NATIVES VERSUS EXOTICS AND GRASSES VERSUS FORBS: A LONG-TERM STUDY OF VEGETATION IN LA JOLLA VALLEY

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ABSTRACT

NATIVES VERSUS EXOTICS AND GRASSES VERSUS FORBS: A LONG-TERM STUDY OF VEGETATION CHANGE IN LA JOLLA VALLEY

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California grasslands are well known for the exotic species invasions they have undergone and the resulting decrease in native flora. Issues with restoring these lands lie in determining the pre-invasion vegetation composition and the mechanisms of invasion. This study compares data from three surveys of a set of permanent quadrats in La Jolla Valley in order to determine changes over time. Each iteration included data on vegetation cover, frequency, and shrub density. It was found that native grass cover has decreased, and exotic grass cover has fluctuated widely. Also, both native and exotic forb cover increased greatly. This supports Minnich's forb-field theory over Clements' bunchgrass theory. The natural enemies and disturbance hypotheses did not accurately predict these results. When the quadrats were divided in valley floor and valley edge categories the post-disturbance hypothesis accurately predicted the result that edge quadrats have greater native grass cover than their floor counterparts.

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CHAPTER 1

INTRODUCTION

California grasslands are a highly invaded habitat with many questions and few answers surrounding them. When Europeans came to the western hemisphere several centuries ago plants and seeds came with them. California in particular became overrun by exotic invasive species, often leading to a decrease in native flora. Due to purposeful and incidental introduction of exotic species to the area, native species were put into competition for survival, and the exotics were usually the ones to dominate. With European settlement and population expansion, the grasslands came under more intensive human impact either directly by land managers or indirectly by domesticated animals. There are very few places in the state that currently contain significant stands of *Stipa pulchra* (also known as *Nasella pulchra*), a perennial bunchgrass considered by some to have been the predominant grass prior to the introduction of grass species from the Mediterranean region (Heady et al. 1991). Today, land managers and academics are trying to restore the grasslands to their pre-invasion state as much as possible, which often entails planting and struggling to maintain *S. pulchra* and other native grasses.

There are multiple possible explanations for why exotic invasions occur and persist. These vary from the loss of natural enemies (see Darwin 1859; Williams 1954; Elton 1958) to the type of disturbances around which species evolve (see Gray 1879; Baker 1974; Mack et al. 2000). While many studies have examined exotic species' abilities to invade and become dominant, most do not examine change over the long-term (e.g., over thirty years). Native California grasses and associated invading exotics in La Jolla Valley (LJV) provide an excellent research setting as the invasion is long-term, the land-use history is known, and there is an excellent historical data set (see below).

Possibly originating from William Henry Brewer's first survey of the state's flora in the 1860s (Brewer and Watson 1876–80) is the theory that pre-Columbian California was covered by perennial bunchgrass grassland (Minnich 2008). The bunchgrass theory, cemented into ecological restoration dogma by Clements, has prevailed to this day (Hamilton 1997). In 2008, Minnich challenged this theory by making the argument for the dominance of wildflowers over perennial bunchgrasses. Minnich cites several Spanish land expeditions (e.g., Gaspar de Portolá and Juan Bautista de Anza) pre-dating William Henry Brewer that indicate California's prairies were dominated by annual forbs (herbaceous flowering plants other than grasses). Minnich's forb-field theory and Clements' bunchgrass theory will be examined as a possible means of explaining the changes found in the vegetation—forbs and grasses alike.

The focus of this study is the grasslands of La Jolla Valley, Point Mugu State Park, Ventura County, California. The valley and surrounding hillsides were used as grazing lands for much of the 20th century until the ranching period ended in 1965. Due to the passage of time since LJV became protected land, post-disturbance recovery hypotheses can be considered, as well. A better understanding of how and why the exotic grasses have been such successful invaders and the impact of anthropogenic disturbance can aid in the ecological restoration of California's grasslands. Knowing which invasive species have persisted in LJV since the end of cattle grazing in 1965 can help restorationists and land managers determine where to apply scarce resources to help recover and maintain native plant populations. The question, however, is which native plant populations.

Previous Research in La Jolla Valley

In 1972 the California Department of Parks and Recreation published a report on the California prairie ecosystem (Barry 1972). This included a section on LJV and provided an overview of the vegetation—especially the state of *S. pulchra*, soils, and a recommendation for resource management.

In 1979 Suzanne Goode conducted an inventory on the species composition of the grassland in LJV, which was published as her master's thesis in 1981. In 1981, Carole Gale followed up on Goode's initial research by establishing and surveying permanent quadrats throughout the valley to enable long-term studies. The resulting content was Gale's master's thesis, published in 1983. Together these studies provide a key baseline for the composition of native grasses in LJV around the time the land was released from grazing and the park formed. After the 1993 Green Meadow wildfire, which burnt the valley, the California Park Service revisited these quadrats and Gale's data, the results of which are compiled in a 1996 report by Margaret Strassforth. This later study provides an indication of trends in species cover change after just over a decade of conservation management. The report finds that *S. pulchra* declined since Gale's data were collected in 1981, but also that cover and frequency data from 1994 to 1996 on the dominant grass species showed little change for those three years. Strassforth ends the report by suggesting a follow-up survey in five years' time to determine if grass cover and frequency had indeed stabilized.

In sum, these earlier works provide a critical baseline of grass, forb, and shrub cover, as well as an indication of how species cover changed immediately following release from grazing and the mechanical disturbances associated with grazing management (Laris, Brennan, and Engelberg 2016).

Purpose of Study

The purpose of this study, then, is to resample all of the original plots and determine the longer term patterns of species cover change in the valley and to relate these to other historical ecological processes. It is first necessary to determine whether the native grass population was increasing, decreasing, or stable in LJV, and second, to relate the observed and quantified changes to the long history of land use and disturbance in the valley so as to determine the causes of species cover change as well as to test the validity of the bunchgrass and forb-field theories.

This research is important because gaining a better understanding of the current state of California grasslands and how they have changed over time makes us more likely to be able to develop successful restoration programs/methods. In particular, knowing more about interspecies interactions will help us understand the success or failure of restoration efforts, such as seeding or herbicide use.

Maintaining and restoring healthy native grasslands is important for other reasons. The deep roots of such species as *S. pulchra* help to stabilize soil and increase water infiltration (cnga.org). Also, the California Native Grasslands Association states that “90% of rare and endangered species in California inhabit grassland ecosystems.” Such animals include several species of Kangaroo Rat (*Dipodomys* spp.), as well as the Western Meadowlark (*Sturnella neglecta*), although it is uncertain if either inhabit LJV. Non-native annual grasses threaten the habitat of kangaroo rats because, unlike patchy native grasses, they form thick mats difficult to forage in (Goldingay 1997). Additionally, some argue that dominance of exotic annuals has potentially altered fire regimes, increased nitrate leaching, and decreased carbon storage (Jackson et al. 1988; D’Antonio and Vitousek 1992; Christian and Wilson 1999; Dyer and Rice 1999).

The following study examines the changes in native grass cover and frequency in LJV after human disturbances have been removed. Building on the work of others conducted in 1981 and from 1994 to 1996, this study analyzes the changes to species composition and diversity to understand better what is happening when native grasses decline. In addition, the study tests several theories regarding exotic plant invasions.

CHAPTER 2

CONCEPTUAL FRAMEWORK

The battle between native and exotic species is a familiar one to ecologists and biogeographers, especially in North America. With the advent of trans-Atlantic travel and the Columbian Exchange came the worldwide dispersal of many plant species, often pitting natives against exotics. Patches of land with native grasses have survived over time, and many are now protected with efforts being made to restore them to their pre-invasion state, important for endangered animal species, which depend on them.

The Original California Prairie

Theories about what happens during species invasions may help us understand the current state of invaded ecosystems and how they came to be the way they are today. In order to apply such theories successfully, there must first be a consensus as to the original, uncorrupted state of the ecosystem that has since been invaded (Higgs 2003). When it comes to California's exotic grasslands, there are two major theories on what pre-invasion California looked like, bunchgrass theory and forb-field theory.

Clements: Perennial Bunchgrasses

Clements' bunchgrass theory, built from his relict plant community theory, has provided the prevailing understanding of California's pre-invasion state. Clements defines a relict as "a community or fragment of one that has survived some important change, often to become in appearance an integral part of the existing vegetation" (1934, 42). The first type, climatic relicts, is usually found in ecotones or where the landscape is divided in some way, such as by a gorge or canyon. The second type, relicts resultant to human actions, is often found at the edges of human involvement or industry, such as lumbering, agriculture, and transportation infrastructure.

Therefore, he proposed that plant communities on the outskirts of vegetation, which he considered to be only lightly or not at all disturbed, such as along railroad rights-of-way or roads, are the remnants of pre-invasion landscapes. With this in mind, he deduced that California was once dominated by perennial bunch grasses.

To the contrary, certain trackways near Fresno, which were some of Clements' prime examples, were burned every year (Hamilton 1997). Additionally, research indicates that *S. pulchra* dominance is promoted by fire (Hamilton 1997; Biswell 1956; Sampson 1944; Jones and Love 1945; Ahmed 1983).[1] Indeed, others have called it "opportunistic, with few of the characteristics of typical climax species," and that "it was a survivor because it is adapted to disturbance" (Bartolome and Gemmill 1981, 182–183).

Minnich: Annual Forbs

Richard A. Minnich proposes a radically different view of what pristine California looked like, arguing they were dominated by annual forbs rather than perennial bunchgrasses (see also Schiffman 2000). In his book, *California's Fading Wildflowers- Lost Legacy and Biological Invasions* (2008), Minnich goes up against bunchgrass theory with his own forb-field theory. He traces support for Clements' bunchgrass theory back to the findings of the state's first official vegetation survey by William Henry Brewer in the 1860s. However, Minnich believes that earlier accounts of the state's vegetation should be considered. Truly to understand what the California landscape looked like before the invasion of exotic species, Minnich urges readers instead to put their faith in the data collected by early Spanish land expeditions. Specifically, he

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[1] For a more comprehensive review of Clements' mistakes and legacy regarding bunchgrass theory, see Hamilton 1997.

[2] There are many theories on species invasion. Some, such as the novel weapons hypothesis, are not applicable to this study as there is no evidence of allelopathy among the species found in the study area. Others, such as disturbance, may provide some insight.

cites the excursions of Portolá (1769–70), Fages/Crespí (1772), Anza (1774 and 1775–76), Anza/Font (1776), Garcés (1776), Arillaga (1796), Zalvidea (1805), and Moraga/Muñoz (1806), the third also being recorded in the journals of Juan Crespí. It should be noted that Portolá's expedition was the only one to explore the southern coast of California, although the area containing the study area, LJV was skirted due to the difficult terrain (Minnich 2008). This lack of direct documentation creates doubt as to the validity of Minnich's forb-field theory when applied to the specific case of LJV.

While Minnich acknowledges the argument that forb-fields in full-bloom may be creating an "optical illusion" of forb-dominance for observers from any era (2008, 68), his argument is strengthened by the fact that Portolá's expedition occurred between July 1769 and January 1770, and therefore did not include the main blooming season for wild flowers. Also, Minnich points out that Brewer conducted his survey during the "catastrophic drought and extensive grazing of the early 1860s" (68). Of course, it is also possible that the Spanish expeditions occurred during years with unusually high precipitation. Another potential issue is that the first Spanish land exploration (1769–70 by Portolá) occurred 227 years after Juan Rodríguez Cabrillo was the first European to see the California coast in 1542 (Minnich 2008). The purposeful introductions of exotic grass species were carried out in the 1800s and beyond, but this does not cover incidental introductions, and the natural ability of these species to disseminate themselves up and down the state in that 227-year period.

Minnich's forb-field theory casts doubt on Clements' bunchgrass theory through a paradigm shift wherein native bunchgrasses are not thought to be the original vegetation cover. That said, we still do not know in what ratio native forbs and grasses existed pre-invasion. Nor do we know the factors, climatic or otherwise, which may have increased or decreased the presence of native bunchgrasses over time prior to European arrival.

