0.29	0.31		2
Total Forb Cover	**6.16**	**10.67**	**6.39**	**1.90**	
TOTAL FOLIAR COVER	**6.32**	**72.63**	**16.58**	**4.60**	
Bare Soil	93.68	27.37	83.42	54.92	
Litter				40.48	

4.4 Apache Springs

Mixed Conifer

The term 'mixed conifer' is used for forests with a mix of tree species (Dieterich 1983). Smith et al. (2008) classified this forest type as either warm-dry or cool-moist. Warm-dry forest types have ponderosa pine with aspen and oak and ponderosa pine with Douglas-fir, white fir, or limber pine. The cool-moist forest type is dominated by Douglas fir, white fir, and spruce. The plots within the mixed conifer in this study were primarily of the warm-dry forest type with ponderosa pine, Douglas-fir, white fir, and aspen. Along the elevation gradient on the slopes of the Sierra de los Valles, there is an increase from warm-dry to cool-moist. Those species within the cool-moist are more shade tolerant and less fire tolerant.

All mixed conifer plots were on Apache Mesa off the Apache Springs trail (Figure 4.70). Burning within the mixed conifer was variable and mostly due to backfiring. On June 20, 1977, depending on the fuel type, the rate of spread was predicted to be from 10 to 37 chains per hour. Forester (1976) reported fuel loads varying from 5.8 to 11.7 tons per acre. Damage in the plots was dependent upon the species, aspen being the most easily damaged and ponderosa pine sustaining the least damage.

Because of lack of time and money, plots on Apache Mesa were not followed up with the frequency of the ponderosa pine plots. Each plot was measured in 1977 and photographed occasionally through the years, but data were not taken until 1993 and again in 1999. In 1993, we located four of the five plots, but, in 1999, I was only able to locate one plot for sure and another plot was questionable even though we had a previous GPS point. The plot we located was Apache Springs 5. The questionable plot was Apache Springs 3. Apache Springs 5 had been severely burned; Apache Springs 3 was only lightly burned. The descriptions we give here are for all five plots, but exact GPS points and data are given below for only two of the plots.

Table 4.22 shows the information available for the various plots.

In 2010, we tried to re-locate the plots without success. The area had grown up and we could not find stakes or any markings of the previously set-up plots. A few photographs were taken.

This area burned again in the Las Conchas Fire but was not photographed immediately after the fire.

Apache Springs 1

Access to the plot was made along "Glendale Boulevard," a firebreak established along the rim of Frijoles Canyon. This firebreak begins at a large curve just beyond the Los Alamos County boundary. The site was visited in 1977, 1992, and 1999.

Understory Condition

The most common seeded grass at the higher elevations was sheep fescue. As can be seen from Figure 4.71, the percent cover of grasses increased. By 1992, primarily sheep fescue, made up 50 percent of the cover. Shrub cover also increased. Another seven years later, in 1999, the percent cover of forbs, grasses, and shrubs had decreased.

Overstory Condition

The area supported nearly 500 mature trees per acre (Figure 4.72) and over 485 trees in the reproductive class (dbh less than four inches) (Figure 4.73) for a total density of over 900 trees per acre. This plot was severely burned with nearly 75 percent of the trees in class 5 (brown needle) or class 6 (no needles) (Figure 4.74). By 1993, the area was littered with downed trees and standing snags (Figure 4.75).

GPS locations for two plots within the Apache Springs area

Plot	Easting	Northing
Apache 1	372935	3965611
Apache 5	375246	3965889

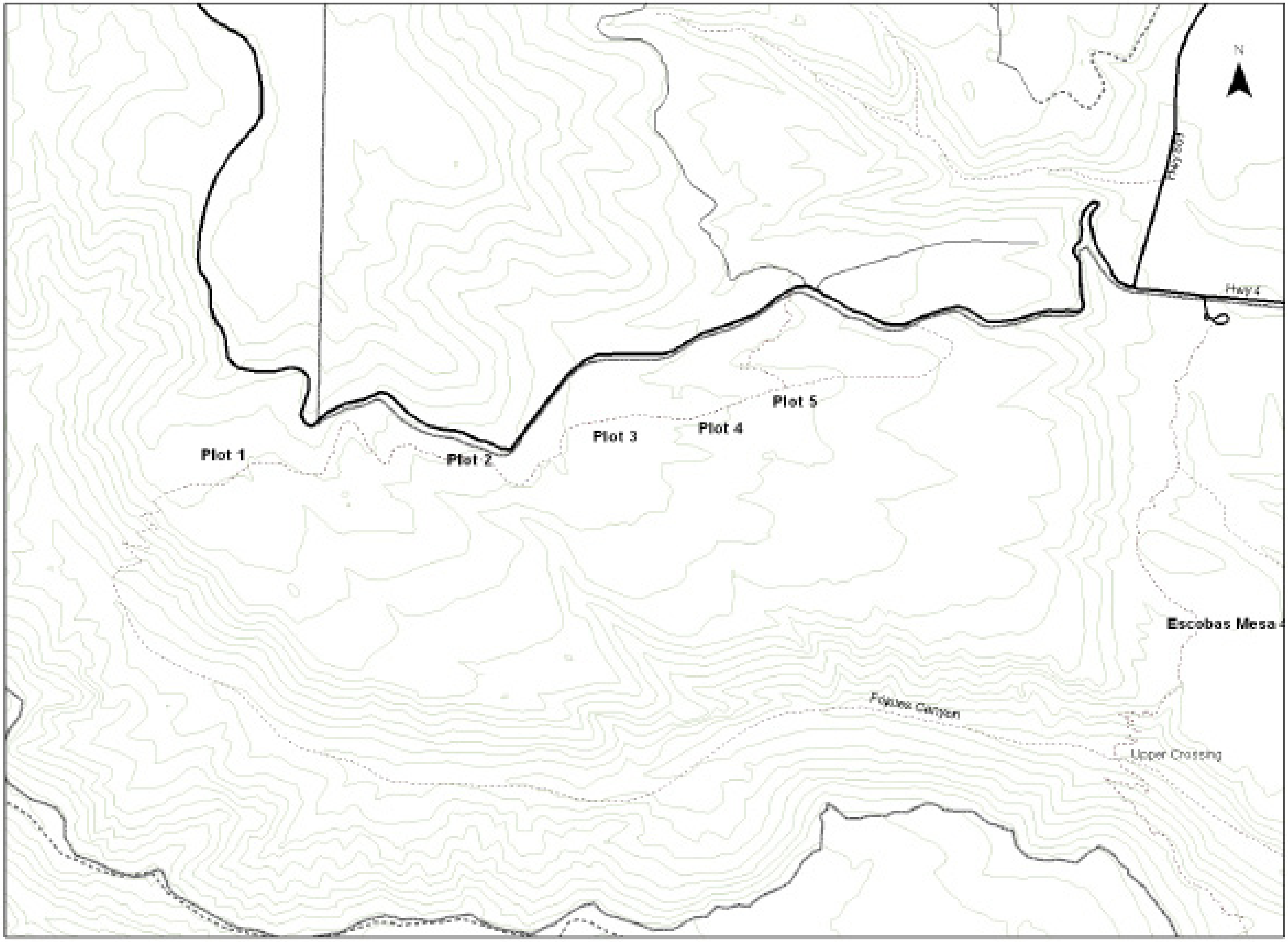


Figure 4.70. General locations of the plots within the Apache Springs area

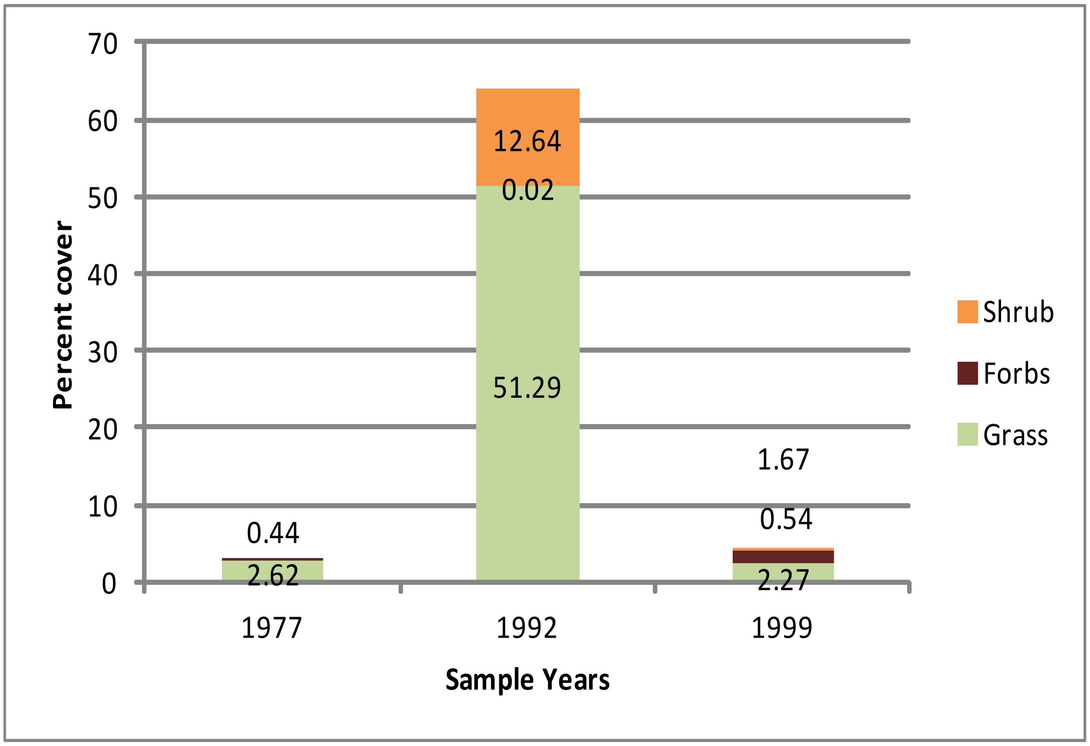


Figure 4.71. Status of grass, forbs, and shrubs in Apache Springs Plot 1 through time

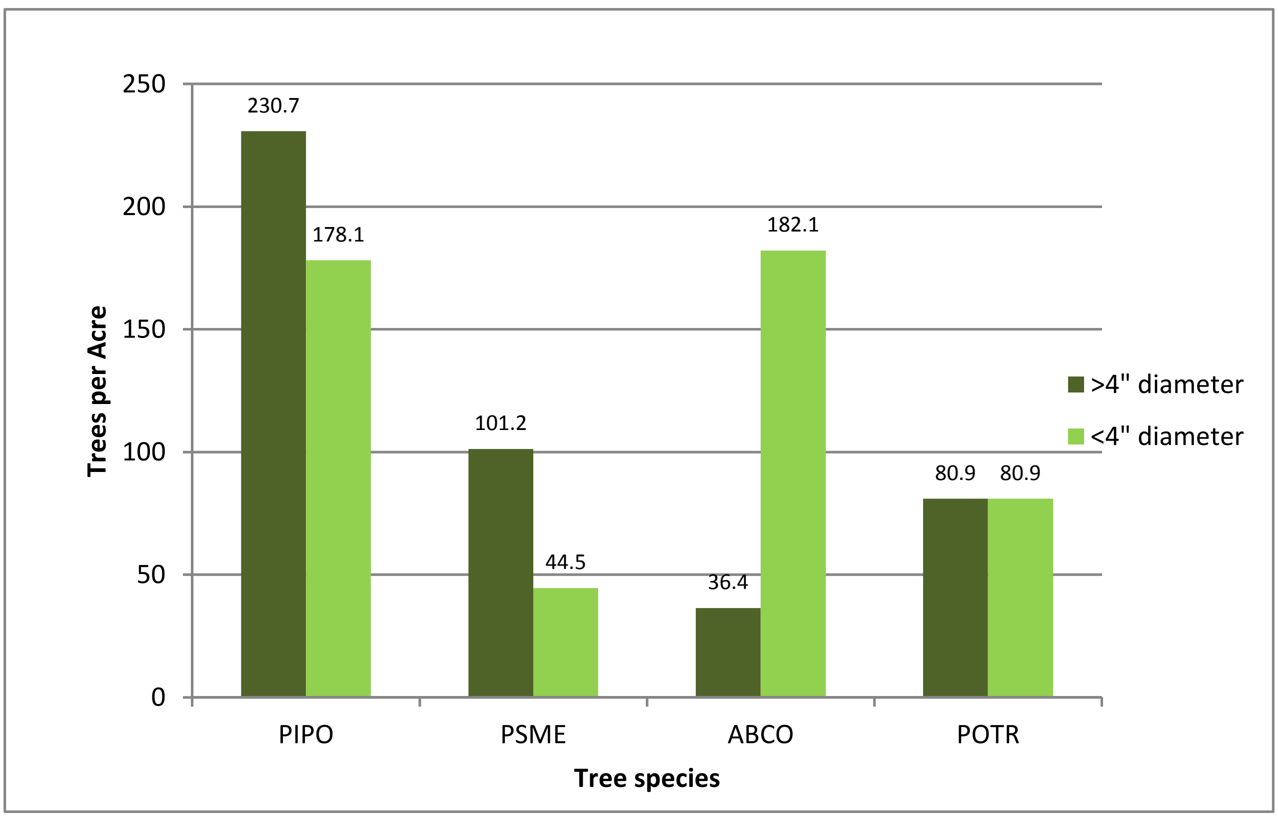


Figure 4.72. Density of trees per acre as related to species in Apache Springs Plot 1. Diameter (DBH) (PIPO = Pinus ponderosa*, PSME* = Pseudotuga menziesii*, ABCO* = Abies concolor*, POTR* = Populus tremuloides*)*

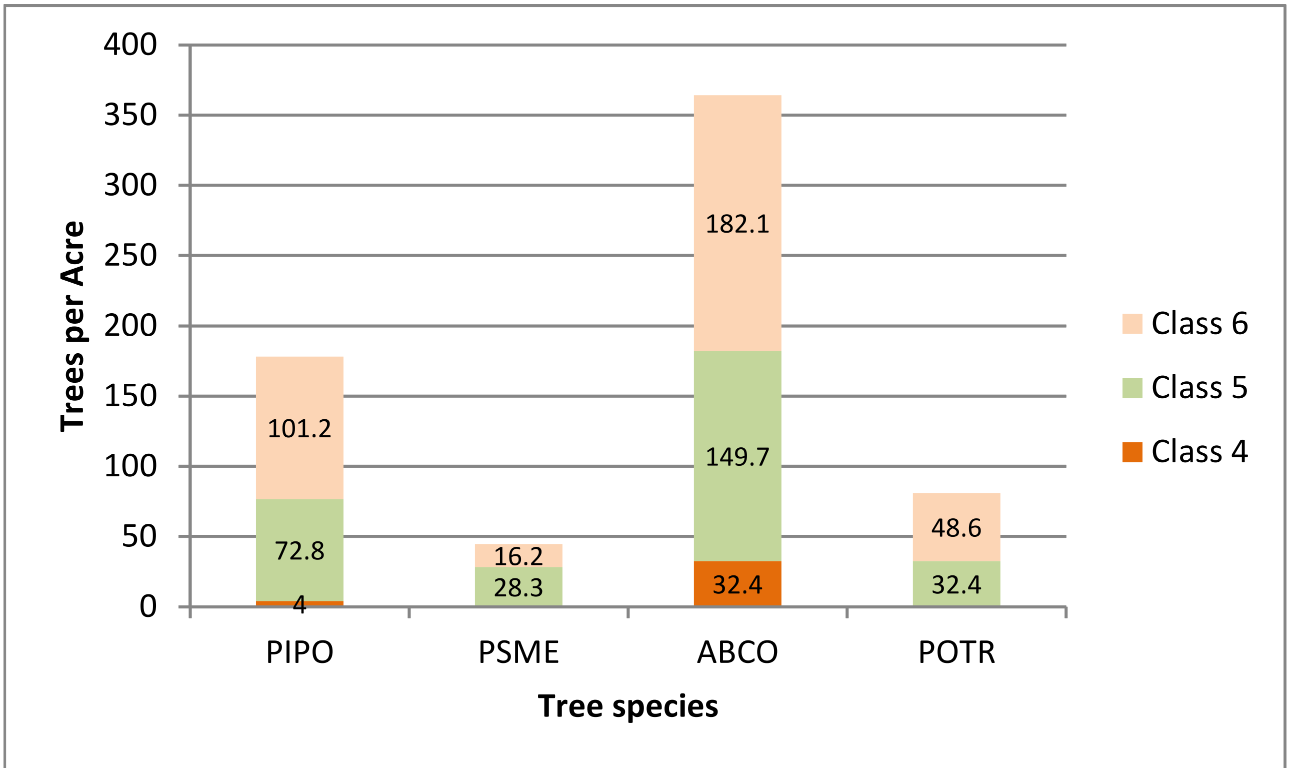


Figure 4.73. Density of trees less than four inches DBH in Apache Springs 1.

(PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor, *POTR* = Populus tremuloides*)*

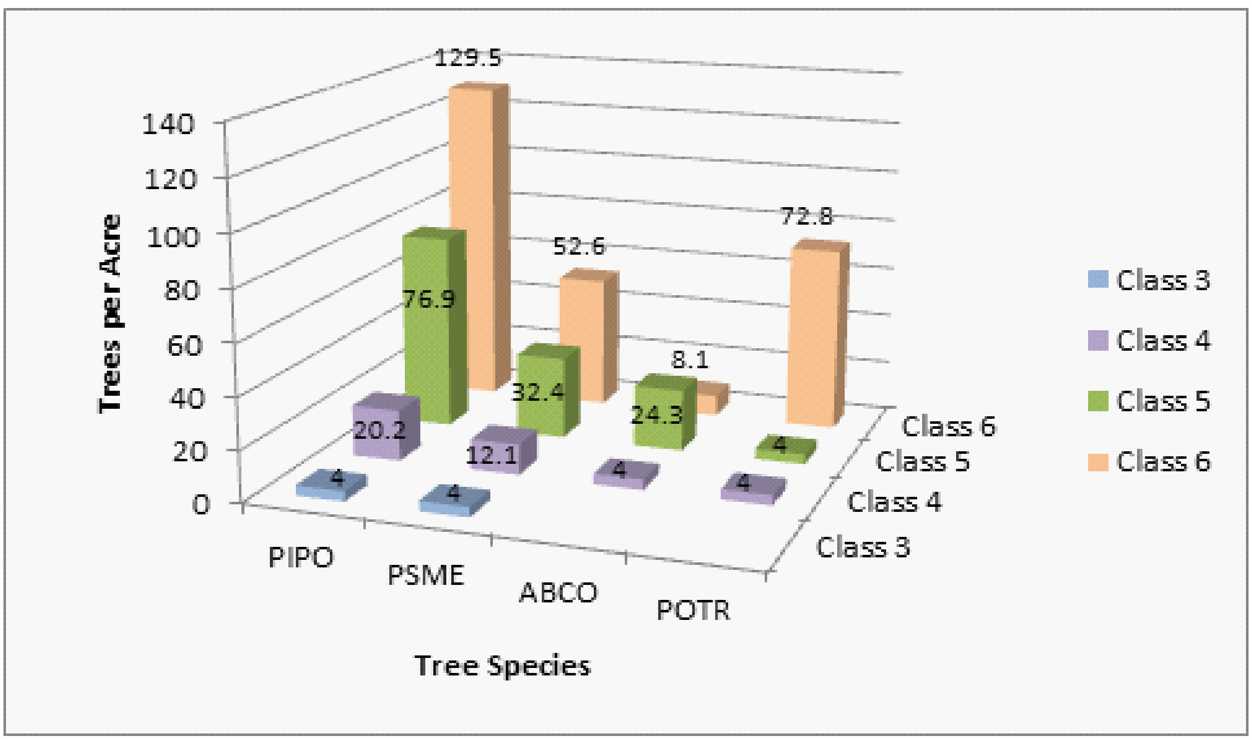


Figure 4.74. Severity classification for mature trees within Apache Springs 1.
Class 6 = no needles, Class 5 = brown needles, Class 4 = 25% crown alive, Class 3 = 50% crown alive. (PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor, *POTR* = Populus tremuloides*)*

Figure 4.75. Severely burned Apache Springs in 1992. Note the density of the grass and the status of the snags.

Table 4.22. Plot Visits and Information for the Apache Springs Area from 1977 to 2012

Plot	Burn Severity	1977	1992/3	1999	2010**	2012**
Apache Springs 1	severely 1025/acre	V, P*	V, P	V, P	0	0
Apache Springs 2	moderately	V, P	V, P	V, P	0	0
Apache Springs 3	lightly	V, P	0	0	0	0
Apache Springs 4	severely	V, P	0	0	0	0
Apache Springs 5	severely	V, P	V, P	V, P	P*	P*

*V = visited, P = photographs taken

**The plot boundaries were not located but general pictures were taken. See Photographic Record for matching pictures.

Apache Springs 2

Apache Springs 2 could be accessed either by the Apache Springs Trail or "Glendale Boulevard" and was considered to be moderately burned. The only information found was what is recorded in Foxx and Potter (1978).

Understory Conditions

The total cover in 1977 was 3.1 percent. Grass made up 2.6 percent of the total and were native rather than seeded grasses.

Overstory Conditions

This plot had slightly over 300 mature trees per acre and 412 trees in the reproductive classification, for a total of over 700 trees per acre (Figure 4.76). Ponderosa pine dominated the plot and sustained all degrees of foliar damage from 1 through 6 (Figure 4.77). All other species also sustained minimal foliar damage.

Apache Springs 3

Apache Springs 3 is accessed by Apache Springs Trail and is just beyond where the trail dips into the canyon and then comes back out. This plot was classified as lightly burned. Ponderosa pine dominated the plot with over 300 trees per acre. The site supported over 400 mature trees per acre and over 600 trees in the reproductive classification (less than four inches dbh) (Figure 4.78) and sustained all degrees of foliar damage from 1 to 6 (Figure 4.79). There were over 1000 trees per acre in this location.

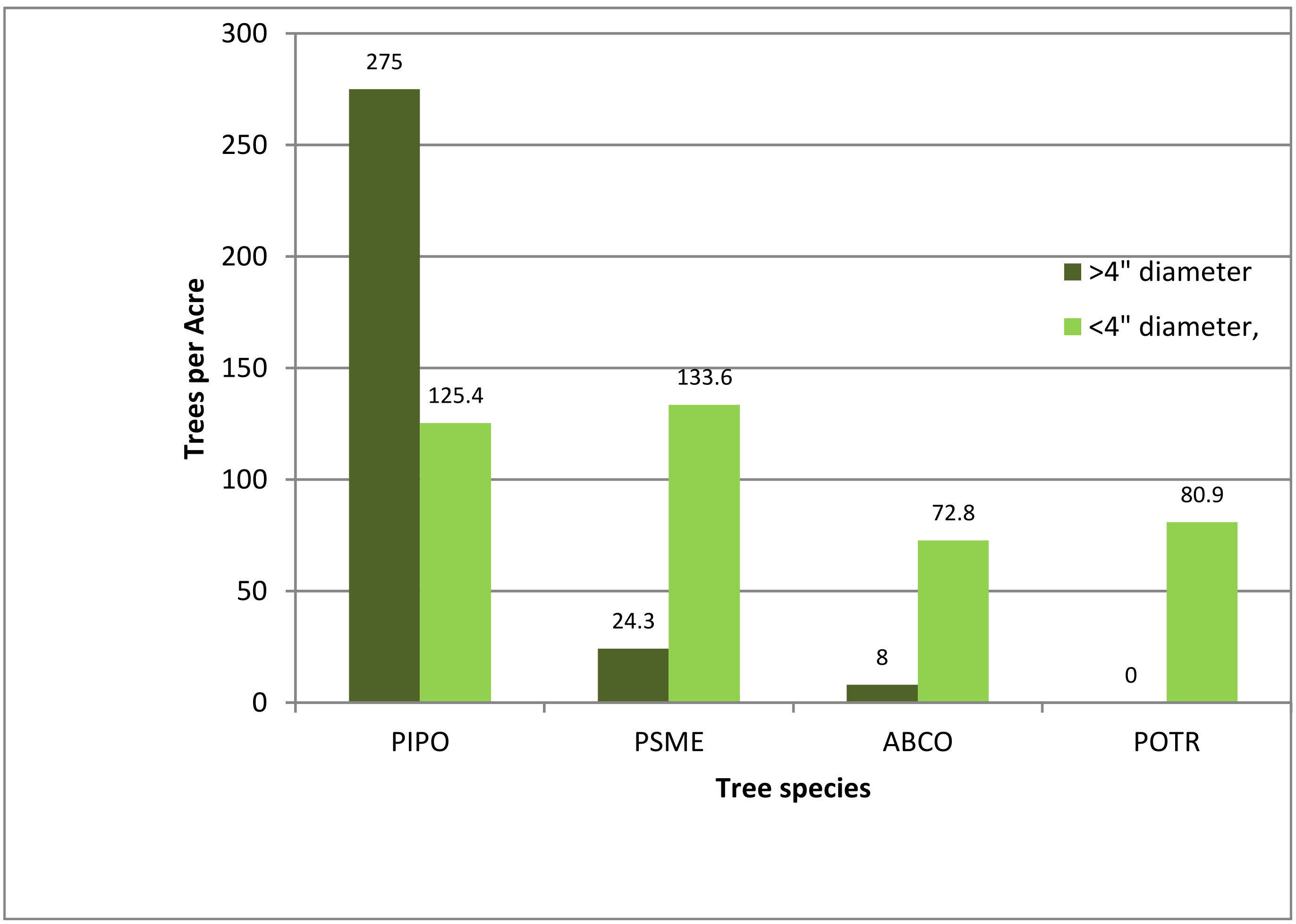


Figure 4.76. Number of trees per acre in Apache Springs 2 by species (PIPO = Pinus ponderosa*, PSME =* Pseudotsuga menziesii*, ABCO =* Abies concolor*, POTR =* Populus tremuloides*)*

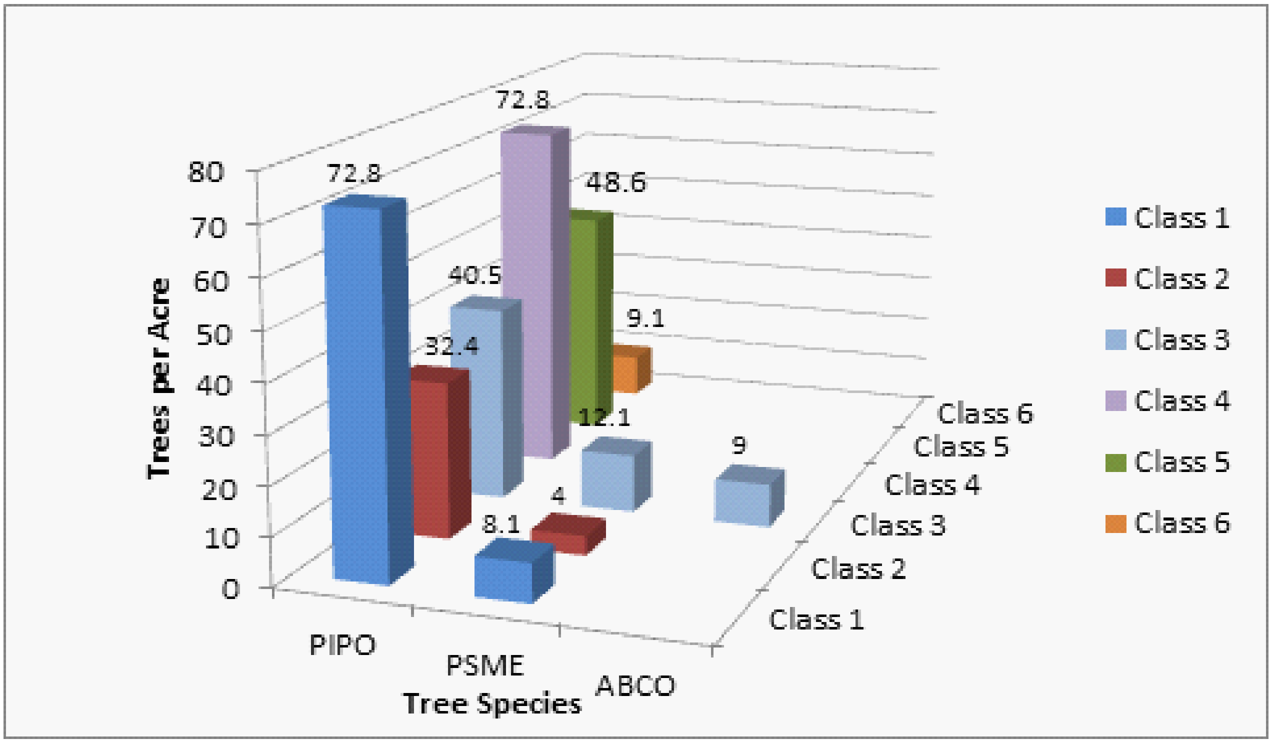


Figure 4.77. Severity classification for mature trees within Apache Springs 2.

Class 6 = no needles, Class 5 = all brown needles, Class 4 = 25% crown remaining, Class 3 = 50% crown remaining, Class 2 = 75% crown remaining, Class 1 = 100% crown remaining. (PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor*)*

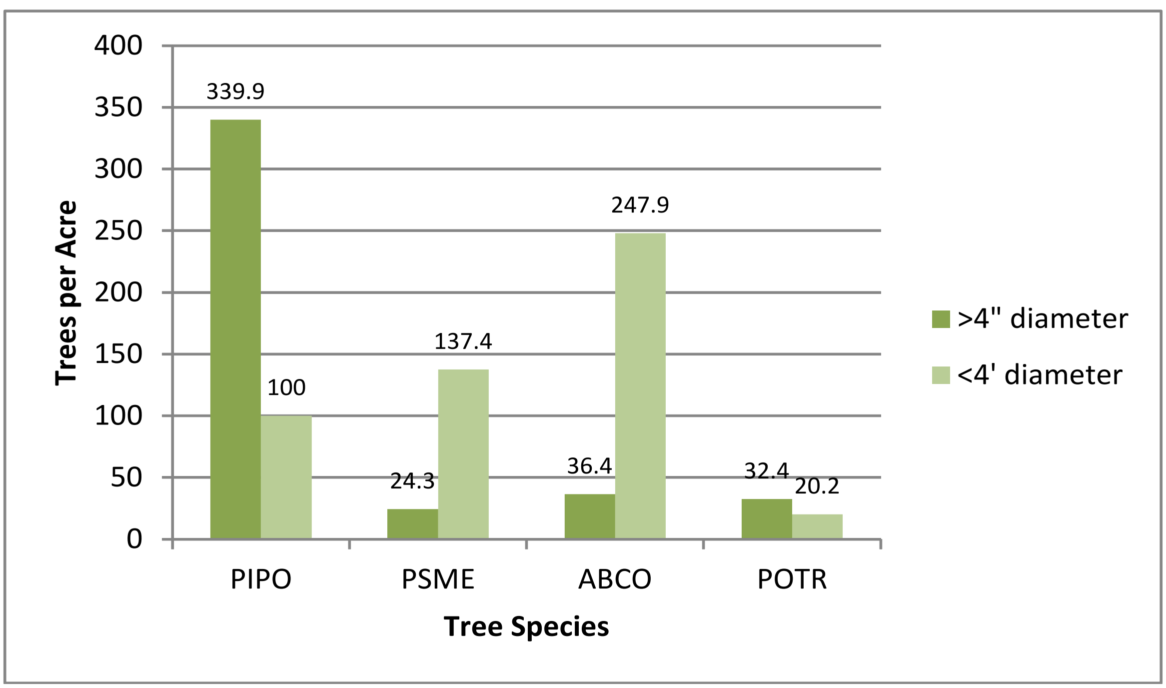


Figure 4.78. Number of trees per acre in mature and reproductive class in Apache Springs 3 by species.

(PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor, *POTR* = Populus tremuloides*) Diameter = DBH in inches*

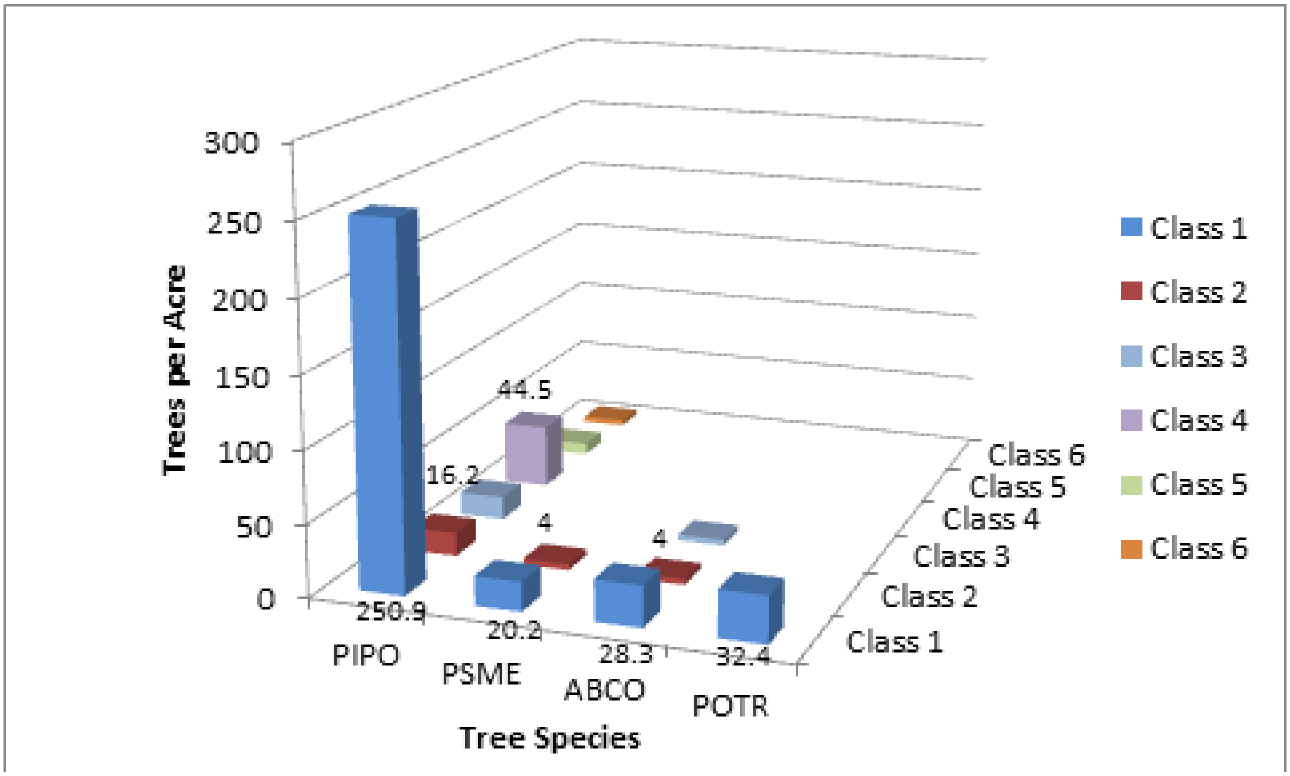


Figure 4.79. Severity classification for mature trees in Apache Springs 3.

Class 6 = no needles, Class 5 = all brown needles, Class 4 = 25% crown remaining, Class 3 = 50% crown remaining, Class 2 = 75% crown remaining, Class 1 = 100% crown remaining
(PIPO = Pinus ponderosa*, PSME* = Pseudotsuga menziesii*, ABCO* = Abies concolor*, POTR* = Populus tremuloides*)*

Apache Springs 4
Apache Springs 4 was not in the immediate vicinity of Wauer's transect; however, it demonstrated a high degree of damage and was selected for observation of sprouting of mixed conifer species. All species sustained a high degree of foliar damage with aspen being most severely scorched (Figure 4.80). We did not find this plot after the 1977 establishment because of the height of the sprouting vegetation. Modern GPS locations certainly make relocation of stakes much more possible but, in 1977, GPS was not available.

Understory Conditions
Raw data were not relocated, but from previous publications, total coverage was 6.3 percent with 6.1 percent of sheep fescue. No further information is available for this plot.

Overstory Conditions
The site had 546 mature trees per acre and over 600 trees in the reproductive classification with a total of over 1100 trees per acre (Figure 4.81). There was a mixture of species within the plot with the species with the highest density being ponderosa pine. The species with the second highest density was Douglas-fir. The site has a few aspen. After the fire all trees were in class 5 (brown needles) or 6 (no needles). Aspen were severely burned.

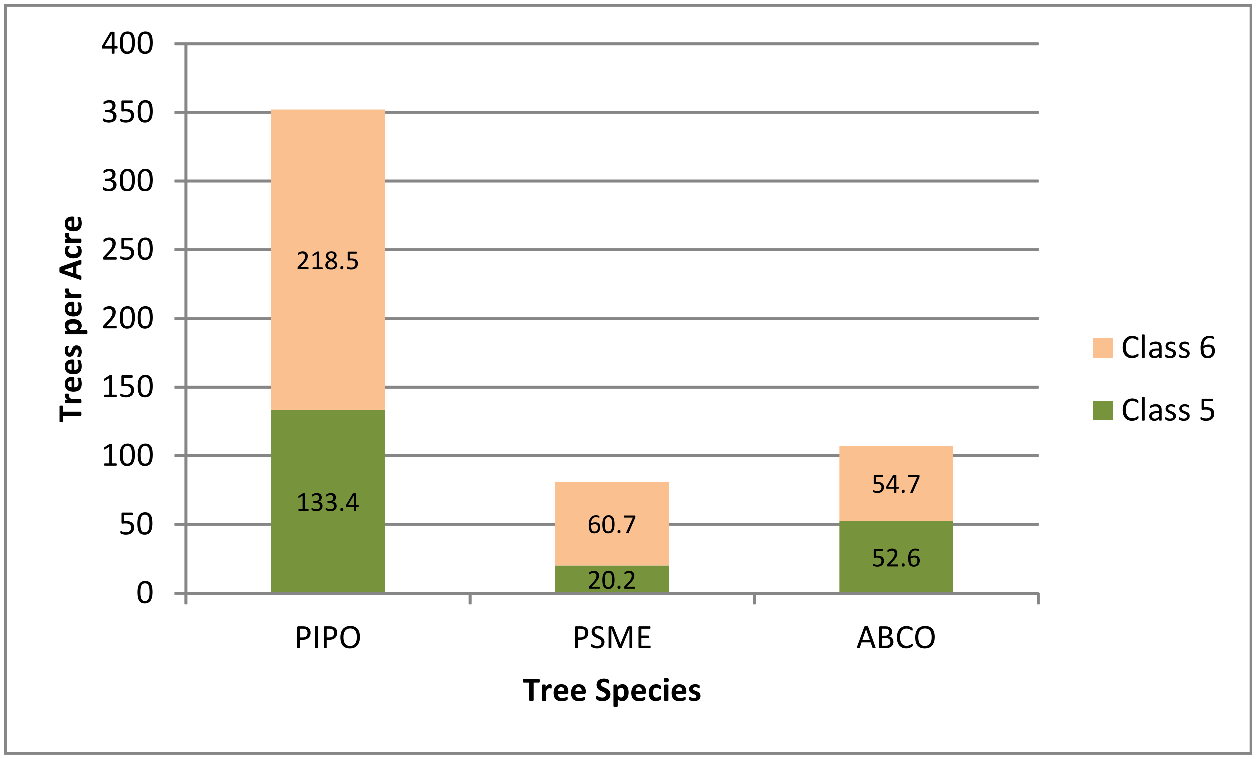


Figure 4.80. Severity classification for mature trees in Apache Springs 4. Class 6 = no needles, Class 5 = brown needles. (PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor*)*

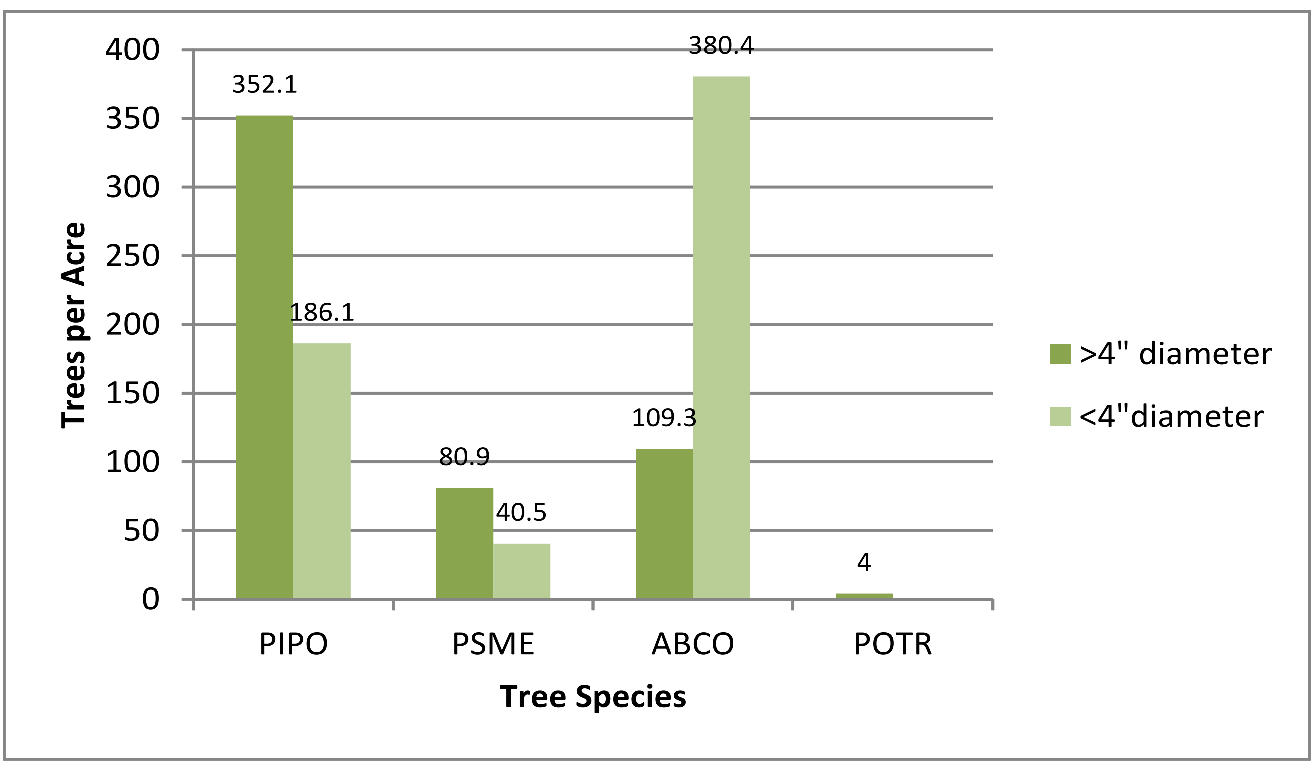


Figure 4.81. Number of trees per acre in Apache Springs 4 by species. Diameter = DBH in inches (PIPO = Pinus ponderosa, *PSME* = Pseudotsuga menziesii, *ABCO* = Abies concolor, *POTR* = Populus tremuloides*)*

Apache Springs 5

Apache Springs 5 is along Apache Springs Trail after the trail turns southwest. Presently, the plot is close to an elk exclosure that was established in 1998. And a tree on the south side of the trail with a knot-like loop is close to the area. Plot 5 is similar to plot 4 and was established to observe sprouting of aspen. All tree species sustained a high degree of foliar damage with aspen being most severely damaged. Since this location is closest to State Route 4, photographs have been taken of the aspen regeneration through the years.

Understory Conditions

The understory cover in this severely burned plot was 3.1 percent in 1977 and was only 4.8 percent in 1999 (Table 4.23). The shift, however, was in the number of species of grass on the site. In 1977, it was primarily the seeded species, sheep fescue. By 1999, sheep fescue was still a dominant species but there was also some mountain muhly. Cheatgrass had a small amount of cover but is consistent with seeing it not before the mid 1990s in the plots. There were a variety of forb species and two shrub species by 1999 (Figure 4.82).

Overstory Conditions

The overstory in this plot was dominated by ponderosa pine (Figure 4.83) with a mixture of Douglas-fir and white fir. A few aspens were within the plot. After the fire all species were within class 5 (brown needles) and 6 (no needles) (Figure 4.84). Aspen recovery has been followed in this plot because of its resiliency (Plate 4.19). Figure 4.85 shows the area of Apache Springs 5 after the Las Conchas Fire with sprouting oak and New Mexico locust.

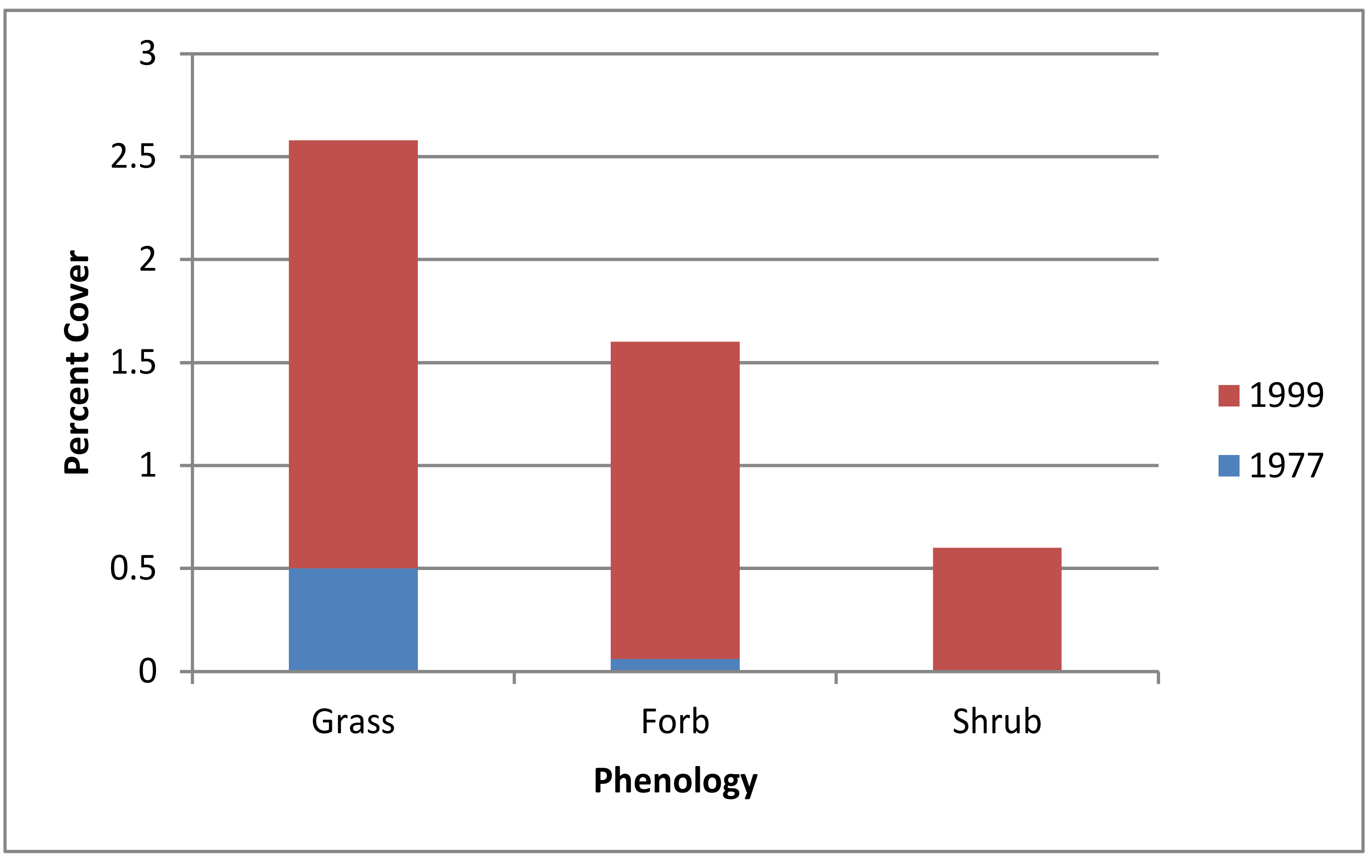


Figure 4.82. Species on Apache Springs 5 by phenology

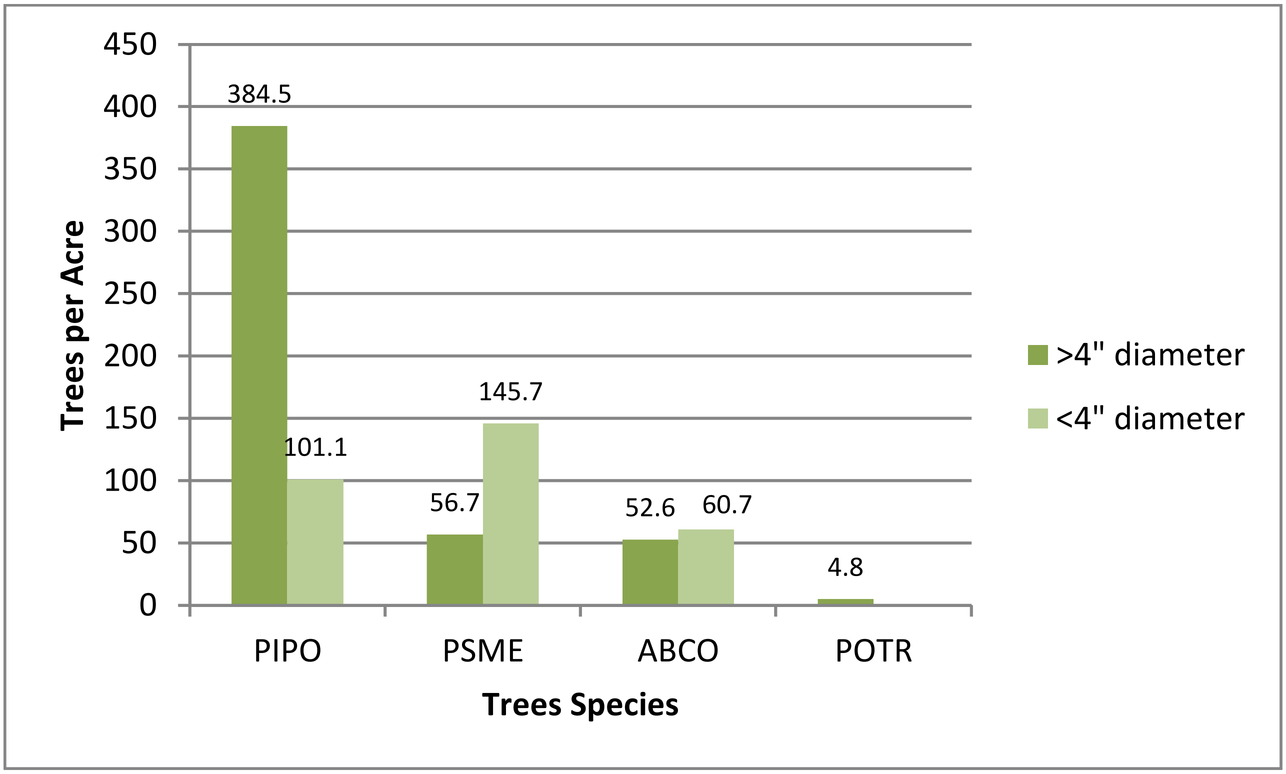


Figure 4.83. Number of mature and reproductive trees per acre in Apache Springs 5 in 1977. Diameter = DBH in inches. *(PIPO* = Pinus ponderosa*, PSME* = Pseudotsuga menziesii*, ABCO* = Abies concolor*, POTR* = Populus tremuloides*)*

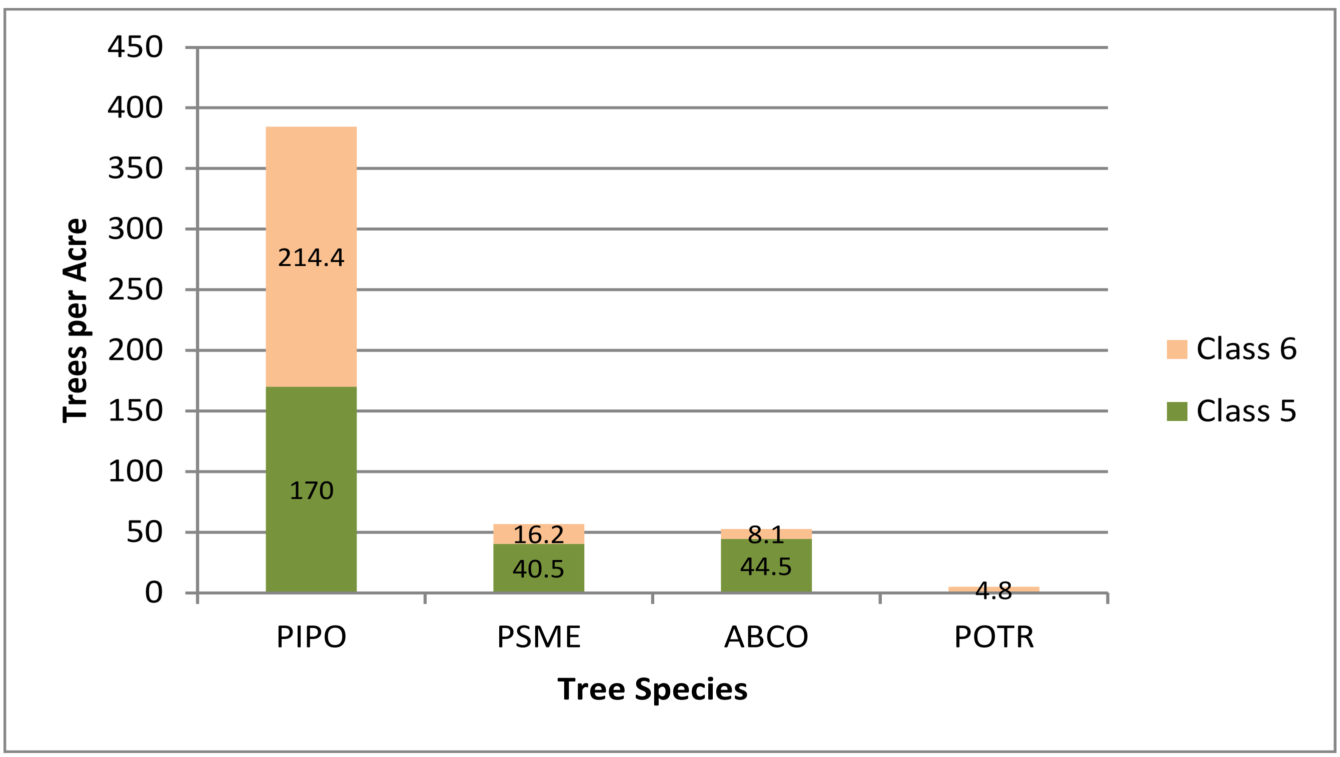


Figure 4.84. Burn severity classification of the mature trees in Apache Springs 5. Class 6= no needles, Class 5=all brown needles. (PIPO = Pinus ponderosa*, PSME* = Pseudotsuga menziesii*, ABCO* = Abies concolor*, POTR* = Populus tremuloides*)*

Figure 4.85. Apache Springs 5 area re-burned by the Las Conchas fire in 2011. Photo taken May 25, 2012. Sprouting oak and New Mexico locust were three to four feet high.

Plate 4.19

Aspen recovery after the La Mesa Fire
22 years post-fire (1999)

View above shows the density of the aspen. View to the left shows the amount of elk browsing on the aspen. Note the exclosure behind six-foot, three-inch Carey Bare. (F1-1)

(Continued on the next page)

Plate 4.19 *(continued) Aspen recovery after the Las Conchas Fire reburned this area in 2011. The mature trees were all dead, but there was vigorous sprouting May 25, 2012, when these pictures were taken. Beth is five feet, one inch tall. The elk exclosure is to the left out of the picture.*

Plate 4.19 *(continued) Apache Springs 5 area in 2010. Note the density of shrubs.*

Table 4.23. Percent Cover of Apache Springs 5 Through Time

Species	**Percent Cover**	
	1977	**1999**
Grass		
Native Grass		
Elymus elymoides		0.14
Muhlenbergia montana		0.30
Total Native Grass	**0**	**.44**
Seeded Grass		
Festuca ovina	2.08	2.22
Total Seeded Grass	**2.08**	**2.22**
Introduced Grass		
Bromus tectorum		0.02
Total Introduced Grass		**0.02**
Total Grass	**2.08**	**2.68**
Total Grass Species	**1**	**4**
Forbs		
Achillea lanulosa		0.12
Arabis fendleri	0.02	
Clematis psuedoalpina		0.20
Fragaria americana		0.56
Geranium richardsonii		0.10
Smilacina spp.		0.02
Thalictrum fendleri		0.54
Unknown Forb	0.04	
Total Forbs	**0.06**	**1.54**
Total Forb Species	**2**	**6**
Shrubs		
Arctostaphylos uva-ursi		0.06
Pachystima myrisinites		0.54
Robinia neomexicana	0.02	0.60
Total Shrub	**0.02**	**1.20**
Total Shrub Species	**1**	**3**
TOTAL FOLIAGE COVER	**2.16**	**5.42**
Bare Soil	97.84	10.72
Litter		87.18
Moss/Lichens		2.10

4.5 Frijoles Mesa

Piñon-Juniper Woodland

The piñon-juniper woodlands are widespread on the Pajarito Plateau at elevations between 5000 and 7000 feet. In New Mexico, 3.6 million hectares consist of piñon-juniper habitat. The dominant species within the woodlands are piñon pine and one-seed juniper. Other species that can occassionally be found are Rocky Mountain juniper and alligator juniper.

Frijoles Mesa consisted of piñon-juniper plots on the south side of State Route 4 (Figure 4.86). There were three plots originally and data were taken in all three plots in 1977. In 1999, only two of the three plots were located. The plots were visited in 2012 and data were taken on all three plots. The three plots represented three burn severities—Plot 1 was lightly burned, Plot 2 moderately burned, and Plot 3 severely burned.

Plots in the piñon-juniper woodland were in two locations, Burnt Mesa and Frijoles Mesa. Piñon-juniper dominates this transect, which is near the interface of the piñon-juniper, ponderosa pine zone. The area was burned between 1100 and 2200 hours June 18, 1977, when the predicted rate of spread was 38 chains per hour. Fuel loads in the vicinity of the plot were 24 tons per acre but in other areas 2.2 tons per acre (Forester 1976). Burning was spotty throughout the area; however, in some areas the fire did crown causing complete loss of some trees. In other areas burning was light with only one side of a tree scorched. In both the light and moderately burned plots, burning was complete only near isolated trees.

In 1999, two of the plots were recorded by GPS coordinates and are presented below.

Frijoles Mesa 1

This plot is west of the BNM entrance by several miles. There is an archaelogical site along the edge of the road and to the north of the plot.

Understory Conditions

This plot was classified as a lightly burned site (Figures 4.87 and 4.88). It was established in 1977 and relocated in 1999 and 2010. Through the years there was an increased cover of shrubs, forbs, and grasses (Figure 4.89). The most common grass was blue grama. Summarized data are presented in Table 4.24.

Overstory Conditions

The site had one ponderosa pine and was primarily piñon-juniper woodland. There were a number of immature piñons but mature junipers dominated the site (Figure 4.90). The junipers had varying degrees of damage and the piñon were primarily either singed with brown needles or in less severe damage classes (Figure 4.91). Frijoles Mesa 1 was mapped through time. Plate 4.20 presents maps for 1999 and 2010.

GPS coordinates for three plots on Frijoles Mesa

Name	Longitude_WGS84	Latitude_WGS84
Frijoles Mesa 2	-106.2990000	35.8084830
Frijoles Mesa 1	-106.2979750	35.8070560
Frijoles Mesa 3	-106.3141480	35.8216110

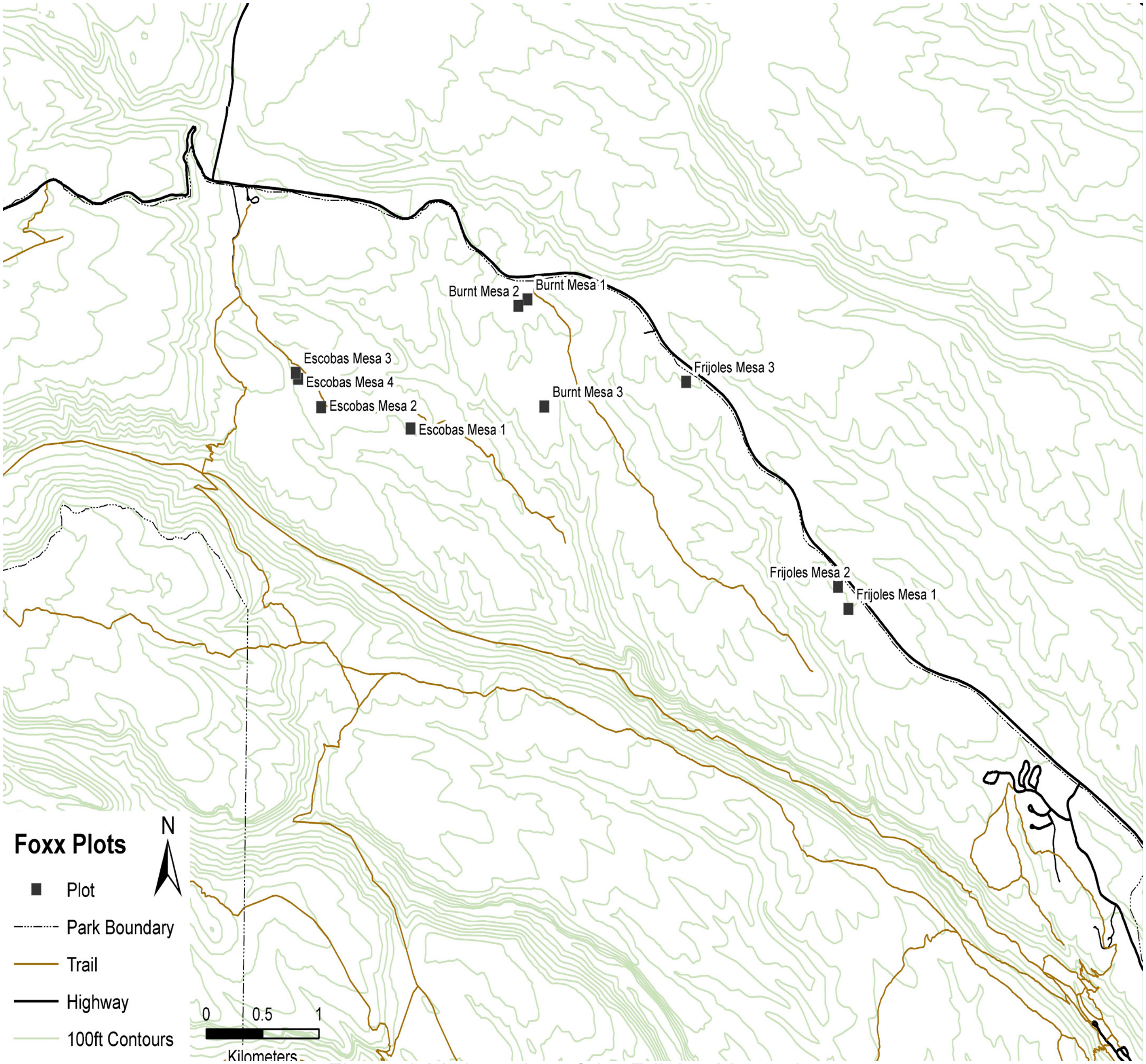


Figure 4.86. Location of the Frijoles Mesa plots

Figure 4.87. Frijoles Mesa 1. Picture taken in 1977.

Figure 4.88. Frijoles Mesa 1. Picture taken in 1999.

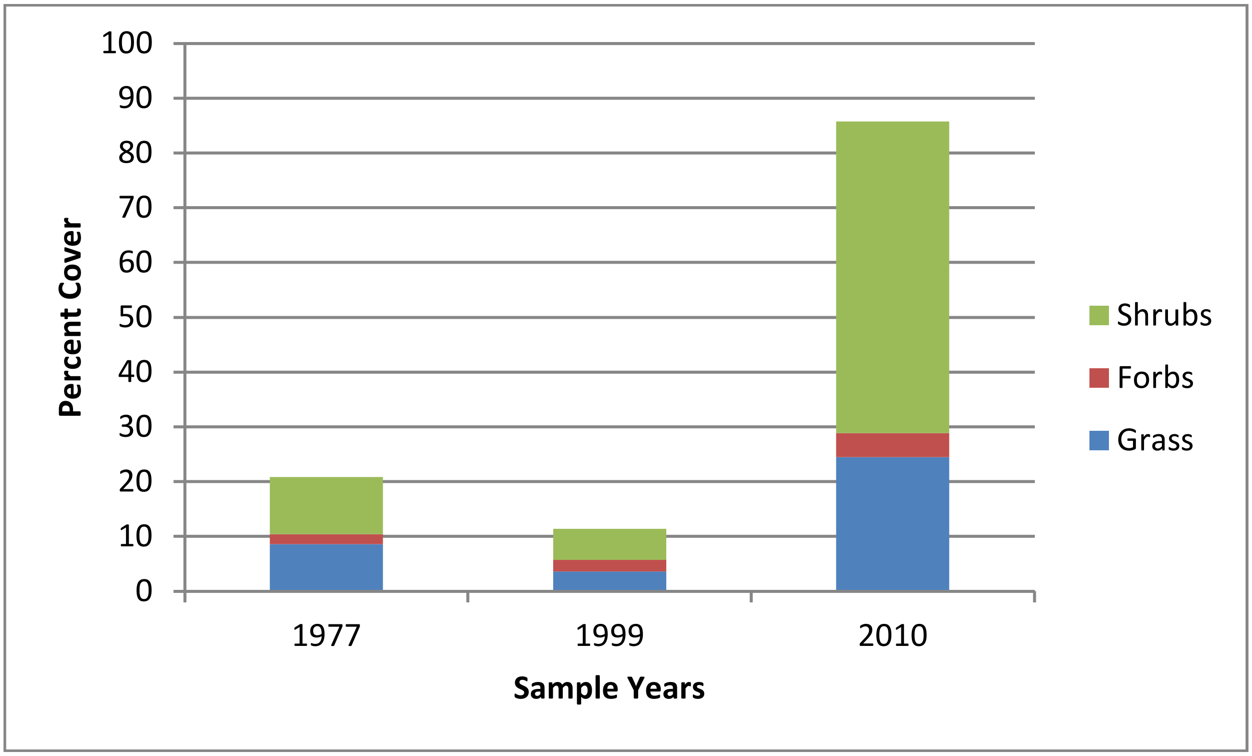


Figure 4.89. Percent cover of grasses, forbs, and shrubs in Frijoles Mesa 1

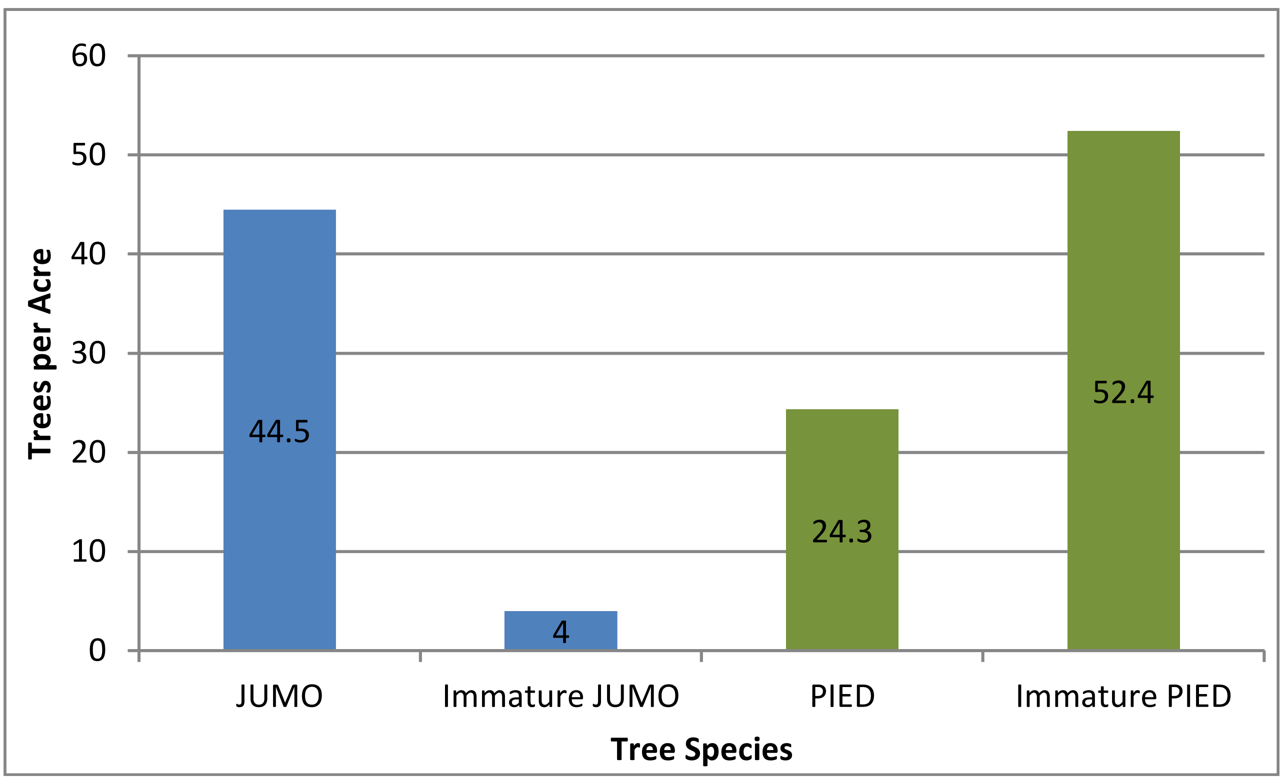


Figure 4.90. Tree species found within Frijoles Mesa 1
(JUMO = Juniperus monosperma*, PIED* = Pinus edulis*)*

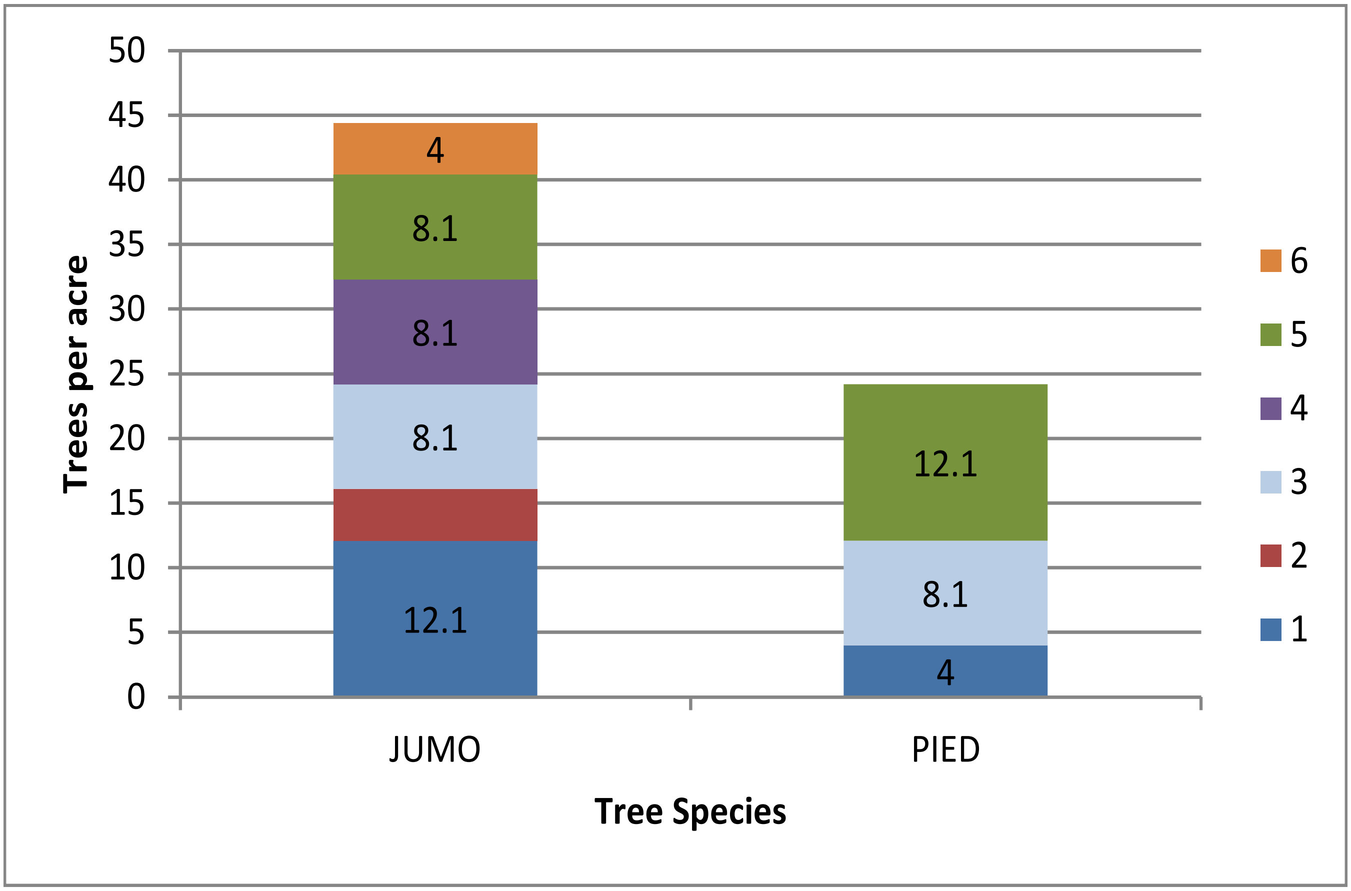


Figure 4.91. Severity classification of mature trees per acre within Frijoles Mesa 1 (JUMO = Juniperus monosperma*, PIED* = Pinus edulis*)*

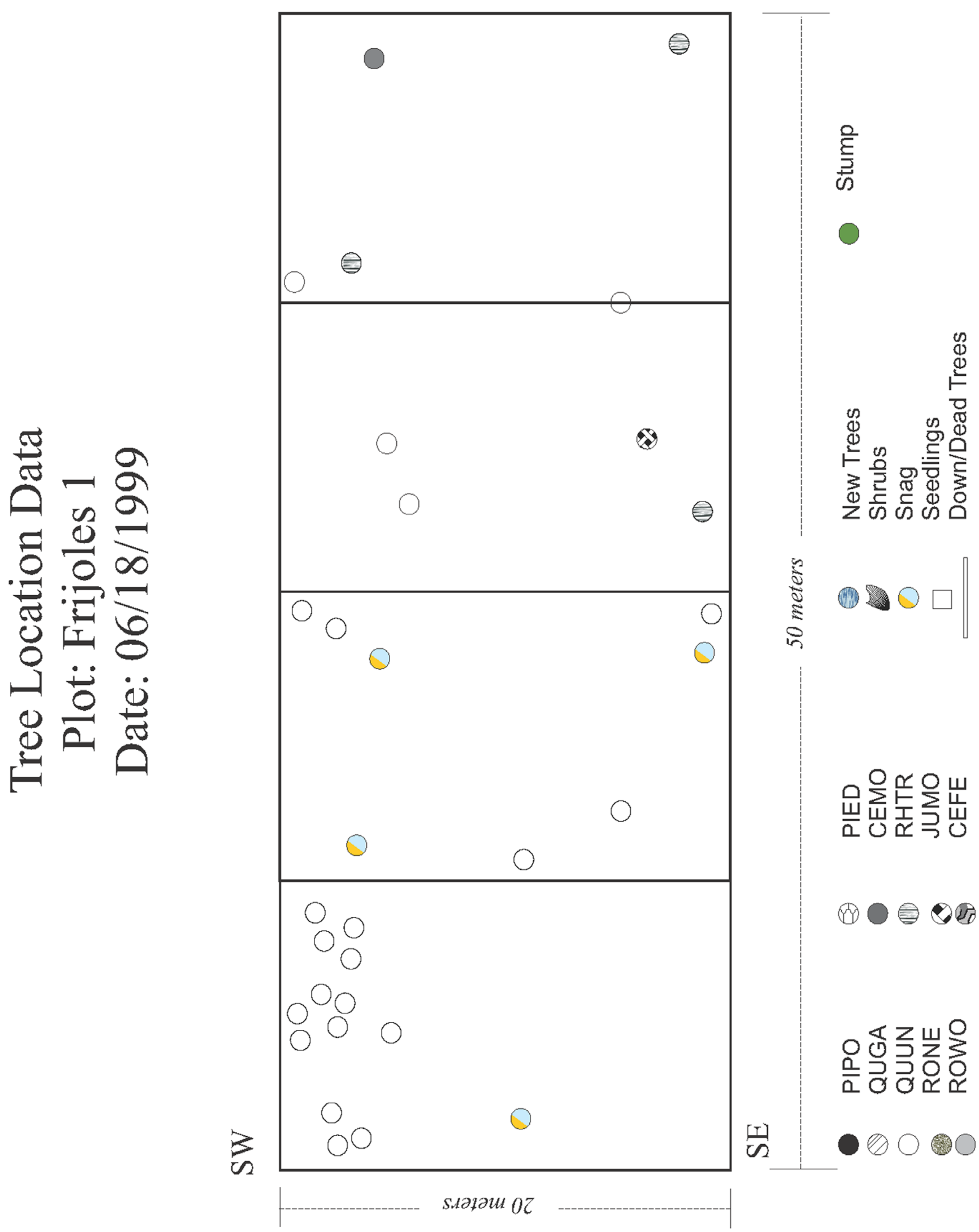


Plate 4.20. *Tree location data for Frijoles Mesa 1 for 1999 and 2010 (continued on next page)*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

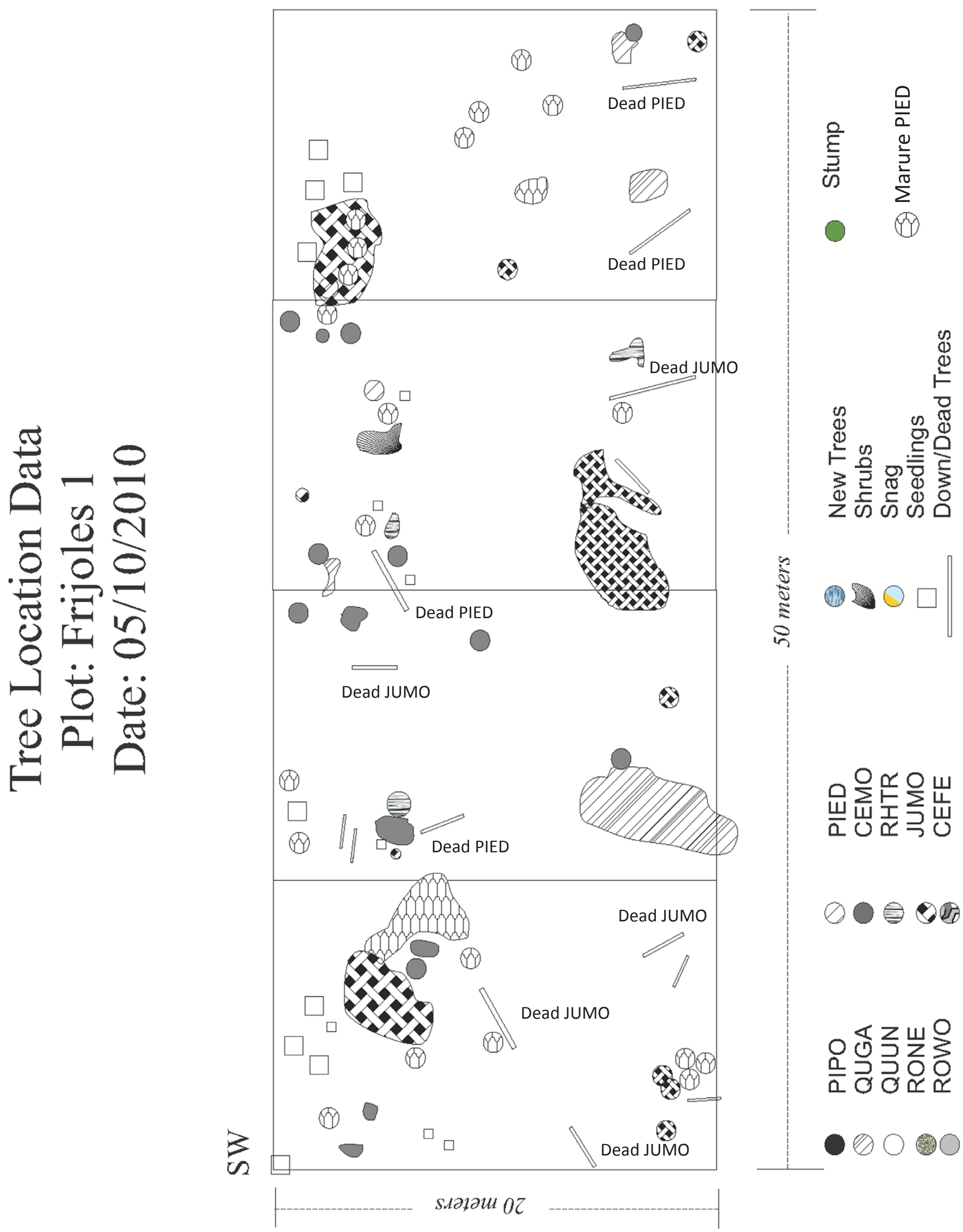


Plate 4.20. (continued)*Tree location data for Frijoles Mesa 1 for 1999 and 2010*

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata)*,RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

Table 4.24. Percent Cover of Grasses, Forbs, and Shrubs Through Time for Frijoles Mesa 1

Species Name	1977	1999	2010	Occurrence
Grass				
Native Grass				
Bouteloua gracilis	7.70	0.74	19.72	3
Elymus elemoides	0.22		0.26	1
Koeleria cristata		0.06	2.62	2
Muhlenbergia montana	0.70	0.97	0.78	3
Poa spp.		0.01	0.40	2
Schizachyrium scoparium		1.78	0.30	2
Stipa spp.			0.40	1
Total Grass Cover	**8.62**	**3.56**	**24.48**	
Total Grass Species	**3**	**5**	**7**	
Forbs				
Amaranthus retroflexus	0.02			1
Artemisia carruthii	0.36	0.41	0.70	3
Bahia spp.	0.42		0.12	1
Castilleja integra	0.12	0.01		2
Chenopodium graveolens	0.11			1
Erigeron divergens	0.02		0.10	2
Erigeron flagellaris		0.02		1
Erigeron spp.			1.00	1
Eriogonum alatum		0.15		1
Euphorbia serpyllifolia	0.34			1
Gutierrezia sarothrae	0.01	0.50		2
Heterotheca villosa	0.02	0.47	0.30	3
Hymenopappus filifolius	0.02			1
Hymenoxys richardsonii		0.20	0.60	2
Lotus wrightii	0.02		0.10	2
Oenothera spp.	0.04			1
Opuntia spp.		0.05		1
Orthocarpus purpureo-albus			0.13	1
Petalostemum candidum		0.11		1
Physalis foetens var. *neomexicana*	0.02			1
Physalis hederlifolia var. *fendleri*	0.02			1
Senecio spp.	0.03	0.05		2
Stipa comata		0.01		1
Thelesperma trifidum		0.13	1.36	2
Unidentified forb	0.22			1
Vicia americana		0.01		1
Total Forb Cover	**1.79**	**2.12**	**4.41**	
Total Forb Species	**16**	**13**	**9**	

Species Name	1977	1999	2010	Occurrence
Shrubs				
Chrysothamnus nauseosus			0.12	1
Cercocarpus montanus		0.01	2.10	2
Juniperus monosperma			15.80	1
Pinus edulis			7.50	1
Quercus spp.			1.92	1
Rhus trilobata			0.54	1
Total Shrub Cover		**0.01**	**27.98**	
Total Shrub Species		**1**	**6**	
TOTAL FOLIAR COVER	**10.41**	**5.69**	**56.87**	

Frijoles Mesa 2

Frijoles Mesa 2 was classified as a moderately burned area (Figure 4.92). The site is west of Frijoles Mesa 1 and was not relocated in 1999 but was found in 2010.

Understory Conditions

The site increased in forbs, grasses, and shrubs through time. By 2010 a majority of the cover was either grass or shrubs (Figure 4.93). Blue grama had the highest cover and, in 2010, cheatgrass had a significant amount of cover. The most common forb species was sagewort (Table 4.25).

Overstory Conditions

In 1977, the site was dominated by piñon and juniper. Juniper had the high number of trees per acre. There was a smaller amount of reproductive stock on this site in 1977 than in Plot 1 (Figure 4.94). Most juniper were killed by the fire but about 50 percent of the piñon survived (Figure 4.95). Figure 4.96 presents a map for 2010.