Minnich is neither the first nor the only academic to question the validity of Clements' bunchgrass theory. In 1925, Jepson proposed an abundance of annual rather than perennial plant species in the Central Valley, and in 1981 Wester suggested, based oneyewitness accounts from the 1800s, that bunchgrasses were confined to the northeast portion of the San Joaquin Valley. Additionally, D'Antonio et al. (2007) note that since the late 1990s, researchers are coming to believe that "perennial grasses likely dominated the wetter portions of the state's grasslands… while annual forbs likely dominated drier valley grassland habitats" (72; also see Hamilton 1997; Schiffman 2000; Schiffman 2007). Furthermore, and preceding this, Bartolome and Gemmill (1981) find that "*S. pulchra* is opportunistic, with few of the characteristics of typical climax species" (181).

Mechanisms Preventing Self-Restoration of California Prairies

Theory, thus, diverges markedly in characterizing the original state of California prairies. This divergence presents an obstacle to efforts to restore these grasslands, because it is not clear what the desired end-state is. Furthermore, there are different proposed interpretations for how the exotic annual grasses maintain their dominance over native species. It is important to understand how their dominance is maintained to succeed in countering that dominance for successful restoration. Several theories or hypotheses suggest an explanation.

Natural Enemies Hypothesis

Bartolome and Gemmill (1981), working within the bunchgrass theory, propose the natural enemies hypothesis (also known as the enemy release hypothesis), to explain how exotic grasses thrive in an altered grassland and prevent native grasses from reclaiming their dominance.[2] The natural enemies hypothesis attributes the success of certain exotics to their new communities lacking specialist enemies (such as herbivores and pathogens) with which they co-evolved and which kept their populations in check (Darwin 1859; Williams 1954; Elton 1958; Hierro, Maron, and Callaway 2005). Some of these "enemies" may simply be successional species that later make-up a climax community, so the natural enemies may be other species that would typically displace a given species in the normal sequence of recovery from a disturbance. A common argument is that there are no true grasslands in the Mediterranean region (where many of the exotic grasses originated). In this view, annual grasses in the Mediterranean are largely confined to unstable, sub-climax ecosystems immediately following a disturbance and are destined to be replaced by shrubs and trees (Jackson 1985). Furthermore, Leiva, Chapin, and Fernandez Alex (1997) found in a survey of Californian and Spanish grasslands that they had only 9% of species in common. This supports the idea that exotic annuals evolved in a significantly different competitive environment from what they are currently experiencing in California. Hierro, Maron, and Callaway (2005) also support this hypothesis in the finding that the most aggressive invasive plant species are often exotic species that are no longer subject to biotic and abiotic controlling factors existing where they evolved.

Looking at this hypothesis with a more traditional view of what an enemy is, there is a three-point argument upon which it is based (Keane and Crawley 2002). First, natural enemies of plants are an important part of how their populations are regulated. Second, native enemies have a greater impact on native species than exotic species as the former make up their original diet. Third, plants are capable of taking advantage of there being fewer enemies, resulting in increased

[2] There are many theories on species invasion. Some, such as the novel weapons hypothesis, are not applicable to this study as there is no evidence of allelopathy among the species found in the study area. Others, such as disturbance, may provide some insight.

population growth (Keane and Crawley 2002). However, an exotic plant may be introduced concurrently with its own native enemy (Keane and Crawley 2002). Also, because the native plants have evolved to coexist with native enemies, there is no obvious reason why these native enemies would be less likely to attack the introduced species (Gandon 1998). Some argue that the successful control of exotic weeds by introducing specialist enemies from the exotic's place of origin provides support for the natural enemies hypothesis (Julien and Griffiths 1998). This is highly circumstantial as the introduced enemies may have a greater impact where they have been introduced compared to where they originated (Fowler et al. 1996). This would be due to the introduced enemies escaping from their own enemies (Crawley 1989; Hosking 1995). Keane and Crawley (2002) find that "the absence of significant specialist enemies and the lower relative impact by generalist enemies both seem to be playing important roles in the enemy release of invasive exotic plants… there is evidence that enemy release might not be important in some cases" (168).

When the natural enemies hypothesis is applied to the case of California's grasslands, it is important to remember that the introduction of cattle ranching was concurrent to the introduction of invasive, exotic species. The hypothesis argues that the species released from their enemies will become dominant. Since cattle came with the Mediterranean grasses, one would expect the exotic grasses not to be dominant during grazing, but becoming dominant when cattle were removed. Through the lens of both bunchgrass and forb-field theories, this predicts a decrease in the cover and/or frequency of natives, and a concurrent increase in exotic grasses once grazing pressure is removed.

Disturbance Hypothesis

While cattle may be framed as an enemy, cattle grazing may also be referred to as a disturbance. The disturbance hypothesis proposes that certain exotics succeed because they have adapted to different types and intensities of disturbances and the native species have not (Gray 1879; Baker 1974; Mack et al. 2000). The removal of herbivores from California grasslands, and sometimes of mowing in experimental conditions, has been found to lead to a decrease in exotic annual abundance and a concurrent increase in native perennial abundance because the exotics evolved to live with herbivory and not without it (Seabloom et al. 2003).

Additionally, annuals are better exploiters of disturbance because they tend to allocate fewer resources to roots, more resources to leaf and seed production, and have an earlier age of maturity (Grime and Hunt 1975; Stearns 1977; Jackson and Roy 1986; Garnier 1991; Holmes and Rice 1996). These trade-offs "should make annuals faster growers," and therefore better disturbance exploiters (Seabloom et al. 2003, 13387). In support of this, their findings indicated that "annuals decreased and perennials increased in abundance once mowing ceased," and "the abundance of annual species increased with increasing levels of disturbance" (13387).

There were increased and new disturbances in the decades after exotic grasses were introduced in California, some occurring accidentally while others purposefully. For example, an especially bad drought in the 1860s left the natives fewer in number and biomass and therefore more vulnerable to invasion while grazing pressure increased (Burcham 1957; Farquhar 1966; Baker 1976; Laris, Brennan, and Engelberg 2016). Also, the exotic grasses had evolved to withstand high grazing pressure (Jackson 1985, 358). Therefore, some researchers have determined that exotic annual grasses invaded California's grasslands due to their ability to take advantage of the disturbed landscape created by livestock grazing (Robinson 1971; Evans and Young 1972). When combined with either theory on the historical character of the California grasslands, this predicts a decrease in natives (either grasses or forbs) and concurrent increase in exotic grasses as long as grazing pressure from livestock persists. The implication of the disturbance hypothesis, then, is that after grazing is discontinued exotics will decline and natives will increase in dominance.

Native Species Recovery and Mode of Disturbance

Bunchgrass theory and forb-field theory make claims about the character of California prairies before the arrival of the Spanish. The natural enemies hypothesis and disturbance hypothesis addressed how the exotic annual grasses came to dominate native species, whether perennial grasses or annual forbs. Both of these hypotheses focus on cattle grazing, framing cattle as either a co-evolutionary predator on exotic annual grasses that kept them in check during the decades of grazing or as a disturbance agent that the exotic annuals could endure while suppressing native species for whom cattle were a new challenge. Exotics could be expected to increase in relation to natives after grazing ends in the natural enemies framework, while natives could be expected to increase in relation to exotics after grazing ends in the disturbance framework. In both cases, the emphasis is on native and exotic species' response to a particular disturbance regime, cattle grazing. The following discussion explores a wider range of anthropogenic disturbances for their impact on post-disturbance recovery, drawing on work done in California sage scrub (CSS).

One post-invasion theory looks to the land's continuing history of disturbance and the kind of disturbance involved as a means of explaining why some plants are able to restore themselves after the disturbance is removed. For example, working in LJV and Serrano Valley, Engelberg et al. (2013) found that "areas of CSS disturbed by grazing or shrub removal recover more quickly than those that have been cultivated, suggesting that cultivation has more significant long-term effects on native shrub return than do grazing and shrub removal" (475).

The human disturbance in LJV did not extend to crop cultivation but did include extensive cattle grazing (removed by 1965) and mechanical disturbance, to maintain pasturage, such as turning and fertilizing of the soil, shrub and brush clearance, and some disking (Goode 1981; Gale 1983; Engelberg et al. 2013). It is unclear as to why shrub removal with turning, fertilizing, and disking of the soil does not produce the same result as cultivation. Laris, Brennan, and Engelberg (2016) argue that the intensity and frequency of the mechanical disturbance regime played an important role in modifying soil conditions. It is possible that the sporadic disking and related activities that occurred in parts of LJV, which have recovered native plant cover, were minimal, with less significant arbuscular mycorrhizal fungi (AMF) disturbance, when compared to those with more frequent and intensive disturbances, such as valley floors. This is important as CSS recovery has been suggested to be reliant on AM fungi's mutualist relationship with it (McGonigle and Miller 1996; Volgelsang and Bever 2009; Engelberg et al. 2013).

At variance with this are the findings of Fleming, Diffendorfer, and Zedler (2009) that the exotic species present are preventing recolonization by natives, rather than past disturbances to the land. It is quite possible that it is their combined effects—intensive soil disturbance, loss of AMF, and competition from exotics—are the collective cause of exotic persistence. It is important to note that both Engelberg et al. (2013) and Fleming, Diffendorfer, and Zedler (2009) were specifically looking at recolonization of CSS species and not native perennial bunchgrasses, although Brennan, Laris, and Rodrigue (2017) find that some native grass colonization tends to accompany CSS shrub recovery especially when beneath the canopy of *Baccharis pilularis*. Hamilton (1997) points out that "[r]esearchers who explicitly rejected Clements' climax theory also came to the conclusion that modern non-native-annual-dominated grasslands had been dominated by chaparral" (322). It seems illogical, however, that LJV would be used for cattle ranching if there was not some amount of grasses or forbs already present. With that in mind, it is more probable that the flatter valley-floor originally had fewer shrubs (with more grasses or forbs) than the slopes at the valley's edges. These slopes are rocky or with rocky and gravelly soil, a substrate often dominated by chaparral or CSS. Furthermore, one might argue that the same areas that had the fewest shrubs, with their softer and finer textured soils, would also receive the most disking and seeding. Therefore, this predicts that quadrats on the valley floor will have fewer natives (forbs and grasses alike) than those on the edges of the valley because of the greater likelihood of mechanical disturbance as well as grazing, while quadrats on the edges will have more natives, but fewer grasses, either native or exotic.

Even if Clements' theory of relict communities and the bunchgrass theory are discredited, one cannot ignore the logic of his methodology presented early in his 1934 paper, "The Relict Method in Dynamic Ecology." In it he promotes the importance of repetition in ecological research. Clements points out three major advantages gained from repetition. First, it allows the researcher to see variation throughout the year. Second, it allows the researcher to see variation due to climate variability. Third, it allows for the researcher to see how human impact may have affected the biome. While Minnich is not wrong to promote the value of early vegetation recordings of Spanish land expeditions, in light of Clements' three-point argument above, they should be integrated with the formal vegetation surveys of the following centuries rather than pitted against them.

Overall, the literature provides diverse insight into the current and past states of California's native flora and poses several competing as well as potentially integrative hypotheses. Clements' bunchgrass theory, although unlikely to govern broad areas, cannot be ruled out for specific locations. Minnich's forb-field theory holds potential for valley bottoms, especially in the more arid parts of California, but may not work in moister pockets that might favor bunchgrasses. In all cases, it is quite clear that disturbance—in the form of intensive grazing and mechanical mechanisms—played important roles in establishing exotics, assisting their spread, and perhaps perpetuating their dominance due to a combination of long-term soil changes (such as the elimination of AMF) and through competitive advantages of the annual exotics themselves. It is clear that our understanding of the vegetation patterns and change in LJV needs augmentation. As Clements suggests, the best way to understand the processes that cause a particular vegetation cover (or suggest its original cover) is via a repetitive and long-term study. Only then can the broader patterns of change (in terms of plant forms and species) be distinguished from seasonal variations such that the ultimate causes can be uncovered.

This thesis is designed to do just that by examining a 35-year data set based on three distinct periods of intensive, plot-level vegetation survey. While striving to improve understanding of pre-European vegetation patterns, it is important also to note the changes that have occurred between data collection periods. Do exotics decline after grazing ends as expected by the disturbance hypothesis or do they increase per the natural enemies hypothesis? Is there a differential geography in the changing balance of native and exotic species depending on the distribution of different disturbances? By reconciling these goals, it might be possible to determine what is best for LJV in terms of restoration.