Figure 4.92. Frijoles Mesa 2 in 1977

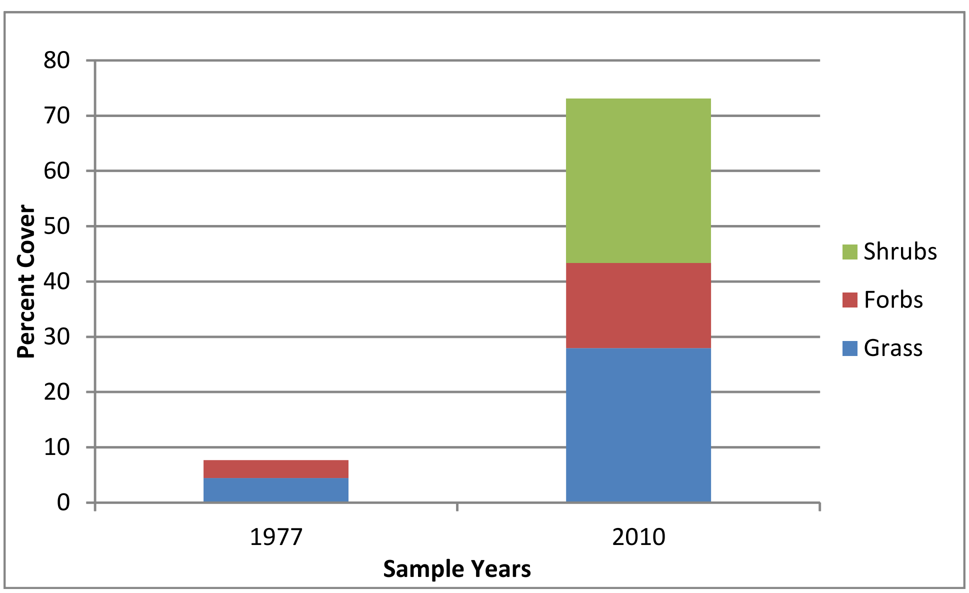


Figure 4.93. Percent cover of grass, forbs, and shrubs through time at Frijoles Mesa 2

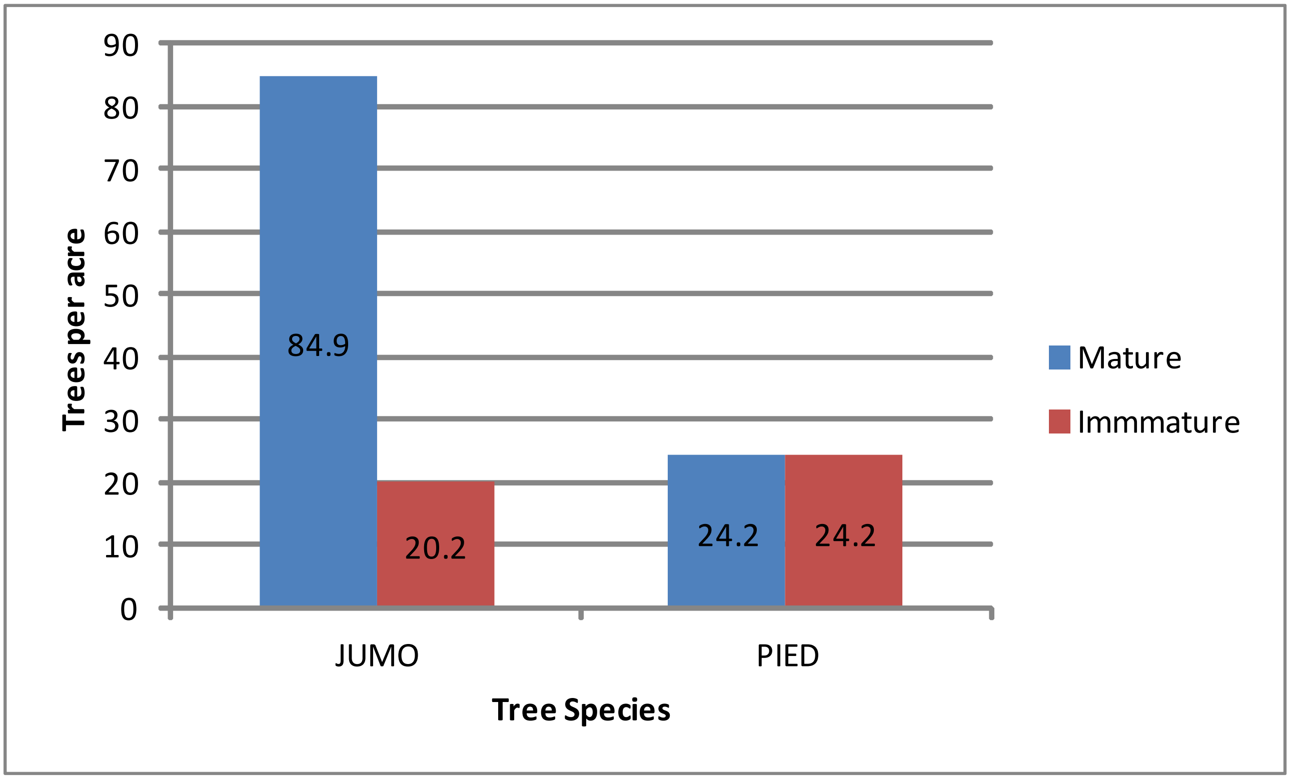


Figure 4.94. Number of trees per acre of juniper and piñon in Frijoles Mesa 2

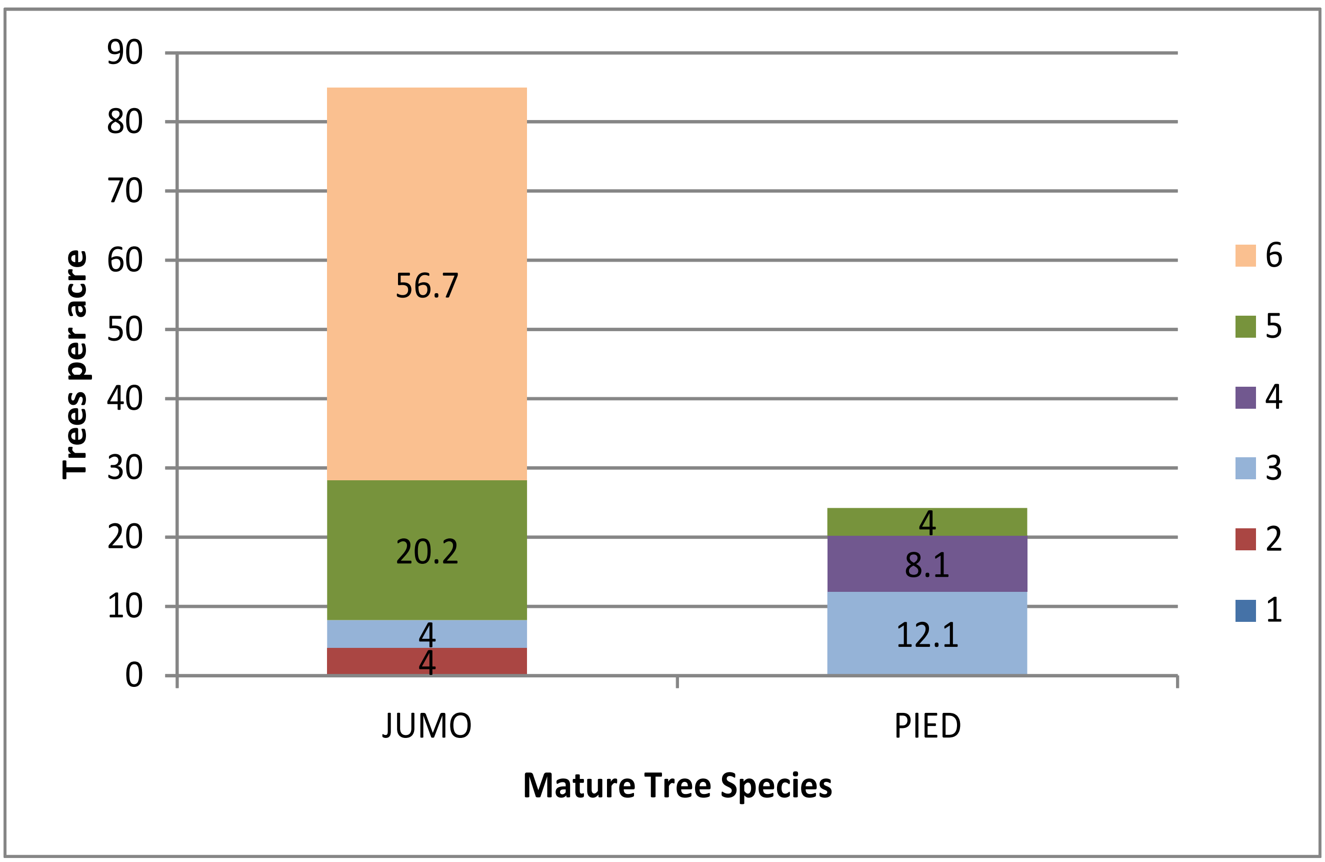


Figure 4.95. Severity class of the mature junipers and piñons in Frijoles Mesa 2.
(JUMO = Juniperus monosperma, *PIED* = Pinus edulis*)*

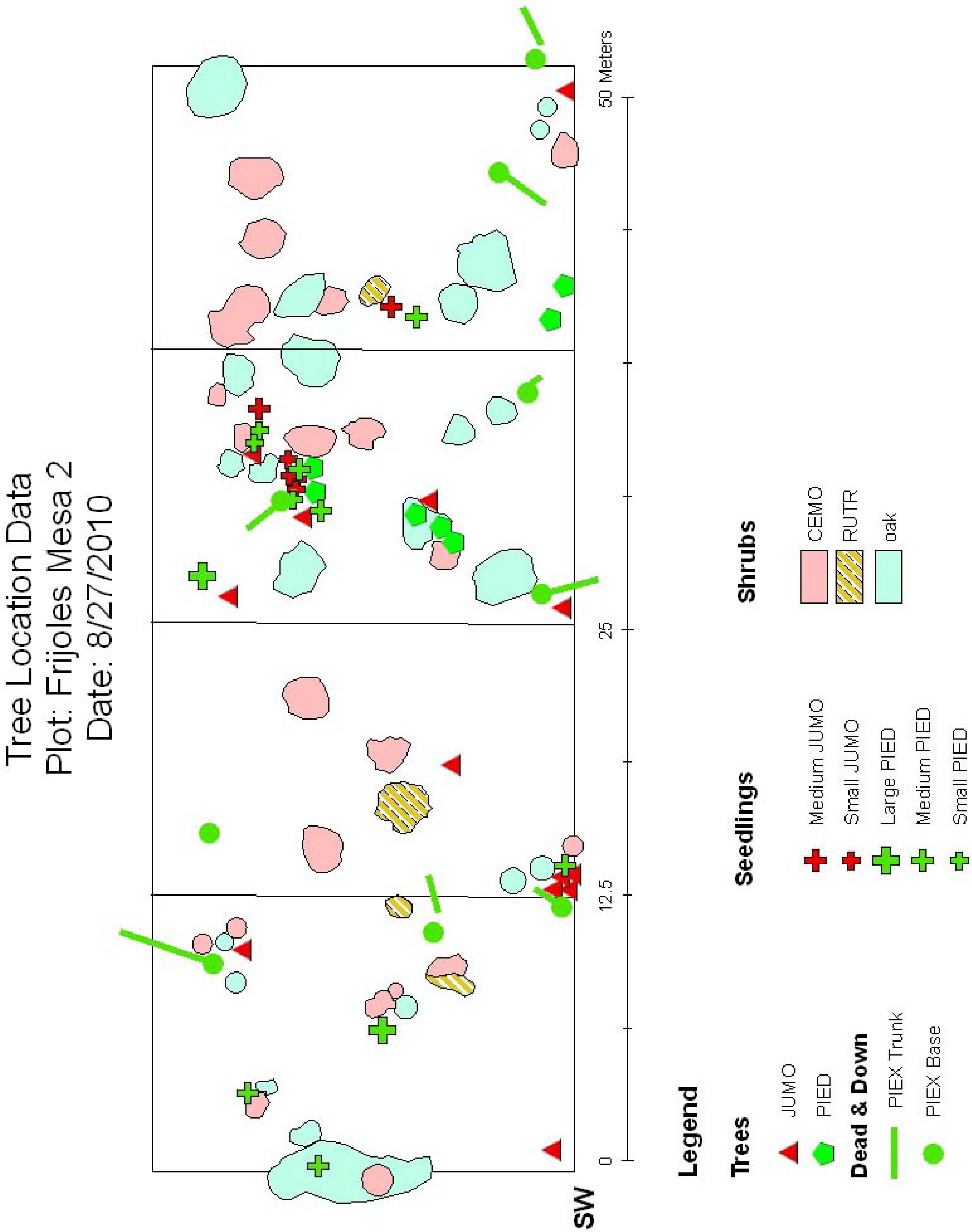


Figure 4.96. Tree location data for Frijoles Mesa 2 in 2010

Table 4.25. Percent Cover of Grasses, Forbs, and Shrubs Through Time for Frijoles Mesa 2

Species Name	1977	1999 NA (plot not found)	2010
Grass			
Bouteloua gracilis	3.42		19.14
Elymus elymoides			1.24
Koeleria cristata			1.24
Muhlenbergia montana	1.02		0.50
Poa spp.			1.00
Total Native Grass	**4.44**		**23.12**
Introduced Grass			
Bromus tectorum			4.60
Bromus japonicus			0.26
Total Introduced Grass			**4.86**
Total Grass Cover	**4.44**		**27.98**
Forbs			
Artemisia carruthii			1.42
Artemisia dracunculus			0.22
Artemisia spp.			1.20
Bahia spp.	0.72		0.12
Castilleja integra			0.32
Chenopodium spp.			0.02
Cordylanthus wrightii			0.12
Erigeron spp.	0.34		
Euphorbia serpyllifolia			0.02
Gutierrezia sarothrae	0.24		2.26
Geranium caespitosum			0.20
Hymenoxys richardsonii			0.14
Heterotheca villosa			0.1
Lotus wrightii			1.90
Petalostemum candidum	0.20		1.44
Senecio spp.	0.12		
Thelesperma trifidum	1.62		4.78
Thalapsi fendleri			0.5
Unidentified forb			0.14
Total Forb Cover	**3.24**		**15.44**
Shrubs			
Cercocarpus montanus			2.10
Juniperus monosperma			7.70
Pinus edulis			2.78
Quercus spp.			2.70
Rhus trilobata			0.60
Total Shrub			**29.68**
Total Foliar Cover	**7.86**		**72.84**

Frijoles Mesa 3

Frijoles Mesa 3 was west of Plots 1 and 2 and closer to the entrance of TA-49. This area was classified as severely burned in 1977. This plot was sampled in 1977, 1999, and 2010 (Figures 4.97 and 4.98).

Understory Conditions

The cover of grasses, forbs, and shrubs increased through time. Forbs dominated the site throughout the years sampled (Figure 4.99). There was about equal cover of mountain muhly and blue grama by 2010. Snakeweed had increased and made up the highest percent cover (Table 4.26).

Overstory Conditions

There orignally were a few ponderosa pine on this site but were severely damaged by the fire and did not survive through time. The largest number of trees per acre in 1977 were piñons (Figure 4.100). The trees were not measured in subsequent years but most of the trees on site in 2010 were from seedling recovery, as the trees were all classified in classes 5 (brown needles) and 6 (no needles or leaves) in 1977 (Figure 4.101). Figure 4.102 presents tree location data for Frijoles Mesa 3 in 2010.

Figure 4.97. Frijoles Mesa 3 in 1977

Figure 4.98. Frijoles Mesa 3 in 2010

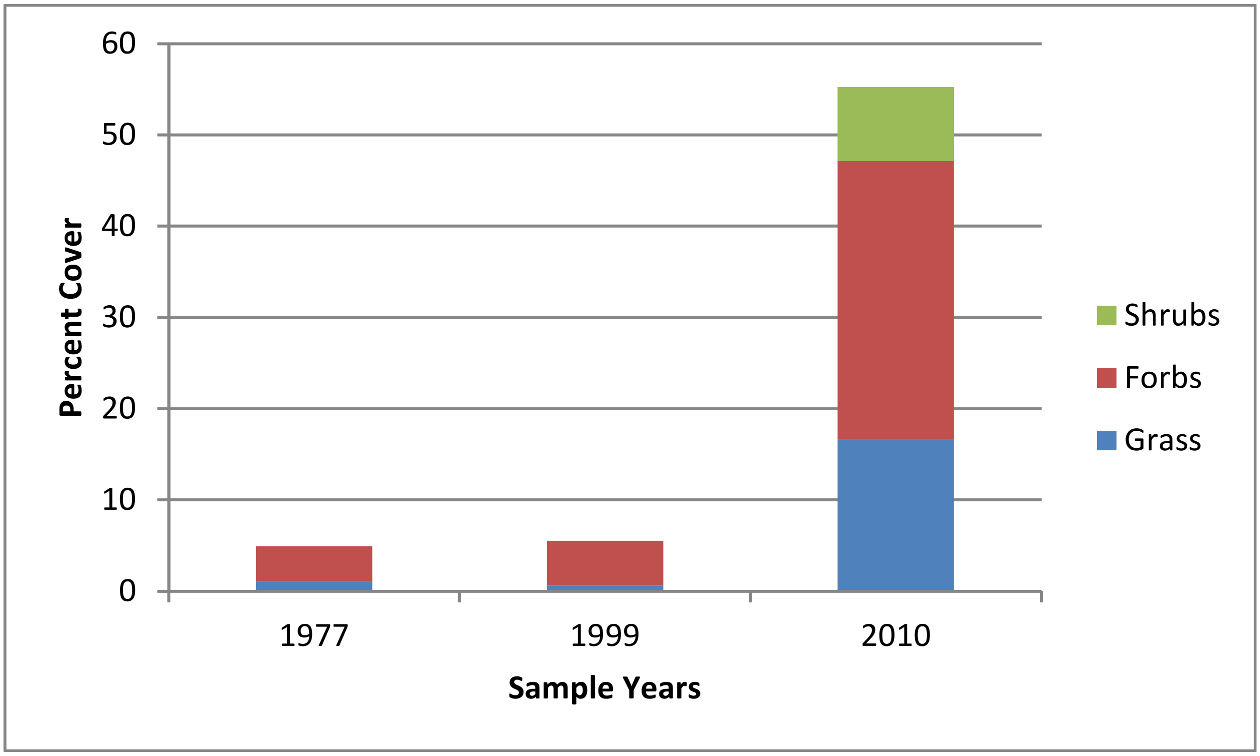


Figure 4.99. Percent cover of grass, forbs, and shrubs through time at Frijoles Mesa 3

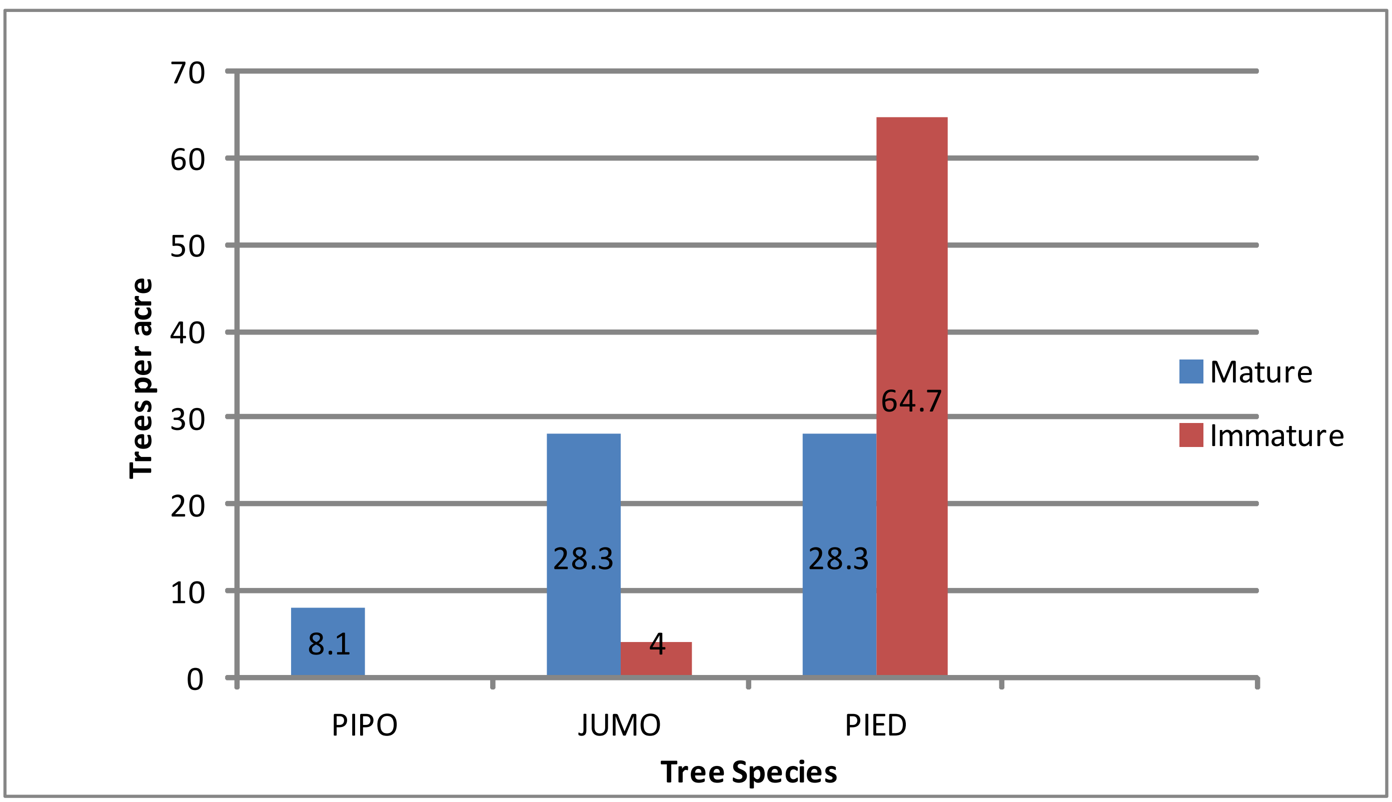


Figure 4.100. Number of trees per acre in Frijoles Mesa 3
(PIPO = Pinus ponderosa*, JUMO* = Juniperus monosperma*, PIED* = Pinus edulis*)*

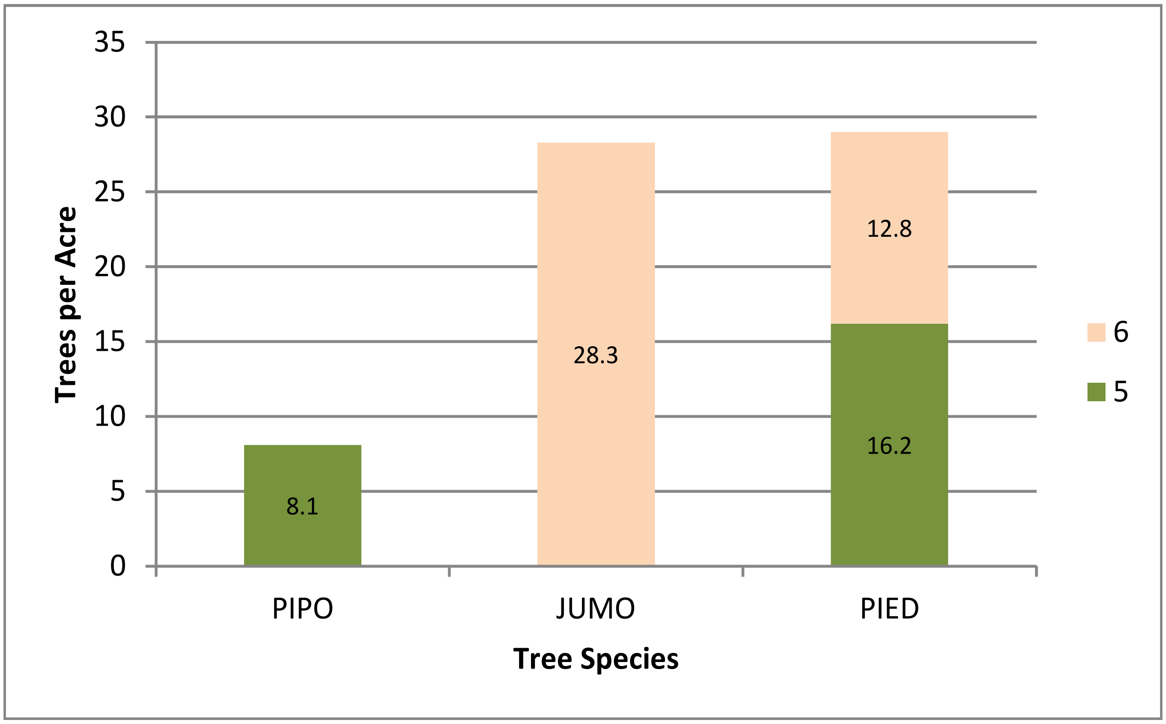


Figure 4.101. Severity classes of mature trees in Frijoles Mesa 3
(PIPO = Pinus ponderosa, JUMO = Juniperus monosperma, PIED = Pinus edulis*)*

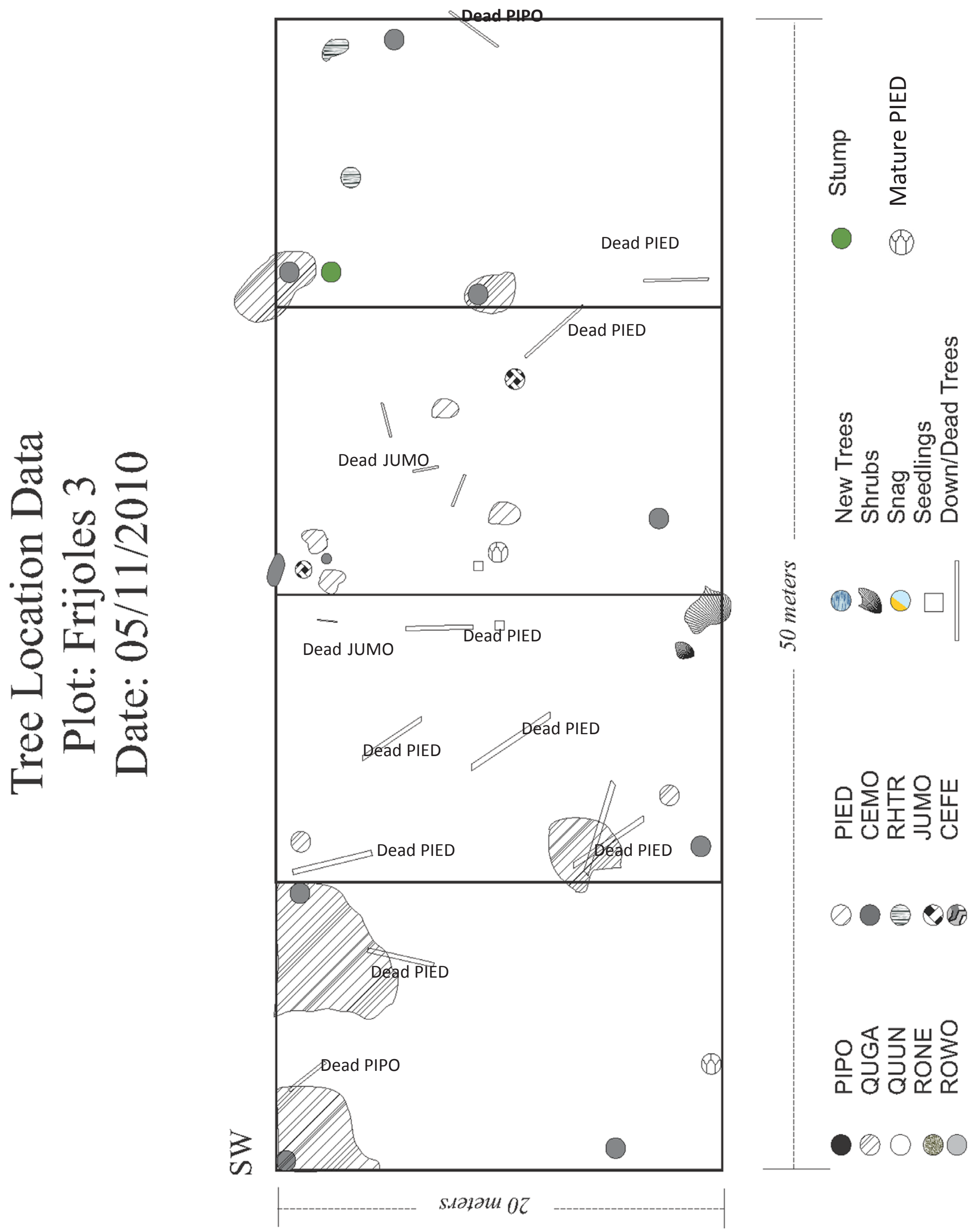


Figure 4.102. Tree location data for Frijoles Mesa 3 in 2010;

Map acronyms: Trees: JUMO (*Juniperus monosperma)*, PIED (*Pinus edulis),* PIPO (*Pinus ponderosa)*, Shrubs: (CEFE) (*Ceanothus fendleri),* CEMO (*Cercocarpus montanus)*, QUGA (*Quercus gambelii*), QUUN (*Quercus undulata*),RHTR (*Rhus trilobata)*, RONE (*Robinia neomexicana*), ROWO (*Rosa woodsii*), RHTR (*Rhus trilobata)*

Table 4.26. Percent Cover of Grasses, Forbs, and Shrubs Through Time for Frijoles Mesa 3

Species Name	1977	1999	2010	Occurrence
Grass				
Agropyron spp.			6.4	1
Aristida longiseta	0.10	0.50	0.06	3
Bouteloua gracilis	0.52	0.10	4.32	3
Bromus spp.			0.12	1
Elymus elymoides			1.40	1
Festuca octoflora			0.06	1
Lycurus phleoides			0.12	1
Muhlenbergia montana	0.42		2.54	2
Poa fendleriana			1.30	1
Sporobolus cryptandrus			0.28	1
Total Grass Cover	**1.04**	**0.60**	**16.60**	
Total Grass Species	**3**	**2**	**10**	
Forbs				
Artemisia carruthii		2.36	2.82	2
Bahia dissecta	0.34		0.88	2
Chenopodium album	0.14			1
Erigeron flagellaris		0.04	1.72	2
Eriogonum spp.			0.28	1
Euphorbia serpyllifolia	0.98			1
Guterrezia sarothrae		0.70	20.56	2
Heterotheca villosa		1.42		1
Hymenopappus filifolia		0.40		1
Hymenoxys argentea			0.08	1
Hymenoxys richardsonii			1.20	1
Linum neomexicanus	0.12	T	0.06	3
Lotus wrightii	0.64			1
Lupinus spp.	0.04			1
Mirabilis linearis	0.12			1
Opuntia spp.			0.24	1
Petalostemum spp.	0.84			1
Physalis neomexicana	0.12			1
Plantago purshii			0.02	1
Polygonum sawatchense			0.16	1
Senecio spp.	0.56			1
Thelesperma trifidum			2.36	1
Unknown forb			0.16	1
Total Forb Cover	**3.90**	**4.92**	**30.54**	
Total Forb Species	**10**	**6**	**13**	
Cercocarpus montanus		**Shrubs**	3.10	1
Pinus ponderosa			2.60	1
Quercus spp.			2.36	1
Total Shrubs			**8.06**	
Total Shrub Species	**0**	**0**	**3**	
TOTAL FOLIAR COVER	**4.94**	**5.52**	**55.20**	

5.0 CONDITION OF THE BURNED AREA AFTER 37 YEARS

This long-term study provides the opportunity to begin to answer some questions related to fire, forest sustainability, and succession. In summarizing the information compiled from 37 years of study and observations, the following questions are asked.

Ponderosa Pine

1) Visually, how has the area changed through time as a result of fire and drought? (Section 5.2)

2) Do the data indicate any connection between climate, drought, and fire? (Section 5.3)

3) What is the growth rate of trees that survived? (Section 5.4)

4) Is there any connection between burn severity and fire history? (Section 5.5)

5) What is the extent of tree mortality 35 years after a fire as related to burn severity and other conditions? (Section 5.6).

6) How quickly do dead trees fall and what is the durability of some snags? (Section 5.7)

7) Is there a connection between tree mortality and seedbed competition? (Section 5.8)

8) Is there a comparison between artificial plantings and natural regeneration of ponderosa pine? (Section 5.9)

9) Is there a relationship between bearberry (*Arctostaphylos uva-ursi*) and pine regeneration? (Section 5.10)

10) What is the reduction of litter cover after fire? (Section 5.11)

11) What are local plant responses to fire? (Section 5.12)

12) What is the long-term establishment of seeded grasses versus natural regeneration of native grasses? (Sections 5.13 and 5.14)

13) Are there any invasive grass species that are present or have gotten a foothold over the past 37 years? (Section 5.15)

14) What are the fire effects on forb species? (Section 5.16)

15) Are there forb species that have been introduced, increased, or decreased with fire over the past 37 years? (Section 5.17)

16) Does fire increase the vigor of plant species? (Section 5.18)

17) What is the relationship of fire, slime molds, and fungi? (Section 5.19)

18) What is the relationship of fire and soil crusts? (Section 5.20)

Mixed Conifer

19) What was the density of the mixed conifer forests burned by the La Mesa Fire? How does that compare to what is considered a pre-1900 density before fire suppression, grazing, and logging? (Section 5.21)

20) What are some observations about aspen regeneration, fire, and elk? (Section 5.22)

Piñon-Juniper

21) Was there any evidence of fire and drought history in the piñon-juniper in the past 37 years? (Section 5.23)

22) Was there any change in species density and composition through time after the La Mesa Fire? (Section 5.24)

23) Were there any specific species in the woodland plots that increased substantially over time? (Section 5.25)

5.1 General Observations and Limitations

In this section, we summarize information scattered throughout several publications from 1978 through 1996 (see Table 2.1) and previously unpublished material collected or observed over the past 37 years. Data are presented on tree mortality, the influence of seeded grass on mortality, success of planting, observations on gigantism, fire-adapted species, and general observations of changes in species composition through time. Plate 5.1 shows a general overview of the fire area through time. Plate 5.2 shows mesas and slopes burned by the fire through time.

Though studies have been conducted for the past 37 years, generalizations about the La Mesa Fire succession are only pertinent from 1977 to 1992 for plots on Burnt and Escobas mesas, or a total of 15 years. In 1998, the area was burned by a prescribed fire, thus resetting the process of succession. The data were not again taken until 2010, 12 years later. The 15-year fire interval is similar to what might be expected in a pre-1900 fire frequency as found by Touchan et al. (1996) and Foxx and Potter (1984). A few plots along the rim of Frijoles Canyon may have a longer La Mesa Fire post-fire history but they have not been visited since 1993 and were burned by the Las Conchas Fire.

Touchan et al. (1996) reconstructed fire history in the Jemez Mountains. They found the pre-1900 fire frequency ranged from 6.5 to 22.1 years. Foxx and Potter (1984) found a mean fire frequency of 17.4 years between 1786 and 1962 from tree ring analysis. Before 1894 the fire frequency was 15.1 years; whereas, the period from 1894 to 1977 showed a fire frequency of 41.9 years. Their data also showed there had been no major fires for 84 years. The areas of known fire history showed that if there had not been a fire within 20 years, the next fire would result in complete loss of the overstory.

5.2 Photographic Records

Question 1: Visually, how has the area changed through time as a result of fire and drought?

Photography is an important tool for documenting history and historical events. Through the eye of the camera, we can understand our connection to the environments in which we live. Change is hard for us to see, comprehend, or remember. When we look at what the camera has captured, at different points in time, we see the full extent of the historical and ecological changes that take place.

Photography allows us to see change in a seemingly changeless world. Using other tools of science we can further define what the eye sees visually and help us determine decisions we should make in the future, once we know about the past.

An example of the photographic record of change can be seen above in Plates 5.1 and 5.2, which show a general overview of the fire area through time. At this overlook site, we see a blackened forest immediately after the fire and 16 years later an open meadow. At 25 years (2002) the meadow is closing in as the trees begin to fill in. At 32 years (2009), the meadow is nearly gone. Finally, at 34 years (2011) the area is fire scarred again but with less intensity.

This study has been a combination of data collected, observations, and photographic documentation. Over the past 37 years, thousands of pictures have been taken to document the status of a plot or area in any one point in time. This extensive collection of photographs taken at photo points throughout BNM are documented in Photographic Records (Foxx 2013.[a]) for each site. A listing of these records is Appendix IV.

5.3 Climate, Drought, and the Plots

Question 2: Do the data indicate any connection between climate, drought, and fire?

Climate records of BNM are limited to file records of precipitation (Figure 5.1) and temperature readings from the headquarters area dating from 1933. More extensive records have been maintained at LANL, approximately 10 miles to the north. A rainfall station was established at the Alamos Ranch in November 1910 and temperature records were begun in October 1918. In 1942, the ranch name was changed to Los Alamos. In January 1943, the ranch was taken over by the Corps of Engineers and later run by the AEC and its predecessors, presently the National Nuclear Security Administration.

Foxx and Potter (1978) collected fire-scar tree samples in their original study. When these fire dates are compared with known drought or below average moisture years, there is an indication that most of the fires occurred in years of drought or low

Plate 5.1. *The La Mesa Fire area through time from the State Route 4 overlook (continued on the next page)*

1977 (year of the fire). Severely burned areas blackened with dead trees.

1993 (16 years after the fire). The trees killed by the fire have fallen and a meadow has developed.

2002 (25 years after the fire). There is evidence of increased encroachment of trees on the meadow and growth of planted trees.

Plate 5.1. *The La Mesa Fire area through time from the State Route 4 overlook (continued)*

2009 (32 years after the fire). The meadow has mostly filled in with trees.

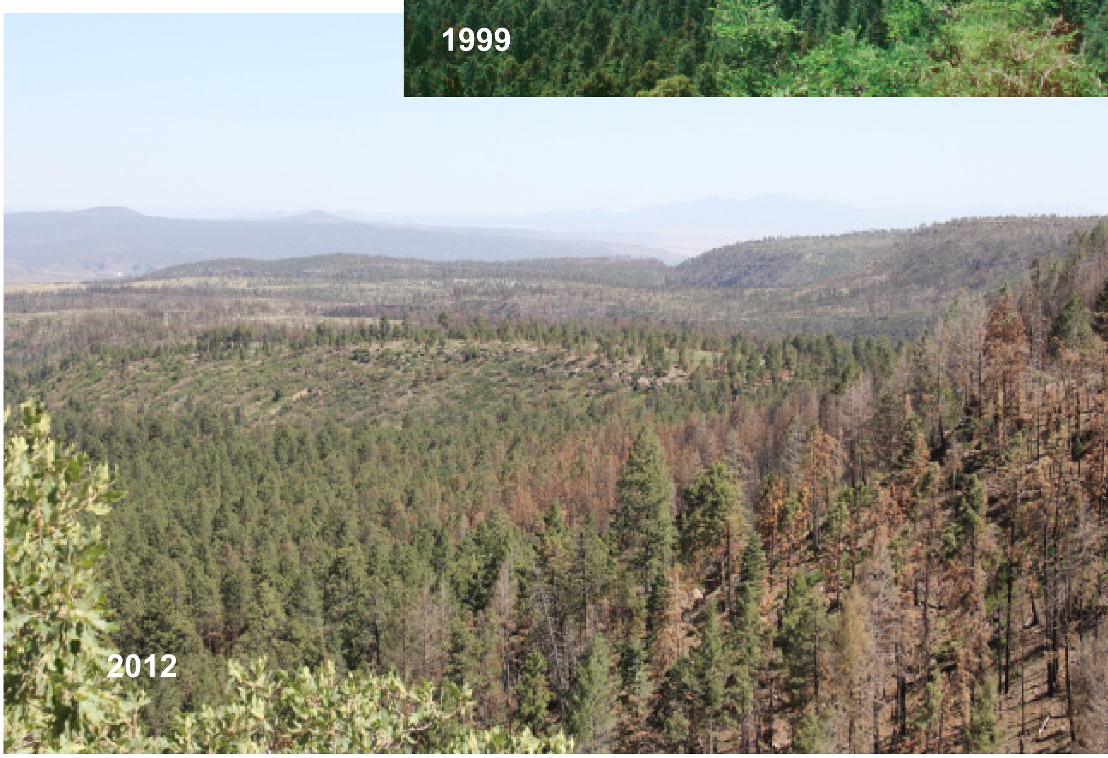
2011 (after the area was reburned by the Las Conchas Fire). Note the haze from the fire.

2012. The area 11 months after the Las Conchas Fire.

Plate 5.2. *Pictures through time showing the mesas and slopes burned by the La Mesa Fire*

1977 (year of the fire). Showing the mesa tops and slopes.

1999 (22 years after the fire). Showing the mesa tops and slopes from overlook on State Route 4.



2012 (11 months after the Las Conchas Fire). Showing the mesa tops and slopes from the overlook on State Route 4.

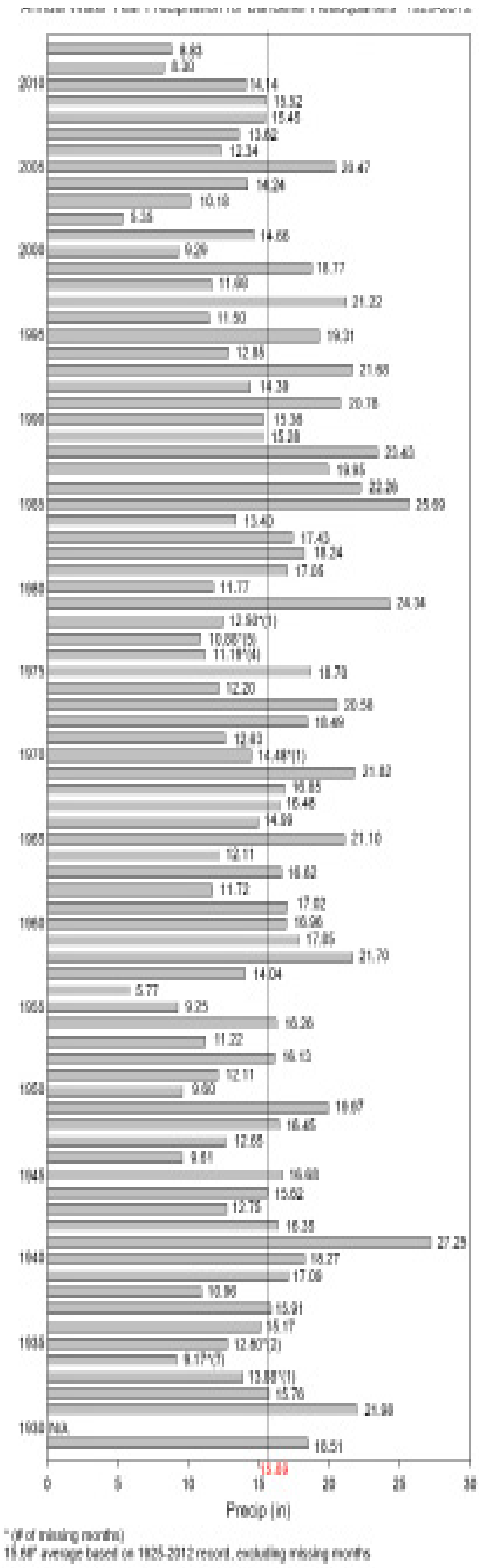


Figure 5.1. Annual water year precipitation (Courtesy of BNM)

moisture (Figure 5.2a and b).

Swetnam and Baisan (1996) did extensive collection of fire-scarred samples within the Southwest, including the Jemez Mountains. Comparing the fire-scar network data (1700–1900) and documentary records of areas burned on all Southwest Region National Forests (1920 to 1978) with a Palmer Drought Severity Index, showed the association between severe droughts and large fire years—and wet periods and small fire years.

Further studies by Touchan et al. (1996) showed the relationship between winter/spring precipitation on the accumulation and moisture content of fuels. A dry spring followed by numerous lightning strikes in the summer can ignite dry accumulated fuels. On the other hand, a wet spring will prevent fire spread. These researchers found that the winter/spring season immediately preceding fire occurrence was drier than normal in ponderosa pine forest. They suggest that during wet years there is a build up of fine fuels and that two unusually wet years before a fire season enhances the probability of fire spread.

Craig Allen collected a cross-section from a tree damaged by the 1977 La Mesa Fire, which had over a 300-year fire history. Over 50 percent of the dates are considered drought years (Figure 5.3).

Recent and Compiled Observations and Data
Of particular interest in this report is the climatic fluctuation from 1977 to 1998, a 21-year interval and from 1998 to 2010, a 12-year interval. In 1998, a prescribed fire was ignited on Burnt and Escobas mesas, therefore resetting the succession process in the plots that were studied after the 1977 La Mesa Fire. Using the information from BNM about water years, we have compared differences in two 12-year periods—1978 through 1989 and 1998 through 2009.

Figure 5.4 shows the water year comparison. The average water year precipitation is considered to be slightly over 15 inches.

We chose to compare the weather records for 12 years post-fire because 2010 was only 12 years post-prescribed fire. From 1977 to 1998, the interval

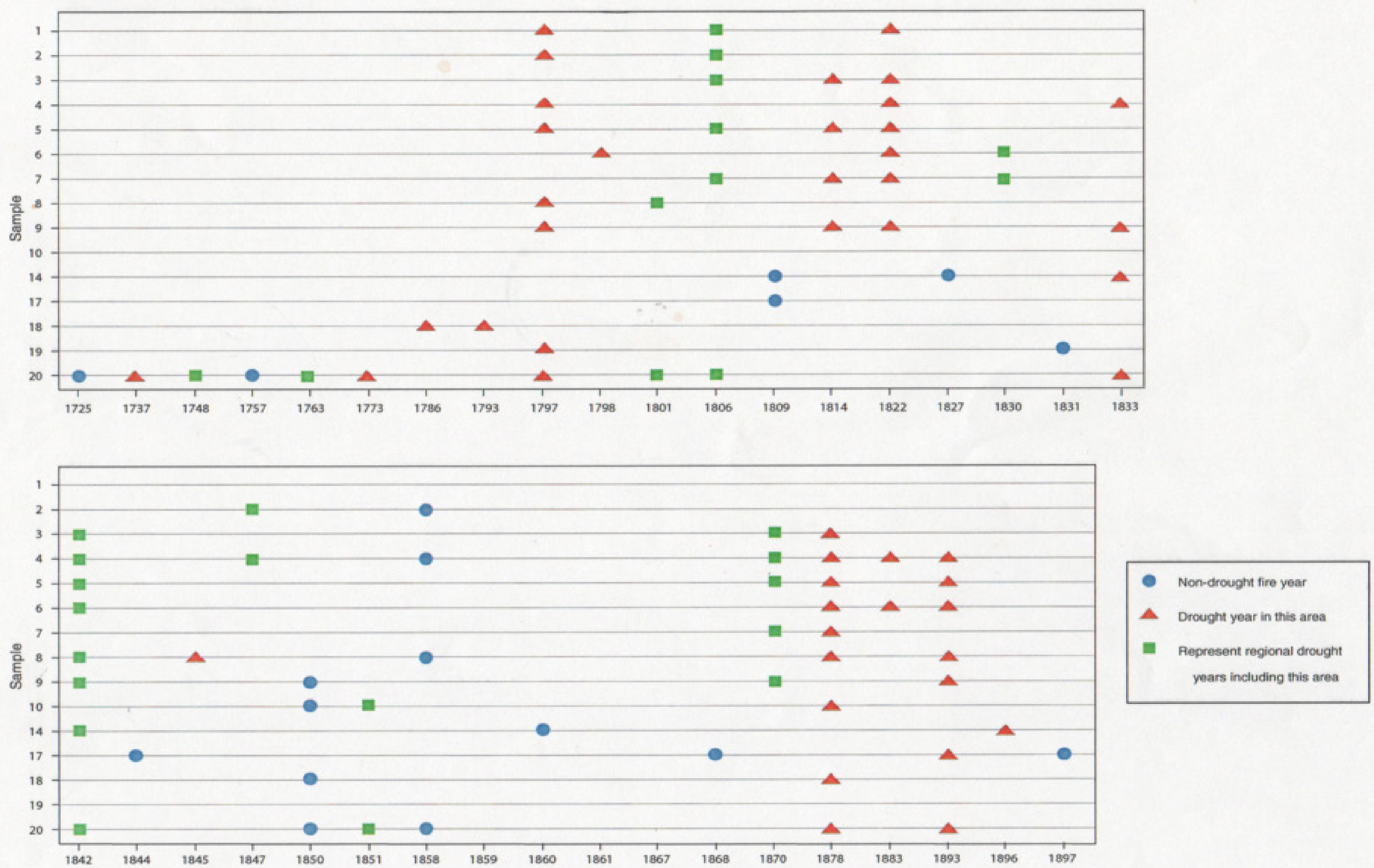


Figure 5.2a. Fire scar dates from the 18 samples collected on Burnt and Escobas mesas by Foxx and Potter showing known drought or below average moisture years before 1900

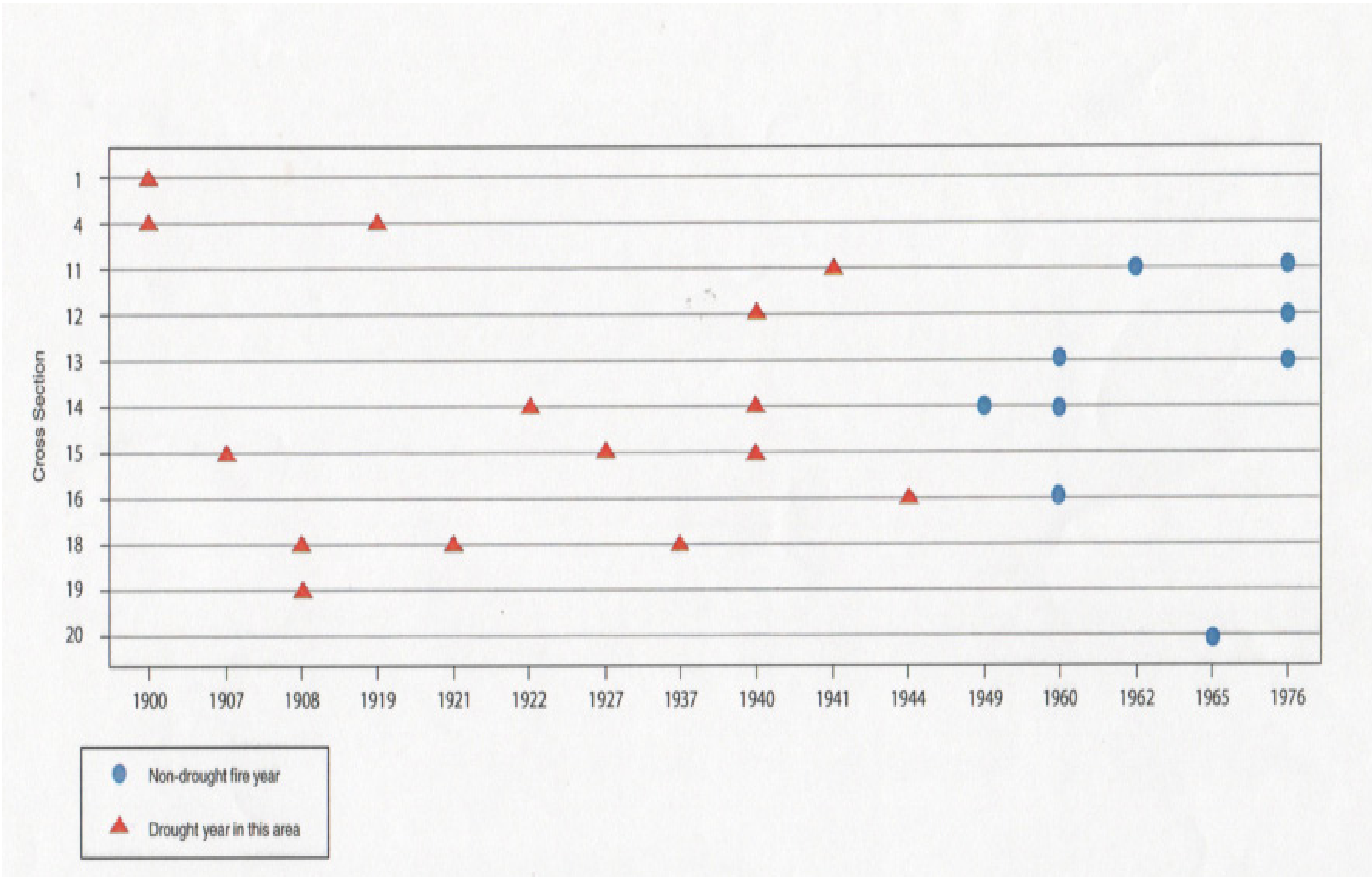


Figure 5.2b. Fire scar dates from 18 samples collected on Burnt and Escobas mesas by Foxx and Potter showing known drought or below average moisture years after 1900 (to La Mesa Fire)

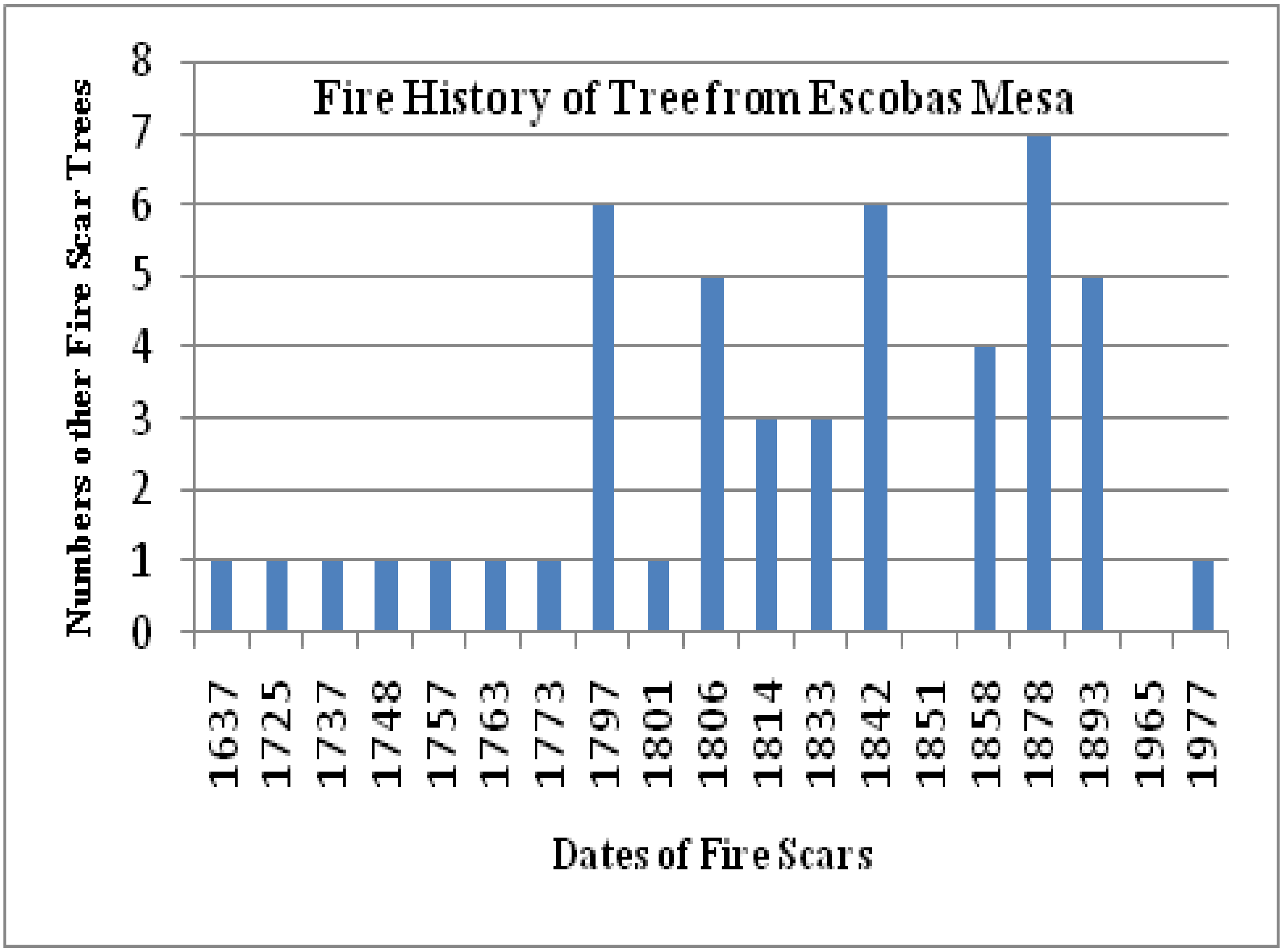


Figure 5.3. Fire history of a ponderosa pine from Escobas Mesa. Dates on X-axis are fire history from one 340-year-old tree. The Y-axis represents the number of samples these dates were found.

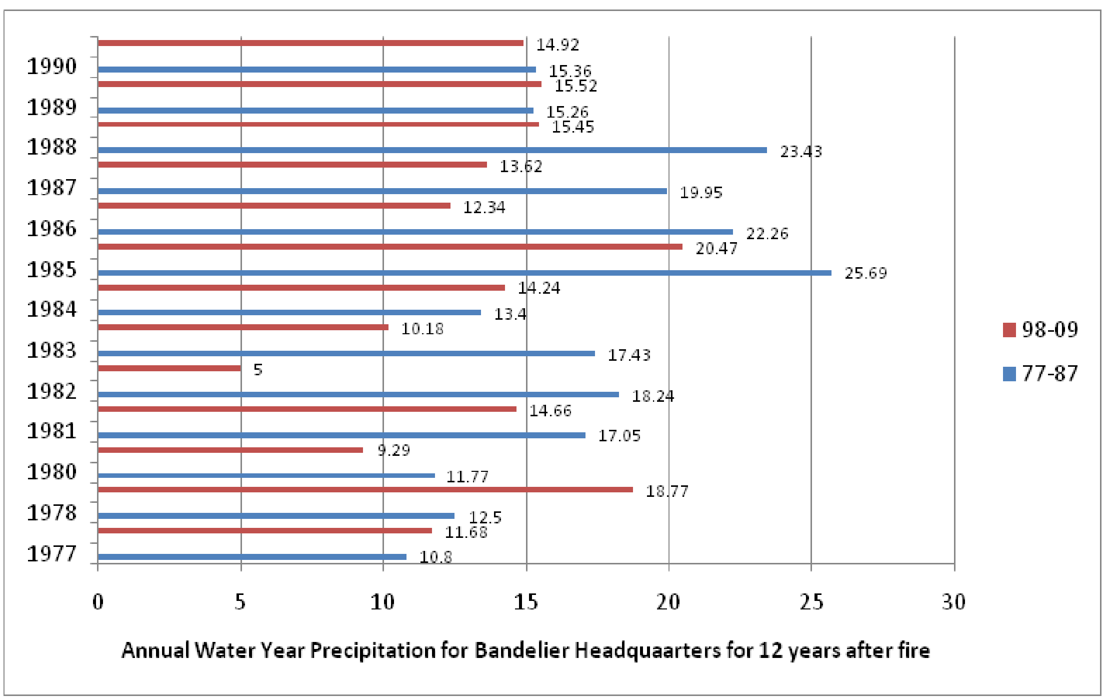


Figure 5.4. Comparison of two 12-year periods after the La Mesa Fire and the prescribed burn

was 21 years. Four data points after the La Mesa Fire had been taken in 1977, 1978, 1985, and 1992. There was an upward trend in percent cover from 1977 to 1985 then decreasing from 1985 to 1992 for some species. Plate 5.3 illustrates the fluctuation of vegetation density over time.

Unfortunately, after the prescribed fire, the plots were not followed up until 2010 so there were no interim data points. This was unfortunate but was a result of funding and personnel.

Nevertheless, this comparison indicates an important element in tree survival, vegetation succession, and restoration trends in the first 12 years after each fire. After the La Mesa Fire there was increasing water year precipitation. In the 1980s, after the wildfire, there was above average precipitation eight of 12 years. After the prescribed fire, only three of the 12 years were above average. The average water year precipitation for 1978 to 1989 was 17.31 inches and for the period from 1998 to 2009 it was 13.41 inches.

The period of 2000 to 2003 was considered an extreme drought period. Piñon mortality was extremely high (Breshears et al. 2005). Allen and Breshears (1998) and Breshears et al. (2005) reported a rapid landscape shift on the Pajarito Plateau due to severe drought in the 1950s (see Plate 5.3).

Because a prescribed fire was conducted 21 years after the La Mesa Fire, mortality of trees post-prescribed fire could have been a result of the fire damage or increasing drought.

Las Conchas Fire

Climatic conditions in 2011 contributed to the Las Conchas Fire that burned 153,000 acres of the Jemez Mountains, including about 60 percent of BNM. Using the Weather Machine at LANL, the total preciptation, including snowmelt, for the first six months of 2011 was 0.86 inches. The average is 6.96 inches. Mean temperatures of 70.1 were higher than the average of 65.1. A comparison of the summer moisture after the major fires of the area can be seen in Figure 5.5. From previous observations, we know that the climatic conditions will influence the recovery of the area.

5.4 Growth Rate of Trees

Question 3: What is the growth rate of trees that survived?

Historical Information

The growth of ponderosa pine is influenced by a number of factors, including nutrients, soil temperature, density, disease, and others. After fire, the survival is dependent on the amount of damage incurred to the cambial layer and the roots. Researchers have examined the effects of repeated burning on the growth rate. Pearson et al. (1972) found that trees with less than 60 percent foliage exhibited increased growth. Hiedmann (1963) found 40 percent of the live crown could be removed without significantly affecting diameter growth. Sutherland et al. (1991) indicated the amount of damage to the cambial layer and the roots will impact growth because of the amount of resources allocated to repair the injury. This will in turn affect growth.

Precipitation in the winter and spring months may also have an effect on the growth of trees. Snow acts as an insulation and there is more absorption into the soils. Garfin and Hughes (2002) indicate the growth of many Southwestern tree species can be linked directly to the total amount of precipitation that falls during the cold season or winter (November to April). Other reseachers such as Oberhuber (2004) have shown that at higher elevations winter precipitation is important in tree growth, especially in arid timberline sites.

Recent Compiled Information and Data

Diameter measurements (dbh) were taken of trees that survived throughout the study. We looked at the radial growth of trees related to the period after the La Mesa Fire to the period of the prescribed fire (1977–1992 or 1998) and the period after the prescribed fire (1998–2010).

We also categorized the radial growth as related to the crown damage the tree suffered. Class 1 represents the average diameter growth of trees with no or little crown damage. Class 3 represents trees with 50 percent crown damage. Class 4 represents trees with 25 percent of the crown remaining after the La Mesa Fire (Figure 5.6).

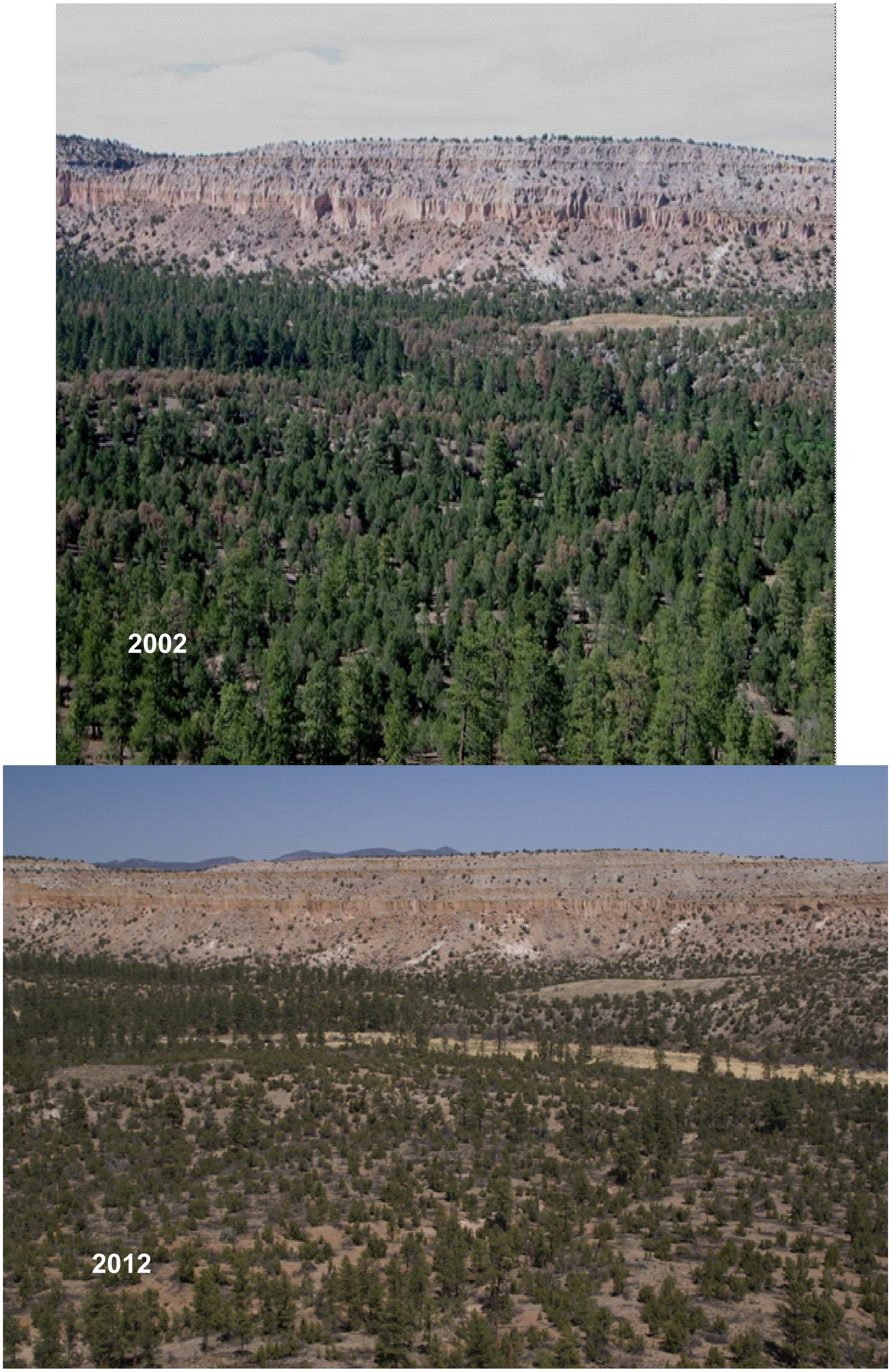


Plate 5.3. *Evidence of landscape shift due to drought and bark beetle kill. The top picture is Pueblo Canyon in 2002. Note the amount of ponderosa pine. The bottom picture is Pueblo Canyon in 2012. The canyon has shifted to a piñon-juniper woodland.*

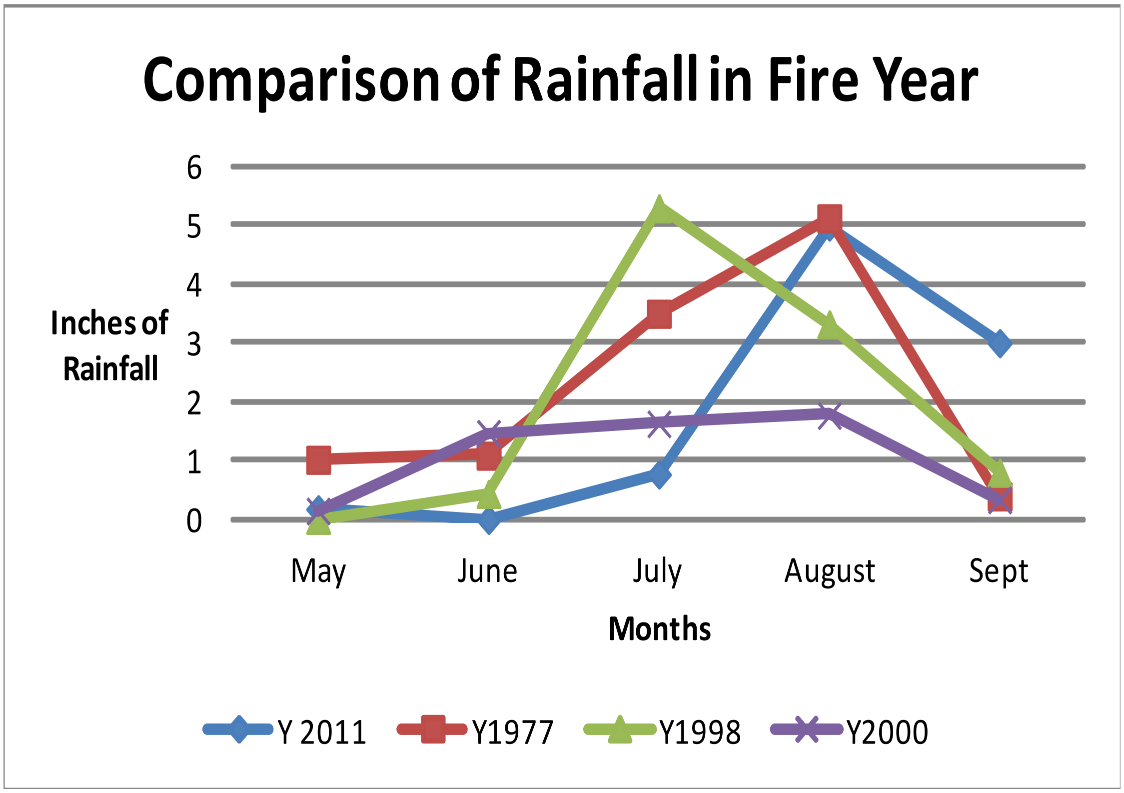


Figure 5.5. Comparison of rainfall in the fire year of four major fires

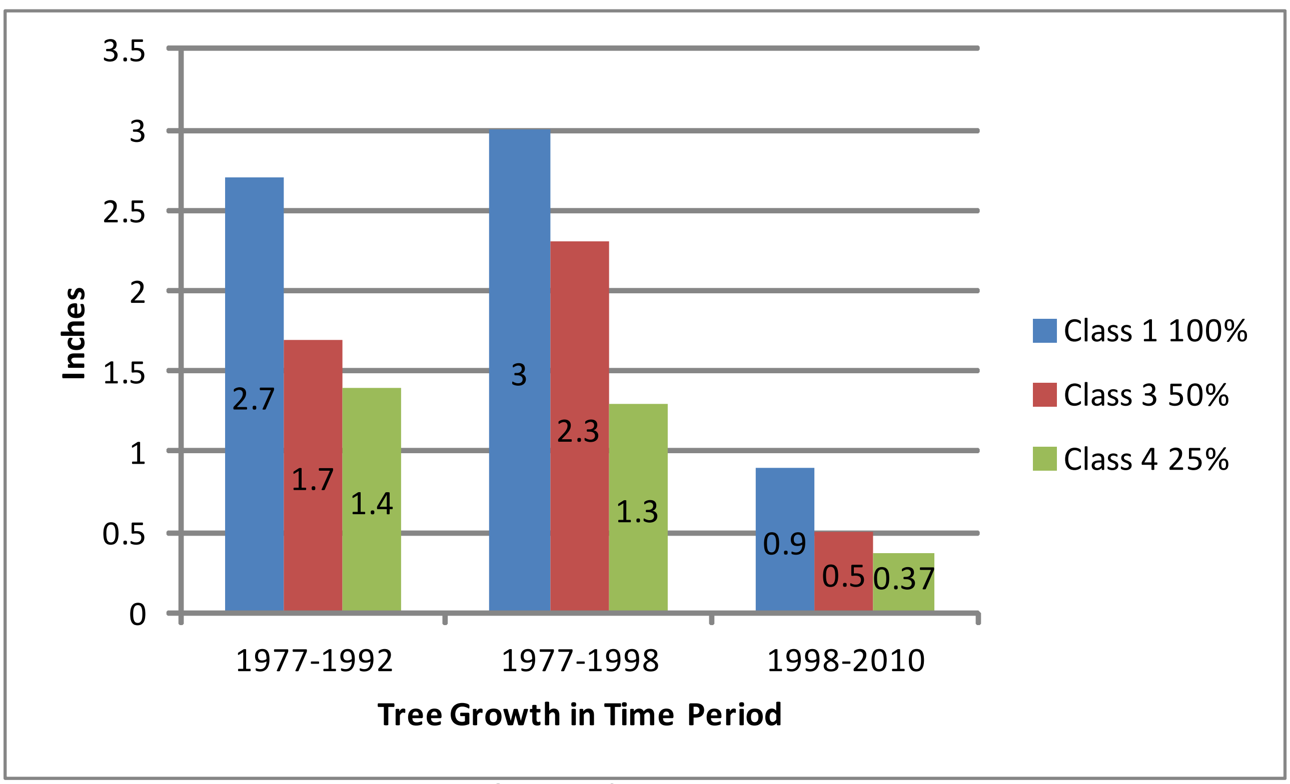


Figure 5.6. Growth of trees related to time periods

As can be seen from Figure 5.6, the greatest radial growth occurred in trees that had full crown and the least in those that had only 25 percent crown remaining.

The average growth for all classes after the prescribed fire was much less than after the La Mesa Fire. The winter moisture after the prescribed fire was nearly 50 percent less than after the La Mesa Fire (Figure 5.7). After 1998, there was a significant drought, which extends even into 2012.

The average growth rate per year for the period 1998 to 2010 was 0.08 inch for trees that had little crown damage (Table 5.1). In the same time period (21 years) at that same rate of growth, the tree would only grow 1.68 inches versus the three inches of growth from 1977 to 1998, if the drought persisted.

Since the amount of crown damage after the prescribed fire was not noted, the slowing of growth could also be attributed to reallocation of resources to repair crown damage after the prescribed fire. However, drought appears to play a significant role in the growth after the prescribed fire period 1998–2010.

5.5 Burn Severity as Related to Fire History

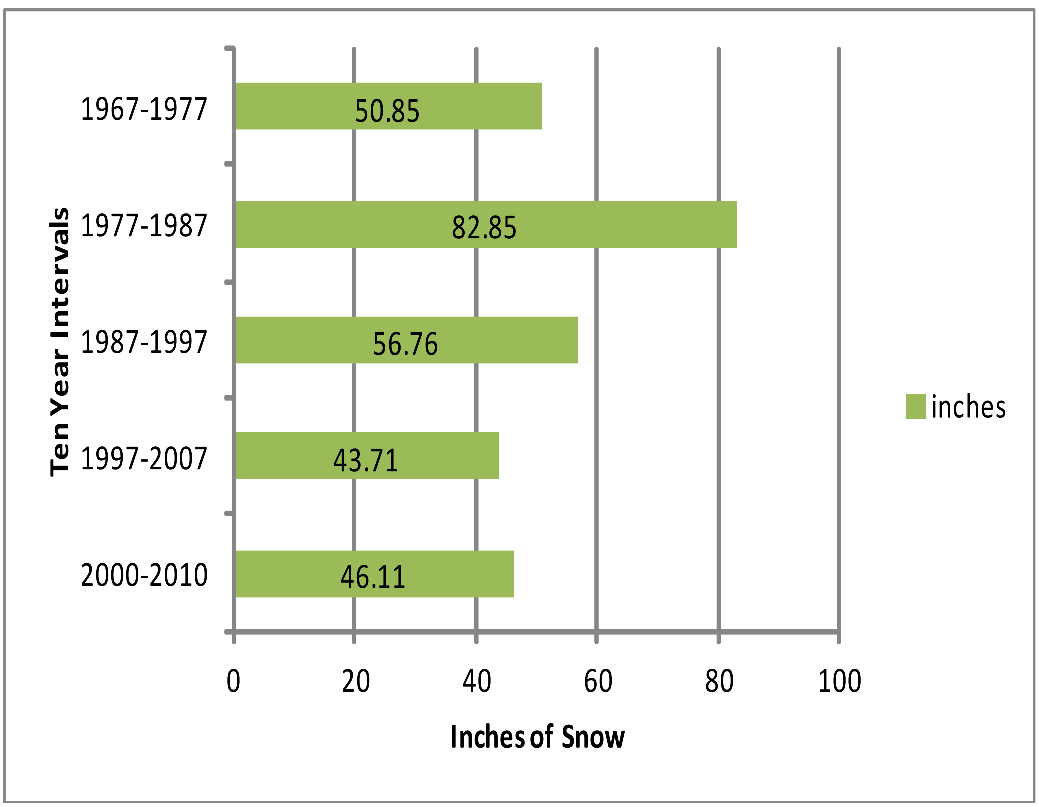
Question 4: Is there any connection between burn severity and fire history?

Historical Information
Studies done by Foxx and Potter (1978) and Touchan et al. (1996) have shown that there was a fire frequency of five to 20 years before 1900.

In the original study done by Foxx and Potter (1978), 26 fire-scarred samples were collected and the data analyzed for fire frequency and mean fire frequencies.

Table 5.2 shows the fire frequencies for the 26 samples collected. The mean fire interval for the samples was 17.4 years. The mean interval years since the last fire on these samples was 63.1 years. This is consistent with the intervals found by other researchers.

Analyses of tree rings from Burnt Mesa, Escobas Mesa, and the rim of Frijoles Canyon indicated a mean fire interval of 15.5 years before 1894. However, in some cases there had been no fire for over 84 years.



5.7. The 10-year snowfall averages for the Pajarito Plateau

Table 5.1. Rate of Tree Growth (inches) as Related to Crown Damage and Drought

Damage Class	(15-year average)	21-year average	12-year average
1 full crown	0.18	0.14	0.08
3 50% crown	0.11	0.11	0.04
4 25% crown	0.09	0.06	0.03

Table 5.2. Fire Interval for 25 Samples Collected by Foxx and Potter

Sample Number	Interval (YR)	Years since last fire
1	34.3	77
2	20.3	119
3	14.4	99
4	11.1	58
5	13.7	84
6	15.8	84
7	14.4	99
8	16	84
9	13.7	
10	9.3	99
11	17.5	15
12	NA	37
13	NA	16
14	16.8	16
15	16.5	37
16	20.2	40
19	27.8	69
20	16.3	
21	25	
22	25	
23	9.7	
24	15	
25	21.5	
26	18.8	
Average Interval	17.8	64.56

When we examined the fire frequency data with the condition of each plot as related to the length of time since the area had previously burned, we found that if an area had not burned in the last 20 years, there was complete loss of the crown (Figure 5.8). The more recent the previous fire, the greater chance of having trees within severity classes with substantial crown remaining (1, 2, 3, and 4).

Las Conchas Fire

Most of the area burned by the La Mesa Fire and Dome Fire were within the path of the Las Conchas Fire. It should be noted that it has been 35 years since the La Mesa Fire and 16 years since the Dome Fire. Photographic evidence also indicated much of Frijoles Canyon did not burn in either of these fires (see Figure 1.7a). It is expected that most of the area of the La Mesa Fire that had not reburned could have a high-severity fire (see Figure 1.7b). Areas of Burnt and Escobas mesas were burned with a prescribed burn 14 years previously and from the fire maps are in the low-severity burn (see Figure 1.20).

5.6 Tree Mortality Based on Fire Damage Assessments

Question 5: What is the extent of tree mortality 35 years after a fire as related to burn severity and other conditions?

Recovery and Mortality of Poles and Mature Trees

Historical Information

Few studies have examined the delayed mortality of fire-damaged trees. Herman (1954) found that trees of saw timber size that did not have 60 percent of viable crown after a fire did not survive six years. In a study in Idaho, Connaughton (1936) found that 57 percent of the trees with less than 50 percent viable crown were dead after three years; compared to 26 percent mortality of trees that had over 50 percent

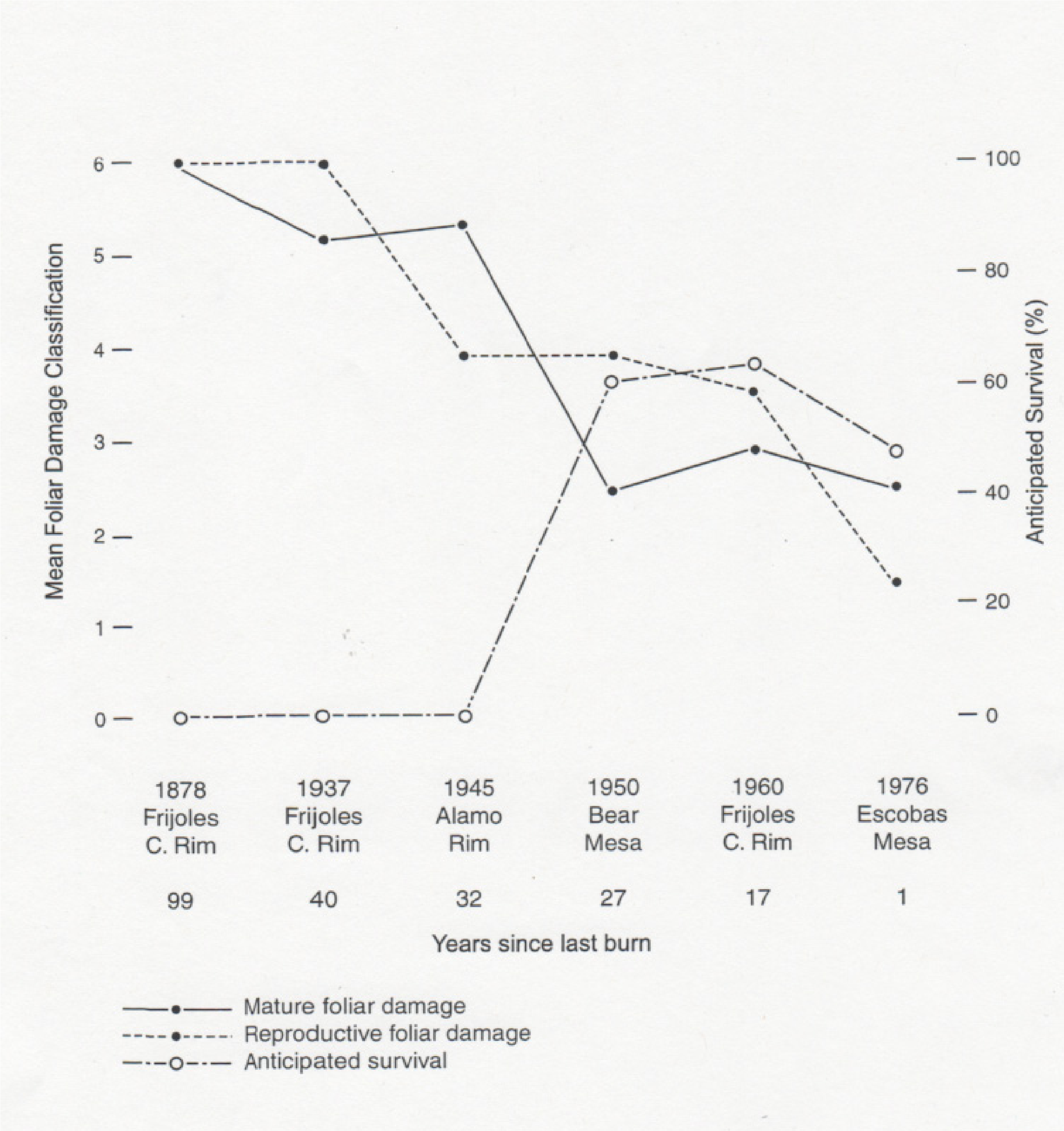


Figure 5.8. The effect of fire interval and years since the last fire on burn severity

of the crown remaining.

Immediately after the fire we classified the trees related to foliar and trunk damage (see Section 3, Methods). Through time we attempted to follow the survival of the trees within the plots. One issue that became important was the stablility of the tree tags. After a number of years the tags were sometimes imbedded into the tree or had fallen off. We did map the location of trees in each plot through time.

Survival of ponderosa pine after fire is complex. No single factor can account for the recovery or death of a particular tree. However, some ecological parameters may be more important than others. First, survival of fire-scorched trees is dependent on the severity of singeing. In some cases, the destruction is such that the tree has no chance of recovery; in other cases, conditions may be such that even a more severely damaged tree can have some growth response, particularly if climatic conditions are favorable.

We found within the first two growing seasons after the La Mesa Fire, trees with over 50 percent of the crown left undamaged showed a low percentage of mortality (Figure 5.9).

Within two growing seasons after the fire there were some general trends. Trees with greater amounts of foliar damaged showed an increasing mortality when compared with those in the less severely burned classes. In the various post-fire foliar damage classes, the following percentages of trees were found to have improved or remained the same: Class 1—91 percent; Class 2—83 percent, Class 3—74 percent; Class 4—83 percent.

Data were taken for the plots on Burnt Mesa (B2) and Escobas Mesa (E1, 2, 3, 4) for 1977, 1978, 1985, 1992, and 1998. Information was not gathered for the line strip plots so the information is only from the accessible plots.

Table 5.3 shows the mortality of trees within each of the Burnt Mesa and Escobas Mesa plots. Over the 21 years, over 50 percent of the trees had died. This reduced the average stand density from 604 trees per acre to 332 trees per acre.

Table 5.4 compares the mortality of the trees within these plots as related to the foliar classification done in 1977. Those trees with a classification of one, or 100 percent of the crown remaining, had a 100 percent survival rate, those trees with over 50 percent of the crown remaining had a 94 percent survival rate, and 54 percent of those trees that had 25 percent of the crown remaining were alive after 21 years. Nearly all the trees that had only brown needles were alive after 21 years. Figures 5.10 and 5.11 show the trends for trees greater than 10 inches dbh and less than 10 inches dbh, respectively.

Recent and Compiled Observtions and Data Related to Survival

Trees were relocated and examined on Burnt and Escobas mesas in 2010 and dbh measurements were taken. The numbers that were alive were compared with those alive after the 1977 La Mesa Fire. Tree survival depended on burn severity. Trees with little crown scorch were alive after 33 years. Eighty-eight percent of the trees that had 50 percent of the crown alive after the fire were still alive in 2010.

At the time of the fire, I was not sure how a tree with only 25 percent of the crown would fair through the years. However, after 33 years, 53 percent of the trees that had only 25 percent of the crown were still alive (Figure 5.12).

Recovery of Seedlings and Saplings after Fire

Trees were classified in this study as to size: Seedlings were trees less than two inches in diameter, saplings were two inches in diameter; poles or immature trees were up to four inches in diameter, and mature trees greater than four inches in diameter.