CHAPTER 3

METHODOLOGY

Site Description

La Jolla Valley is located approximately 1.3 km inland from the Pacific coast in Ventura County, California, approximately twenty kilometers northwest of Malibu, California (Fig. 1). The climate is Mediterranean with cool, wet winters and hot, dry summers. From 1998 to 2008, for the nearby city of Oxnard, California, the average summer daily maximum temperature was around 71 degrees F, and the average daily minimum temperature in the winter was 46 degrees F. Average annual precipitation is 10.39 inches (Western Regional Climate Center 2009).

History of La Jolla Valley

The Chumash People, whose shell middens can still be found in the valley to this day, are the first known inhabitants of LJV. In 1846 the valley was included in lands granted to Isabel Maria Yorba of Los Angeles (Goode 1981, 2). In 1873 William R. Broome of Santa Barbara purchased land, which included the valley, and used it as pastureland for his cattle ranch (Goode 1981, 3).

As was the case for many ranchlands in California, a series of actions was taken to improve the grazing potential of LJV. These efforts most often included disking to remove shrub cover and the planting of exotic grasses for forage (Laris, Brennan, and Engelberg 2016). In 1946 *Phalaris aquatica*, *Stipa miliacea*, and *Festuca perennis* were seeded throughout the valley (Gale 1983, 5). In the 1950s, still under the ownership of the Broome family, the middle and eastern portions of the valley were upturned, fertilized with phosphorus, and seeded with *P. aquatica*, *Ehrarta calycina*, and *Trifolium subterraneum* (Gale 1983, 5–6). In 1966 the State of California acquired the land from William's grandson, John Broome (Goode 1981, 2–3). In

1979, when Suzanne Goode collected her data she noted that *F. perennis* was the most abundant grass, to which she credited the removal of the cattle. This species in particular, along with *P. aquatica*, had previously been kept in check through grazing (Gale 1981, 16, 22).

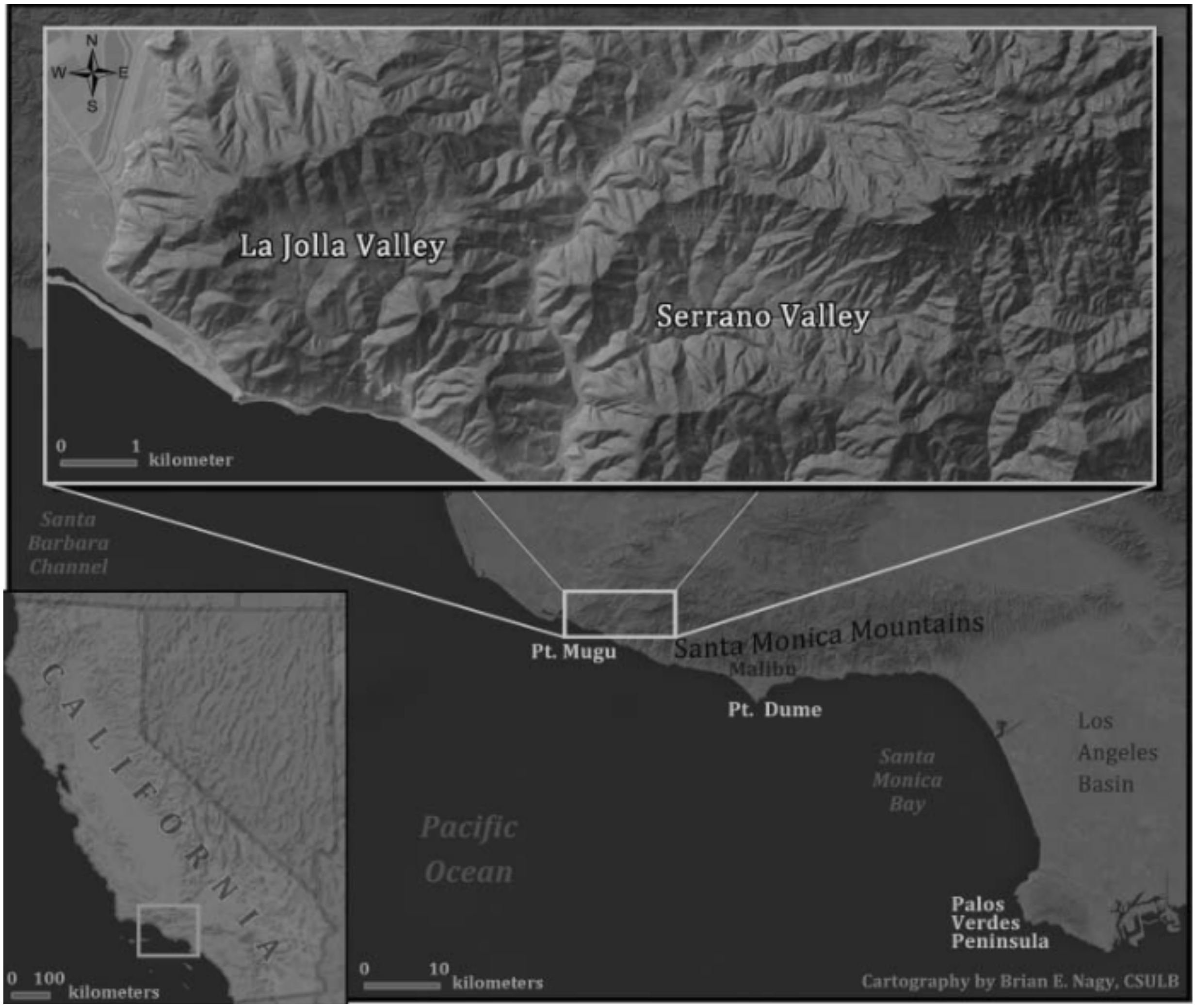

FIGURE 1. Location of Point Mugu State Park in Southern California (taken from Engelberg et al. 2013).

Method of Data Collection- Description of Quadrats

In 1981 Carole Gale and Suzanne Goode chose fifteen locations throughout the valley for their 24 m x 16 m quadrats. These locations were chosen because of the presence of native grasses, namely *S. pulchra* but also *S. lepida*, as well as a limited number of exotic grass species with which they competed. This was done to reduce complexity (Goode 1983, 10). A list of coordinates for the corners of each quadrat is included in Appendix A, and pictures were taken of and from most corners. Many of the corners were demarcated by an angle iron or rebar sticking out of the ground with rocks surrounding it, others had only rocks, and a few were not marked at all. In the present study, the locations of the unmarked corners were determined using their distance from the other corners. With all of the corners identified, a grid was set up to divide the quadrat into sixteenths ("plots") (4 m x 6.25 m each), using orange plastic flags such as those used in landscaping at each plot corner (Fig. 2).

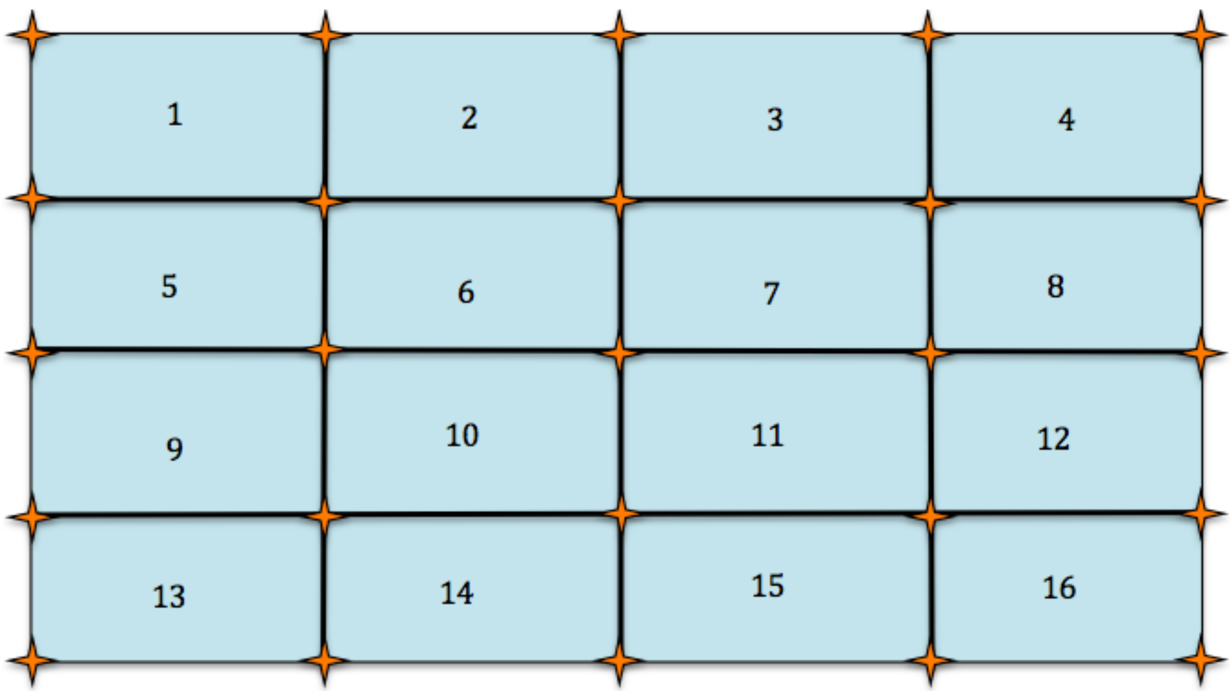

FIGURE 2. Diagram of gridded quadrat. Each four-pointed star represents the location of a landscaping flag.

Method of Data Collection- Frequency Using Mini-Quadrat

To measure the frequencies of forb, shrub, and grass species, a 25 cm x 25 cm mini-quadrat was constructed out of PVC pipe. Beginning one meter below and one meter to the right of the quadrat's upper-left corner, the mini-quadrat was dropped and all species within it recorded. As the researcher walked within the quadrat in a spiral pattern (Fig. 3) the mini-quadrat was dropped every fifth step to the instep of the researchers foremost foot. The dropping of the mini-quadrat and recording of species was repeated throughout the quadrat a total of fifty times. It was separately noted if the mini-quadrat encompassed only bare ground.

Method of Data Collection- Cover Using Transects

Using a "stratified random draw of cards numbered 1–16…in four-card sets," Carole Gale chose four sixteenths in each quadrat, one from each quarter of the quadrat, in which to conduct the cover methodology (1983, 13–14).[3] For this iteration of the study the same sixteenths ("plots") were used, although the system of numbering the plots in the past is not

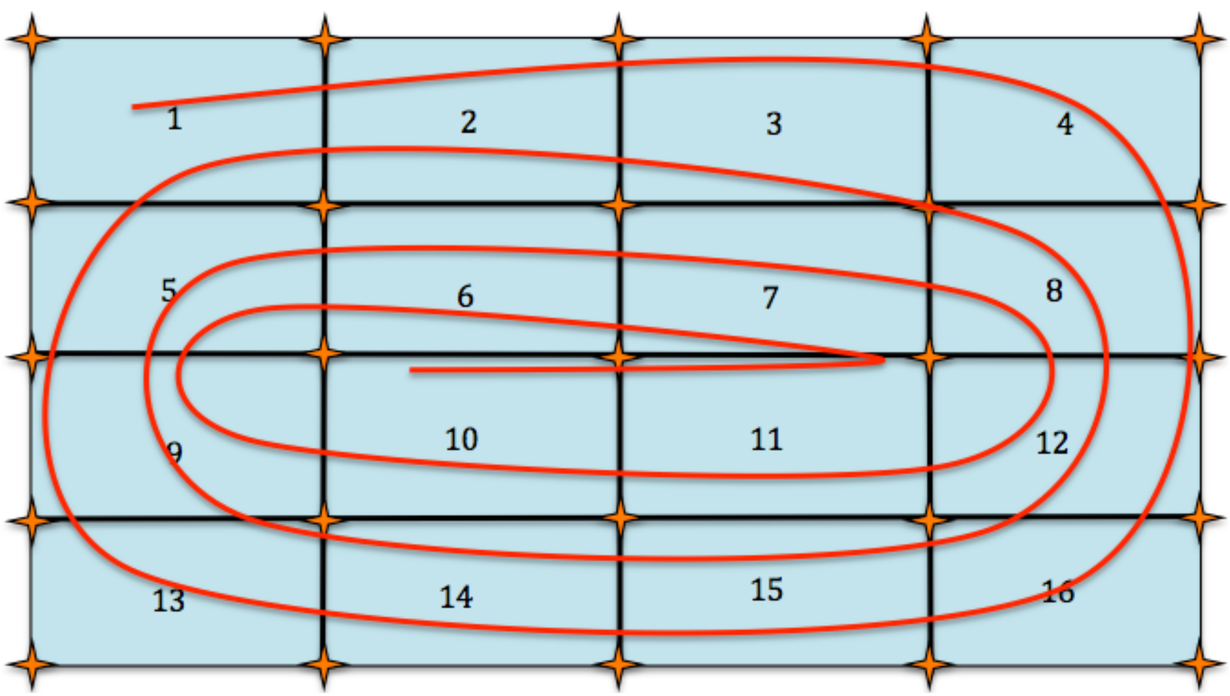

FIGURE 3. Diagram frequency method. The red line approximates the researcher's path when using the mini-quadrat frequency method.