Seedling recovery after the La Mesa Fire was surprising. Many of the seedlings three feet tall with stem diameters of about one inch had all brown needles. We assumed they would die. However, within a few weeks the branch tips began to sprout new needles and within a year the damaged trees were fully green. The following years there was damage from browsing and rubbing of the small trees by deer or elk. These trees, however, survived into 2010 (Plate 5.4). At that time the seedling was reclassified as a sapling. The same pattern was seen after the 1998 prescribed fire in lightly burned plots

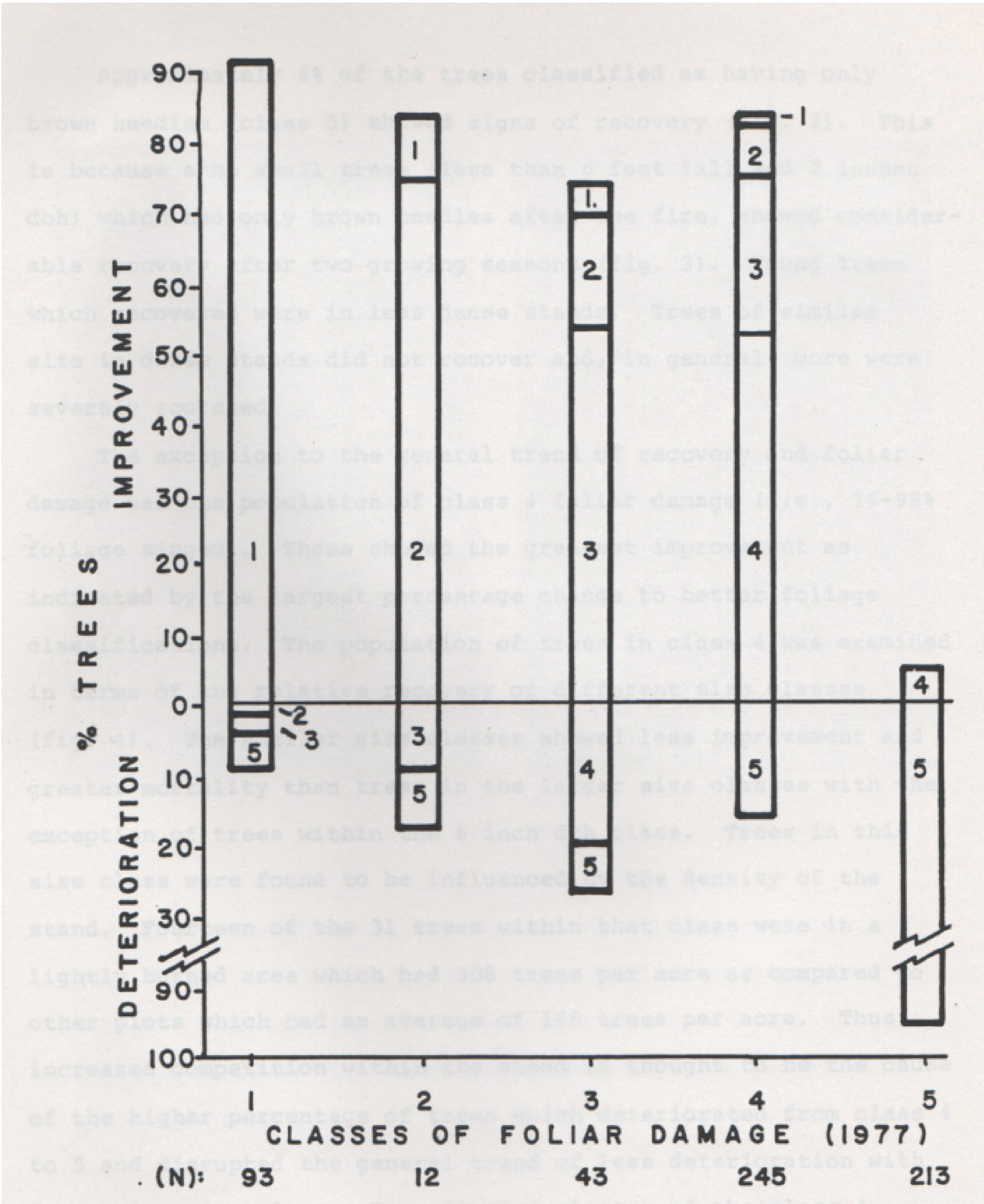


Figure 5.9. Crown damage and tree condition two years after the La Mesa Fire

Table 5.3. Number of Trees Alive during the Sample Years from 1977 to 1998 (21 years)

Plot	1977	1978	1985	1992	1998
Burnt Mesa 2	11	5	3	2	2
Escobas Mesa 1	18	18	9	7	5
Escobas Mesa 2	81	81	76	73	63
Escobas Mesa 3	12	12	4	2	1
Escobas Mesa 4	29	29	19	18	12
Live Trees	**151**	**145**	**111**	**102**	**83**
Trees per Acre	**604**	**580**	**444**	**408**	**332**

Table 5.4. Number of Trees Alive as Related to Foliar Damage Classification after 21 Years

Foliage Class	1	2	3	4	5
1998 (21 years post-fire)	3	0	15	64	1
1977 (fire year)	3	0	16	119	13
Percent Alive Year 21	**100**	**0**	**94**	**54**	**less than 1**

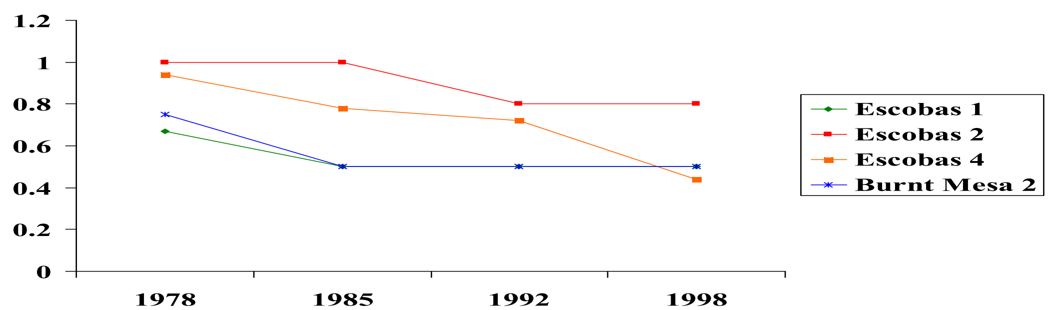


Figure 5.10. Survival of Class 4 trees greater than 10 inches dbh

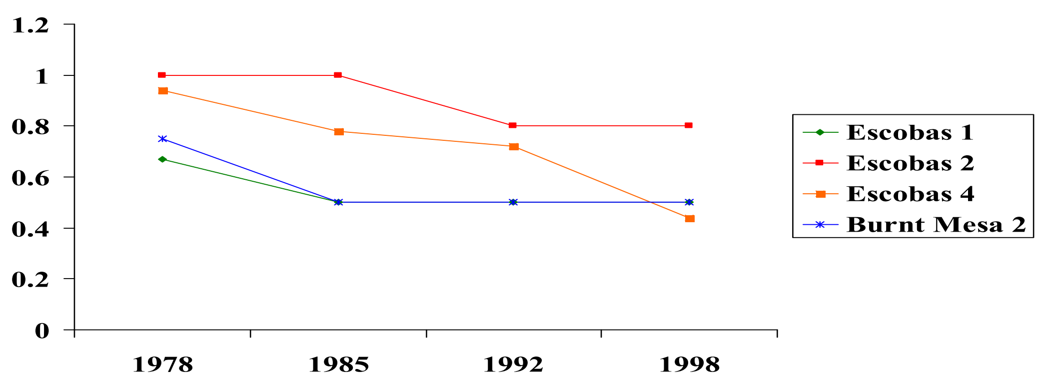


Figure 5.11. Survival of Class 4 trees less than 10 inches dbh

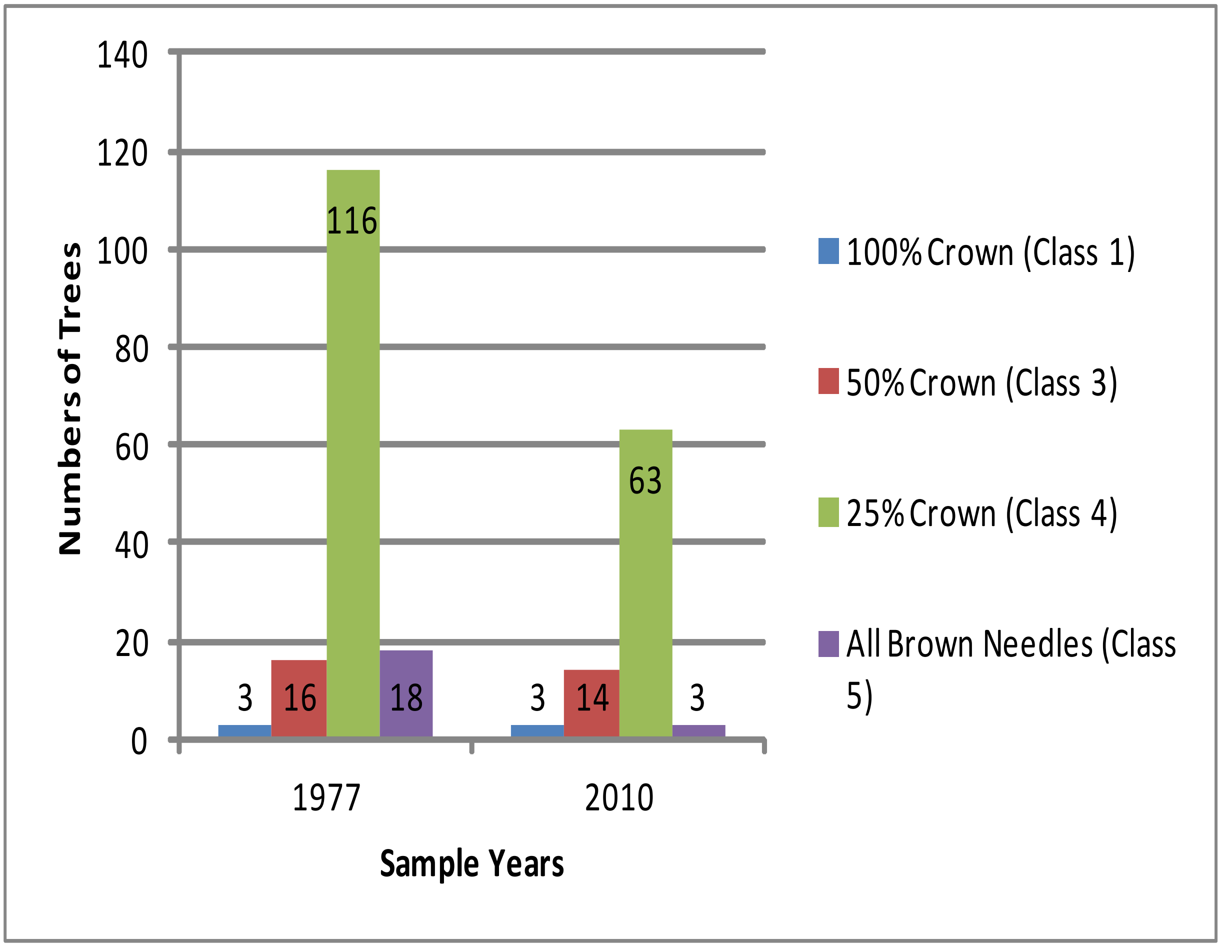


Figure 5.12. The number of trees alive after the La Mesa Fire as compared to 33 years later (2010)

but not in severely burned plots.

Recent Observations and Data
Similar recovery was observed after the Cerro Grande Fire. Trees on Burnt Mesa burned by the Las Conchas Fire were also putting on new leaves within a month after the fire (Figure 5.13).

The long needles protect the tip growth buds in these small trees from the heat of the fire and short canopy shields the stem. Escobas Mesa 1 had been lightly burned by the La Mesa Fire. In the severely burned plots all the small trees died.

5.7 Tree and Snag Fall

Question 6: How quickly do dead trees fall and what is the durability of some snags?

Tree Fall
No specific data were taken as to snag density and tree fall. However, we made two observations about snags, snag fall, and jack-straw trees. We observed that the trees first broke off at about six feet (Figure 5.14) and then by 1985 most of the trees had fallen. The 1998 prescribed burn reduced the "jack-straw" trees within the Escobas and Burnt mesas area (Figure 5.15). After the 2000 Cerro Grande Fire, a number of trees were still standing at 10 years. This again is probably due to the weather patterns and less moisture after the Cerro Grande Fire or the La Mesa Fire.

Lyon (1984) followed snag densities of lodgepole pine on the Sleeping Child Burn. Within the first two years less than two percent of the snags fell, but over the next 13 years 85 percent of the snags were down and within 21 years 93 percent of the snags had fallen.

Passovoy and Fulé (2006) studied snag density on seven wildfire sites in the Coconino National Forest in northern Arizona. They found snag density declined rapidly in the first three to four years (57.7%)

Picture of a seedling in Escobas Mesa 1 (lightly burned) August 1977 (above) and August 1981 (below)

Recovery of the needles on the seedling in 1978.

Seedling that survived the La Mesa Fire after the prescribed fire in 1998. Taken August 1998.

Plate 5.4. *Recovery and growth of seedlings after the La Mesa Fire to after the Las Conchas Fire (continued on the next page)*

Plate 5.4 *(continued). Recovery and growth of seedlings after the La Mesa Fire to after the Las Conchas Fire*

Seedlings that survived the La Mesa Fire that were saplings in 2010

Saplings in Escobas Mesa 1 after the Las Conchas Fire. Note this area appears to mainly have been a ground fire.

Figure 5.13. Needles sprouting from the protected meristematic tissues a month after fire

Figure 5.14. Initial breakage of burned trees was at three to six feet above the ground.

Figure 5.15. Trees by 1985, eight years after the fire

and by eight years few snags were standing (5.2% of the dead trees standing on one fire and 2.1% on another fire). They found there was no consistent pattern of breakage or wood decay.

Long-Term Snag Survival

Long-term snag survival is important to many cavity nesting birds and mammals. In monitoring for fuel reduction, the number of snags per acre and the longevity of those snags can be important in determining impact to wildlife.

There are a number of factors that determine the longevity of snags: tree size, species, cause of the mortality, soils, climate, fire, and winds. Observations made during the La Mesa Fire studies show some snags that were standing in 1975 are still standing in 2012, regardless of being subjected to repeated fire (see Figures 4.8 and 4.9). There is other qualitative information concerning long-term survival of snags. Snags identified in photographs taken by Illingworth with Custer's expedition in 1874 into the Black Hills of South Dakota are some of the same snags standing today, over 138 years (Frank Carroll, personal communication).

Harrington (1996) studied the fall rates of prescribed fire-killed ponderosa pine in southwestern Colorado. He found that the creation of snags was determined by two factors: 1) the percent crown scorch and 2) the amount of time it took for a tree to die after injury by fire. Trees that died within the first year and had greater than 80 percent crown scorch had an 82 percent probability of falling within 10 years after the fire. Trees with less than 80 percent crown scorch, yet died within the first year, had a 75 percent probability of falling. Trees with less than 80 percent crown scorch that survived two to three years post-fire had a 27 percent probability of falling within 10 years.

Schmid et al. (1985) found beetle killed trees did not fall as quickly as fire-damaged trees. They noted that most of the snags fell between year 4 and 10 and broke off within two feet of the ground level. Dahms (1949) found that Jeffrey and ponderosa pine break off incrementally more often than lodge pole pine, which broke off at the base.

One of the questions that has been posed is "Does fire harden ponderosa pine?" Trees that survive fire will produce pitch, particularly in fire-scarred boles, as healing begins. These trees may be subjected to repeated fires and the repeated hardening occurs (Frank Carroll, personal communication). As found by Harrington (1996), trees with less crown injury recover and have a low probability of falling. Wood gatherers prefer what they call "pitch trees," standing snags that have been hardened by pitch (Charles Foxx, personal communication).

Further study on the function of tree size, fire frequency, and tree fall is needed.

5.8 Tree Mortality and Seedbed Competition

Question 7: Is there a connection between tree mortality and seedbed competition?

Historical Information

Studies conducted by Pearson (1942) demonstrated strong competition between coniferous tree seedlings and established grasses and concluded that dense herbaceous vegetation would retard and prevent the natural regeneration of forest trees. In particular, he noted that ponderosa pine seedlings had greatly reduced shoot and root development when grown in competition with a grass sward of predominantly Arizona fescue, a cool-season grass, but less growth inhibition when grown with mountain muhly, blue grama, and pine dropseed, all warm-season grasses. Studies by other researchers (Pearson 1942, Larson and Schubert 1969) indicated that the native grass, mountain muhly, would compete less than the introduced sheep fescue.

In 1982, we conducted studies to determine the influence of seeded grass on ponderosa pine regeneration (Potter et al. 1982, Barnes 1984).

Barnes made field observations on root structure, seasonal patterns of plant water status, and soil moisture to investigate the partitioning of the soil water from the coexisting species (Potter et al. 1982, Barnes 1984).

She compared the root structure and found that sheep fescue had a very dense shallow root system that extended 10 to 15 centimeters deep with an impenetrable mat (Figure 5.16). The roots were

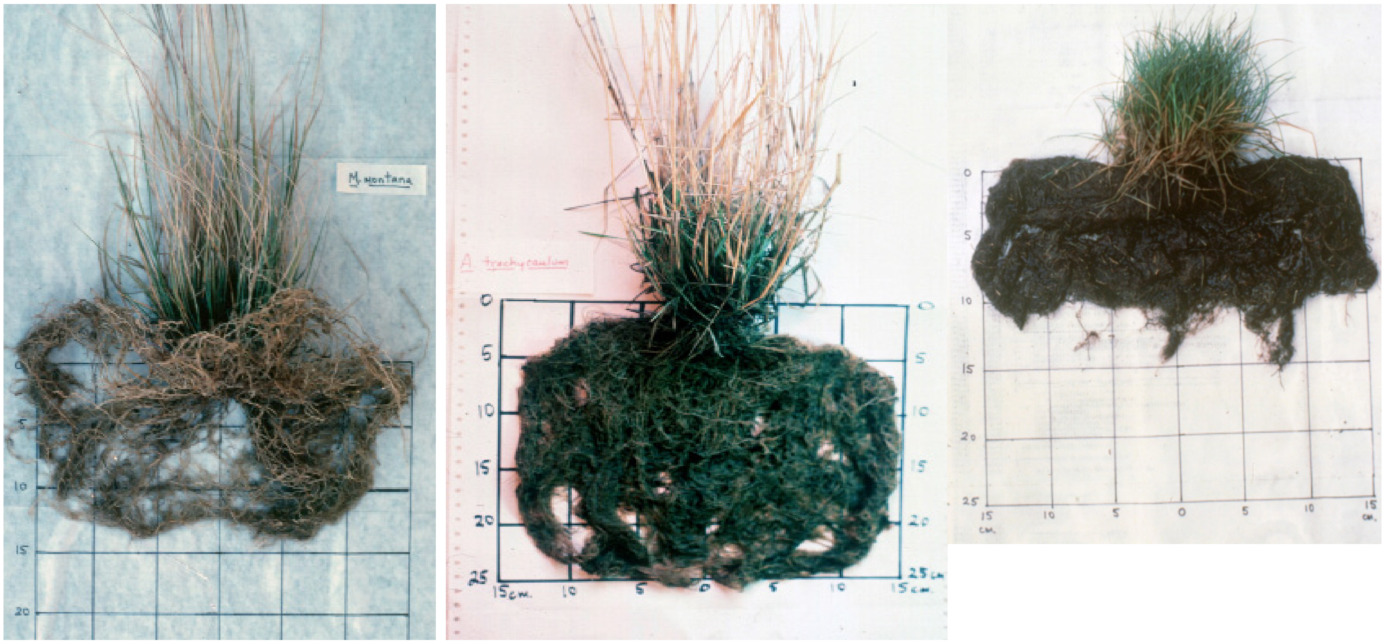


Figure 5.16. Rooting structure of three grasses—mountain muhly, slender wheatgrass, and sheep fescue (left to right)

very fine and fibrous. Mountain muhly had a more diffuse root system extending 20 centimeters in the soil. Slender wheatgrass had a dense root system extending 30 centimeters. The newly germinated ponderosa pine seedling had a very short root system that extended only two to three centimeters into the soil. Three-year-old seedlings extended only 12 centimeters into the soil (Figure 5.17).

Barnes' leaf water potential studies indicated that the maximum growth of mountain muhly usually occurred after the growth of pine seedlings ceased. However, sheep fescue growth was during the time of the growth of the seedlings, setting up a competition for water resources. Barnes concluded the native grass—mountain muhly—had a phenology complementary to the growth patterns of ponderosa pine.

McConnell and Smith (1971) observed that litter fall on bared soil improved the production of hard fescue, while removal of litter fall did not enhance production. In 1977, two adjacent plots provided excellent contrast of the effect of needle fall upon grass seed germination. Escobas Mesa 4 had 116 trees per acre and had been selectively logged some 60 years previously and most of the trees had over 50 percent of the crown scorched that resulted in considerable amount of needle fall. The adjacent plot had 800 trees per acre and all the trees were killed and most of the needles consumed. By 1998, only one tree remained living.

Measurements on September 27, 1977, showed that the success of seeding, based on the number of grass seedlings per average rate of seeding, was 52 percent in the area with needle fall and eight percent in the area with no needle fall. In June 1978, the needle mulch had held the soil, preventing erosion and retaining moisture and seeds. Slender wheatgrass germinated at a 97 percent rate. In Escobas Mesa 3, where there was no needle mulch, the soil was not protected from erosion and seed loss, the success of germination was only 24 percent for slender wheatgrass. These same relative trends in germination rates were also observed for sheep fescue.

In our 1993 study, we noted that sheep fescue was dominant on plots in severely burned sites followed

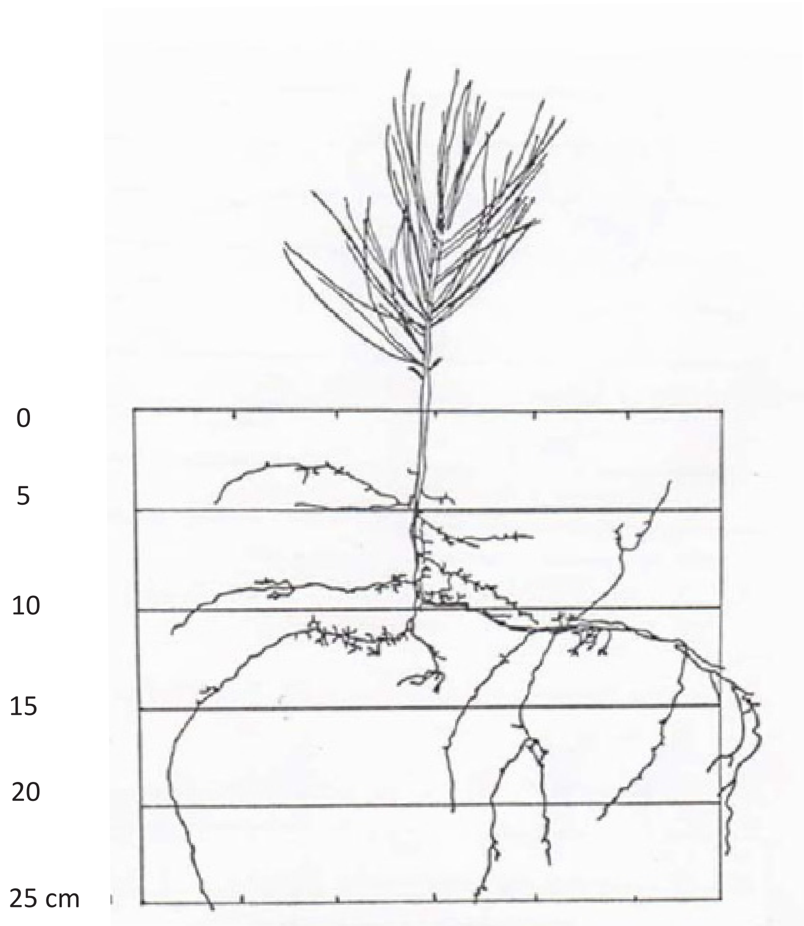


Figure 5.17. Root structure of a three-year-old ponderosa pine (Barnes 1984)

from 1975 to 1993. Sheep fescue also dominated the grass component in the severely burned 20- by 50-meter plots on both Burnt Mesa and Escobas Mesa. The litter fall in the logged/moderately burned plot was higher than in the severely burned plot. There was a substantial difference in the cover of the seeded grasses in the logged/moderately burned plot as compared to the severely burned plot. We believe this is the same as what McConnell and Smith (1971) observed with hard fescue (*Festuca brevipila).*

Recent and Compiled Observations and Data Related to Survival
We compared both seeded grasses and dominant native grasses at three different intervals: one year after the fire to allow for germination of seeds; 21 years after at the time of the prescribed fire, and 33 years later in 2010 (Table 5.5). The seeded grasses had a higher percent cover for each of the three years.

Seeded grasses may have dominated because of the competition for water resources that Barnes showed in her study. Ponderosa pine is shallow rooted. During the drought period of the year (May and June), sheep fescue is maturing. If the trees were already weakened, this additional competition may have contributed to a lower survival rate.

5.9 Regeneration of Ponderosa Pine

Question 8: Is there a comparison between artificial plantings and native regeneraton of ponderosa pine?

Three aspects were related to regeneration of ponderosa pine: germinant reforestation, plantings of 2.0 stock, and natural regeneration.

Germinant Reforestation
Historic Information
BNM did not participate in planting of two-year-old

Table 5.5. Percent Cover of Seeded and Dominant Native Grasses for Plots on Escobas Mesa

Plot/Grass	Burn Severity	1978	1998	2010
	moderate	**ESCOBAS 1**		
Elymus trachycaulus		5.46	1.25	0
Fetuca ovina		1.92	0	0
Total		**7.38**	**1.25**	**0**
Bouteloua gracilis		2.37	0.50	2.40
Muhlenbergia montana		1.01	1.31	6.30
Total		**3.38**	**1.81**	**8.70**
	light	ESCOBAS 2		
Elymus trachycaulus		1.00	0	0
Festuca ovina		1.19	0.05	0
Total		2.19	0.05	0
Bouteloua gracilis		0	0.05	0
Muhlenbergia montana		1.06	1.55	0.56
Total		**1.06**	**1.60**	0.56
	severe	ESCOBAS 3		
Elymus trachycaulus		2.05	0	8.50
Festuca ovina		2.54	5.45	1.88
Total		**4.59**	**5.45**	**10.38**
Bouteloua gracilis		0	0	1.10
Muhlenberia montana		0.58	0.40	13.6
Total		**0.58**	**0.40**	14.7
	logged/moderate	ESCOBAS 4		
Elymus trachycaulus		4.28	0.10	0
Festuca ovina		7.88	3.26	8.94
Total		**12.16**	**3.36**	8.94
Bouteloua gracilis		0	0	0
Muhlenbergia montan		0	0.54	7.02
Total		**0**	**0.54**	7.02
ELTR=*Elymus trachycaulus* , FEOV = *Festuca ovina*, BOGR = *Bouteloua gracilis*, MUMO = *Muhlenbergia montana*				

ponderosa pine stock because of the undetermined genetic variability in the stock. However, studies had been done by researchers about germinated pine seeds that were from the Jemez zone. Therefore, in 1982, germinated pine seedlings were planted on BNM and, in 1981-82, 2.0 stock were planted on the adjacent LANL property (Foxx 1983).

We followed up the plantings of the germinated pine seedlings (designated as germinants) in September and October of 1982. Survival counts were also made in May 1983, June 1983, and August 1983. A total of the 808 planting sites were examined out of the 1696 germinants planted. During September and October 1982, two percent of the germinants could not be relocated. In June of 1983, seven percent of the germinants could not be relocated. This was primarily because of grass encroaching on the sites and tree fall. Table 5.6 compares the survival rates at the monitoring intervals.

These germinants were not counted or monitored officially in subsequent years but were checked occasionally and photographs were taken. Plate 5.5 illustrates the germinant planting study and Plate 5.6 records the growth of trees through time. By 2008, the trees within the area were 20 to 25 feet tall.

Las Conchas Fire
The areas along State Route 4 and where the germinants were planted was burned by the Las Conchas Fire (Plate 5.7). Many of the trees had only 25 percent of the crown remaining. By 2012, most had lost their needles and were struggling to survive.

La Mesa Fire Rehabilitation for DOE Land
After the La Mesa Fire, approximately 125 acres of DOE forestland, located primarily between State Route 4 and Water Canyon, were studied and rehabilitation recommendations were made (Figure 5.18). They "clear-cut" the area, which exposed Laboratory facilities located on the north side of Water Canyon. These facilities were basically unattractive and they wished to plant for screening purposes. A few trees that had survived the fire were retained for seed source. They cut the dead standing trees for the purposes of fire control.

From March 1981 through March 1982, planting of two-year-old ponderosa pine stock was done with planting bars. The planting densities varied between light and heavy. Light densities had 600 to 800 seedlings with a target survival rate of 300 to 400 seedlings per acre. Heavy densities were 800 to 1200 seedlings per acre with 600 to 800 remaining after establishment (Barela 1979).

Figure 5.19 shows the height and density of the trees in 1999.

Las Conchas Fire
The planted trees on the LANL side did not burn severely during the Las Conchas Fire.

Comparison of Plantings with Natural Regeneration of Ponderosa Pine
In 1993, we compared sites for pine tree regeneration on two planted sites—LANL planted site (1981-82) and BNM germinant planted site (1982)—and areas of natural regeneration—1893 line strip, 1937 line strip, and the 20- by 50-meter plots of Burnt Mesa and Escobas Mesa. These areas had been either moderately or severely burned. Figure 5.20 shows a natural seedling, and the results are seen in Table 5.7.

The LANL site had cover of 14.9 percent and a density of 493 trees per acre. The area planted with

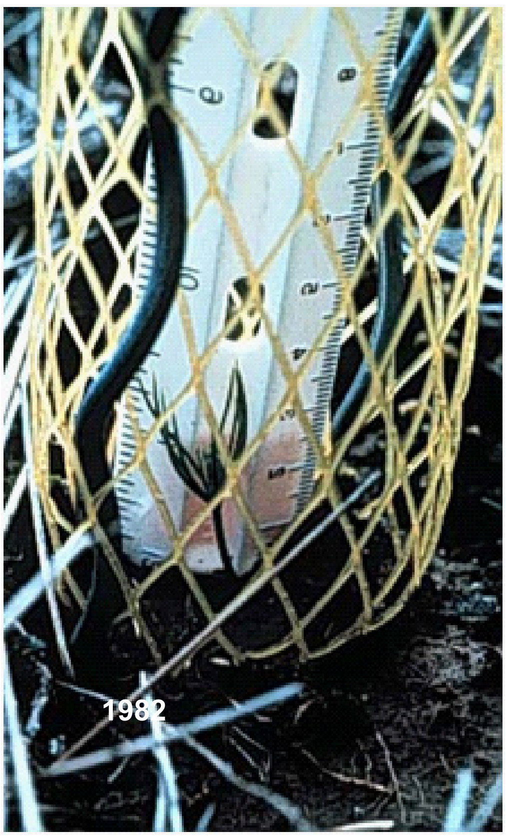
Table 5.6. Comparison of Percent Survival of Germinants in the State Route 4 Sites for Four Different Survival Counts

Planting Site	Sep-82	Oct-82	Jun-83	Aug-83
Log	72	71	61	56
Stump	73	72	63	57
Cleared	69	64	59	52
Uncleared Control	63	58	54	44
Total	**69**	**66**	**59**	**54**

Germinated pine seedling ready for planting

Planting germinant

Germinant planted near log



Germinated pine seedling protected with vexar.

Surviving germinant in 1985, three years after planting.

Plate 5.5. *Planting germinanted ponderosa pine seeds in 1982*

Plate 5.6. *Planting site through time*

a. Planting site, 1982. Note the height of the slender wheat-grass.

b. Checking the germinant survival in 1983, one year after planting. In some areas, trees had fallen; in others, trees were still standing.

c. Planting site in 2008, 26 years after planting. Person in photo is 5'4" tall.

Plate 5.7. *Planting site after the Las Conchas Fire*

After the Las Conchas Fire in 2011

Eleven months after the Las Conchas Fire

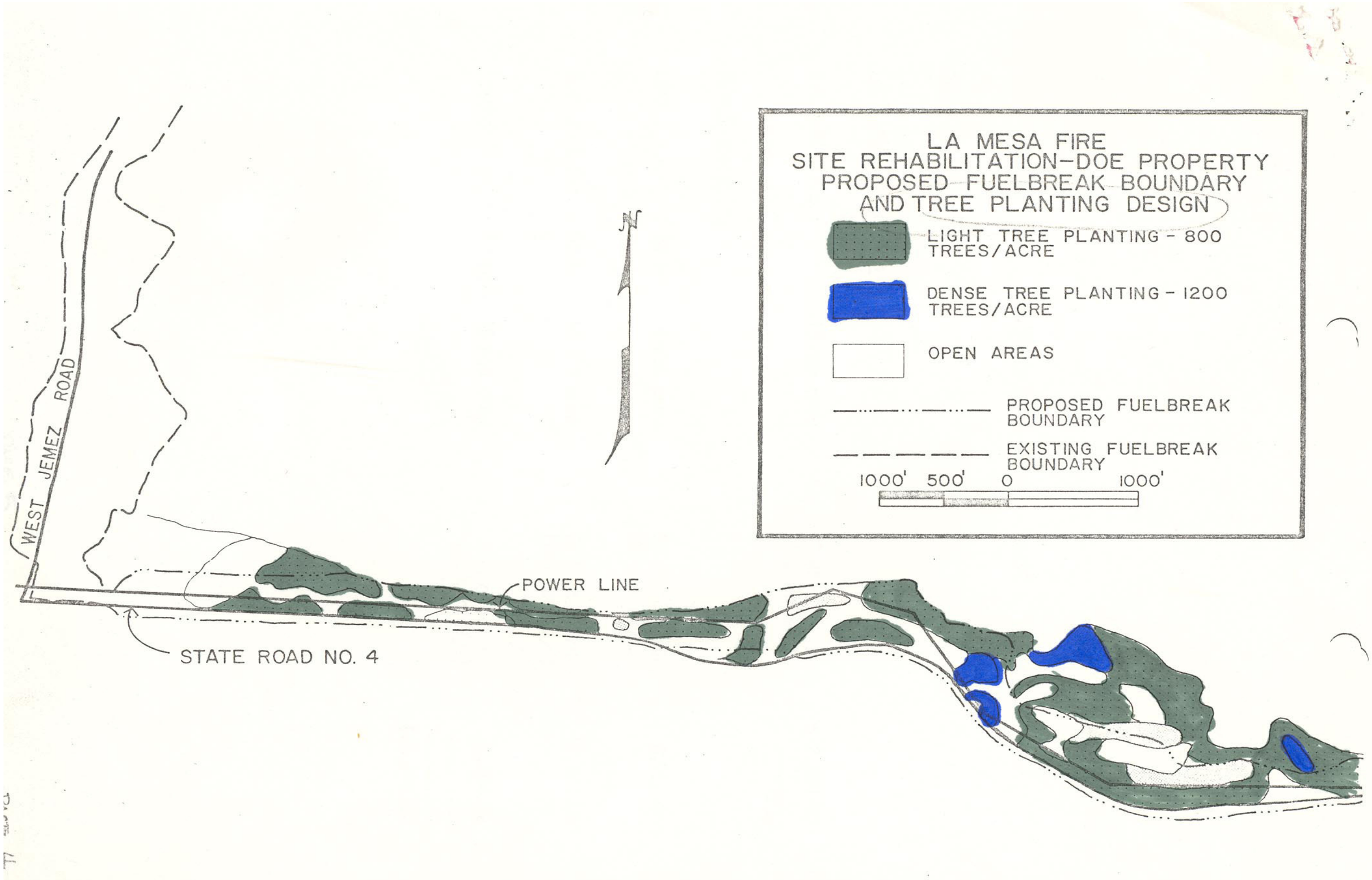


Figure 5.18. DOE planting design 1981-1982 (Barela 1979)

Figure 5.19. The height and density of the trees in 1998 on the LANL side of State Route 4, planted in 1981-1982

Figure 5.20. Naturally germinated seedling

germinants in 1982 had a cover of 1.9 percent with 395 trees per acre. Areas with only natural regeneration, exemplified by 1937 and 1893 plots, had less than one percent cover and around 24 to 88 trees per acre.

Certainly, trees planted, either 2.0 stock or germinants, had a higher density per acre than the areas where natural regeneration was taking place. In fact, those areas were above the ideal spacing of approximately 100 trees per acre. The areas where natural regeneration was taking place had less than 100 trees per acre and were more random in spacing. This would be more comparable to natural sites found by Reynolds and colleagues (Youtz et al. 2008).

In 1992, Escobas Mesa 3 had 148 seedlings per acre. In 1998, the prescribed fire singed most of the small trees and in 2010 very few seedlings were found.

The lack of survival of the small trees may have been related to climate. The 10 years after the La Mesa Fire the average precipitation was 17.3 inches; whereas, after the prescribed burn it was 13 inches, below the historic average precipitation. The years after the prescribed fire were considered drought years (Figure 5.21). Plate 5.8 illustrates seedling tree density from 1998 to 2010 in Escobas Mesa 3.

Table 5.7. Comparison of Post-Fire Regeneration, Tree Numbers, Size, and Recovery as of 1993 in Planted Sites as Compared to Natural Regeneration

Location	Planting Type	Average diameter	Percent Cover	Trees/Acre
TA-26	2.0 stock	1.9	14.9	492
BNM	Germinants	1.1	1.1	395
1937	Natural	0.1	<1	24.3
1893	Natural	0.6	<1	88.3
Burnt Mesa 2 (Moderate)	Natural		<1	24.3
Burn Mesa 3 (Severe)	Natural		<1	16.2
Esocbas Mesa 1 (Moderate)	Natural		<1	12.1
Escobas Mesa 3	Natural			148
Escobas Mesa 4 (Moderate/Logged)	Natural		<1	8.1

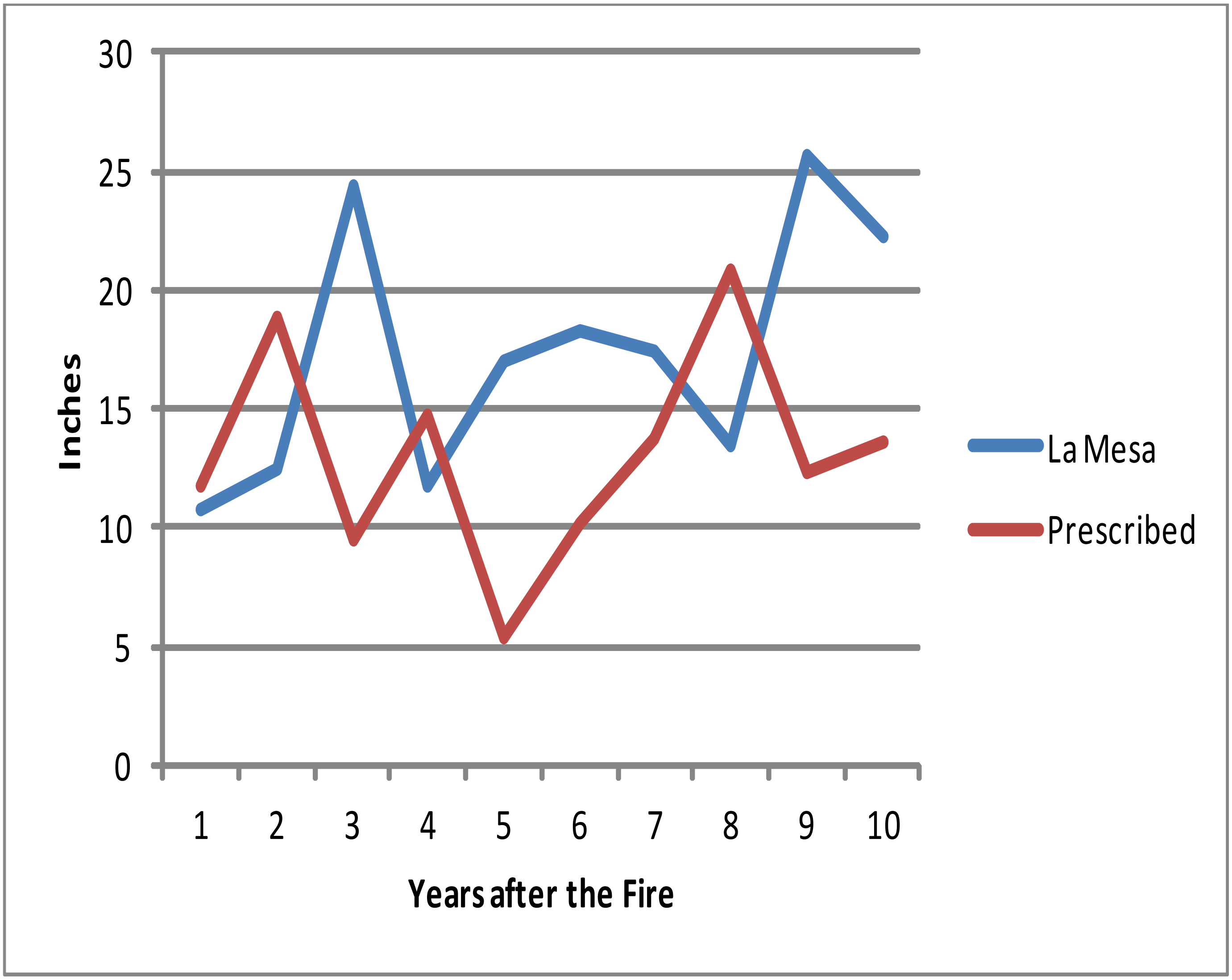


Figure 5.21. Annual water preciptation 10 years after the La Mesa Fire and 10 years after the prescribed fire

5.10 Bearberry (*Arctostaphylos uva-ursi*) and Ponderosa Pine Regeneration

Question 9: Is there a relationship between bearberry (*Arctostaphylos uva-ursi*) and pine regeneration?

In May 1980, studies were conducted on previously burned areas (1954 fire, Las Conchas[1] Fire) to compare the seedling survival of ponderosa pine with those in the La Mesa Fire. A population of 1431 seedlings was examined for microsite characteristics such as soil texture, litter depth, litter composition, living ground cover, phenology of ground cover, growth form of ground cover, vertical canopy, potential tree shade, seedling proximity, need for protective objects, relation to trees, distance to trees, slope, and slope direction.

The best ponderosa pine seedling survival was in fine soils, that is, conifer litter less than one centimeter, sparse ground cover, and some shade or ground cover of bearberry (*Arctostaphylos uva-ursi*) (Figure 5.22). There was found to be a high association of seedlings to native grass, mountain muhly, and bearberry. Bearberry appeared to almost act as a nurse plant.

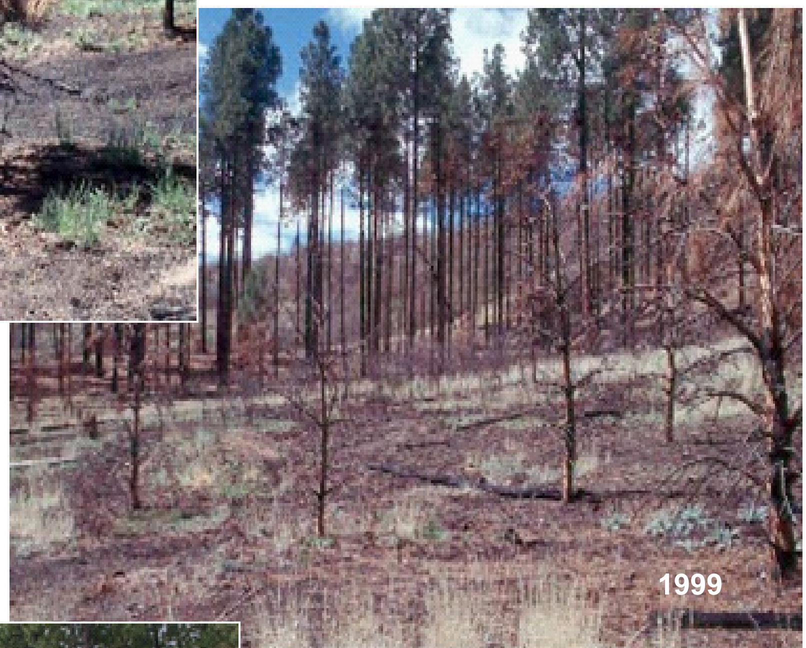
Bearberry is found in the upper elevations and within the canyons of the Pajarito Plateau. According to Crane (1991), this subshrub sprouts from the root crown and also establishes from the soil seedbank after fire. Germination appears to be activated

1*This was a previous fire in the Jemez and should not be confused with the 2011 Las Conchas Fire.

Plate 5.8. *Escobas Mesa 3, comparative photographs showing seedling tree density through time*

a. Tree scorching after the 1998 prescribed burn.

b. 1999, one year after the prescribed burn.



c. 2002, four years after the prescribed burn.

d. 2010, note the lack of trees and increase of false tarragon.

by the heat from fire. After fire it sprouts vigorously and expands rapidly.

In our observations, the mats of bearberry appear to be a catch for pine seeds, which germinate readily within the patches (Figure 5.23). More research needs to be done.

5.11 Changes in Litter Cover after the 1998 Prescribed Fire

Question 10: What is the reduction of litter cover after fire?

Before the La Mesa Fire, we had taken litter samples, dried, and weighed them (Foxx and Potter 1978). However, after the La Mesa Fire we did not collect litter and until 1992 did not break the non-vegetative cover down into various components. To determine if there was a reduction of litter from the prescribed fire we compared these two years. Nearly all plots saw a reduction in the litter cover with the exception of the severely burned plot Escobas Mesa 3. Because we don't know the intensity of the fire, it is hard to speculate as to the lack of reduction. A photograph taken at the beginning of the Escobas Mesa road visually shows how the prescribed fire reduced some of the downed trees creating ghost logs (Plate 5.9).

We also compared the severely burnt Burnt Mesa 3 with areas on LANL. The areas within the Laboratory were not burned by prescribed fire and therefore there was a higher cover of litter. The litter was reduced from the 1992 data, but this may be a reflection on natural reduction of large fuels through decay (Figure 5.24).

5.12 Plant Response to Fire

Question 11: What are local plant responses to fire?

The Jemez Mountains is a fire-adapted environment; therefore, there are a number of plants that respond to fire. The 37 years of observations on specific species were too extensive for this report and have been compiled in *Fire Effects on Plants of the Jemez Mountains and the Pajarito Plateau* (Foxx n.d.[b]). What is presented here are generalizations about fire effects on plant species.

Studies have found many factors that will affect survival of plant species in a burned area. Wendt et al. (1952) determined seven different categories: distribution and presence of seed, differential germination, competition, soil differences, climatic differences, pests and disease, and differential survival.

In addition, a number of factors can cause plant mortality, including temperature, tissue susceptibility/sensitivity, location of the tissue, reproductive

Figure 5.22. Bearberry in fruit

Figure 5.23. Small pines growing in a patch of bearberry

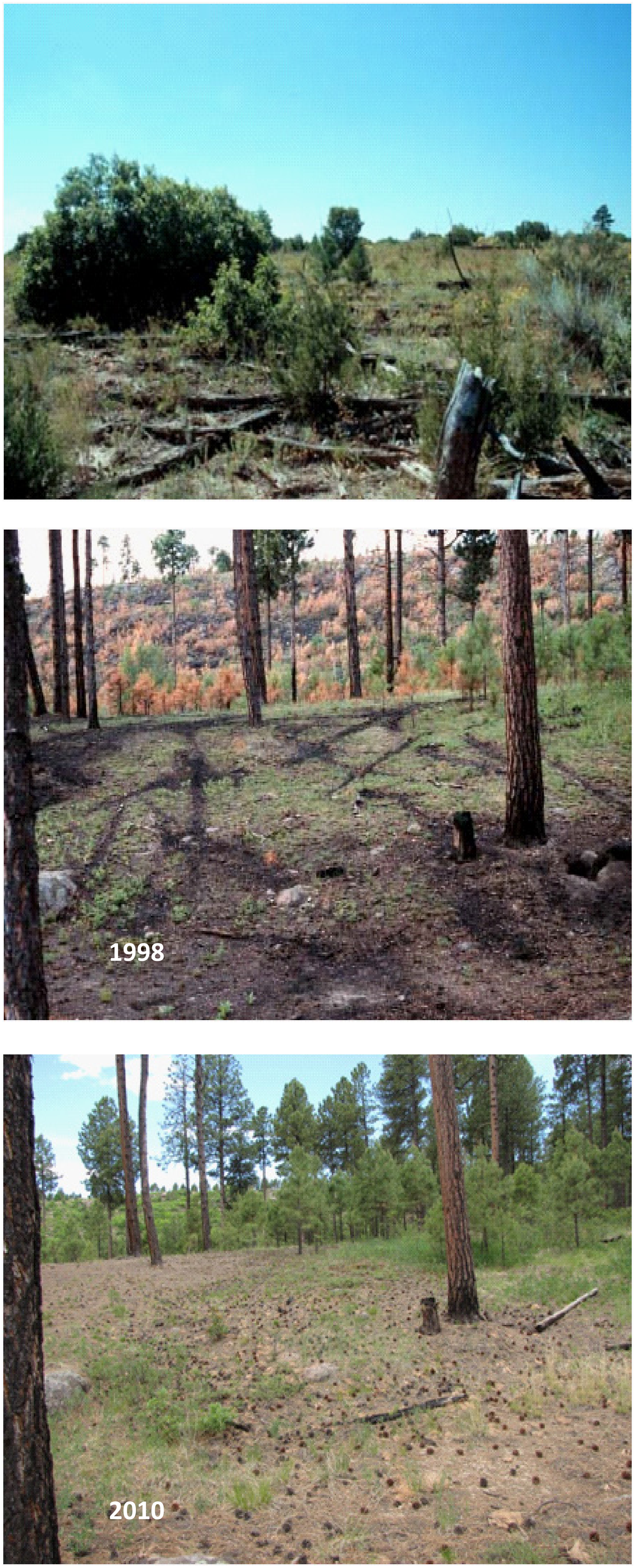


Plate 5.9. *The beginning of Escobas Mesa road before (top) and after the prescribed burn. Note the ghost logs remaining from downed trees (middle). The same area in 2010 (bottom).*

mechanisms, and the ability to recover from injury.

Researchers have found that mortality depends on temperature that is reached during a fire and the length or duration of that temperature. Cells die at 50 to 55 degrees centigrade (122 to 131 degrees farhenheit) *(Fire Effects Manual)*. The lethal temperature is also related to the length of time the plant tissue is exposed and is generally considered 60 degrees centigrade for 10 minutes.

There are a numbr of reproductive mechanisms that can provide means for plants to revegetate or recoolonize an area: sprouting from undamaged parts, germination of seeds in the soilbank, and recolonization from unburned areas. Appendix IV lists the most common grass, forb, shrub, and tree species and the primary means of regeneration.

Sprouting Plants

A number of plants can sprout after fire, particularly those with bulbs, corms, tubers, rhizomes, and lignotubers. The meristem, the growing part of the plant, has a higher moisture content than other cells and therefore is more susceptible to damage. The size and location of those tissues are also important. Cells that are protected, such as those in roots, are less likely to be damaged than those above ground. Dormant buds and bud primoria on underground stems and roots such as stolons, rhizomes, and roots deeper than a few inches are stimulated to develop after fire. In undamaged plants these are inhibited from growing by inhibitors such as auxin. If plant parts are removed either by fire or other means, these growth inhibitors are eliminated and sprouting begins. In areas of high-severity fire, plant parts are damaged above the ground and sometimes seem nonexistent but sprouting can come from below.

A number of plant species that have been seen to sprout in the various fires of the Pajarito Plateau are discussed in *Fire Effects on Plants of the Jemez Mountains and Pajarito Plateau* (Foxx n.d.[b]). Only two species, which are widespread and significant in the areas of the La Mesa Fire, are discussed here.

*Oak (*Quercus *spp.)*

Several species were found to grow within the

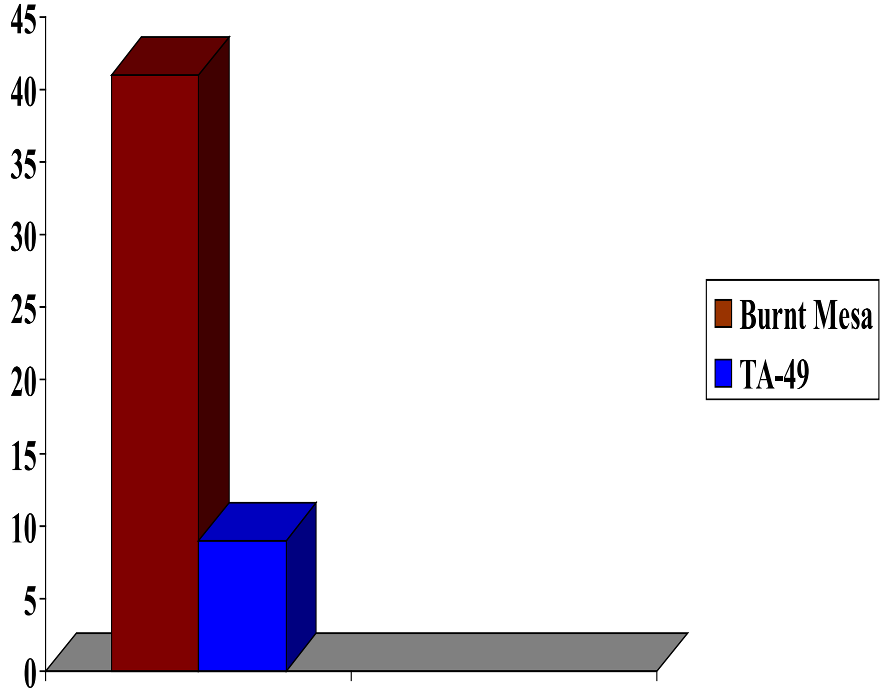


Figure 5.24. Comparison of litter cover in a prescribed burn plot (Burnt Mesa) and an unburned plot (TA-49)

study area; however, Gambel's oak predominated. Throughout the fire, the crowns of the oaks were completely destroyed; however, these species were the fastest sprouting species and in some areas were up to six inches high within five days after the fire. By October the oak sprouts were as much as three feet tall. Others have reported vigorous sprouting. Kittams (1973) found species of oak at Carlsbad National Park to grow 10 to 15 inches in three years. Many areas of the La Mesa, Dome, and Cerro Grande fires have large patches of oak (Plate 5.10).

*New Mexico Locust (*Robinia neomexicana*)*
One of the most rapid sprouters after the La Mesa Fire was New Mexico locust. Like the oaks, New Mexico locust regrowth was immediately after the fire. In later years, there were areas that were dominated by New Mexico locust. This was probably not solely from sprouting of underground rootstocks but germination of seeds. After the 1998 prescribed fire, the areas such as the severely burned Escobas Mesa 3 were dominated by *Robinia* (Plate 5.11).

Fire-Induced Germination of Seeds
Many plants colonize an area through soilbanks or seedbanks. Seeds can lie dormant for a number of years. The heat from fire can break the seed coat so germination can take place. Appendix V has a listing of species that can be found in the seedbank. More specific informtion can be found in *Fire Effects on Plants of the Jemez Mountains and Pajarito Plateau* (Foxx n.d.[b]). We discuss only one species in this document, buckbrush (*Ceanothus fendleri*).

Ceanothus was rarely observed by this researcher in the BNM area before the La Mesa Fire. An occasional plant was found along trails. However, after the fire, this species increased in many areas. Buckbrush was aptly named as it was often browsed by deer and elk, in some cases reducing the vigor and size.

Researchers have noted that seeds of buckbrush can remain in the forest floor seedbanks for years until heat from fire allows them to germinate. They have also found *Ceanothus* uses a dual regeneration strategy in response to disturbance—with low-intensity fire, sprouting from underground branches and root crowns occurs, high-intensity fires cause seeds to germinate (Huffman 2009). Fire-induced germination of buckbrush has also been reported by Gratkowski (1962). According to the US Department

Sprouting oak in an area severely burned and with hydrophobic soils (June 1977)

Height of oak sprouts three months after the fire in an area with hydrophobic soils

Plate 5.10. *Regeneration of oak (*Quercus *spp.)* *Height of oak one year after fire*

Immediate post-fire sprouting of New Mexico locust

Large patches of sprouting of New Mexico locust.

Plate 5.11. *Regeneration of New Mexico locust*

of Agriculture Agricultural Handbook 450 (1974), germination tests had not been made of *C. fendleri*, but it appears germination is anywhere from 30 to 90 days for most species. Within the La Mesa Fire area, *Ceanothus* was seen by September and October 1977 (Plate 5.12), but not immediately after the fire.

Huffman and Moore (2004) studied the responses of buckbrush to overstory thinning, prescribed fire, and drought. They found that in unburned plots no seedlings were found; but seedlings were found in 44 percent of their burned plots.

Buckbrush is a nitrogen-fixing plant and because of this it has higher levels of crude protein in the leaves, stems, and other parts. *Ceanothus* is sought after by animals such as mule deer, Rocky Mountain elk, porcupine, and rabbits. In studies by Huffman they found that the reduction of growth by browsing was from 79 percent to 92 percent.

5.13 Success of Seeded Grasses Through Time

Question 12: What is the long-term establishment of seeded grasses versus natural regeneration of native grasses?

Historic Information
One of the main questions concerning fire rehabilitation is whether or not to seed or not to seed. Broadcast seeding is one of the most widely used post-wildfire emergency response treatments intended to reduce soil erosion, increase vegetation cover, and minimize the establishment of non-native species. Part of the BAER projects for the La Mesa, Dome, Cerro Grande, and Las Conchas fires included reseeding.

The biggest concern for the seed mix for the La Mesa Fire was the presence of sheep fescue (*Festuca ovina*). It was not normally found in the area and labels on sacks indicated the seeds were "hard fescue." According to Hitchcock (1950), hard fescue was *Festuca ovina* var. *duriuscula*, which was an exotic introduced from Europe. According to Barkworth et al. (2007), it is a native of Europe. In addition, it was not a common plant within the flora

Germinated buckbrush after the La Mesa Fire

Germinated patch

Mature plant

Plate 5.12. *Germination and growth of buckbrush (*Ceanothus fendleri*)*

of the Pajarito Plateau and Jemez Mountains.

Sheep fescue is a fine-leaved and densely tufted perennial cool-season grass. It develops slowly but is very competitive with abundant roots. It has 680,000 seeds per pound of live pure seed and the success of germination is usually only eight percent. This species was much more tenacious and was found in most of the severely burned plots even after 22 years. In the mixed conifer plots, sheep fescue was dense and almost carpet-like (Plate 5.13). In the higher-elevation mixed conifer plots it was sod-like.

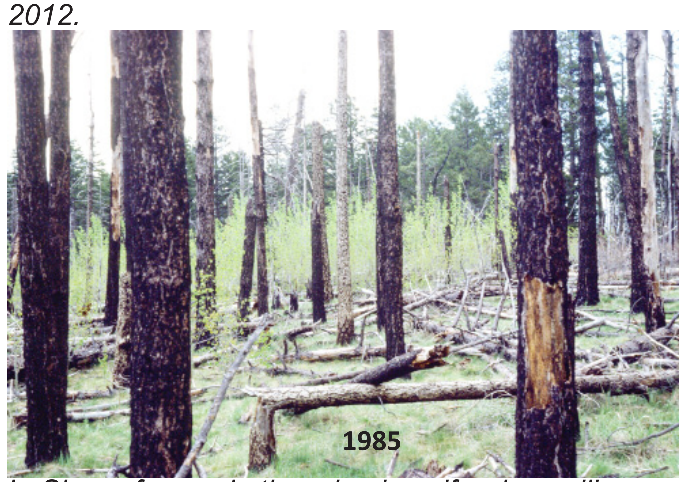
Of the six grasses that were broadcast seeded by helicopter within a month after the fire (Section 1: Table 1.3), only three showed long-term survival and success: slender wheatgrass, sheep fescue, and spiked muhly.

Slender wheatgrass and sheep fescue germinated the best of the six seeded grasses. Slender wheatgrass is a short-lived perennial that yields well up to five years and after that the production declines (Flory and Marshall 1942). Slender wheatgrass was the dominant seeded grass through 1985. By 1992, the cover had decreased and, in 1998, we did not find this grass in the plots studied. During the first few years, the grass made up from 25 percent to 60 percent of the cover, depending on the plot. The species has 159,000 seeds per pound of live pure seed (USFS 1948) and the success of germination is 27 percent. Slender wheatgrass has also been used in the seed mixes of the Dome Fire and the Cerro Grande Fire.

The other seeded grasses did not show significant germination 14 months after the fire (Potter and Foxx 1979a). Spiked muhly (Figure 5.25) was the other more commonly found seeded grass 22 years after the fire. It tends to like coarse soils and has very small seeds (a related species has 2,424,000 seeds per pound) (USFS 1948). Blue grama is a common grass in a variety of habitats and there was no noticeable germination after the fire and it is difficult to assess if the seeding made any significant difference in the cover through time.

The factors that were related to the success of germination of the seeded species included density of native grass cover, pre-fire tree density, severity

Sheep fescue, a fine-leaved, tufted, cool-season grass broadcast seeded in 1977, still present in 2012.



b. Sheep fescue in the mixed conifer dense like a sod grass (1985).

Slender wheatgrass in 1978 in dense stands.

Plate 5.13. *Seeded grasses*

*Figure 5.25. Spike muhly (*Muhlenbergia wrightii*) was commonly found after fire.*

of scorching of the trees as related to fire history, and the presence of needle mulch. The density of seedlings of seeded grass was inversely related to the amount of native grass. In areas where the pine stand was less severely burned, the germination of seeded grass was considerably less (Potter and Foxx 1979a).

In 1979, we compared plots that had been seeded with those that had been unseeded at TA-49 (Figure 5.26). Plots in the seeded area were found to have a greater foliage cover than those in the unseeded plots. *Chenopodium* species were dominant in the unseeded plots.

In 1981, Fairly Barnes looked at the leaf water potential of two seeded grasses (slender wheatgrass and sheep fescue) and one naturally occurring (mountain muhly). We were interested in determining if the seeded grasses would have any potential for competition with ponderosa pine and if conditions would suppress natural regeneration of ponderosa in severely burned areas of the fire. This information was reported in Potter et al. (1982) and Barnes (1984).

The results of soil moisture and leaf water potential studies indicated that ponderosa pine seedlings would experience severe competition for water from sheep fescue early in the growing season, and continued competition with slender wheatgrass through the summer. Mountain muhly seems to have a water usage pattern and phenology that coordinates well with know requirements for ponderosa pine seedling survival. The results indicated that artificial or natural regeneration of pine seedlings can be suppressed.

In 1993, we reported that there was a dramatic shift in the grass species that dominated the study

Figure 5.26. Unseeded area at TA-49, 1977 (S 3)

sites from 1985 to 1993. The seeded grass, slender wheatgrass, virtually disappeared from the ecosystem sometime after 1985. In every plot that had slender wheatgrass as a dominant species within one year after the fire, this seeded grass had disappeared from the study plots by 1993. This is consistent with information in Flory and Marshall (1942). On the other hand, sheep fescue increased continuously through time in all plots, particularly in areas where the tree canopy had been destroyed and there was little competition from tree shading and native grasses. Native grasses also increased in cover from 1978 to 1993 with mountain muhly being the dominant species.

Recent and Compiled Data Related to the Success of Seeding

Sheep fescue and slender wheatgrass were found in a few instances on Burnt and Escobas mesas in 2010. However, the cover did not dominate the plots. Certainly, the first 10 years these seeded grasses had the highest cover in some plots. What this did to the natural regeneration of forbs is unknown as the control unseeded plots in TA-49 seemed to have blow-over from the seeding of BNM.

The fact that a few of the plots had these species in 2010 may be a matter of seed dispersal. At least slender wheatgrass was used in the seed mixes for the Dome and Cerro Grande fires.

Researchers have conducted evidence-based review to examine the effectiveness and effects of post-fire seeding treatments. Of the 94 scientific papers they reviewed they found that seeding suppressed native species and introduced many non-native species (Peppin et al. 2012).

5.14 Effect of Fire on Native Grasses

Grasses are likely to die if the meristematic tissues are subject to lethal temperatures or increased residence time. The growth form, fuel loadings, and density will influence the grass survivability or mortality. Rhizomatous grasses generally have better survivability than do bunch grasses. Death of bunch grasses is usually related to residence time of the fire on an individual clump. Conrad and Poulton (1966) developed the following damage class for bunch grasses that are common in the area:

1) Unburned, although foliage may be scorched;

2) Plants partially burned, but not within five centimeters of the crown;

3) Plants severely burned, but with some unburned stubble less than five centimeters;

4) Plants extremely burned, all unburned stubble less than five centimeters and mostly confined to an outer ring;

5) Plants completely burned, no unburned material above the root.

After fire, many species of grass were seen sprouting quickly (Figure 5.27).

Specific Native Grass Response to Fire

Mountain Muhly (*Muhlenbergia montana*)

Historic Information

Mountain muhly is a dominant native grass in the ponderosa pine zone of the Pajarito Plateau (Figure 5.28). It is a warm-season bunchgrass that reproduces by seed. It can also reproduce vegetatively by tillering, and spreads slowly by this method.

Mountain muhly density generally decreases from prefire values during the first few years after fire, but it may increase over original values thereafter. Mountain muhly usually takes at least three years to fully recover from fire.

Recent Compilation and Data

Data from plots on Burnt and Escobas mesas show that mountain muhly increased in density with time. During the first six to 10 years, the seeded species dominated; but once the seeded species began to disappear out of the plots, the native species such as mountain muhly and little bluestem increased.

Big Bluestem (*Andropogon gerardii*)

Historic Information

Big bluestem was seen throughout the burned area, sometimes in only severely burned areas. It responds vigorously to post-fire conditions and sometimes produced fruiting stalks and attained a height of seven feet (Figures 5.29, 5.30). Komarek (1965)

Figure 5.27. Grass sprouting after the La Mesa Fire

Figure 5.29. Big bluestem responding vigorously to post-fire conditions and producing fruiting stalks, which attained a height of seven feet

Figure 5.28. Mountain muhly, a common species of the ponderosa pine plant community

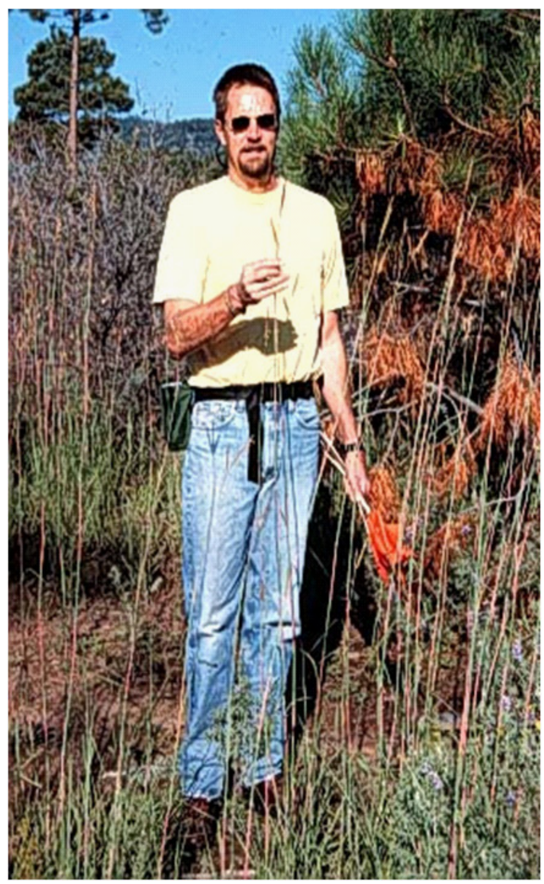


Figure 5.30. The height of big bluestem. Individual is 6'3" tall.

observed that bluestem grasses have a remarkable resistance to even hot fires. He can be quoted as saying, "If any family of grasses can be called 'fire grasses,' the Andropogonaeae certainly can be so called."

Big bluestem is a prairie species. Therefore, much of the information is based in the prairie/grassland ecosystems but can be pertinent to the response of bluestem in the fire areas of the ponderosa pine. Grasslands of the prairie, historically, have lightning strike fires every one to six years. Because of the frequency of fire, big bluestem is fire adapted. After the above-ground foliage has been damaged, new growth is initiated from rhizomes that are one to two inches below the soil surface. Flower stock production increases following fire. Plants burned during the spring quickly send up vigorous new growth because of stored carbohydrate reserves in below-ground organs. If burned during the summer when plants are actively growing, plants survive by initiating new growth from rhizomes; however, regrowth may be slower and less vigorous than in plants burned when dormant.

Generally, it takes two to five years after burning for litter accumulation to equal that of unburned areas.When the fire interval is greater than about five years, bluestem prairie becomes unproductive because the large accumulations of standing dead material stifle growth. However, fires occurring more frequently than every two years will probably lower biomass production. Since many areas burned by the La Mesa Fire had not seen fire for over 70 years, the production of big bluestem was probably hindered.

Recent Compilation and Data
Through the past 35 years, big bluestem has been seen to increase in vigor after the fires. It has been observed as one of the early sprouting species, particularly in areas where there is a moderate or severe burn classification.

Blue Grama *(Bouteloua gracilis)*
Historic Information
Blue grama is a common component of the piñon-juniper and ponderosa pine plant communities on the Pajarito Plateau.

Blue grama is a densely tufted, native, warm-season perennial grass (Figure 5.31). It reproduces by seed and the seed can be dispersed by wind, insects, and ingestion by large herbivores, as well as by adhesion to animal hides, fur, and feathers.

Fire favors blue grama, generally increasing its occurrence, production, and percent cover. Blue grama frequency may increase but productivity may decrease for a few years following fire. Blue grama has on-site surviving rhizomes that may be stimulated by fire. Response of blue grama to fire may be dependant on precipitation following the fire; "wet" years tend to increase blue grama yield. Blue grama seed and seedstalk production may also be stimulated by fire. Fire exclusion, and subsequent woody plant invasion, has resulted in blue grama decline.

Recent Compilation and Data
The response of blue grama to fire has been remarkable. After the La Mesa Fire there was a profusion of blue grama in the meadow on Burnt Mesa that gradually decreased through time consistent with literature information (Arnold 1950). Production of blue grama was increased again when the area was burned by the prescribed fire and then later by the Las Conchas Fire. Figure 5.32 shows the abundance of blue grama on Burnt Mesa within three months after the Las Conchas Fire.

Not only was there an increase in the abundance of blue grama after these fire, but it was observed that there was an increase in vigor of the plant. The seedheads of the blue grama were measured and found to be larger than those not in a burned area (Figure 5.33).

5.15 Invasive Grass Species

Question 13: Are there any invasive grass species that are present or have gotten a foothold over the past 37 years?

Cheatgrass, Downy Chess (*Bromus tectorum*)
Historic Information
Cheatgrass is a cool-season grass blooming in the spring and setting seed early. The seeds are easily attached to animal fur and clothing of humans and thus this hitchhiking plant can easily spread from one area to another.

Figure 5.31. Ripened blue grama seedheads

Figure 5.32. The density of the blue grama after the Las Conchas Fire 2011

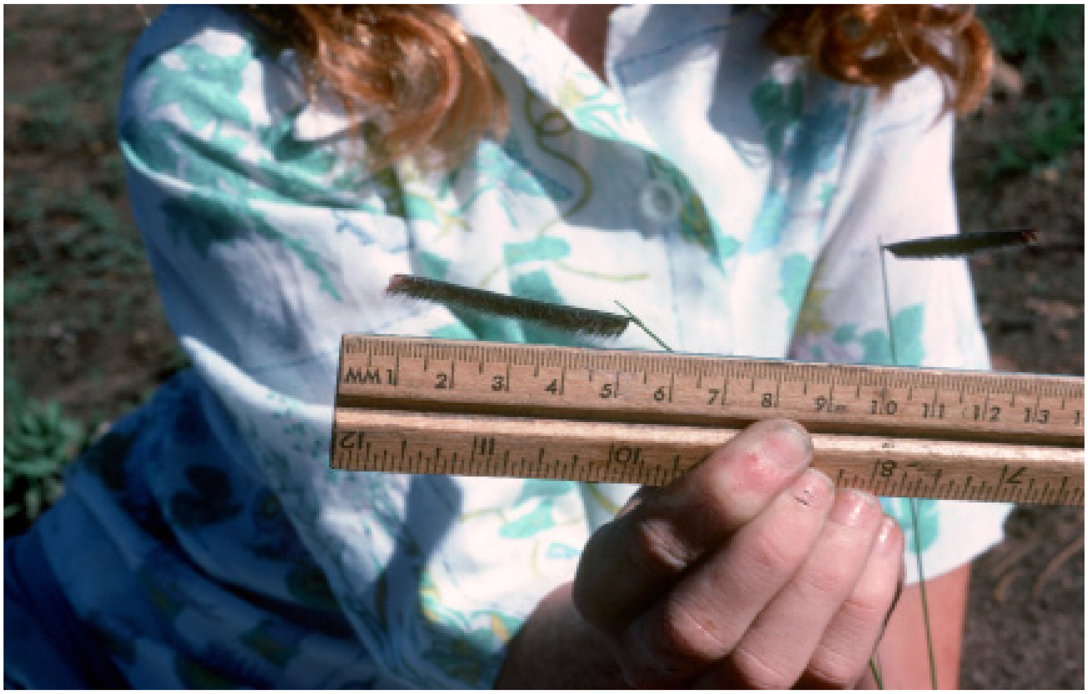


Figure 5.33. Measuring the size of blue grama seedheads

Cheatgrass is a native of Europe and was first reported in the US in 1861 and became a dominant factor in sagebrush/bunchgrass communities, but its distribution extends to higher-elevation juniper and piñon-juniper woodlands. More recently it has become a species of interest in ponderosa pine forests (Keeley 2001).

This annual establishes by seeds, sprouts in the spring, and grows rapidly. Density of the plants can be up to 1400 plants per square foot. It blooms from mid-April through June and has tremendous seed production (sometimes as many as 300 seeds per plant). The seeds can remain dormant in the soil and withstand high soil temperatures.

One critical factor is that cheatgrass success is heightened by disturbance. Because of that, after fire, cheatgrass establishes easily from soil-stored and transported seed. The plant is highly adapted to a regime of frequent fire (Keeley and McGinnis 2007).

Cheatgrass is a strong competitor in the post-fire environment, where it takes advantage of increased resource availability and produces an abundant seed crop. Where it has established itself in ponderosa pine forests, such as those in the Sierra Nevada, low-intensity prescribed burning favored its continued persistence. Keeley and McGinnis (2007) found that frequent fire regimes may enhance alien plant invasion.

Recent Compilation and Data

Photographic evidence shows that cheatgrass was present on Burnt Mesa in 1978 (Figure 5.34). However, it was only an occasional plant and not of sufficient cover to show in the plot data until 1992. By 2010, the percent cover of cheatgrass had increased substantially.

Certainly, the introduction of cheatgrass in areas of Burnt Mesa is not surprising because of the hitchhiking nature of the plant and the location of the mesa. The seeds adhere to vehicle tires, clothing, fur, and feathers. These trails are popular, and the area is adjacent to State Route 4.

The prolific nature of the seed production and soil banking makes it a plant that can spread and remain within the ecosystem for years. Research by Billings (1994) found that there is a large viable seed bank for cheatgrass (about 106 seeds per square foot) in the top six inches of soil.

Young and colleagues found that, once cheatgrass has established on a site and gone through a couple of cycles of seed production and dispersal, the seed-

Figure 5.34. Cheatgrass, a cool-season grass, in the spring of the year (1978; Burnt Mesa)

bank can contain two or three times as many viable cheatgrass seeds as there are established plants in the community (Young and Clements 2000,Young 2000).

Researchers have also found that cheatgrass establishes from soil-stored and transported seed after fire. It can thrive and maintain dominance for decades even after plantings of competitive plants. In the case of the La Mesa Fire, cheatgrass had the highest percent cover in areas of high-burn severity.

Cheatgrass is a species of disturbed sites. It invades recently burned sites where it does not usually dominate or did not previously occur if there is an available seed source. Researchers have also found that invasive grasses benefit from recurrent fire. Soil crusts are killed and the bare soil provides a good seedbed for germination.

Cheatgrass can survive and expand during drought. The combination of drought and repeated fires in this area (prescribed fire 1999 and Las Conchas 2011) probably has enhanced the cover of this species.

Whether or not cheatgrass poses a problem in this area should be investigated. Time and temperatures of prescribed fires may be important in preventing further spread of this exotic species.

Smooth Brome (*Bromus inermis*)

Historic Information

Smooth brome is an exotic cool-season grass native to Eurasia (Figure 5.35). In North America it occurs from Alaska and all the Canadian provinces and territories south to southern California and New Mexico, northern Oklahoma, and North Carolina.

It reproduces by seed, rhizomes, and tillers and spreads by seed. Most smooth brome cultivars are rhizomatous and survive fire by sprouting from rhizomes.

Periodic early spring or fall fire promotes smooth brome by removing litter from sod-bound plants. Smooth brome has been extensively planted to increase forage and reduce erosion in burned areas. This practice has been questioned because native species appear to be at least equally effective in reducing erosion, and exotic grasses such as smooth brome may interfere with the growth of native forbs and grasses.

Figure 5.35. Smooth brome grows in patches because of reproducing by underground rhizomes.

Smooth brome was part of the seed mix for the Dome Fire (1996). Oertel et al. (2012) reported that post-fire succession has been markedly altered due to expansion of smooth brome. Twelve years after the Dome Fire, much of the pre-fire ponderosa pine forest has become a mixture of shrubland and grassland dominated by smooth brome. Oertel concludes that use of seed mixes after fire or logging may contribute to significant alteration of the post-disturbance succession and ecosystem recovery.

Recent and Compiled Information Related to the Presence of Smooth Brome

Smooth brome was present in the Burnt Mesa and Escobas Mesa plots in 2010. Although there was a low percent cover, the mere presence indicates that this species has spread from the initial seeding of the Dome Fire.

Smooth brome has been observed in various other areas such as the Cerro Grande Fire burn and has been increasing throughout the area. Because it can spread by rhizomes, large patches are generally formed at the exclusion of other species.

Time and heat of a prescribed fire may be important in the additional spread of smooth brome. Late-spring burning has sometimes been only marginally effective in controlling smooth brome (Old 1969). Kirsch (1974) reported that smooth brome was actually stimulated by an early May prescribed fire.

Barnes (1984) showed that native grasses generally have a more compatible niche with ponderosa pine seedlings than the cool-season grasses. The effect of smooth brome on pine regeneration should be studied.

5.16 Fire Effects on Forbs

Question 14: What are the fire effects on forb species?

Historic Information

There are a number of factors that affect the recovery of forb species after fire, including the time of year of the fire (dry or wet season) and site characteristics such as fuel loadings. These factors will influence the burn severity and temperatures, which in turn, influence plant survival. Plant morphology, especially the location of meristematic tissues, will affect the survival. Soilbanks full of seeds or plants with growth tissue protected by soil can influence survival or mortality. Many have the ability to regenerate from below-ground buds, rhizomes, or taproots. Only general information will be discussed here. For information about specific plants, go to *Fire Effects on Plants of the Jemez Mountains and the Pajarito Plateau* (Foxx n.d.[b]).

Throughout the 37 years, there were over 100 forb species found within the plots in various surveys. In all but the lightly burned plots, the number of species increased with time.

The observation was that immediately after the fire the relative cover of forbs was generally greater than grasses. This pattern also existed after the prescribed burn. There were no remarkable changes in the forb cover through time for most plots and most species. The meadow plot on Burnt Mesa was dominated by forbs throughout all the years; whereas, the lightly burned forest stand plot on Escobas Mesa was not.

To determine the forbs most commonly found on the plots, we used an importance index which is an average of the relative percent cover and the relative frequency and the number of plots and years the plant occurred in. Golden aster, Carruth sagewort, wild onion, wild chrysanthemum had the highest indices.

We did a similar sorting of the plots on TA-49. We separated these two sites out because of the increased disturbance on the TA-49 plots and lack of seeding increased the weedy species.

With analysis of the percent cover and presence data, it should be noted that there were five species that were found in a number of plots over a number of years: *Allium cernuum* (ALCE), *Hetertheca villosa* (CHFO), *Artemisia carruthii* (ARCA), *Bahia dissecta* (BADI), and *Lotus wrightii* (LOWR). Other species with a high incidence are found in Figure 5.36.

5.17 Forb Species That Have Recently Appeared or Increased

Question 15: Are there forb species that have been introduced, increased, or decreased with the fire over the past 37 years?

False Tarragon (*Artemisia dracunculus*)

Historic Information

Although false tarragon was recorded in many plots, the impression is that over the years, especially after the 1998 prescribed burn, this species increased in the landscape. On Burnt Mesa, particularly in the severely burned plot, the slopes were covered with false tarragon. In the Frijoles Rim 1960 plot, tarragon constituted 0.14 percent actual cover and 0.30 percent relative cover in an area. After the 1977 La Mesa Fire, studies conducted to determine long-term vegetative impacts found no tarragon one, eight, or 16 years after the fire (Foxx 1996).

Tarragon is found in dry, open places. Common in areas of disturbance, tarragon increases in frequency where disturbance results in decreased competition.

There is not much information in the literature about this species as related to fire. It is believed that the immediate effect is that it is likely top-killed and can sprout from rhizomes.

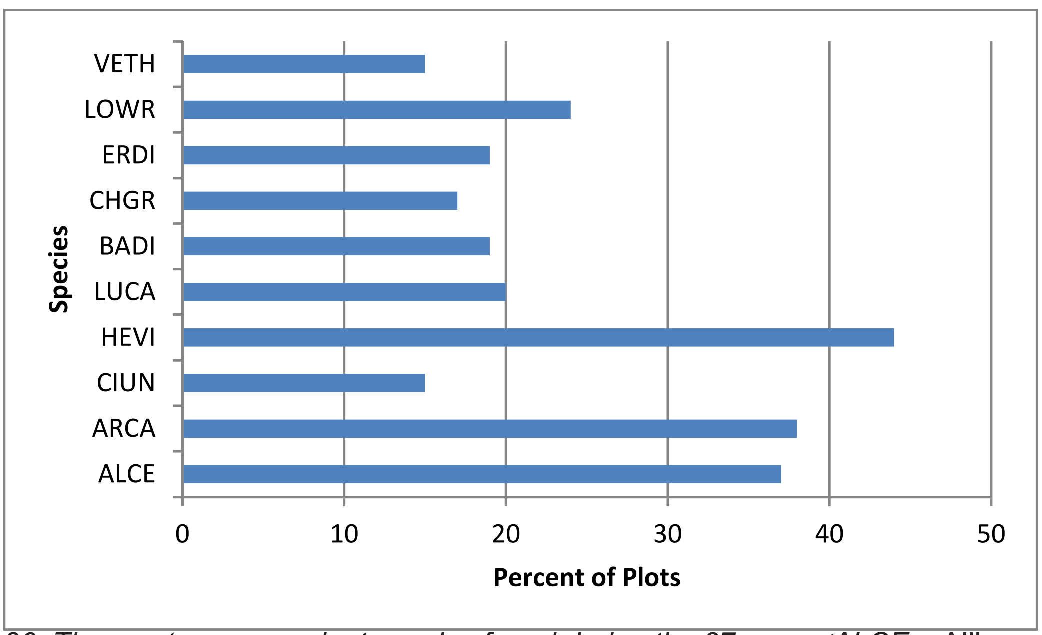


Figure 5.36. The most common plant species found during the 37 years (ALCE = Allium cernuum*, ARCA =* Artemisia carruthii*, CIUN =* Cirsium undulatum*, HEVI =* Heterotheca villosa*, LUCA =* Lupinus caudatus*, BADI =* Bahia dissecta*, CHGR =* Chenopodium graveolens*, ERDI =* Erigeron divergens*, LOWR =* Lotus wrightii*, VETH =* Verbascum thapsus*)*

Tarragon has been observed before and after two prescribed burns and one natural fire. Four years after a prescribed summer burn in western North Dakota, the frequency of tarragon was nearly three times that found in an adjacent unburned area. It was speculated that the increase was due to a reduction in interference of other species following the fire and the species' ability to inhabit disturbed sandy soils and roadsides. Tarragon provides forage for elk and mule deer.

Recent and Compiled Information Related to the Success of Seeding
We first visually saw a difference in the amount of false tarragon after the 1998 prescribed fire on Burnt and Escobas mesas. Also, comparative pictures in Burnt Mesa 3 and Escobas Mesa 3 emphasized the shift of forbs to false tarragon (see Plate 4.5, Section 4 and Plate 5.8, Section 5).

The visual impression was confirmed through data gathering. Figure 5.37 shows the increase in false tarragon through the years on Burnt Mesa.

The shift in the composition to more drought-tolerant species such as false tarragon is probably due to the periods of low moisture we have experience since the 1998 prescribed fire.

Dayflower (*Commelina dianthifolia*)
This plant was of particular interest due to the patches observed within the burned area (Figure 5.38). Dayflower had been collected in the area by Ora M. Clark in 1932; however, it had not been observed by this investigator within BNM until patches were observed in 1976 after the severe burn on Burnt Mesa in 1975. This plant was seen in patches throughout the area after the La Mesa Fire and found in trace amounts in line strip plots in 1985. Because of the irregularity and randomness, although observed, it was not recorded in the plots. The plant has a corm or tuber, thus it falls in a fire-resistant category (McLean 1969 and Lyons and Stickney 1976).

Las Conchas Fire
The dayflower was only recorded the first year after the La Mesa Fire and not after the prescribed fire on Burnt Mesa. This species was again seen within weeks of the Las Conchas Fire on Burnt Mesa, particularly in Burnt Mesa 3, which is devoid of overstory vegetation.

5.18 Gigantism

Question 16: Does fire increase the vigor of plant species?