[3] Plots 1, 2, 5, and 6 make up one quarter. Plots 3, 4, 7, and 8 make up the second, et cetera.

known.[4] The method used in 2015 was to stand facing away from the nearest trail (in certain cases it was to the oak riparian area; specifics may be found in Appendix A), and count the plots as shown in Figure 2.

In each of the four pre-determined plots, two transects were laid out, running the 6.25 m length of the plot. Beginning twenty-five centimeters in, and every twenty-five centimeters thereafter, one of the landscaping flags was placed. Every species touching the metal wire of the flag (or would be touching it if it were taller) was recorded. This resulted in twenty-five readings per transect, fifty per plot, and 200 per quadrat. As with the frequency data, the readings were divided into forbs, shrubs, and grasses. If no plants were present, a designation of bare ground was recorded.

Method of Data Collection- Shrub Density

To measure the density of the various species of shrubs within the quadrats, counts of each species were taken by plot, as laid out in Figure 2. This was done, rather than counting for the entire quadrat at once, to promote greater accuracy. It was decided to also count all burned shrubs (those that were not re-sprouting), to provide an estimate of the number of shrubs in the quadrats pre-fire, thus providing future researchers with an idea of how the quadrats looked when undisturbed by fire for twenty years, as the previous fire had occurred in 1993.

Method of Data Analysis

The data presented in the 1996 Strassforth report, which included the 1981 data fromCarole Gale, were entered into an Excel spreadsheet along with the 2015 data. The cover

[4] Gale wrote that "[f]uture workers will be able to relocate specific plots by … referring to the quadrat grid diagram in the Data Notebooks" (1983, 14). Unfortunately, the Biology department at CSU Los Angeles no longer possesses said notebooks and the Strassforth report does not explain it either. That being said, the numbering system could not be verified, and the one used did not reliably place one plot in each quarter of the quadrats.

data presented in the 1996 report treated numbers less than one in a particular manner. If the value was 0.5 to 1.0, 1.0 was the number reported. For values less than 0.5, <1 was used. For the purpose of data comparison and analysis, all <1 have been changed to 0.25 so that they may be included in all calculations. It was decided to average the data across the three years of the 1996 report in order to generate single values for that data collection period, and, therefore, be better able to compare it to the data sets from 1981 and 2015 due to the amount of time between each field season.

For each quadrat, cover data was divided into the following categories: native grasses, exotic grasses, native forbs, exotic forbs, shrubs (all found were native species with the exception of *Nicotina glauca*, found in a single quadrat in 1981), and bare ground. The results for the individual quadrats were then averaged to obtain a general picture of the valley. This provided insight into how species composition had changed over time, and, thus, the validity of any predictions based on Clements' bunchgrass theory, Minnich's forb-field theory, and the natural enemies and disturbance hypotheses.

In order to test the prediction made based on the post-disturbance hypothesis, the quadrats were categorized by location, either on the valley floor or at the valley edge (Fig. 4). The data for the quadrats in these categories were averaged for 1981, the 1990s, and 2015.

To test the statistical significance between years and locations, z-tests of the difference of proportions were performed. Due to the small sample size, it was decided to put the level of significance at 0.10.

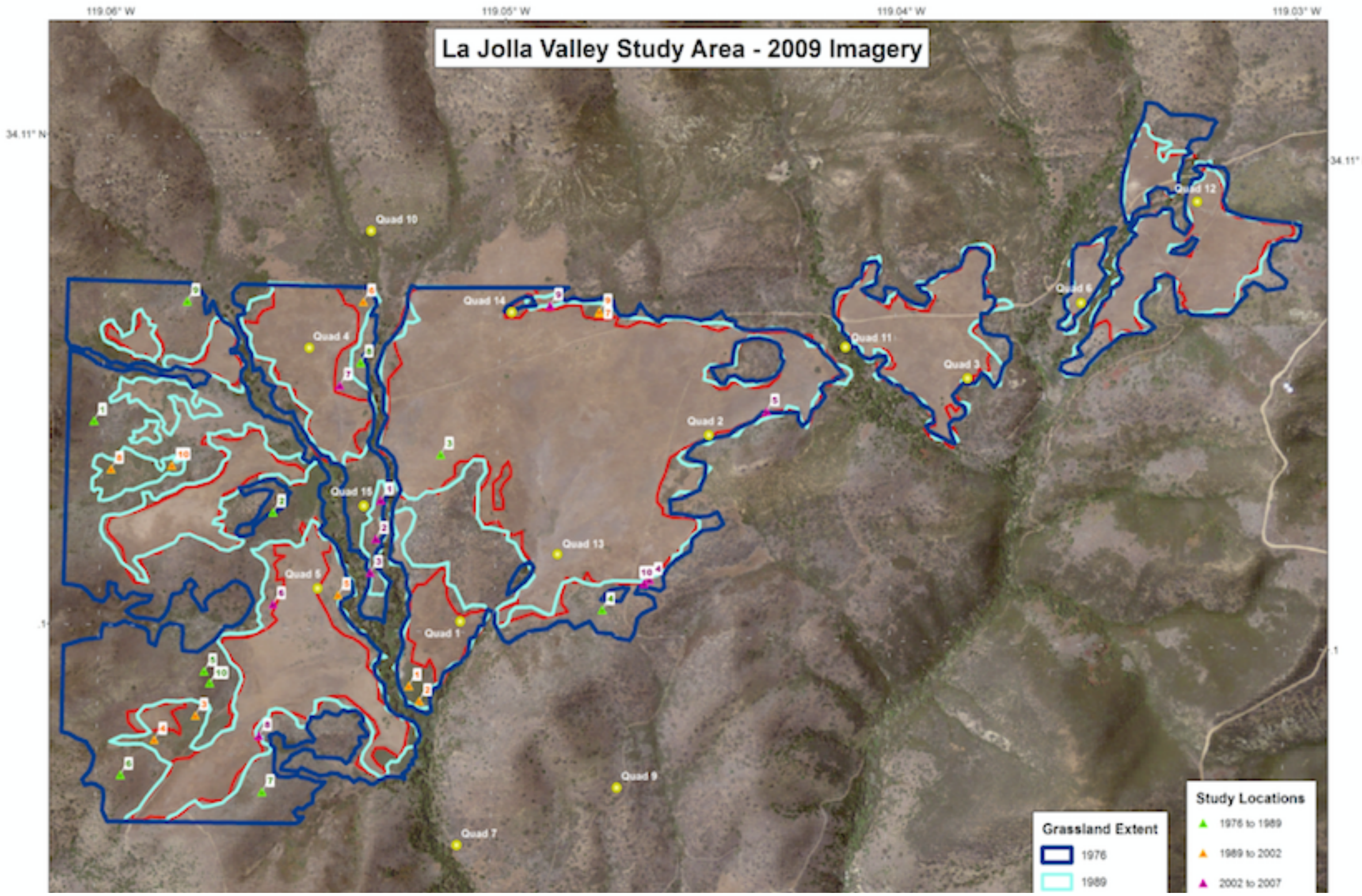

FIGURE 4. Locations of quadrats within LJV

CHAPTER 4

RESULTS & ANALYSIS

Floristics

Pooling data from all of the collection methods, fifty-four species of grasses, shrubs, and forbs were identified in the fifteen quadrats, forty-two of which are native to the region (~78%). All fifteen of the shrub species are native. Two out of the five grass species are native, *S. pulchra* and *S. lepida* (40%). Lastly, twenty-five of the thirty-four forb species are native (~74%). It should be noted that the record of forbs present might be incomplete as their flowering periods are brief and when they flower varies by species; therefore, they may easily be misidentified or missed. The number of species per quadrat ranged from eight to thirty, with an average of 17.2 species.

Percent Relative Cover[5]

Grasses

The grasses with the greatest cover were the *Avena* species—*Avena barbata* and *Avena fatua* (see Fig. 5). The two species were not identified separately because of the difficulty of doing so, as well as the fact that they had been combined in earlier studies. The *Avena* species were present in nine out of fifteen quadrats. When all fifteen quadrats were considered the average relative cover was 29%. This increased to just below 49% when only the quadrats in which *Avena* was present were analyzed. Cover per quadrat ranged from 1% to 78%.

[5] The percent relative cover of each species in each quadrat is displayed in tables within Appendix B.

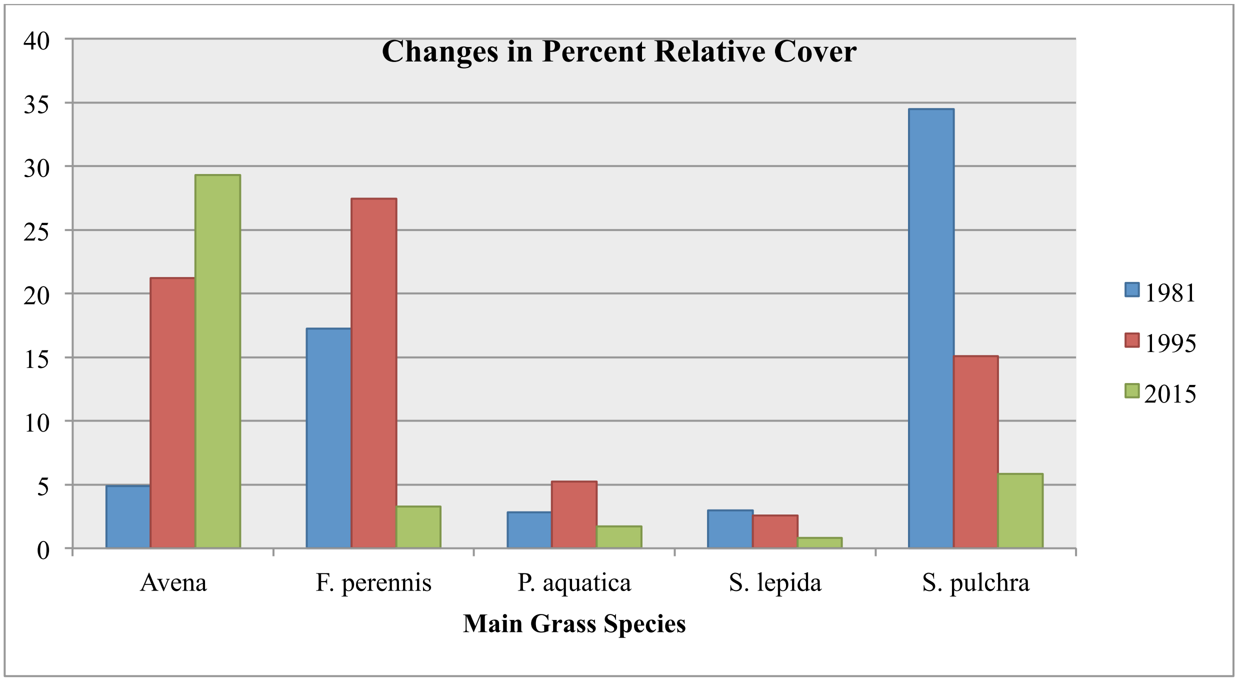

FIGURE 5. Changes in percent relative cover of grasses in LJV over time.