Historic Information
After the La Mesa Fire, we observed a remarkable increase in size of a number of species (Foxx and Potter 1978), including *Chenopodium graveolens*, *Physalis neomexicana*, *Andropogon gerardii*, and *Taraxacum officinale*. Plate 5.14 shows an example of gigantism (a term we coined for plants with excessive growth) in the common dandelion, woolly Indian wheat, and big goldenpea. The normal size of wooly Indian wheat is between the thumb and finger.

Studies done by other researchers (Ahlgren and Ahlgren 1960, Viro 1974) indicate the nutrient flux after fire may stimulate growth. That, along with decreased competition for available nutrients, provided an ideal growing environment. In general, the following factors can influence plant growth: soil temperature, nutrient availability, nitrogen, and air and water movement through the soil.

In the Rocky Mountains, soil temperatures in a severely burned forest can be 65 degrees Fahrenheit at midday (Hungerford and Babbitt 1987). These increased temperatures increase the activity of soil microbes and enhance decomposition and nutrient release.

Recent Observations and Data
After the 1998 prescribed fire and the 2000 Cerro Grande Fire, the increased size was not observed. This may be accounted for by the weather patterns. Ahlgren and Ahlgren (1960) found that the nutrient release usually lasted about two to three years. After the La Mesa Fire the first three years were wetter than those after the prescribed fire or Cerro Grande Fire (Table 5.8). The moisture within the first few months after the fire may also be important.

After the Las Conchas Fire, there were a number of incidences of increased sizes of leaves (see Plate 5.14). The rain patterns were more like the La Mesa Fire.

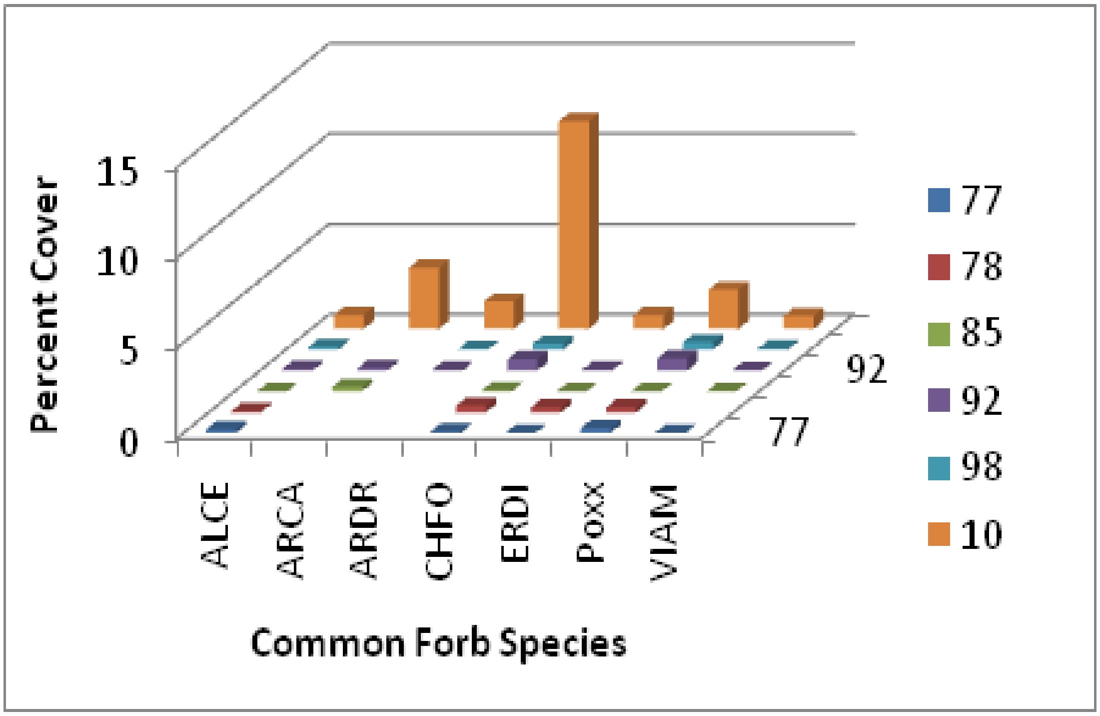
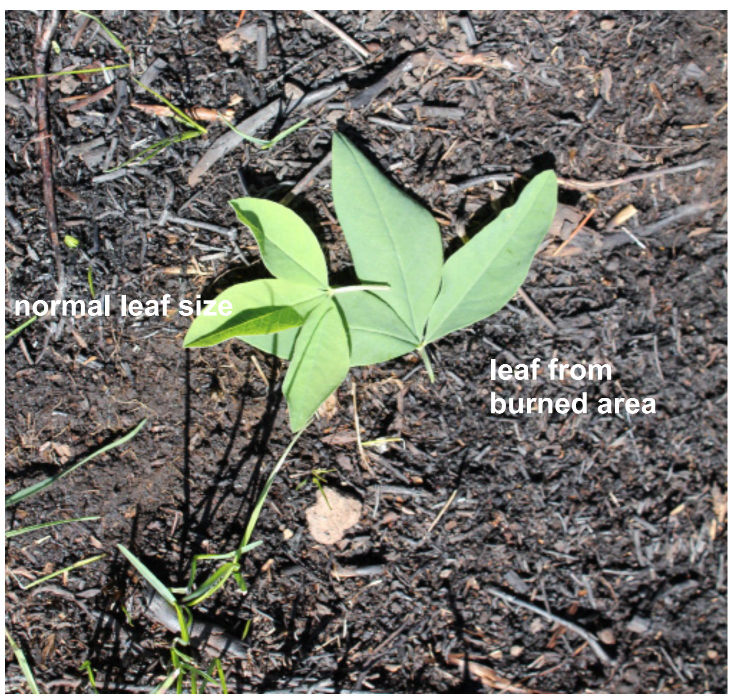


Figure 5.37. The increase in false tarragon and other weedy species in Burnt Mesa 3 (ALCE = Allium cernuum*, ARCA* = Artemisia carruthii*, ARDR* = Artemisia dracunculus*, CHFO* = Crysopsis foliosa*, ERDI* = Erigeron divergens*, Poxx* = Potentilla *spp., VIAM* = Vicia americana*)*

*Figure 5.38. Dayflower (*Commelina dianthifolia*), close-up of flower (top) and whole plant (bottom)*

Exceptionally large dandelion after the La Mesa Fire

Wooly Indian wheat. Plant on the left is after fire; plant on the right is normal size.



Comparison of leaf size of the big goldenpea after the Las Conchas Fire

Plate 5.14. *Gigantism in plants after fire*

Table 5.8. Annual Average Water Precipitation (inches) for Three Years after the La Mesa Fire, Prescribed Fire, and Cerro Grande Fire

La Mesa Fire	Prescribed Fire	Cerro Grande Fire
1977–1979	1998–2000	2000–2002
15.8	13.32	9.82

5.19 Slime Molds and Fungi

Question 17: What is the relationship of fire, slime molds, and fungi?

Historical Information
Slime molds are soil-dwelling amoeba, a single-celled organism, often containing multiple nuclei. They are found on forest floors where they break down rotting vegetation, feeding on bacteria, yeast, and fungus. Generally, the slime mold thrives as a single-celled organism, but when food is scarce, it combines forces with its brethren and grows. Starving amoebas work in tandem, signaling to each other to join and form a multicellular mass. Once the mass is formed, the cells reconfigure, changing their shape and function to form stalks, which produce bulbs called fruiting bodies. The fruiting bodies contain millions of spores, which get picked up and transported by the wind, a passing insect, or an animal. The spores start the process again as single-celled organisms.

Recent Compiled Data
Slime Molds: Slime molds have been reported after fire but there is little information. We did observe these organisms in areas burned by the La Mesa Fire and Cerro Grande Fire (Figure 5.39). Local expert, Relf Price, identified this slime mold as *Fuligo septica*, found on dead trees burned by fire (personal communication).

The relationship between these organisms and fire is only just being studied.

Fungi: Interesting fungi have been found within the area. Studies were done in 1991–1993 on macromycete diversity after the La Mesa Fire (Jarmie and Rogers 1996). However, hikers have provided pictures of several representatives since the Las Conchas Fire and are included here for documentation and to encourage further research.

Figure 5.40 is an ascomycete (sac or cup fungus) *Rhizina undulata* (sometimes called fire fungus) collected by Amy Ross and identified by Relf Price. According to the literature, it is a widespread fungus that colonizes burned forest areas and causes root rot in various conifers. The dormant ascospores are in the soil and are activated by heat of the fire (Lygris et al. 2005).

*Figure 5.39. Slime mold (*Fuligo septica*) found on burned trees*

Figure 5.40. Fire fungus (Rhizina undulata) found in the mixed conifer along the Apache Springs trail (photo by Amy Ross)

Other fungi commonly found in the burned area are 'earthstars' (Figure 5.41). They belong to a group of fungi called Gasteromycetes or 'stomach fungi.' They are related to puffballs. Their fruiting bodies are a stomach-shaped sac filled with dry spores. Closed earthstars are onion shaped. There are three layers. When it rains the outer two layers split and uncurl, forming a 'star.' As the fungus dries, the outside 'star arms' fold in again. The inside, stomach-shaped sac can open to release spores (herbarium.usu.edu; accessed 2012).

5.20 Soil Crusts

Question 18:What is the relationship of fire and soil crusts?

Historic Information
In the early data collections we did not compile information other than vegetative cover. In 1993, we took the data in four different elements—bare soil, litter, vegetation, and soil crusts. Since we did not record soil crust cover from 1976 to 1985, we have no succession information. However, the areas that were most severely burned and devoid of trees had the highest cover of soil crusts in 1993 (2.3% to 3.5%), while those areas that had lots of needle litter in 1993 had lower cover of soil crust (0.14% to 1.6%).

Cryptogamic crusts are generally found in the top one to four millimeters of soil (Figure 5.42). They are a soil community that consist of moss, lichens, fungi, green algae, and cyanobacteria (Marble and Harper 1989). The exact composition of the crust community varies with temperature, rainfall, soil chemistry, and vascular plant community structure (Rosentreter and Belnap 2001). Cryptogamic crusts confer numerous benefits to ecosystems:


Figure 5.41. Earthstars found on Burnt Mesa


Figure 5.42. Moss and soil crusts in the mixed conifer. Note the elk pellets.

- soil stability and erosion
- atmospheric N-fixation
- nutrient contributions to plants
- soil/plant/water relations
- infiltration
- seedling germination
- plant growth

A cursory search of the literature did not yield much information about the importance of soil crusts after fire. Loftin and White (1996) looked at the potential nitrogen contribution of soil cryptogams as related to post-disturbance. They found the contribution of cryptogamic crusts depended on the abundance and activity of the crust organisms.

Observations made during this study indicate soil crusts are important, particularly in the severely burned areas, however, the relationship is not known. Studies by other researchers show some species found in the area such as sixweeks fescue (*Festuca octoflora*), desert blazing star (*Mentzelia multiflora*), mountain peppergrass (*Lepidium montanum*), and scarlet globemallow (*Sphaeralcea coccinea*) benefit from crust presence (Belnap 1994, Belnap and Harper 1995, Lesica and Shelly 1992, Harper and Marble 1988).

Mixed Conifer

The plots studied were within the warm-dry forest type of the mixed conifer forest with ponderosa pine, Douglas fir, white fir, and aspen. Potter and Foxx (1979b) did evaluate a higher-elevation plot that had not burned on the Cerro Grande idenified as a cool-wet mixed conifer forest that is more shade tolerant and less fire tolerant (Figure 5.43). Historically, the warm-dry type experienced low- to moderate-intensity fires frequently (Evans et al. 2011).

There have been dramatic changes in the composition of these mixed conifer forests since 1900. These forests are denser than before 1900 when settlement, grazing, logging, and fire suppression changed the fire intervals in the Jemez Mountains. Over the years there has been an increase in shade-tolerant species such as white fir and a decrease in aspen, ponderosa pine, Southwestern white pine, and Douglas fir that are less shade tolerant (Johnson 1994, Covington et al. 1998). There have been changes in species dominance and tree density. Fire suppression has increased the impact of stresses such as drought (Savage 1997). When fires do spread through a mixed conifer forest, the thin-barked, shade-tolerant species are more easily killed by fire. Allen (1989) found open montane grasslands in the Jemez Mountains decreased by 55 percent between 1935 and 1981 because of lack of fire. Johnson (1994) found aspen stands in the Southwest have decreased significantly—46 percent between 1962 and 1986. In growth of shade-tolerant species has also increased the density of many mixed conifer stands (Dahms and Geils 1997).

Touchan et al. (1996) found the historic fire frequencies in the mixed conifer in the Jemez. The fire frequency at elevations between 8000 and 9000 feet was 4.5 to 9.5 years. Above 9000 feet the fire frequency was 12.0 to 25 years. These frequent fires were interrupted between 1870 and 1900, the structure and composition of mixed conifer forests began to change (Swetnam and Baisan 2003). Fire histories show lack of frequent fires in the higher elevations after the late 1800s.

One concern is fire in the lower-elevation, ponderosa pine forests that can spread upslope and impact the mixed conifer forests. That was the situation in the La Mesa Fire. The other large fires (Dome, Oso Complex, Cerro Grande, and Las Conchas) were started at higher elevations and moved down slope into pure ponderosa pine stands.

5.21 Density of Mixed Conifer

Question 19: What was the density of the mixed conifer forests burned by the La Mesa Fire? How does that compare to what is considered a pre-1900 density before fire suppression, grazing, and logging?

Historic Information

Various authors have discussed the pre-1900 density of western mixed conifer forests. They generally believe that most of the mixed conifer burned under low/moderate intensity with patches of high intensity. Subsequent bark beetle (*Dendroctonous* spp.) attack on damaged trees led to further openings. Pre-settlement mixed conifer were relatively open with large trees distributed in clusters and there were lower stem densities than today. However, human activities, including grazing of sheep and cattle, fire suppression, and logging, have changed the composition to high stand densities. The result is that the lower light levels have caused a shift in species composition to shade-tolerant species such as white fir (*Abies concolo*r) (Schmidt et al. 2006). Researchers (Fulé et al. 2009), studied a warm-dry mixed conifer forest in southwestern Colorado. The study shows tree density increased from 142 trees per hectare in 1870 to 677 trees per hectare (271 tree per acre) in 2003 (Table 5.9). Forest inventories in the Kaibab forest north of Grand Canyon National Park showed the basal area doubled from 1909 to 1955 and was also double of that of 1909 in 1990 but had decreased by 28 percent for trees greater than 30 centimeters in diameter. Tree density for shade-tolerant species show greater than 600 percent increase between 1909 and 1990; whereas, ponderosa pine showed little increase (Sesnie et al. 2009).

The pre-settlement density of the mixed conifer within the area is not known. However, there was considerable grazing within the area until the 1950s. The pre-La Mesa Fire density of the mixed conifer was established after the fire in the 20- by 50-meter plots that were at an elevation between approxi-

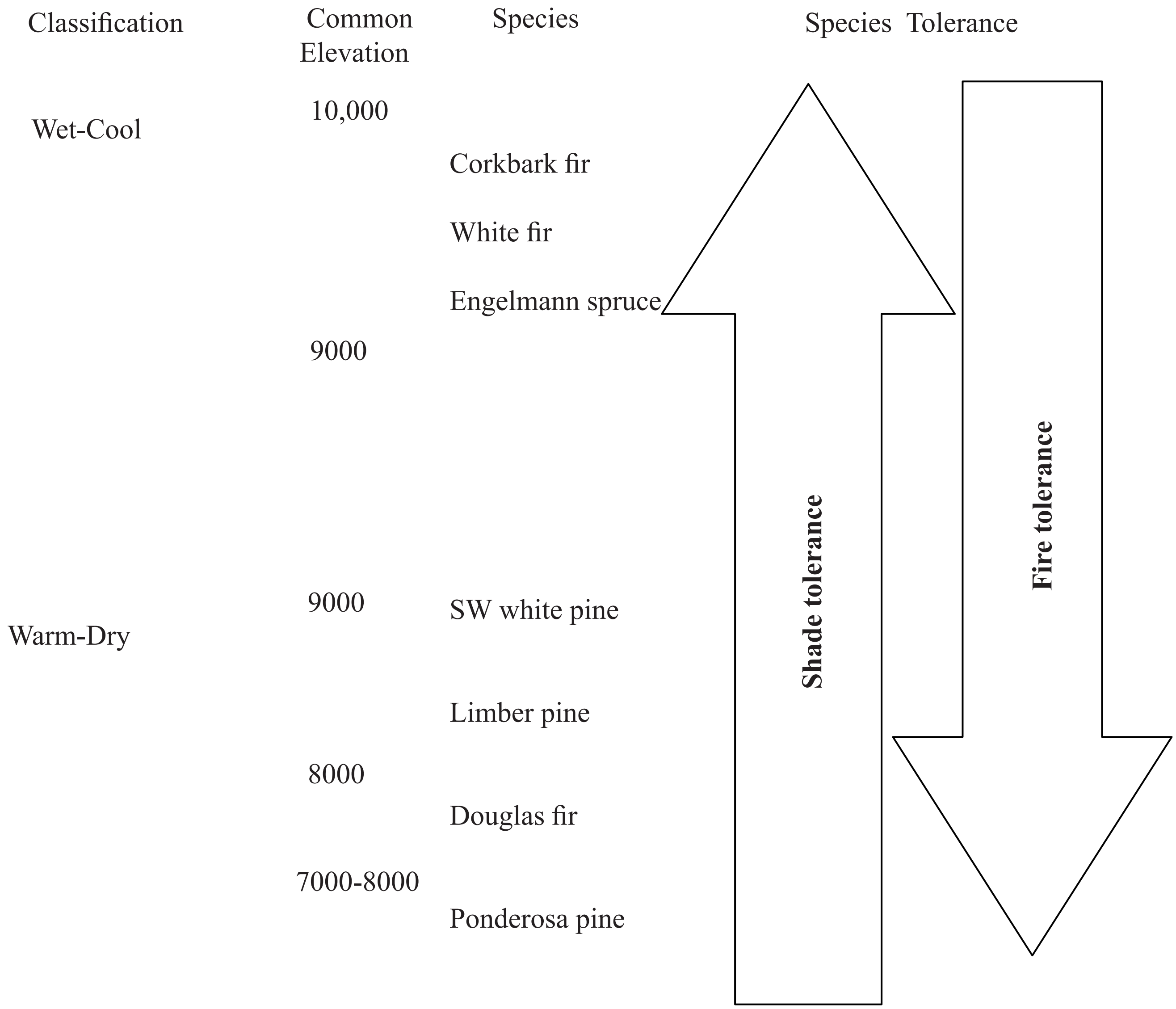


Figure 5.43. The comparison of species shade and fire tolerance as related to classification for the mixed conifer forests of the area (after Burns and Honkala 1990)

Table 5.9 Literature Values for Pre-Settlement Densities

Researcher	Date	Location	Pre-Settlement (acre)	Basal area	
Sq ft/acre	Recent (trees/ acre)				
Fulé 2009		Southwestern Colorado	56		271
Fulé et al. 2003	1880s	Grand Canyon	98	77	
Fule et. al. 2002	1880s	Grand Canyon		124	

mately 8300 to 8500 feet. The density of the trees per acre varied from a high of over 1000 trees to the lowest of 729 trees per acre (Table 5.10). Of these trees the highest relative basal area was ponderosa pine (69%) and the lowest aspen (1%) (Table 5.11). Three of the plots burned in the high-severity class and one in the light. Surprisingly the lightly burned plot had one of the highest stems per acre. The burn intensity may have been due to fire behavior and topography.

In February of 1977, 3,076 acres were annexed to BNM. Potter and Foxx (1979b) did some surveys of the Cerro Grande Accession. One plot was placed at approximately 8900 feet and had a much lower density of trees. This plot had a very low relative basal area of ponderosa pine (4%) with the highest relative basal areas of aspen (58%) and *Abies concolor* of 28 percent. At this higher elevation there was some Engelmann spruce and limber or southwestern white pine tending toward a wet-cool mixed conifer (see Table 5.10).

Recent and Compiled Information Related to Mixed Conifer Density
The plots established after the fire in the mixed conifer were closed stands with over half of the density from trees less than four inches in diameter (52%). This indicates there had been no fire in the area for some time, perhaps since the late 1800s to early 1900s. The Accession plot had a higher percent of aspen and a lower basal area indicating sprouting, larger trees, and fire or disturbance in the past (see Table 5.11).

The more recent fires in the east Jemez have included extensive areas in the mixed conifer. Unfortunately, in the La Mesa Fire study we were unable to relocate the plots in 2010 and most of our effort was in the ponderosa pine over the years. In 2010, the density of trees, shrubs, and aspen was visually dense and in 2012, nine months after the Las Conchas Fire, there was healthy aspen sprouting (Plate 5.15).

5.22 Aspen and Elk Utilization

Question 20: What are some observations about aspen regeneration, fire, and elk?

Historic Information
Rocky Mountain elk *(Cervus elaphus nelsoni)* were found in the Jemez Mountains and by 1906 they were extirpated from the area. Elk were transplanted in 1948 and present herds are from that herd of 28 animals (Allen 1996).

Elk heavily used the La Mesa fire area, most particularly before the Dome Fire and the Cerro Grande Fire of 2000 (White 1981, Roland et al. 1993). Before 1977, the 1954 S-Site Fire provided a principle forage area. Figure 5.44 presents a graphic that shows the increasing elk population in BNM after the fire.

Aspen generally occurs in the mixed conifer areas of BNM. Vegetative regrowth by sprouting from underground roots was observed (see Plate 5.15). By October 1977, the sprouts were as much as two feet tall. Section 4, Plate 4.19 shows the succession of aspen for over 22 years. Browsing on aspen shoots was observed by this researcher; however, data were not collected. Bandelier staff and other researchers have studied the impact on aspen regeneration (Sandoval et al. 2005, Biggs et al. 2010). Three top forage species for elk and mule deer were oak, ponderosa pine, and mullein.

Table 5.10 Basal Area (sq ft/acre) in Mixed Conifer Plots

Plots	PIPO*	PSME	ABCO	POTR	PIEN	PIFL	Total	Trees/ Acre
1	64.50	27.20	7.70	20.00			119.40	481.78
2	87.70	23.30	1.70				112.70	456.29
3	93.30	30.60	7.40	8.50			139.80	562.75
4	96.30	32.20	22.50	0.60			151.60	613.77
5	164.80	17.70	15.40	12.60			210.50	852.23
Accession Plot (1978)	5.20	9.30	32.80	68.20	1.40	0.60	117.00	473.68

*PIPO = *Pinus ponderosa*, PSME = *Psuedotsuga menziesii*, ABCO = *Abies concolor*, POTR = *Populus tremuloides*

Table 5.11 Percent Basal Area (sq ft/acre) of Species in the Mixed Conifer Plots

Plots	PIPO	PSME	ABCO	POTR	PIEN	PIFL	Burn Severity
1	54	23	6	17			Severe
2	78	21	2	0			Moderate
3	67	22	5	6			Light
4	64	18	7	1			Severe
5	78	8	8	6			Severe
Accession Plot (1978)	4	8	28	58	1	1	Unburned

*PIPO = *Pinus ponderosa*, PSME = *Psuedotsuga menziesii*, ABCO = *Abies concolor*, POTR = *Populus tremuloides,* PIEN = *Picea engelmanii,* PIFL = *Pinus flexilis*



Plate 5.15. *Succession of aspen and the damage by elk in the area of Apache Springs. Note the height of elk damage in the top, left photo (the individual is over six feet tall).*

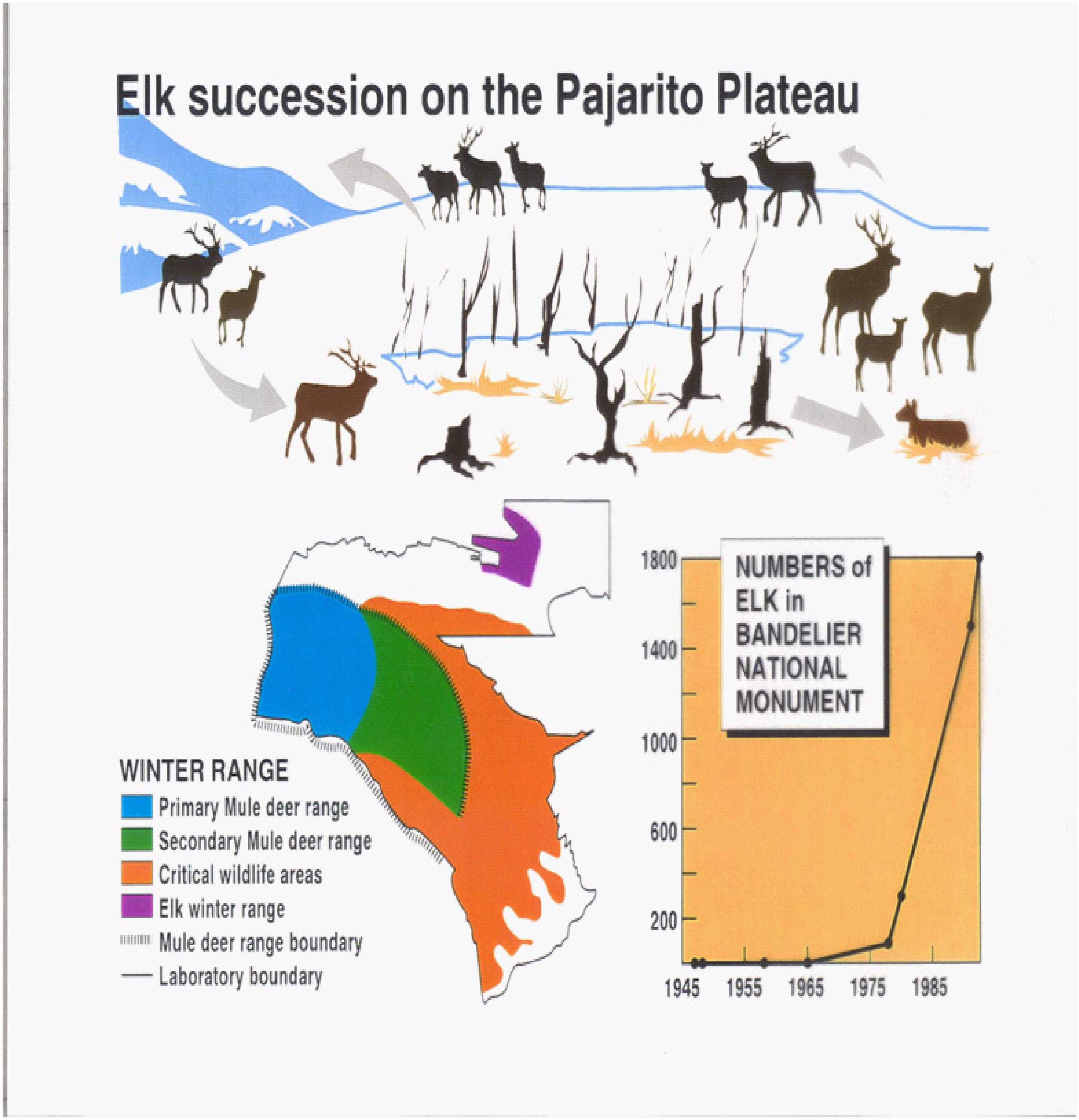


Figure 5.44. Elk succession on the Pajarito Plateau (White 1981)

After the Cerro Grande Fire, Biggs et al. (2010) evaluated the effects of elk abundance and foraging intensity on regenerating aspen communities. They observed only a few impacts of browsing on aspen patch size or height but there was evidence that size and height decreased when twig browsing levels exceeded 35 percent.

Recent Observations and Data
Sprouting of the aspen in the Apache Springs area after the Las Conchas Fire is extensive. Elk exclosures (Figure 5.45) placed by the Park Service will provide information as to the impact of elk in the area.

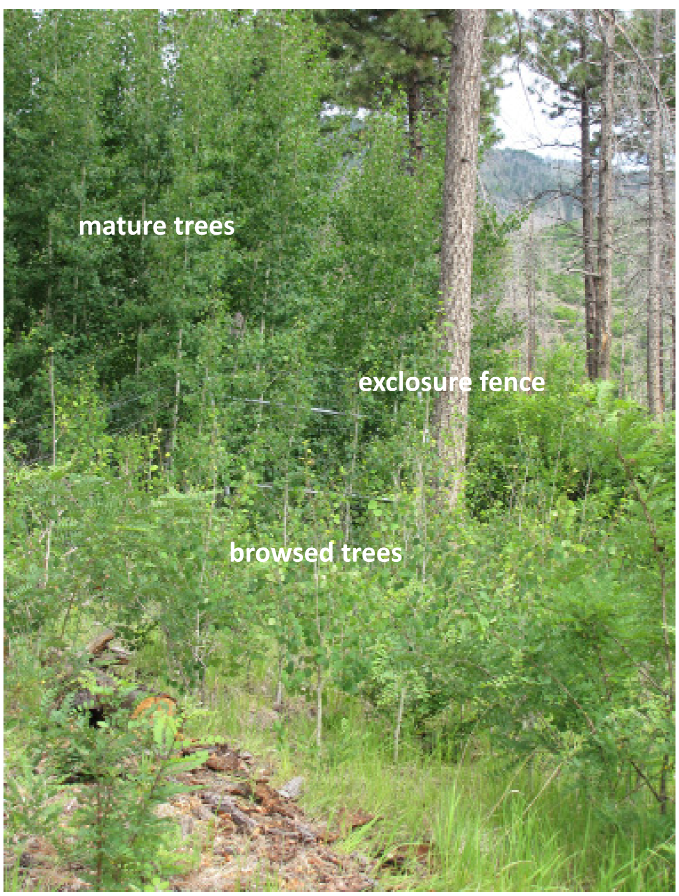


Figure 5.45. Elk exclosure on American Springs road. Note size of trees in and outside the exclosure.

Piñon-Juniper Woodlands

5.23 Fire History and Drought

Question 21: Was there any evidence of fire and drought history in the piñon-juniper in the past 37 years?

History of sheep, cattle, and burro grazing on the Pajarito Plateau has altered herbaceous vegetation. Because of the nature of the species there is little documentation as to the fire history in these woodland communities. However, the influence of drought on woodlands has been well documented. Allen and Breshears (1998) found a drought-induced shift in the forest-woodland ecotone. There is considerable visual evidence of the widespread loss of piňons on the plateau during the drought period in the early 2000s (Plate 5.16).

Fire histories in the piñon-juniper woodlands are probably longer than in other forested types on the plateau. Bauer and Weisberg (2009) found a fire cycle in the Nevada piñon-juniper woodlands of 427 years. Studies done in northern New Mexico by Huffman et al. (2008) may be more applicable.

Using charred tree distributions and tree-ring analysis, they studied fire history in the woodlands in Arizona and New Mexico. In the Canjilon area of New Mexico, they found the piñon patches to be two to three hundred years old. They made the following conclusions: 1) The standing-age distributions suggested a fire rotation of 290 years. 2) Fires in the ponderosa pine historically did not move into the woodlands. 3) There was no evidence of lethal fires in 300 to 400 years because of the age of the piňons. 4) Fires were patchy in nature and not widespread.

Recent fires, including the La Mesa Fire and Las Conchas Fire, moved from the ponderosa pine zone into the lower-elevation woodlands. These have been hot, fast-moving fires that have caused mortality in the species within the woodlands of BNM.

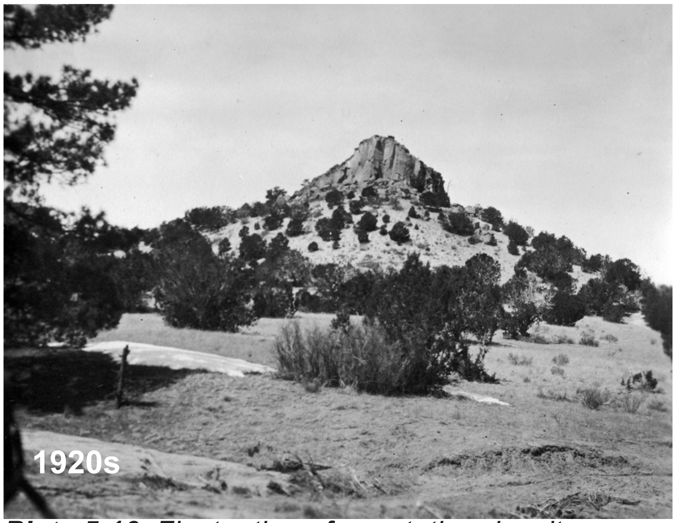
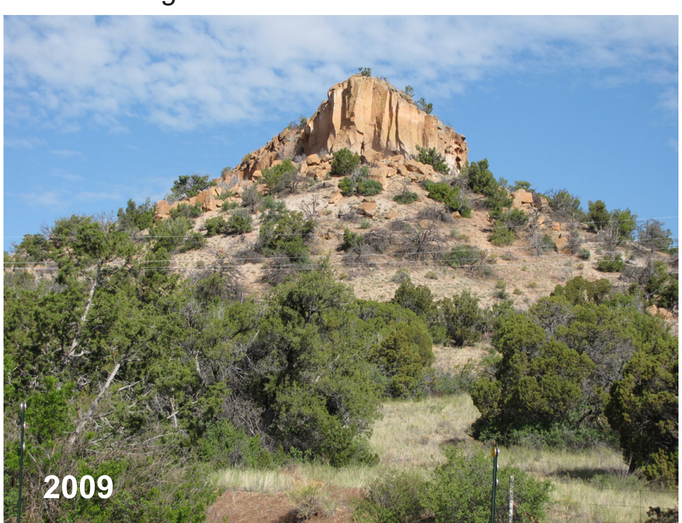


Plate 5.16. *Fluctuation of vegetation density over time. (Top) Mesa along State Route 4 in the 1920s (Pond photograph, Courtsey Los Alamos Historical Museum)*

Mesa along State Route 4 in 1999. Note the increase in vegetation.



Mesa along State Route 4 in 2009 after drought. Note the loss of piñons. Ponderosa pine to left is dead.

5.24 Species Density and Composition after Fire in the Piñon-Juniper Woodland

Question 22: Was there any change in species density and composition through time after the La Mesa Fire?

Most of the effort over the past 37 years was done in the ponderosa pine. Like the mixed conifer plots, not all plots were relocated and the plots were not visited as frequently. However, the cover of grasses, forbs, and shrubs was compared for the three life forms between 1977 and 2010.

As can be seen from Table 5.12, the percent increase over time was greatest in the severely burned plot and the least in the lightly burned plot. Grasses increased in cover much more than did forbs. The severely burned plot had the lowest cover in 1977 and thus increased throughout the 35 years since the fire. The lightly burned plot had established vegetation that had not burned. Shrubs were not noted in 1977 data sets, a few appeared by 1999 but there was substantial cover of shrubs by 2010.

5.25 Plants That Increased Over Time in the Piñon-Juniper Woodland

Question 23: Were there any specific species in the woodland plots that increased substantially over time?

Figures 5.46 and 5.47 show grass and forb species that increased to over one percent from 1977 to 2010. Blue grama was the most common species that increased in all plots. Greenthread and snakeweed increased as did Carruth sagewort. These forb species are common in the piñon-juniper woodland of the plateau.

Ten species were found in the plots in 1977 but not in 2010 (Table 5.13). This could be because they are early successional species such as lambsquarters and groundcherry or the survey time. It may be noted that most of these species were very low in percent cover in 1977.

Table 5.12 Total Cover of Grasses, Forbs, and Shrubs in 1977 and Percent Increase 33 Years Later (2010) as Related to Fire Intensity

Plot	Species	1977	2010	Percent Cover Increase	Burn Severity
1	Grass	8.6	24.48	185	Light
	Forbs	2.5	4.6	84	
	Shrub	0	32.36	infinite	
2	Grass	4.4	27.72	530	Moderate
	Forbs	3.24	15.44	377	
	Shrub	0	28.68	infinite	
3	Grass	1.04	16.66	1502	Severe
	Forbs	5.18	31.44	507	
	Shrub	0	19.9	infinite	

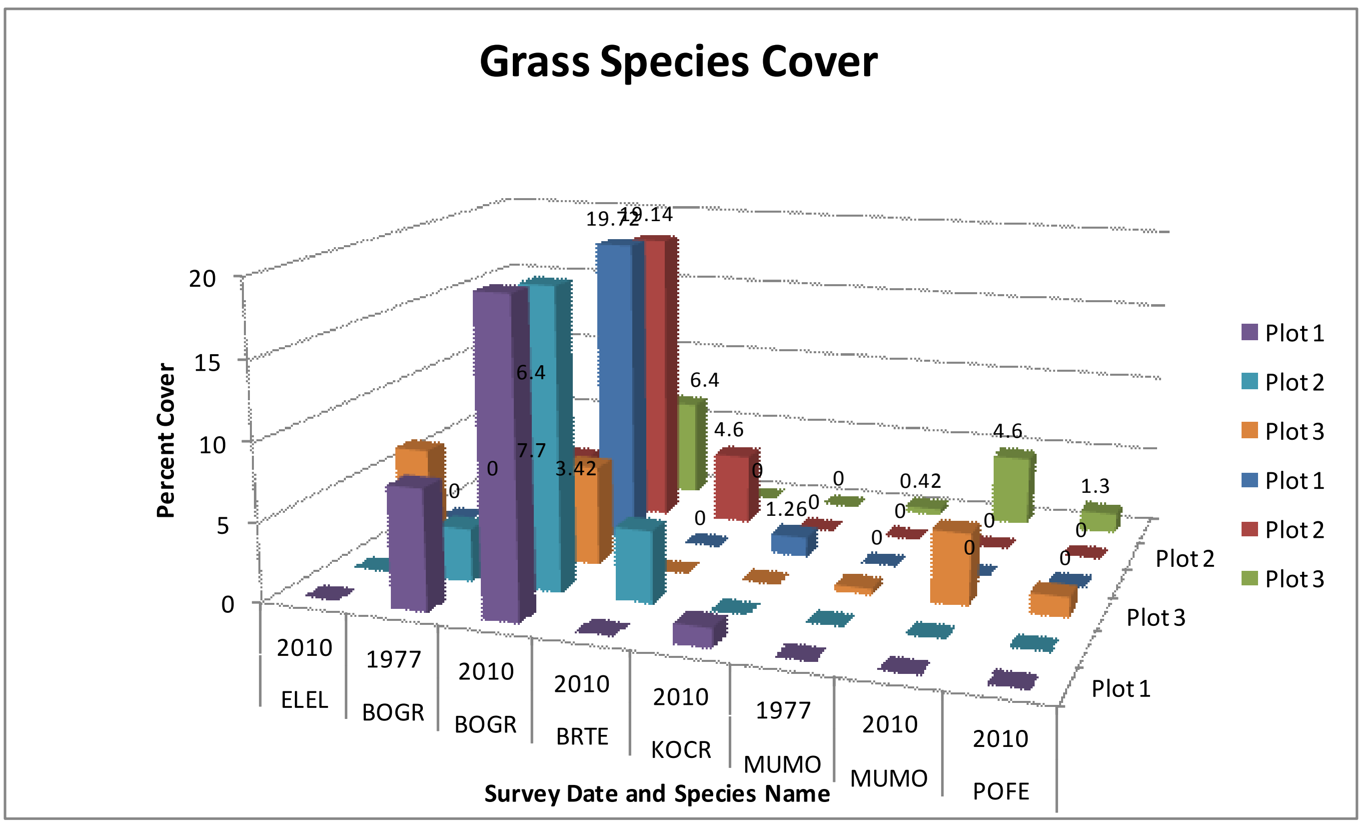


Figure 5.46. Comparison of percent cover of grasses identified in the plots in 1977 and 2010. Selected species had greater than one percent cover in 2010.

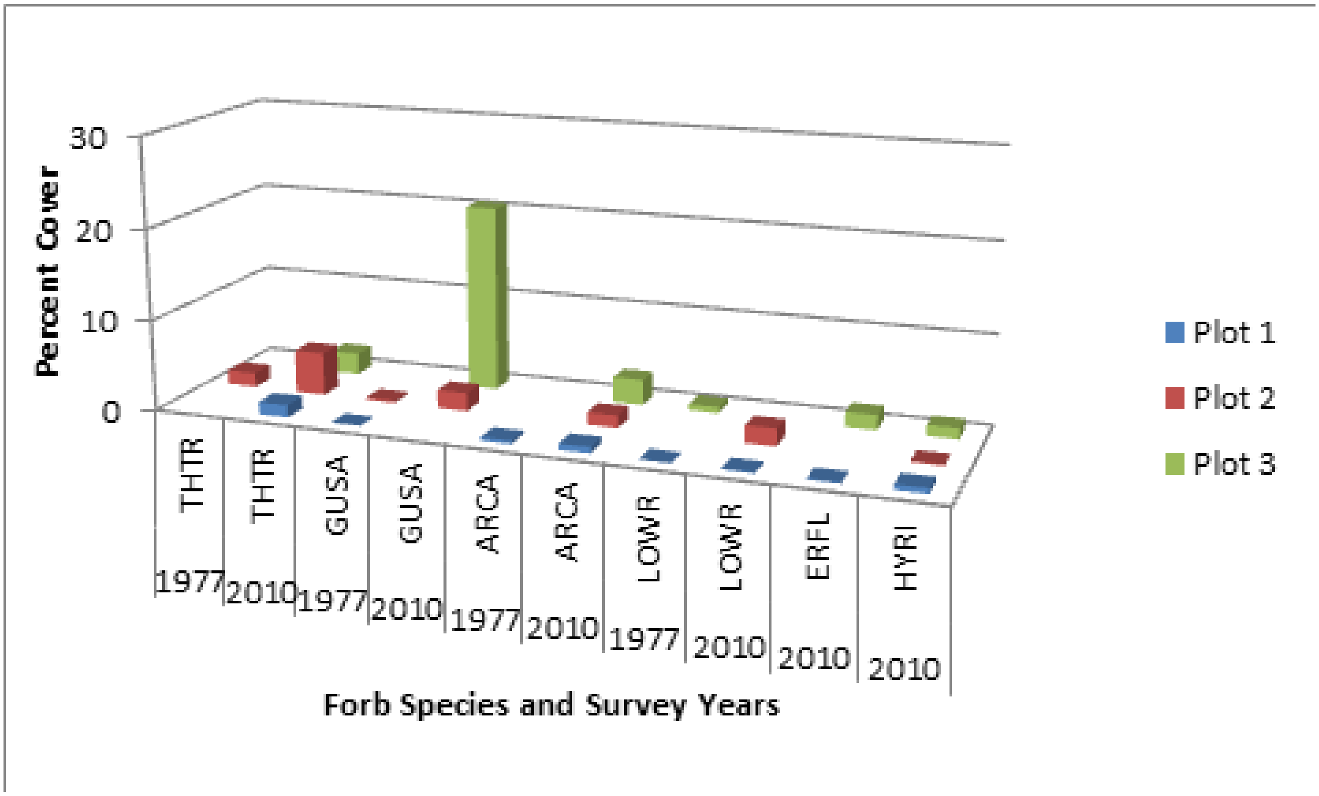


Figure 5.47. Comparison of the percent cover for forbs identified in the plots in 1977 and 2010. Selected species had greater than one percent cover in 2010.

(*THTR* = Thelespermum trifidum, *GUSA* = Guterrieza sarothrae, *ERFL* = Erigeron flagellaris, *HYRI* = Hymenoxys richardsonii, *ARCA* = Artemisia carruthii, *LOWR* = Lotus wrightii)

Table 5.13 Species That Were Present in the Plots in 1977 That Were Not Noted in 2010

Species	Plot 1	Plot 2	Plot 3
Chenopodium album			0.14
Hymenopappus filifolius	0.02		
Lupinus spp.			0.04
Mirabilis linearis	0.12		
Oenothera spp.	0.04		
Petalostemum spp.			0.84
Physalis foetens var. *neomexicana*	0.04		0.12
Senecio spp.		0.12	

Fire and the Ecosystem, an Observer's Conclusions

A study as this is never complete but ongoing. Change in the ecosystem is continual and so there is no real endpoint. Studies are a snap-shot in a point in time. The importance of a long-term study is that it allows for several snap-shots and reveals the nature of change. In 1977, we thought the study was nearly done but then the La Mesa Fire changed everything. Now those same plots have been burned by another fire, Las Conchas, and the process of succession continues.

From the point of view of science, what has been presented must stand on its own. Each new researcher will add to the information, for the study of fire in the ecosystem is complex and the opportunities to understand the problem are enormous. As information is compiled, more and more problems can be solved. Paul Anastas, former assistant administrator of the US Environmental Protection Agency said, "The reason to deeply understand a problem is to empower its solutions." (2011)

Solutions concerning the dynamics of fire in our forests are needed. In the preface, I indicated we hear the same words we spoke 35 years ago spoken today. The difference is the fires are larger and more menacing to human populations at the forest/urban interface.

When I began this journey 37 years ago, my perceptions of fire and forest were quite different than they are now. Smokey told me "all fire is bad" and "you must stop fire immediately." But now we know that fire is an integral part of the ecosystem and stopping it immediately has had a long-term impact on the ecosystems that are fire adapted. But I also am hearing from some that we must stop these fires immediately because of their size and dangerous nature. I hope we don't simply make the same mistake, and because of fear, try and stop all fire.

Today, I fully understand our forests will and must burn to be healthy. And in times of drought it is expected. The real question is how can we prevent mega-fires that are stand replacing and threaten communities and homes? How do we prevent mega-fires that are basically unstoppable? At this point, I don't think we can. Drought happens and overstocked forests are a reality. We have not been successful at managing the forests except in small patches of land. The costs are high and the job daunting because of the acreage. Prescribed fire is a good tool but incidents of escaped fire have made people fearful. Thinning is expensive and tedious. But we must not give up.

Education and community involvement are absolutely essential to help people understand the dynamics of fire to make their community or homes as fire-proof as possible. An interdisciplinary approach, bringing different perspectives to the table, is important. For example, we need to combine human ecology and understanding with what we know as scientists.

The understanding of peoples' perception about trees and their importance is required. Trees are the most common theme in myths and stories. They are bigger than us, live longer than us, and are anthropomorphized. Homes cannot be fire-proofed with trees standing thickly around and overhanging. People resist cutting trees because of their love for them and their anthropomorphic connection to them. Rather than not only using science to encourage people, we must look at perceptions and build those into our approach to education. Scientists must understand human perceptions to better educate.

I can see my evolution in understanding fire just by my titles to reports. One report in 1979 was entitled "Success of Seeding after a Holocaustic Fire." The definition of holocaustic is "great destruction resulting in the extensive loss of life, especially by fire." This definition did not and could not explain the La Mesa Fire. I have also ceased using the term "devastated" because if I have learned anything in this 37 years, it is to be amazed at how the ecosystem is fire adapted and what happens after fire events.

Here are some of my conclusions:

1) The inevitability of change and how quickly it takes place (see Photographic Records).

2) The intricate interaction of trees to their environment (see Sections 5.4 Growth Rates of Trees; 5.6 Tree Mortality; 5.8 Tree Mortality and Seedbed Competition; 5.9 Regeneration of Ponderosa Pine;

and 5.10 Relationship with Bearberry).

3) The fire adaption in these ecosystems and the necessity for fire intervals (see Section 5.5 Burn Severity and Fire History; Description of Recent Fires).

4) The reality of the interaction of fire and climate (see Section 5.3 Climate, Drought, and Plots)

5) How quickly plants begin to regenerate even in places we think impossible (See Sections 5.9 Sprouting Plants, 5.12 Native Grass Response to Fire, and 5.16 Fire Effects on Forbs).

6) How quickly trees begin to fall and decay. On the other hand, how long some snags and logs are sustained (see Section 5.7 Tree and Snag Fall, and Photographic Records).

7) The intricate interactions between soil and vegetation (see Sections 5.17 Gigantism and 5.10 Changes in Litter Cover).

8) Our decision making and lack of understanding of consequences (see Section 5.13 Invasive Grass Species).

9) How there is so much more to learn (see Section 5.20 Slime Molds, Fungi, Soil Crusts).

10) The differences in various tree species, habitats, and fire (ponderosa pine, mixed conifer, piñon-juniper).

The changes I have seen would not have been possible without these long-term observations. We cannot see the big picture without years of observation. Unfortunately, funding cycles, personnel changes, and changing priorities generally prevent such studies. This study has been done only because of an intense interest in seeing what happens, not because funding was available all along the way.

But most of all what this journey has taught me is to realize that we as scientists must be willing to be open to new ideas and base our ideas on the best science we can. Strive to solve problems. It has also taught me that when all is black—very soon new life emerges. Be prepared to be surprised and awed!

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APPENDIX I: Narratives About Fires

1954 Water Canyon Fire

The first of these catastrophic fires occurred in early June of 1954. It was started by an attempt to burn trash and construction debris in the upper Water Canyon area. Because of winds up to 72 kilometers per hour (45 miles per hour), the trash fire quickly spread to the adjacent forests. In the ensuing days, the fire swept to the north along a swath up to one mile in width. Firefighters from Los Alamos constructed fire-breaks with bulldozers, but they were unable to contain the blaze (*Santa Fe New Mexican* 1954).

"Smoke rose like a Plumed Serpent from Barrancas Mesa, marking for me the place where Los Alamos, NM, lay nestled in the Jemez Mountain range. The date was May 29, 1954. We were driving up La Bajada Hill between Albuquerque and Santa Fe. We stopped at 109 East Palace to get my gate pass into the Secret City. That evening, sitting on the front porch of the Sundt apartment my sister rented, I inhaled the fragrance of burning pine cones from her fireplace. The fire on Barrancas was almost out by now, but we could still see flames across the canyon.

My second Los Alamos fire was on Saturday in the early 1950s, after we had moved to 46th Street, and I got the car while Curt babysat our three sons. A girlfriend and I had decided to drive the 35miles to Santa Fe to shop. We spent the day walking through the old town, enjoying the beauty of the State Capitol. When we decided it was time to go home, we headed north and west, and started our upward climb home.

When we first noticed the smoke in the mountains we couldn't believe how heavy and dark it was. When we reached the Guard Gate, there was too much smoke to see the town beyond. I wondered if our house of 46th Street was still standing. Smoke blew across our path as we drove across the fill on Diamond Drive, then up Urban to our dead-end 46th Street. We were choked by the heavy fumes. Cinders were falling among the pine trees and on the flat roof of our house. Curt stood on the roof with the water hose, and put them out one by one.

We watched all night, out our west kitchen window, as the flames leaped through the forest. We did some tall praying, and we were safe.

Wanda B. Sewell, Los Alamos Resident 1945–1957

Fire Danger High Despite Weekend Showers (June 7, 1962). (LASL News 1962)

Forest Fire! The Atom July 1964. "There have been a number of damaging fires in nearly all forest lands.

Several potentially serious blazes in canyons and brush areas within the community have been knocked down by quick action of the fire department. These pictures were made June 20 as firemen battled flames and smoke that started in brush but spread to trees in the woods just west of Los Alamos Western Area.

Forest Fire Ranges Near Los Alamos (June 1964). The biggest blaze was on Baca Location No. 1, consuming more than 400 acres of timber. This fire was located on the south edge of Valle San Antonio, lapping over into the Valle San Louis according to the owner of the 100,000-acre ranch James P. "Pat" Dunigan.

Two other smaller fires broke out Monday and were brought under control relatively quickly. One was located in the western part of Bandelier National Monument. Another was about two miles west of the Los Alamos County line on the Baca Location at the head of Frijoles Canyon.

Dunigan said his ranch needed rainfall badly. “The dryness is just terrible,” he said.

March 1934

Shortly after 1:00 on March 9, a fire was spotted about two miles down the Canyon from the CCC camp. With about 40 men from the camp reaching the fire at 1:30, we got it under control about 2:30. During the clean-up work, CCC Leader, Santos Martinez, who had been placed in charge of the clean-up crew, was hit by a falling tree. (Report March 1934, Southwestern Monuments)

May 1937 Fire in Frijoles

About 3:00 PM Thursday, the 20th, a fire was reported in the head of Alamo Canyon but on further investigation it was found to be in Frijoles Canyon a mile below the west boundary. Jim Fulton left immediately with a crew of men to go in by the upper crossing; shortly after this crew had gone in, the Forest Service came in with a crew from Sawyer Mesa; shortly after this crew arrived, Jim Eden and Ed, construction foreman, arrived with their crews.

The fire started in the bottom of the canyon and crowned out on both sides. Due to the steepness of the canyon, suppression was quite difficult, by 8:00 PM the fire was under control, after burning an area of approximately 100 acres.

Suppression measures were ably carried out by Foreman Fulton. Forest Service cooperated 100%. (Reported in Bandelier Forest Fire Records, Southwest Monuments Monthly Reporter, May 1937)

1937

General forest fire situation. From June 23 to June 27 a total of 2.09 inches of rain fell. That amount and 0.95 inches, which fell between July 1 and 10, served to make fire danger at Bandelier very small. However, during the past two weeks, duff and litter have been dry enough that we have been alert for fires. (Southwestern Monuments Monthly Report, July, 1937)

August 1940

The fire lookout was begun this month. At the present time, the walls are completed for three courses on the second story. The second-story framing is also completed and ready for finish carpentry. The two fires we had this month were discovered by me from this lookout during construction work. (Southwest Monuments Monthly Report, August 1940)

Two fires occurred this month. Both were caused by lightning and were suppressed by J. E. Wright, per diem fire guard, with no assistance from CCC personnel with the exception of discovery by lookout construction crews.

Upper Crossing Fire 1960

This fire was presumably started by a fisherman on Saturday, May 21, 1960, at approximately 12 noon.

It was first discovered by the Forest Service lookout on St. Peter's Dome who reported it to Bandelier headquarters at 1:45 PM. The Bandelier lookout reported sighting the smoke at 1:50 PM, and the Los Alamos lookout sighted it immediately thereafter. Elapsed time between the start of the fire and detection is attributed to the prevailing southwest wind, which dispersed the smoke down canyon.

The three reported azimuth readings were plotted on the Bandelier fire map, and placed the fire ¾ miles down canyon from the Upper Crossing on Bandelier west boundary.

The Los Alamos fire department sent a two-man patrol unit and tanker truck to investigate the smoke at 1:55 PM. District Ranger, Widmer, and Park Archaeologist, Jahns, were dispatched from Bandelier at 2:10 PM. The Bandelier crew traveled via Jeep to the north rim of Frijoles Canyon above Upper Crossing, and then via trail down into the canyon at that point. They arrived at the fire in the bottom of the canyon at 2:40 PM; and were the first crew there.

Widner sized up the fire and reported it ¼ mile down canyon from Bandelier west boundary, burning 200 yards down canyon, about half way up the north cliff wall, a finger burning up the south slope. He also reported it crowning in the trees on the south slope and estimated the fire three acres in size. Widner requested 10 men to suppress the fire. Since no additional park personnel were immediately available, this request was made to the AEC for firemen.

The first reinforcements did not arrive at the fire until 4:20 PM. At 3:00 PM Widmer reported the fire burning within 100 feet of the top of the south slope, and he requested 10 additional men to bring the fire under control. This request was also made to the AEC, and they advised it would take one to one and a half hours to get this second crew on the fire. When Widmer was informed of this he requested an additional 10 men making at total of 20 requested for the 2nd reinforcements.

Since the AEC firemen would have to be relieved to return to their regular duty stations, it was decided that a 25-man SWFFF crew should be requested. This request was made to the Regional dispatcher, Ratcliff, in Santa Fe. At approximately 5:30 PM Ratcliff informed headquarters that the Jemez crew was available and would leave the pueblo at 7:00 PM.

The first reinforcements, nine Los Alamos firemen, reported to Widner on the fire at 4:20 PM. This crew was put to work hotspotting on the east and west flanks of the fire.

The first half of the 2nd reinforcements arrived on the fire at 5:30 PM, and Widmer assigned this 10-man crew to building line across the east flank.

At 6:30 PM 10 additional men arrived at the fire. This crew was made up of Los Alamos volunteer fire brigade members, the Los Alamos Assistant Fire Marshall, Albro Rile, came in with this crew. They went up the south slope and arrived at the south head of the fire at 8:15 PM. At this time Rile discovered the fire burning across the canyon on the north mesa. He left two men on the south rim to build line and took the rest of the crew across the canyon via the Upper Crossing trail to the north mesa.

At 7:15 PM the 10 additional firemen requested as part of the 2nd reinforcements arrived on the fire line in the canyon. This crew was assigned to building line on the west flank.

Headquarters received the report that the fire was out on the north mesa at 8:00 PM. Fire Control Aid, Salazar, was dispatched to scout the north fire. He reported it burning in grass, snags, and new growth and spreading rapidly.

The last available firemen crew in Los Alamos, five men, was requested and dispatched to the north mesa with the Bandelier Trail Maintenance man, DeVargas, in charge. At 8:15 PM Widmer was requested to send 10 men out of the canyon via the Upper Crossing trail to the north mesa. By 11:00 PM there were 27 men on the north mesa fire. Rile took charge of the control action.

At 9:00 PM the Superintendent called the Regional Dispatcher to inquire about the availability of any additional SWFFF crew. He was told that it was unlikely that anymore could be made available for some time since they had difficulty getting the first crew.

The AEC offered additional help in the form of Zia Company crews and heavy equipment. Since headquarters had no assurance that additional SWFFF crews could be made available, it was decided to request 50 Zia Company men to go on the fire at daybreak.

There were 18 firemen left in the canyon until 11:00 PM when seven had to be released to return to Los Alamos. These men were replaced with six other firemen at 1:55 AM and seven more firemen at 2:10 AM. This left 23 men in the canyon for the remainder of the night.

During the night the fire in the canyon and up the south slope dropped out of the tree crowns with the exception of snags. These large, burning snags were the greatest threat to control since they were showering sparks down canyon.

The 25-man Jemez crew arrived at park headquarters at 10:30 PM and left for the fire at 11:00 PM. Chief Ranger Von der Lippe went to the fire with the Jemez crew. They were met at the west gate to Los Alamos by District Ranger Pfefferle, USFS, and Bandelier Maintenance Foreman Chilcoat.

The Jemez crew and above listed overhead arrived at the north mesa fire at 1:30 AM. Von der Lippe contacted Rile and reviewed the initial control action taken on this sector. A line averaging two feet wide had been completed around the east, north, and west sides of the fire. The fire made no runs after this line was put in. Many large snags adjacent to the fire line were burning their full length, and they were the biggest immediate hazard.

Von der Lippe dispatched Chilcoat back to the fire camp to get a chain saw. The Jemez crew was started improving the initial control line. Since the winds had subsided it was decided to relieve all of the Los Alamos firemen and volunteers and back up the Jemez crew with Zia Company reinforcements at daybreak. The Los Alamos crew and Rile were released from the fire at 4:00 AM.

At this time Von del Lippe and Pfefferle went to the canyon rim to determine where the fire came up on the mesa and to size up the entire fire. That night it was impossible to determine the number of points at which the fire had jumped out of the canyon or the feasibility of getting line-building crews down the north side. There was still considerable fire on the south slope adjacent to the east and west flanks. It was determined that a continuous hand line would have to be built beginning at the top of the south slope and across the canyon to the north slope. Von del Lippe returned to the fire camp. At 2:00 AM he was informed by headquarters that two more SWFFF crews were due in the park before daybreak.

The Taps crew arrived at park headquarters at 4:30 AM and left for the fire at 5:15 AM. Bob Blanchard, USFS, was crew boss for this crew. They were met by Von der Lippe at the Los Alamos west gate and dispatched with a 25-man Zia Company crew under Swede Linstrom to the Upper Crossing. These two crews were met by Widmer at the Upper Crossing and taken via Upper Crossing trail to the south rim of Frijoles Canyon. The Zia crew arrived on the west flank of the fire at 7:15 AM and the Taos crew was on the east flank by 8:15 AM. Both crews were put to work building permanent fire line down the south slope.

Alamo 1 Fire 1976

The Alamo 1 fire at Bandelier National Monument was first observed by the lookout at approximately 1:20 PM on Thursday afternoon.

A trail crew working within a mile-and-a-half was dispatched immediately to the fire, arriving at the fire at 2:05 PM and beginning action. Heavy fuels, rough terrain, and high winds helped to drive the fire across the fire line and a second crew was dispatched at 5:00 PM and slurry tanker bombers ordered at 5:05 PM. Three slurry drops were successfully made. Containment was achieved at 8:00 PM and control at 11 PM.

Mop-up was accomplished throughout the night, and the fire crew relieved in the morning by a small crew to watch for any possible flare-ups. Due to the absence of lightning in the area, the cause of fire was determined to be human caused. Besides destroying six to eight acres of beautiful pines, a small trail shelter was completely burned.

Superintendent John D. Hunter has asked that everyone coming into our area be aware of Extreme Fire Danger we are experiencing, and to be extra careful with any materials that could cause a fire.

Escobas Mesa 1 1976

News Release

The Escobas Mesa 1 fire at Bandelier National Monument was first observed at 10:45 AM, Thursday morning, July 8, 1976. A National Park Service crew was dispatched immediately to the fire and upon arrival ordered a slurry drop by U S Forest Service aircraft stationed in Santa Fe. The fire spread rapidly through heavy dry ponderosa pine fuel, and a second Park Service crew was dispatched at 1:00 PM. Four slurry drops by the US Forest Service were extremely helpful to the ground crews in containing the fire. The fire was declared contained at 4:05 PM.

A Forest Service SWFCO crew was called in from Espanola and arrived on the scene at 5:00 PM. With this additional manpower, and the help of some rain, the fire was declared controlled at 7:00 PM. Mop-up continued throughout the night, and a small crew remained on the fire to watch for flare-ups.

The fire was believed caused by a lightning storm that passed through the area Wednesday night. The fire burned 12 to 14 acres of ponderosa pine forest.

Even though the fire was lightning caused, Superintendent John. D. Hunter asks that everyone visiting the Monument be especially careful. Everyone is reminded that there is still extreme fire danger and that Bandelier backcountry remains closed to overnight camping. All backcountry use requires a permit.

Easter Fire 1977

Easter Fire began 4/10/1977—reported 18:15 hours and placed on hold over status due to extremely wet conditions in the area and difficulty of ground attack—cause: lightning.

Ground force dispatched 4/11/77 at 07:00 hours via Upper Crossing to the Alamo Rim Trail.

Fire was located in SW ¼ of the NE ¼ section of section 16, T18N, R6E. First attack 11:50 hours: Control 13:30.

The fire was a small snag in mixed ponderosa pine/pinon juniper/oak brush/grama grass. 10% slope, aspect east. Last rain in area 4/10/77 approximately 16:00 hrs. 0.5+ inches. Ground moisture 12" plus. Wind from SW at 10 mph. RH at 13:00, 15/Dew point 16. Light fuels were extremely dry—light ground cover in immediate vicinity of fire—heavy and flashy fuels to N, NE, NW of fire.

The fire consumed the snag—one pinon, one juniper burned badly. Hand line built around fire, duff and burning snag put out. Abandoned Easter fire 15:00 hrs. Ground force returned to HQ Bandelier via Corral Hill, Frijoles Ruin Trail.

Fire declared out 4/12/77.

Stone Lions Mesa

On May 14, about 0730, I received a radio message at Base Camp from the Fire Lookout alerting me to a smoke observed in the vicinity of Boundary Peak.

I took a shovel and hiked to the reported area. No fire was to be seen. But looking back to the Stone Lions from Boundary Peak I could see the smoke. It was on the high mesa NW of Stone Lions.

I crossed Capulin Canyon and reached the area about 11:00. One snag on the ground was burning. One starting snag was burning at the top about 30 feet off the ground. I extinguished the ground fire, then went down the second snag and extinguished that blaze. On checking the area the next morning I found more fire in the snags. This time I really extinguished the fire! Total time on fire—8 hrs.

The fuels in this area were grasses, small bushes, and widely scattered native ponderosa pine.

APPENDIX II: Annotated Checklist of Plants

Commonly used or new scientific names	Old nomenclature	Common name	Family	Sea-son	Origin	SYM
Achillea millefolium var. *occidentalis*	*Achillea lanulosa* ACLA	Western yarrow	Asteraceae	P*	N**	ACMIO
Pascopyrum smithii	*Agropyron smithii*	Western wheat-grass	Poaceae	P	N	PASM
Allium cernuum		Nodding onion	Liliaceae	P	N	ALCE
Amaranthus retroflexus		Redroot amaranth	Amarantha-ceae	A	N	AMRE
Andropogon gerardii		Big bluestem	Poaceae	P	N	ANGE
Schizachyrium scoparium	*Andropogon sco-parium* ANSC	Little bluestem	Poaceae	P	N	SCSC
Elymus trachycaulus	*Andropogon trachy-calum* ANTR	Slender wheat-grass	Poaceae	P	seeded	ELTR
Muhlenbergia wrightii		Spike muhly	Poaceae	P	seeded	BOWR
Antennaria parvifolia		Pussytoes	Asteraceae	P	N	ANPA
Apocynum androsaemifolium		Spreading dogbane	Apocynaceae	P	N	APAN
Arctostaphylos uva-ursi		Kinnikinnik	Ericaceae	Shrub	N	ARUV
Aristida arizonica		Arizona threeawn	Poaceae	P	N	ARAR
Aristida divaricata		Poverty threeawn	Poaceae	P	N	ARDI
Aristida purpurea	*Aristida longiseta*	Purple threeawn	Poaceae	P	N	ARPU
Artemisia carruthii		Carruth's sagewort	Asteraceae	P	N	ARCA
Artemisia dracunculus		False terragon	Asteraceae	P	N/I	ARDR
Artemisia ludoviciana		White sagebrush	Asteraceae	P	N	ARLU
Asclepias spp.		Milkweed	Asclepiada-ceae	P	N	ASCLE
Astragalus spp.		Milkvetch	Fabaceae	P	N	ASTRA
Bahia dissecta		Ragleaf bahia	Asteraceae	A, B, P	N	BADI
Blepharoneuron tricholepis		Pine dropseed	Poaceae	BLTR	P	N
Bouteloua curtipendula		Sideoats grama	Poaceae	BOCU	P	N
Bouteloua gracilis		Blue grama	Poaceae	BOGR	P	N
Brickellia spp.		Brickellbush	Asteraceae	P	N	BRICK
Bromus anamolus		Nodding brome	Poaceae	BRAN	P	N

**P = perennial, A = annual, B = Biennial*
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Commonly used or new scientific names	Old nomenclature	Common name	Family	Sea-son	Origin	SYM
Bromus inermis	*Bromus inermis*	Smooth Brome	Poaceae	P	N	BRIN
Bromus tectorum	*Bromus tectorum*	Cheatgrass	Poaceae	A	I	BRTE
Carex	*Carex*	Sedge	Cyperaceae			CAREX
Castilleja integra		Wholeleaf Indian paintbrush	Scrophularia-ceae	P	N	CAIN
Ceanothus fendleri		Buckbrush; Fendler's ceano-thus	Rhamnaceae	P	Shrub, N	CEFE
Cerastium arvense		Field chickweed	Carophylla-ceae	P	N/I	CEAR
Cercocarpus montanus		Alderleaf mountain mahogany	Rosaceae	p	n	CEMO
Chenopodium album		Lambsquarters	Chenopodia-ceae	A	N/I	CHAL
Chenopodium fremontii		Goosefoot	Chenopodia-ceae	A	N	CHFR
Chenopodium graveolens		Fetid goosefoot	Chenopodia-ceae	A	N	CHGR
Heterotheca villosa	*Chrysopsis villosa* CHVI	Hairy goldenaster	Asteraceae	P	N	HECA
Chysopsis nauseosus	*Chrysothamnus nauseosus*	Chamisa, Rubber rabbit brush	Asteraceae			
Clematis pseudoalpina		Rocky Mountain clematis	Ranuculaceae			
Cirsium neomexicanum		New Mexico thistle	Asteraceae	B/P	N	CINE
Cirsium undulatum		Wavyleaf thistle	Asteraceae	B/P	N	CIUN
Commelina dianthifolia		Birdbill dayflower	Commelinea-ceae	P	N	CODI
Convolvulus arvensis		Field bindweed	Convolvula-ceae	P	I	COAR
Conyza canadensis		Canada Horseweed	Asteraceae	A/B	N	COCA5
Corydalis aurea		Scrambled eggs	Fumariaceae	A/B	N	COAU
Cryptantha cinerea	*Cryptantha jamesii*	James cryptantha	Boraginaceae	P	N	CRCI

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Commonly used or new scientific names	Older nomenclaure	Common name	Family	Sea-son	Origin	SYM
Cyperus esculentus		Chufa flat-sedge; Yellow nutsedge	Cyperaceae	CYES	P	N/I
Cyperus fendleri						
Erigeron divergens		Spreading fleabane	Asteraceae	B	N	ERDI
Erigeron flagellaris		Trailing fleabane	Asteraceae	B	N	ERFL
Eriogonum jamesii		James buckwheat	Polygonaceae	P	N	ERJA
Eriogonum spp.		Buckwheat	Polygonaceae	P	N	ERIOG
Erysimum capitatum		Sanddune wall-flower; Western wallflower	Brassicaceae	B, P	N	ERCA
Euphorbia serpyllifolia		Thymeleaf sand-mat	Euphorbia-ceae	A	N	CHSEH
Vulpia octoflora var. *octoflora*	*Festuca octoflora*	six-weeks fescue	Poaceae	A	N	VUOC
Festuca ovina	*Festuca ovina*	Sheep fescue	Poaceae	P	seeded	FEOV
Fragaria americana		Strawberry	Rosaceae	P	N	FRAM
Galium spp.		bedstraw	Rubiaceae	P	N	GALIU
Gaura coccinea		Scarlet gaura	Onagraceae	P	N	GACO
Geranium caespitosum		Purple geranium	Geraniaceae	P	N	GECA
Geranium richardsonii		Richardson's gera-nium	Geranicaceae			
Goodyera oblongifolia		Western rattle snake plantain	Orchidaceae	P	N	GOOB
Grindelia nuda var. *aphanactis*		Curlyleaf gumweed	Asteraceae	A, B, P	N	GRNUA
Gutierrezia sarothrae		Broom snakeweed	Asteraceae	P	N	GUSA
Helianthus petiolaris	*Helianthus petiolaris*					
Pleuraphis jamesii	*Hilaria jamesii*	James' galleta	Poaceae	P	N	PLJA
Hymenopappus filifolius		White ragweed; Fineleaf hymeno-pappus	Asteraceae	P	N	HYFI
Tetraneuris acaulus	*Hymenoxys acaulis*	Stemless four-nerve daisy	Asteraceae	P	N	TEAC

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Commonly used or new scientific names	Older nomenclature	Common name	Family	Sea-son	Origin	SYM
Hymenoxys argentea		Perky Sue	Asteraceae			
Hymenoxys richardsonii		Pingue rubber-weed	Asteraceae	P	N	HYRI
Ipomopsis aggregata		Scarlet gilia	Polemonia-ceae	B, P	N	IPAG
Juniperus monosperma						
Bassia scoparia	*Kochia scoparia*	Burningbush	Chenopodia-ceae	A	I	BASC5
Koeleria macrantha	*Koleria cristata* KOCR	Prarie Junegrass	Poaceae	P	N	KOMA
Lactuca serriola		Prickly lettuce	Asteraceae	A, B	I	LASE
Lappula spp.		Stickseed	Boraginaceae	B, P	N	LAPPU
Liatris punctata		Dotted gayfeather; Dotted blazing star	Asteraceae	P	N	LIPU
Linum neomexicanum		New Mexico yel-low flax	Linaceae	A, B, P	N	LINE
Lithospermum multiflo-rum		Manyflowered stoneseed	Boraginaceae	P	N	LIMU
Lotus wrightii		Wright's deervetch	Fabaceae	P	N	LOWR
Lupinus caudatus		Tailcup lupine	Fabaceae	P	N	LUCA
Lupinus kingii		King's lupine	Fabaceae	A	N	LUKI
Lycurus phleoides		Common wolfstail	Poaceae	P	N	LYPH
Medicago sativa		Alfalfa	Fabaceae	A, P	I	MESA
Melilotus officinalis		Yellow sweetclover	Fabaceae	A, B, P	I	MEOF
Mentzelia pumila		Blazing star	Loasaceae			
Mirabilis decipiens	*Mirabilis linearis*	Broadleaf four o'clock	Nyctaginaceae	P	N	MIDE5
Mirabilis multiflora		Showy four o'clock; Colorado four o'clock	Nyctaginaceae	P	N	MIMU
Muhlenbergia montana		Mountain muhly	Poaceae	P	N	MUMO
Muhlenbergia wrightii		Spike muhly	Poaceae		P	N
Muhlenbergia asperifolia		Scratchgrass	Poaceae	P	N	MUAS
Muhlenbergia minutis-sima		Annual or Little-seed muhly	Poaceae	A		MUMI

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Commonly used or new scientific names	Older nomenclature	Common name	Family	Season	Origin	SYM
Oenothera spp.	*Oenothera* spp.	Evening primrose	Onagraceae	P	N	OENOT
	Opuntia spp.					
Orthocarpus purpureo-albus		Purplewhite owl's-clover	Scrophulariaceae	A	N	ORPU
Oxalis violaceae		Violet woodsorrel	Oxalidaceae	P	N	OXVI
Mirabilis linearis	*Oxybaphus linearis*					
Pacystima myrisinites	*Pacystima myrisinites*					PAMY
Panicum miliaceum		Broom corn or proso millet	Poaceae	A	I	PAMI
Penstemon secudiflorus		Sidebells penstemon	Scrophulariaceae	P	N	PESE
Penstemon barbatus		Beardtongue	Scrophulariaceae	P	N	PEBA
Dalea candida var. *candida*	*Petalostemum candidum*	White prairie clover	Fabaceae	P	N	DACAC
Dalea purpurea var. *purpurea*	*Petalostemum purpureum*	Purple prairie clover	Fabaceae	P	N	DAPUP
Phacelia crenulata var. *corrugata*	*Phacelia corrugata*	Leftleaf or cleftleaf wildheliotrope	Hydrophyllaceae	A	N	PHCRC
Physalis hederifolia var. *fendleri*						
Physalis subulata var. *neomexicana*	*Physalis foetens var. neomexicana*	New Mexico groundcherry	Solanaceae	A	N	PHSUN
Pinus edulis	*Pinus edulis*					
Pinus ponderosa	*Pinus ponderosa*					
Plantago patagonica	*Plantago purshii*	Woolly Indianwheat; Woolly plantain	Plantaginaceae	A	N	PLPA
Poa fendleriana	*Poa fendleriana*	Muttongrass	Poaceae	P	N	POFE
Polygonum arenastrum	*Polygonum aviculare*	Oval-leaf knotweed	Polygonaceae	A, P	I	
Polygonum convolvulus		Black bindweed	Polygonaceae	A, vine	I	POCO
Potentilla spp.	*Potentilla* spp.	Cinquefoil	Rosaceae			POTEN
Pteriodophya	*Pteriodophya*	Unidentified				PT xx

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Commonly used or new scientific names	**Older nomenclature**	**Common name**	**Family**	**Sea-son**	**Origin**	**SYM**
Quercus gambelii		Gambel Oak	Fagaceae	tree, shrub	N	QUGA
Quercus X pauciloba	*Quercus undulata*	Wavyleaf oak	Fagaceae	Tree, shrub, p	N	QUPA
Rhus trilobata		Lemonade bush				RHTR
Robinia neomexicana		New Mexico locust	Fabaceae	Shrub, tree, P	N	RONE
Rosa woodsii		Wood's rose	Rosaceae	Shrub ,P	N	ROWO
Salsola kali		Russian thistle	Chenopodia-ceae	A	I	SAKA
Senecio spp.	*Senecio* spp.	Ragwort	Asteraceae	P	N	SENEC
Elymus elymoides	*Sitanion hystrix* SIHY	Bottlebrush squir-reltail	Poaceae	P	N	ELEL
Maianthemum spp.	*Smilacina* spp.	Solomonplume; Mayflower	Liliaceae	P	N	MAIAN
Solidago spp.	*Solidago*	Goldenrod	Asteraceae	P	N	SOLID
Sorghastrum nutans		Indiangrass	Poaceae	P	N	SONU
Spheralcea coccinea		Scarlet globemal-low	Malvaceae	B ,P	N	SPCO
Sporobolus cryptandrus		Sand dropseed	Poaceae	P	N	SPCR
Stephanomeria spp.	*Stephanomeria*	Wirelettuce	Asteraceae			STEPH
Hesperostipa comata	*Stipa comata* STCO	Needle and thread grass	Poaceae	P	N	HECO
Taraxacum officinale		Common dande-lion	Asteraceae	P	N/I	TAOF
Tetraneuris argentea	*Hymenoxys argen-tea*	Perkysue	Asteraceae	P	N	TEAR
Thalictrum fenderli		Fendler's meadow-rue	Ranuncula-ceae	P	N	THFE
Townsendia incana		Hoary Townsend daisy	Asteraceae	A, B, P	N	TOIN
Tragopogon dubius		Yellow salsify	Asteraceae	A, B	I	TRDU
Trifolium repens		White clover	Fabaceae	P	I	TRRE

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Commonly used or new scientific names	Older nomenclature	Common name	Family	Season	Origin	SYM
Verbascum thapsus		Flannel mullein; Common mullein	Scrophularia-ceae	B	I	VETH
Vicia americana		American vetch	Fabaceae	P	N	VIAM
Heliomeris multiflora var. multiflora	*Viguiera multiflora*	Showy goldeneye	Asteraceae	P	N	HEMU
Viola adunca		Violet	Violaceae	P	N	VIOLA
Yucca bal	*Yucca angustissima*	Narrowleaf Yucca	Agavaceae	Sub-shrub, shrub, forb/herb, P	N	YUBA

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APPENDIX III: Listing of Photographic Records and Data

Title	Location	Information	Years
Photographic Record and Data 1893	Rim Frijoles Canyon	Line strip data photographs	1977–1993
Photographic Record and Data Frijoles Rim Plot 1960	Rim Frijoles Canyon	Line strip data photographs	1976–1993
Photographic Record and Data Frijoles Rim Plot 1937	Rim Frijoles Canyon	Line strip data photographs	1976–1993
Photographic Record and Data Escobas Mesa 1976	Escobas Mesa near Escobas Mesa Plot 2	Line strip data photographs	1976–2010
Photographic Record and Data Alamo Rim 1945	Mesa between Frijoles and Alamo Canyon	Line strip data photographs	1976–1985
Boundary Peak 1950	Near Boundary Peak	Line strip data photographs	1975–1996
Photographic Record and Data Bear Mesa	Bear Mesa	Line strip data photographs	1975
Photographic Record Alamo Canyon Burn	Alamo Canyon	Photographs of Alamo Canyon fire	1976
Photographic Record and Data Apache Springs	Off Apache Springs trail	20- by 50-m plots photographs	1977–2012
Photographic Record and Data Inner Frijoles Canyon	Inner Frijoles downstream from Upper Crossing	Line strip data photographs	1975–1977
Photographic Record of Mesa del Rito	Along road on Mesa del Rito	Photographic records	1975–1985
Photographic Records of Frijoles Mesa	Frijoles Mesa along state Route 4	20- by 50-m plots photographs	1977–2010
Photographic Records and Data Escobas Mesa Plot 1	Escobas Mesa	20- by 50-m plot photographs	1977–2011
Escobas Mesa Plot 2	Escobas Mesa	20- by 50-m plot photographs	1977–2011
Photographic Records and Data Escobas Mesa Plot 3	Escobas Mesa	20- by 50-m plot photographs	1977–2011
Photographic Records and Data Escobas Mesa Plot 4	Escobas Mesa	20- by 50-m plot photographs	1977–2011
Photographic Records and Data Burnt Mesa Plot 1	Burnt Mesa	20- by 50-m plot data and photographs	1977–2011
Photographic Records and Data Burnt Mesa Plot 2	Burnt Mesa	20- by 50-m plot data and photographs	1977–2011
Photographic Records and Data Burnt Mesa Plot 3	Burnt Mesa	20- by 50-m plot data and photographs	1977–2011
Photographic Records and Data TA-49, LANL	TA-49 LANL	20- by 50-m plot photographs	1977–1998

APPENDIX IV: Listing of Species and Their Primary Means of Regeneration

Species	Common Name	Sprouting	Seed Regeneration
GRASS			
Andropogon gerardii	Big bluestem	Sprouting from rhizomes	
Aristida spp.	Three-awn		Reproduces by seed; soilbank
Blephareoneuron tricholepis	Pine dropseed		
Bouteloua gracilis	Blue grama		
Bromus inermis	Smooth brome	Spread by rhizomes	
Bromus tectorum	Cheatgrass, downy chess	Surviving rhizomes	Seeds; soilbank
Carex spp.			
Elymus elymoides	Bottlebrush squirreltail		
Elymus trachycaulus	Slender wheatgrass		Seeds
Festuca ovina	Sheep fescue		Seeds
Koeleria cristata	June Grass	Sprouting from residual rhizomes	Seed
Muhlenbergia montana	Mountain muhly	May sprout after aerial portions burned	Produces mainly by seed
Muhlenbergia wrightii	Wright's muhly		Seed
Pascopyrum smithii	Western wheatgrass		
Schizachyrium scoparium	Little bluestem		Produces largely by seed
Sporobolus cryptandrus	Dropseed		Prolific seeder; seedbank
FORBS			
Allium cernuum	nodding onion	Sprouting from bulb	
Antennaria parvifolia	pussytoes	Root crowns can survive fire and sprout	
Artemisia carruthii	Carruth sagewort	Sprout from rhizomes	
Artemisia dracunculus	False tarragon	Surviving rhizomes can sprout	
Bahia dissecta	ragleaf bahia		Seed
Castilleja integra	Wholeleaf paintbrush	Sprout from root crowns	Seeds; seedbank
Chenopdium album	Lambsquarters		Seeds
Chenopodium graveolens	Ragleaf goosefoot		Seeds
Circium neomexicanum	New Mexico Thistle		Off-site seed dispersal
Commelina dianthifolia	Dayflower	Sprout from bulb or tuber	

Dalea candida var. *candida (Petalostemum candidus)*	White prairie clover	May sprout from root crown	Seeds in soilbank
Erigeron divergens	Spreading fleabane		
Erigeron flagellaris	Spreading fleabane		
Chamaescyce serpyllifolia var. *hirtella*	Thymeleaf sandmat, spruge		Reproduces by seeds
Gaura coccinea	Scarlet gaura		
Geranium caespitosum	Purple geranium	May sprout from rhizomes	
Hetrotheca canescans (Chrysopsis villosa [CHVI]*)*	Hairy golden aster		
Ipomopsis aggregata			
Liatris punctata		Rhizomes	Wind dispersed seed
Linum neomexicanaum			seed
Lithosperum multiflorum	Many flowered stoneseed		
Lotus wrightii			seeds
Lupinus caudatus	Tailcup lupine	Sprouts from caudex	Germinates from buried seed
Medicago satvia			Seed
Melilous officinalis			Seed
Mirabilis linearis	Four o'clock		
Opuntia spp.	Prickly pear	Sprouts from root crown	
Orthocarpus purpureo-albus			
Penstemon spp.	Beardtongue	Sprout from root crown	Seeds in soilbank
Physalis subulata var. neo-mexicana (Physalis foetens var. neomexicana)	Groundcherry		Seeds
Potentilla spp.	Cinquefoil	Caudex sprouting	seeds
Portulaca oleracea	Common purslane		seeds
Senecio spp.	Groundsel		
Taraxacum officinale	Common dandelion		seeds
Tetraneuris acaulus (Hy-menoxys acaulis)	Stemless four-nerved daisy		
Thelesperma filifolium (Thelesperma trifidum)	Greenthread		seeds
Thermopsis divaricarpa) Thermopsis pinetorum	Piney goldenpea	Sprouting from rhizomes	Fire stimulate germination
Townsendia incana			
Tragopogon dubius	Goat's beard		Seeds; offsite colonizer
Verbascus thapsus	Flannel mullen		Smoke stimulate germina-tion; soilbank
Vicia americana	American vetch	Sprouting from rhizomes	

SHRUBS			
Artostaphylos uva-ursi	Barberry	Root crown sprouting	
Berberis fendleri	Colorado barberry	Sprouting from root crown	
Brickellia grandiflora	Tassel brickellia		
Ceanothus fendleri	Fendler buckbrush		Seeds; soil bank
Cercocarpus montanus	Mountain mahogany	Root crown and rhizomes	
Clematis pseudoalpina	Rocky Mountain clematis		
Dasiphora fruticosa	Shrubby potentilla	Sprouting from caudex	
Fallugia paradoxa	Apache plume	Root suckers	
Gutierrezia sarothrae	Snakeweed		Seed; seedbank
Paxistima myrisinites	Mountain lover; Oregon boxwood	Root crown sprouting	
Physocarpus monogynus	Mountain ninebark	Vigorous sprouter	
Prunus virginiana var. *melanocarpa*	Chokecherry	Root crown and rhizomes	
Quercus gambelii	Gambel oak	Lignotubers and rhizomes	
Quercus undulata	Shrub oak	Lignotubers and rhizomes	
Rhus radicans			
Rhus trilobata	Skunkbush sumac	Root crown	Seeds
Ribes cernuum	Wax currant; gooseberry	Sprouting from root crown	Repoduces mainly by seed; seedbank
Robinia neomexicana	New Mexico locust	Vigorous sprouter	
Rosa woodsii	Wood's rose, wild rose	Sprouts from root crown	Seeds
Rubus strigosus var. *arizonica*	Wild raspberry	Sprigs and tubers	Seeds
Yucca angustissima	Sprouts from rhizomes	Sprouts from rhizomes	
TREES			
Acer glabrum var. *neomexicanum*	New Mexico maple	Rapid sprouting	
Acer negundo	Boxelder	Sprouts from root collar	
Juniperus deppeana	Alligator juniper	Sprouts from the base	
Juniperus monosperma	One-seed juniper		Seeds
Pinus edulis	Colorado pinon		Seeds
Pinus ponderosa	Ponderosa pine		Seeds
Populus tremuloides	Quaking aspen	Sprouts rapidly	