The grass with the next highest cover was *S. pulchra*. It was present in eleven of the quadrats, averaging just under 6% and ranging from 1% to just below 27%. Following *S. pulchra* were *F. perennis*, *P. aquatica*, and *S. lepida*.

Another way to examine the cover data is to look at the change in percent cover of each category (grasses, forbs, shrubs, or bare ground) in each quadrat. From this perspective, it becomes clear that, even though some species of grass have increased in cover over time, grasses in general have provided less relative coverage per quadrat compared with all cover types in 2015 than in previous studies. From the 1990s to 2015, all but one quadrat (quadrat 11) showed a decrease in percent relative cover by grasses (Fig. 6), and every quadrat showed an increase for forbs (Fig. 7). Shrubs were split, with six quadrats showing an increase in cover by shrubs, and eight showing a decrease (Fig. 8). Additionally, all but one quadrat showed an increase in bare ground (Fig. 9).

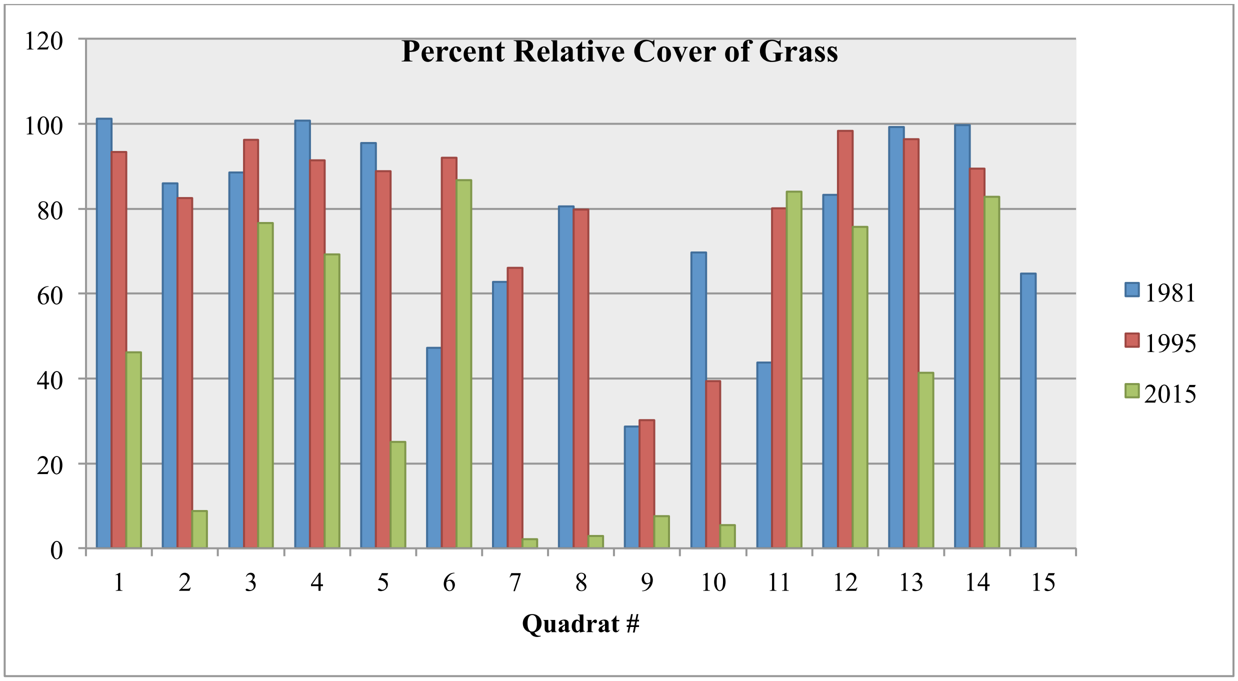

FIGURE 6. Percent relative cover of grasses by quadrat over time in LJV.

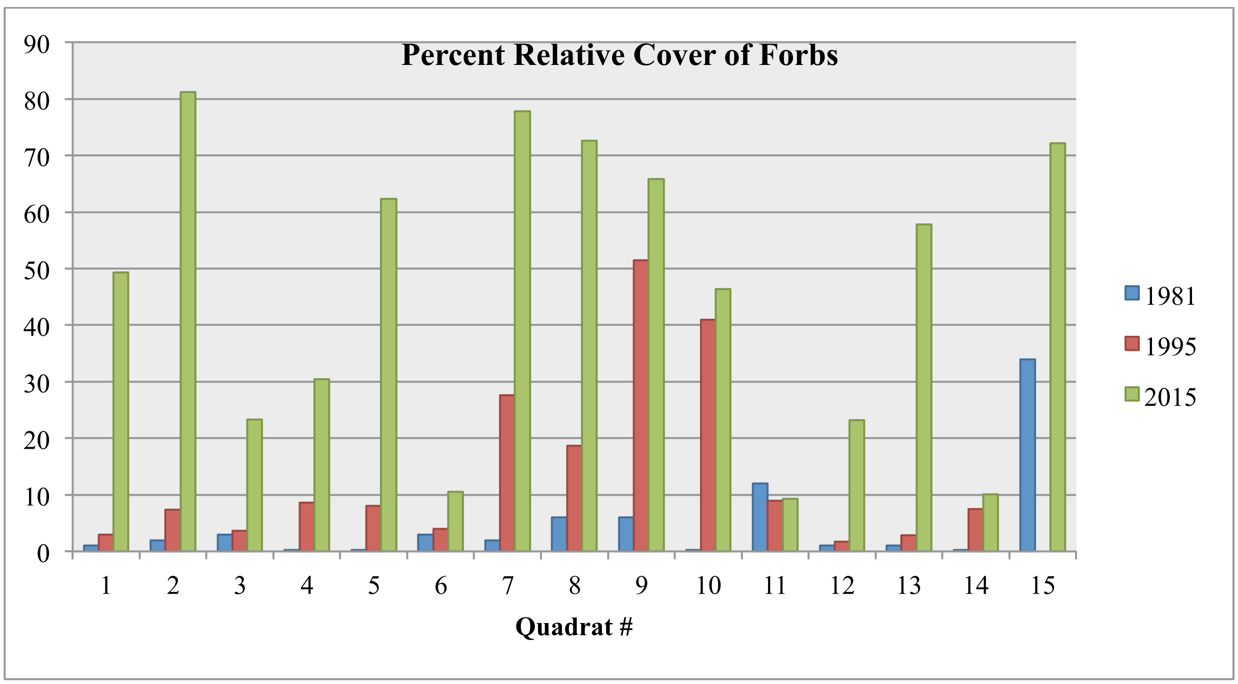

FIGURE 7. Percent relative cover of forbs by quadrat over time in LJV.

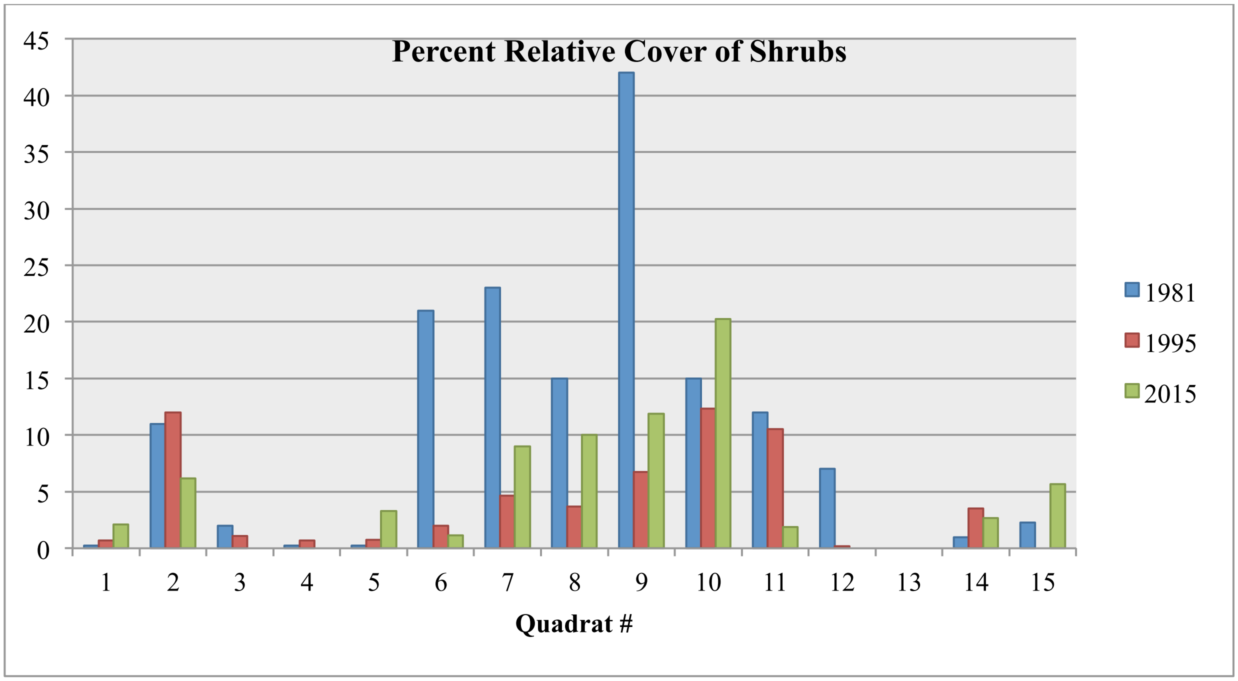

FIGURE 8. Percent relative cover of shrubs by quadrat over time in LJV.

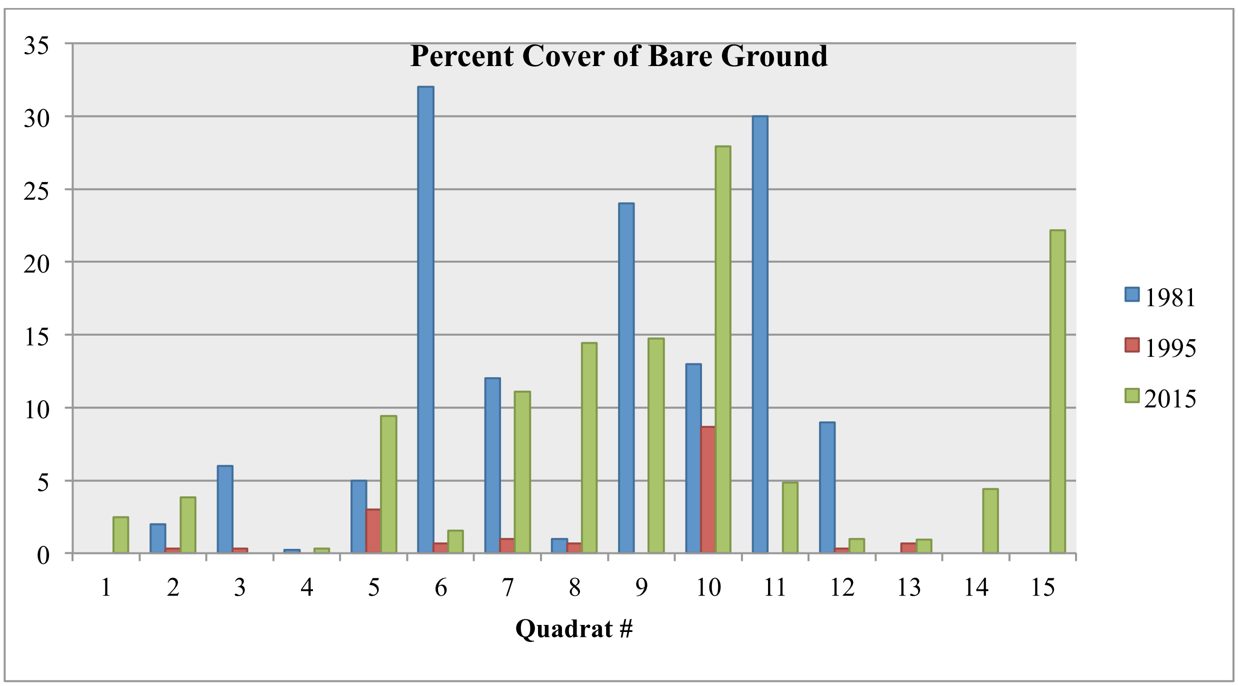

FIGURE 9. Percent relative cover of bare ground by quadrat over time in LJV.

Forbs

Deinandra fasciculata was the forb species with the greatest cover with an average percent relative cover of 10.9%. It was found in ten of the quadrats, and ranged from 1% to 55.4%. Only including the quadrats with its presence, *D. fasciculata* had an average relative cover of 16.3%.

Shrubs

The shrub with the greatest percent relative cover was *Malosma laurina*. Its average percent relative cover was the highest among the shrubs at 1.6%, and ranged from 0.4% to 11.7%. *M. laurina* was present in six of the quadrats, and its average percent relative cover for only those quadrats was 3.9%. The shrub with the next highest cover was *Eriogonum cinereum*, with an average percent relative cover of 1.2%, and ranged from 0.9% to 6.1% in the five quadrats where it was identified.

Bare Ground

A complete lack of cover, recorded as "bare ground" was found at fourteen of the quadrats, ranging from 0.3% to 27.9% relative cover (quadrats 3 and 10, respectively). The average amount of bare ground was 7.9%.

Frequency[6]

Grasses

As with the cover data, the exotic *Avena* species had the greatest average percent frequency, 42.4%. Its frequencies ranged from 0% to 96%. Excluding the eight quadrats where the species were not found, the average frequency rose to 90.9%.

[6] The percent frequency of each species in each quadrat is displayed in table format in Appendix C.

The second most frequent grass species was *S. pulchra*. It had an average frequency of 15.6%, and ranged from 0% to 42%. Excluding the three quadrats where *S. pulchra* was not found, the average frequency rose to 19.5%. Next was the exotic species *F. perennis* with 13.7% average frequency, or 25.8% excluding the seven quadrats where it was not present. Second to last was the exotic species *P. aquatica* at 7.3% average frequency, or 27.5% including only the four quadrats where it was found. Lastly, *S. lepida* had the lowest average frequency at 2.5%, or 9.5% only including the four quadrats in which it was identified.

Forbs

The forb with the greatest average frequency was *Deinandra fasciculata* with 33.9%. It was also the forb with the greatest percent relative cover. *D. fasciculata* was tied in frequency with *Dichelostemma capitatum*, and the exotic *Sonchus asper* being found in thirteen of the fifteen quadrats. The exotic *Erodium cicutarium* had the second highest average frequency, 24.1%. *Calystegia macrostegia*, *Di. capitatum*, and *So. aspe*r with average frequencies of 22.4%, 19.6%, and 16.7% follow it respectively. Four of the five most frequent forbs were native species. The fifth forb species, *So. asper*, ranged from 0.1% to 14.5% average frequency.

Shrubs

The shrub species with the greatest frequency was *Eriogonum cinereum*. Out of the fifteen quadrats its average frequency was 6.9%. The next most frequent shrub species were *Artemisia californica*, *Salvia leucophylla*, and *M. laurina* with 2.3%, 2.1%, and 2.0% average frequencies respectively. Only one other shrub species, *Grindelia camporum*, had an average frequency over 1% (1.3%). The six other shrub species had average frequencies of less than 1%.

Bare Ground

Only four quadrats had any "bare ground" as measured with the mini-quadrat frequency methodology with an average frequency of 0.5%. Excluding the quadrats without any "bare ground" readings, the average frequency rose to 2%.

Shrub Density[7]

The shrub species with the highest average density across all quadrats was *E. cinereum* with an average of 119 individual plants per quadrats, or a density of 0.30 plants per meter squared. Burned shrubs were the second most dense, averaging 64.53 plants per quadrat, or 0.16 plants per meter squared. Third was *A. californica*, with an average of 41 plants per quadrat, or 0.10 plants per meter squared.

It should be noted that no distinction was made between seedlings and mature plants. Additionally, it was decided to include a count of burned shrubs that had not re-sprouted in effort to understand the shrub density prior to the May 2013 fire.

Results from Data Combination[8]

Percent relative cover was determined for all species in all quadrats. For each quadrat, the species' cover values were combined into the following categories: native grasses, exotic grasses, native forbs, exotic forbs, shrubs, and bare ground. Finally, the quadrats' values for these categories were averaged to provide a general picture of the valley for each data collection period. The percent relative cover by year is visually depicted in the graphs below in Figure 10 (1981), Figure 11 (1990s), and Figure 12 (2015).

Several trends became apparent when the data from the three iterations are combined and then divided into the abovementioned categories. Both native and exotic forbs increased between

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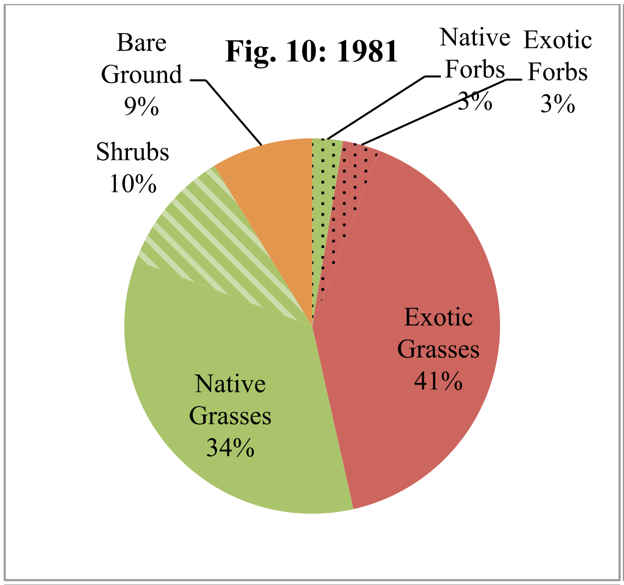
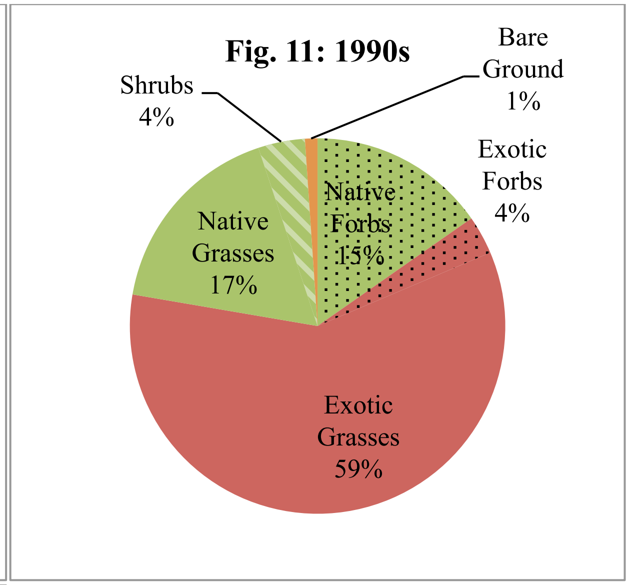
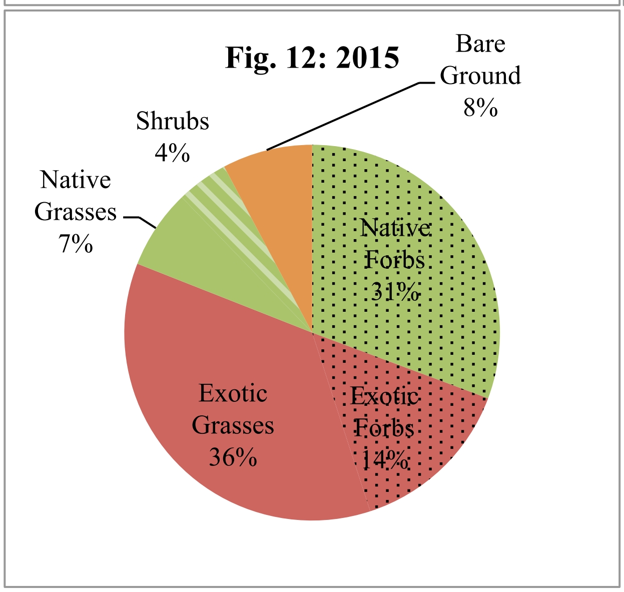
[7] The shrub densities for all species encountered in the fifteen quadrats are displayed in tables within Appendix D.

[8] Some calculations of percent change were undefined, as when a species was absent in 1981 but then present in the 1990s.







FIGURES 10–12. Percent average cover by category. These charts depict percent relative cover, averaged for all quadrats throughout the valley for each data collection period.

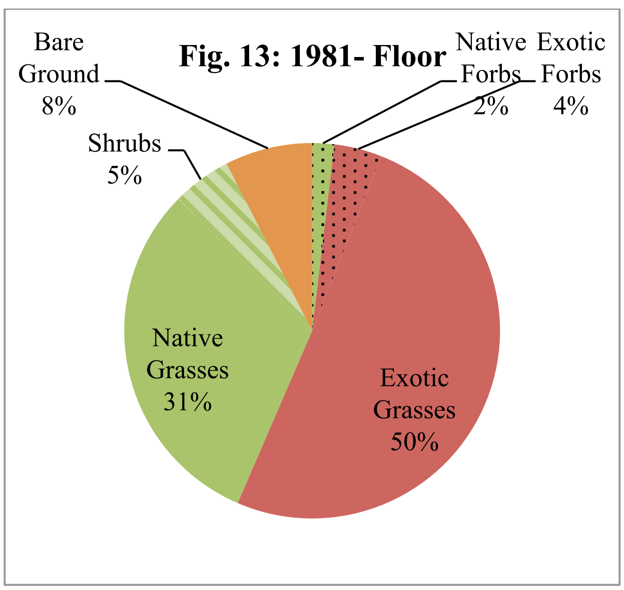
each data collection, significantly so for native forbs in the 1981 and 2015 comparisons ($p < 0.05$), and there were consistently more native forbs than exotic ones, though not significantly so (p ranges from 0.35 to 0.14, dwindling through time). Native grasses decreased in cover, significantly so in the 1981 and 2015 comparison ($p = 0.03$), and, though exotic grasses fluctuated, they always made up a greater amount of cover than their native counterparts, significantly so by the 1990s and 2015 ($p < 0.05$). Lastly, cover of bare ground fluctuated and shrubs declined, neither significantly (p ranges from 0.15 to 0.50).

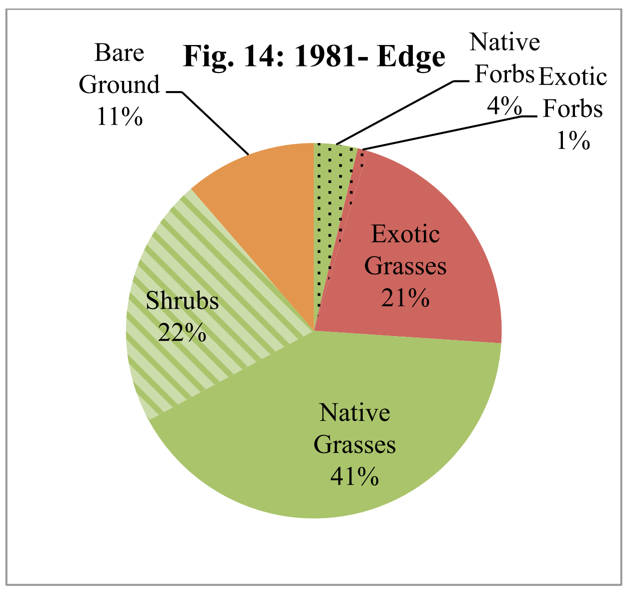
In 1981 (Fig. 10) grasses averaged 75% relative cover, with 34% natives and 41% exotics. The cover of grasses remained close, 76% into the 1990s (Fig. 11), but native grasses decreased to 17% and exotics increased to 59%. By 2015 (Fig. 12), average grass cover had decreased to 43%, 7% native and 36% exotic. Forbs, on the other hand, had increased in average cover between each data collection period. In 1981 forb cover was only 6% (3% native and 3% exotic) but increase to 19% in the 1990s (15% native and 4% exotic). By 2015 forbs made up 44% of cover (31% native and 14% exotic), thus surpassing grasses. Shrubs decreased from 10% in 1981 to 4% in the 1990s and in 2015. All shrubs found were native species, with the exception of *Nicotiana glauca* found in quadrat 15 in 1981. Bare ground cover fluctuated from 9% in 1981, to 1% in the 1990s, to 8% in 2015.

From 1981 to the 1990s, the thirteen quadrats with *S. pulchra* decrease in percent cover of this species, and did so by an average of 52.3%, or 3.7% per year. From the 1990s to 2015, twelve quadrats contained *S. pulchra*, and only ten showed a decrease in cover (76.9% on average, or 3.8% per year). This shows a steady state of decrease despite the spring 2013 fire. Quadrats 4 and 11 showed an increase in *S. pulchra* cover from the 1990s to 2015, 65% (3.25% per year) and 73% (3.67% per year), respectively. In 1981 Carole Gale found only exotic grasses in quadrat 15, it was not resampled in the 1990s, and in 2015 no grasses were found in this quadrat.

Native grasses also declined in the number of species present. *S. pulchra* and *S. lepida* were present in all data sets, but *Bromus carinatus* was only found in 1981, and *Elymus condensatus* was not present after the 1990s. In 1981 and the 1990s *S. lepida* was present in three quadrats, averaging 14% and 11.9% relative cover, respective of their date of data collection, an average decrease of 29.9%, or 2.1% per year. By 2015 *S. lepida* was found in six quadrats, with an average 2.0% relative cover, a decrease of 95.8%, or 4.8% per year—more than twice the previous rate of decline.

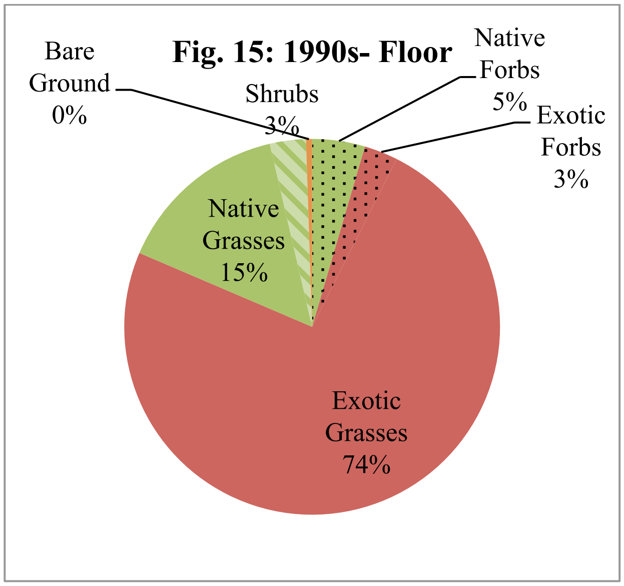
To see if percent relative cover results differed based on location within the valley, quadrats were categorized into one of two categories: [valley] floor or [valley] edge (see Fig. 4). Quadrats 7, 8, 9, and 10 made up the latter category, with the remaining (1–6 and 11–15) making up the former. Percent relative cover for native and exotic grasses and forbs, shrubs, and bare ground were averaged among the quadrats of each category. These values were the basis for comparison, and depicted in Figures 13–18.

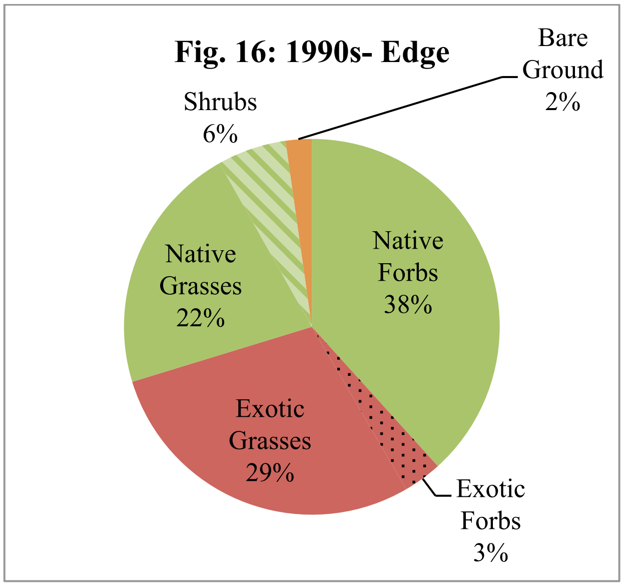




FIGURES 13 & 14. Percent average cover by category for floor and edge quadrats in 1981.

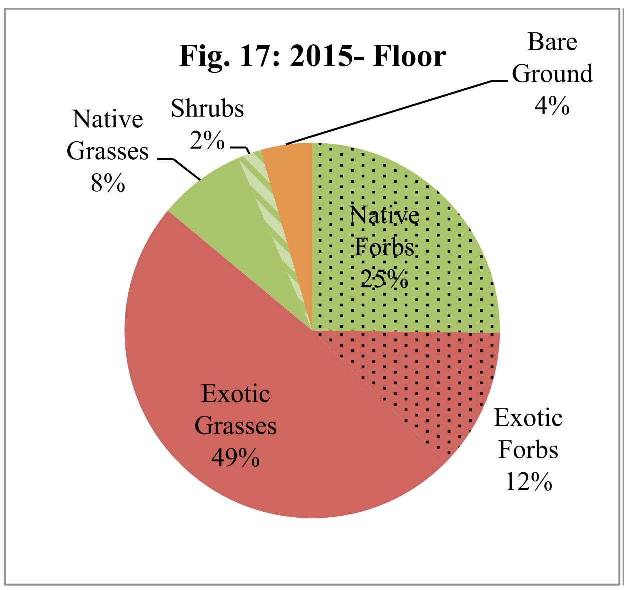
When divided into edge and floor categories, many trends remain the same as when they were combined. Exotic grasses increased then decreased in cover over time and native grasses always decreased, these latter significantly through the whole period ($p < 0.05$). Also, bare ground cover decreased then increased. While exotic grasses made up a greater percentage of cover than native grasses in the valley in general, and this held true for quadrats on the valley floor, quadrats on the valley edge had more native than exotic grass cover in 1981, though not significantly so ($p = 0.27$) (Fig. 14), and 2015 (Fig. 18). Native and exotic forbs increased in each data collection interval, significantly so from 1981 to 2015 ($p < 0.05$ for natives and $p < 0.10$ for exotics), with the exception of exotic forbs on the valley floor from 1981 to the 1990s (4% to 3%). Looking at shrub cover for all three categories of quadrats (floor, edge, and overall) they all showed a decrease from 1981 to the 1990s. From the 1990s to 2015 the floor quadrats showed further decrease and edge quadrats increased (though not back to 1981 levels), but overall shrub cover remained the same. Native forbs did increase significantly in general ($p = 0.01$), on the floor ($p = 0.05$), and on the edge ($p = 0.05$) for all years, but at the edges the increase from the 1990s (Fig. 16) to 2015 (Fig. 18) was minimal at 4.5% (44.3% to 45.7%), with a p value of 0.40.

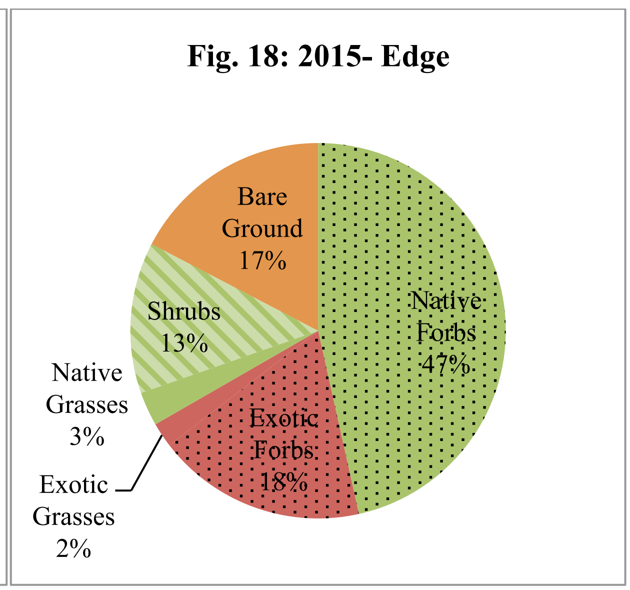




FIGURES 15 & 16. Percent average cover by category for floor and edge quadrats in the 1990s.

The most notable difference between floor and edge was native versus exotic grasses. In 1981, quadrats on the valley edge showed greater cover by native than by exotic grasses (41% versus 21%), as shown in Figure 14, though, with a p value of 0.27, the difference was not significant. Moving forward to the 1990s, native grass cover decreased (to 22%), and exotic grass cover increased (to 29%) to out-weigh the former at the valley edge (Fig. 16), though not significantly ($p = 0.41$). Native grasses continued to decrease by 2015 (to 3%), but this time exotic grasses decreased as well (to 2%), enough to again make up less cover than their native counterparts (Fig. 18), again not significantly ($p = 0.46$). On the valley floor, exotic grass cover averaged for the eleven quadrats (ten in the 1990s) was always dramatically higher than native grass cover (Figs. 13, 15, and 17), significantly so in the 1990s ($p < 0.001$) and 2015 ($p < 0.01$).





FIGURES 17 & 18. Percent average cover by category for floor and edge quadrats in 2015.

CHAPTER 5

DISCUSSION

This study finds that over the past 34 years native California bunchgrasses have declined dramatically in LJV. Between the first iteration of the study in 1981 and the second from 1994 to 1996, *S. pulchra* declined by 56.86%, or 4.02% per year. The findings of the current study indicate that *S. pulchra* declined by 61.11%, or 3.06% per year, from 1990s levels. Somewhat surprisingly, the results indicate that exotic grasses have also declined, although slightly, over time while native forbs show a pronounced increase. Shrub cover fluctuated during the study period, as well as bare ground. The study also finds that vegetation cover varies somewhat between valley floor and edge or slope of valley locations. Most notably, edge quadrats show greater coverage by native grasses. Overall, the findings tend to support Minnich's forb-field theory, that the original plant cover in the valley was not bunchgrasses, but contained a larger amount of forbs. The study further sheds light on the other hypotheses and theories previously introduced.

Theory suggests that competition from invasive exotic annual grasses is a major factor causing a decrease in native grasses over time in Southern California (Hamilton, Holzapfel, and Mahall 1999); however, the data clearly show a decline in most exotic grasses as well native grasses. The data also find that forbs, and especially native forbs, increased during both periods. Together these findings suggest that the cause of native grass decline is more complicated; they force a reconsideration of the assumption that native bunchgrasses were the original vegetation cover in LJV. While the results seem to support Minnich's alternative hypothesis that forbs were the original cover in many of California's valleys, there are a few caveats that require discussion.

Natural Enemies and Disturbance Hypotheses

By compiling the 2015 data alongside the earlier data sets, it is possible to assess the validity of the predictions made based on the natural enemies, disturbance, and post-disturbance hypotheses, as well as the bunchgrass and forb-field theories. Both the natural enemies and disturbance hypotheses predict that over time there would be an increase in exotics and concurrent decrease in native species. The validity of the natural enemies and disturbance hypotheses is determined by comparing cover of native species to exotic species, while grass versus forb comparisons provide insight into the debate between Clements' bunchgrass theory and Minnich's forb-field theory. Further dividing these results based on their location within the valley provides for the assessment of the post-disturbance hypothesis.

The natural enemies hypothesis predicts that invasions occur when the exotic species no longer have to cope with the threat of their natural enemies, which would normally keep their populations in check (Darwin 1859; Williams 1954; Elton 1958; Hierro, Marron, and Callaway 2005). In the case of LJV, enemies such as cattle and other grazing/herd animals were brought over at the same time as many of the exotic grasses; therefore, there was at least one enemy they did not escape. This presents the possibility that initial invasion by exotics was tempered by the presence of cattle, suggesting that invasion would intensify with the disappearance of cattle.

The findings of the present study do not corroborate this prediction. While exotic grass cover does initially show an increase in the 1990s, in 2015 it subsequently declines to below 1981 levels (Figures 3–5). As for forbs, which may or may not be impacted by cattle to the same degree as grasses, both native and exotic species increase between each data collection (Figures 3–5). Once more, the natural enemies hypothesis cannot consistently explain the findings (i.e., it accounts for the increase in exotic forb cover, but not for the increase in native forb cover).

The disturbance hypothesis proposes that exotic invasions are enabled by the invading plants having the particular advantage over the native plants of evolving to coexist with certain disturbances (e.g., cattle grazing) (Hierro, Marron, and Callaway 2005; Gray 1879; Baker 1974; Mack et al. 2000). The invasion of exotic annual grasses coinciding with the use of LJV for cattle ranching provides support for this hypothesis. The disturbance hypothesis can be extrapolated to suggest that the removal of cattle would herald an end to this evolutionary advantage and the beginning of native plants reestablishing their dominance. Barry's review of LJV in 1972 for the California Department of Parks and Recreation provides evidence that this indeed occurred. He found that "the release of grazing pressure on the valley has apparently shifted the competitive position of needlegrass. Under a no-grazing regime, native perennial needlegrasses are favored over exotic annual grasses in much of La Jolla Valley" (44). The data from this study show that this trend did not last, and, therefore, neither did support for the disturbance hypothesis. Instead, native grasses have not become dominant and have decreased. Exotic grasses have continued to exist, though not in a stable state, as suggested by their increase and subsequent decrease in cover (Figures 10–12). While some exotic grasses have done better than others, particularly *Avena* ssp., *P. aquatica*, and *F. perennis*, *Bromus carinatus,* another exotic grass species, had disappeared from all quadrats by 2015. Possibly, only some species of exotic annual grasses truly have evolved to depend upon grazing or other disturbances.

Unfortunately, Barry (1972) does not mention past or then current states of forb species in LJV. In this study, native forbs always make up a greater percentage of relative cover than exotic forbs, although both showed increases between each pair of study periods. As this does not show natives becoming dominant while exotics lose their position of dominance, the disturbance hypothesis again goes unsupported.

When all natives are compared to all exotics, the exotics neither consistently increase in cover, nor remain stable. In 1981, natives made up 50% of relative cover, and exotics made up 41%. In the 1990s, natives decreased to 37% cover, and exotics increased to 62%. In 2015, native cover increased (although not up to 1981 levels) to 42%. Concurrently, exotic cover decreased to 50% (again, not back to 1981 levels). With only three data points to analyze, it is not yet possible to determine a pattern or trend. The natural enemies and disturbance hypotheses are unable to explain these changes. In this case investigating the role of fire in future studies may provide an explanation. For those exotic species that have persisted, other types of disturbances, such as shrub removal or disking, which often occurred in conjunction with grazing, may be playing a role, as explored below with the post-disturbance hypothesis.

Bunchgrass and Forb-field Theories

Minnich's forb-field theory suggests that forbs were dominant prior to European contact. Clements' bunchgrass theory advocates for perennial bunchgrasses as the original dominant cover. If we assume that the currently dominant species (or those becoming dominant) are indicative of what the valley looked like before invasion, then this study provides support for Minnich's theory. Figures 10, 11, and 12 clearly indicate that forbs have increased overall since the first study. Shrubs first decreased, and then remained the same. This may be due to the second data set being collected in the growing seasons directly following the Green Meadow Fire of 1993, as fire has a stronger impact on shrub cover as they die back after a fire. Grasses were very similar for the first two studies, but drop significantly by 2015. This supports Minnich's forb-field theory over Clements' bunchgrass theory, although that is contingent upon believing that self-restoration is possible.

According to Barry (1972), LJV had the finest stands of purple needle grass either he or Dr. Harold F. Heady had ever seen. Additionally, he writes, "Dr. Heady also noted that the stands had expanded greatly since 1965" (1972, 36). It appears this trend did not continue as the data collected from the quadrats clearly show native grasses declining since the early eighties. The anecdotal findings from Barry (1972) suggest that Clements' bunchgrass theory is correct, but the more recent findings of the present study suggest Minnich's forb-field theory is correct. It is presently unknown whether this change was inevitable and Minnich was right, or if an unknown factor came into play between 1972 and 1981 that dramatically altered the fate of *S. pulchra*. It is important also to note the possibility of bias by Barry and Heady as Clements bunchgrass theory was then accepted as true.

While Barry (1972) does not mention changes in native forbs, our data show they have increased substantially in cover in twelve out of fourteen quadrats from 1981 to the 1990s. Native forb cover further increased from the 1990s to 2015 in eleven of fourteen quadrats. While this may be a sign that LJV is becoming, or even returning to, a forb-field state, it is extremely important to keep in mind the great variance in forbs. That is, their presence and abundance is largely dependent upon annual precipitation rates, as demonstrated by Minnich (2008, 204–220), and the time of year when the data are collected. Strassforth's data from the 1990s were averaged to make data from three years into a single figure for that time period, but when examined by individual year, significant variation is apparent in just that short amount of time. Evidence of this can be seen in the numbers of forb species present in the cover data for each year (see Appendix E). Forbs overall, both native and exotic, show an increase in cover in twelve out of fourteen quadrats from 1981 to the 1990s and from the 1990s to 2015.

While Minnich's forb-field theory may explain the increase in forbs in LJV (i.e., that forbs were the original dominant form of vegetation in the valley) it does not necessarily explain the continued decrease in native grasses. For one, if forbs were the predominant cover, why were there more and rather large patches of native grasses at the time of the original vegetation studies in the valley? There is some research to suggest that *S. pulchra* is effective at colonizing mechanically disturbed sites (Barry 1972). Moreover, it is also possible that Native American burning practices historically increased perennial grass cover—there is substantial evidence that they had a long term and important presence in LJV. Additionally, it is highly likely that burning of the valley persisted throughout much of the ranching era, as this was a very common practice (Laris, Brennan, and Engelberg 2016).

Post-disturbance Hypothesis

The post-disturbance hypothesis predicts that an area's ability to self-restore (once the disturbance is removed or ended) is determined by what type of disturbance the land underwent as well as the intensity of the disturbance. The valley's history of grazing, disking, and shrub removal is known, but there is some uncertainty as to which parts of the valley had shrubs removed or were disked and why. Common sense, some photographic evidence, and historical documents strongly suggest that the most intensive and frequent disking occurred on the more level and less rocky valley floor (Laris, Brennan, and Engelberg 2016). With this in mind, the quadrats may be divided into two categories based on their location—valley floor or hillside/valley edge—with approximately eleven landing in the valley floor and four landing in hillside/valley edge categories. The quadrats located on the valley floor are likely to have been disturbed to a greater degree than those on the hillsides and valley edges, and, therefore, contain fewer natives than the latter. The present study supports this hypothesis as the edge quadrats always have more native than exotic cover, while the reverse is true for quadrats on the valley floor (Figures 13–18). This is consist with the earlier findings of Barry (1972), that "[n]o native species were found in the center of the valley" (44). The post-disturbance hypothesis may explain the different balances of native versus exotic species cover based on location, but does not provide insight as to why the grasses (native and exotic alike) decline while forb cover increases.

There has been minimal disturbance since the removal of cattle and the end of mechanical disking in 1965, with the exception of highly localized chemical spraying of *P. aquatica* and fires in 1973, 1993, and 2013 (which do not represent an unusual fire frequency for the region) (California Department of Forestry and Fire Protection 2015). Thus, it is possible to assess the impact of the end of frequent disturbances on the native grass cover. Strassforth (1996) found that native grasses had decreased since 1981, but also hypothesized that this transition was coming to an end and that a new steady state was soon to come. The results of the present study suggest this is not true. Indeed, rather than stabilizing, native grasses have continued to decline (*S. pulchra* at almost the same rate as before, while some other native grasses disappeared completely). At the same time, shrub cover has increased quite dramatically in the valley (Engelberg et al. 2013), although most, but not all, shrub advancement has occurred on the valley edges and slopes and not on the more level valley floors where the grass plots were placed (Figure 19, from Engelberg et al. 2013).[9] It is readily apparent that a new steady state has yet to be reached.

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[9] The finding in Engelberg et al. (2013) that shrubs are advancing is contrary to the finding of this study that shrub cover has decreased over all since 1981, and is fluctuating in the edge quadrats. This discrepancy is most likely due to how the quadrats were selected originally (See Gale 1983).

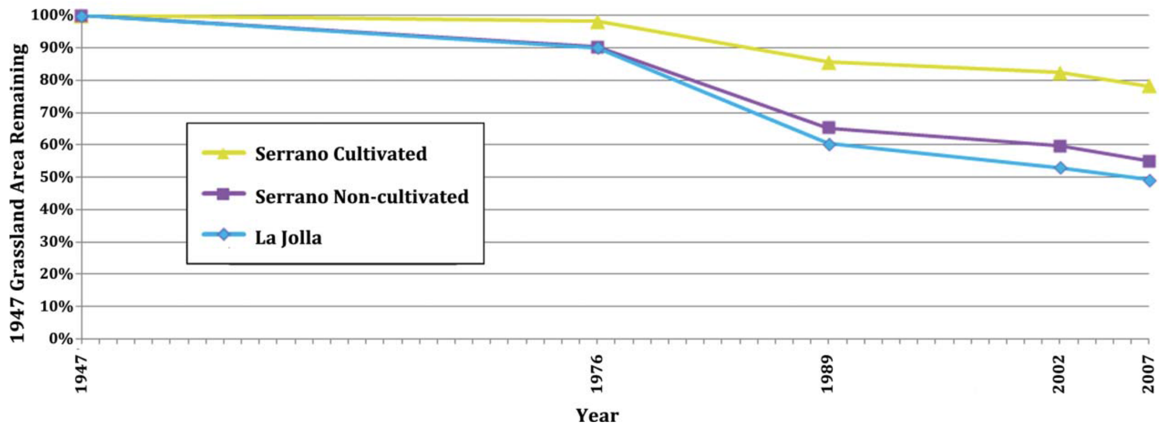

FIGURE 19. This graph shows how grassland has declined (and shrub cover has increased) similar to the uncultivated areas of Serrano Valley, LJV's neighbor to the east.

Limitations

In addition to the variable nature by which forbs appear to researchers, other limitations existed to the present study. Due to the considerable lag time between iterations of this study it was decided to average the results of the data collection from 1994 to 1996. While this does not utilize that set of data to its full potential (identifying minor changes on a year-to-year basis), in effort to compare it accurately to the data from 1981 and 2015, it needed to be looked at as a single entity. As future years should provide additional year-to-year data, the data from the 1990s may be reexamined with greater detail. This may provide greater insight into the short-term changes in the quadrats for the years directly following a fire. It should also be noted that the results of the fieldwork are not necessarily representative of the valley in general. The quadrat locations, as selected by Suzanne Gale, were chosen because of the presence and abundance of native grasses, *S. pulchra* in particular (1983, 10). Because the quadrats inherited from the previous studies are not random samples of the valley in general, this study's results may not fully represent what is happening in the valley in terms of general trends due to potential sampling error. In terms of the inherited quadrats, however, native and exotic forbs are increasing, native grasses are decreasing, and exotic grasses are fluctuating widely. With that caveat, the general trends suggest that native and exotic forbs are increasing in LJV, native grasses are decreasing, and exotic grasses are fluctuating dramatically through time.

Lastly, the present study is underpowered due to the small sample size (n=15), an issue inherited from the previous studies. This at times caused comparisons between the study's iterations to narrowly miss statistical significance. Additionally, the findings are further weakened by the irregularity by which some quadrats were surveyed in the 1990s.

CHAPTER 6

CONCLUSION

Native perennial grasses are known to be scarce and in decline in California (D'Antonio et al. 2007). Park managers and conservationists have long thought that the elimination of grazing and other disturbances would result in a recovery of these grasses. Evidence from the LJV study clearly demonstrate that such a recovery is not occurring, and indeed native grasses are experiencing rapid decline. Average cover of native grasses was 37% in 1981, fell to 17% in the 1990s, and fell again in 2015 to 7%. Exotic grass cover fluctuated from 39% in 1981 to 59% in the 1990s and then to 36% in 2015. Meanwhile, both native and exotic forbs have shown continual increase in cover (3% and 1% in 1981, 15% and 4% in the 1990s, and 31% and 14% in 2015).

The reasons for the decline of native grasses are difficult to discern and possibly multiple. The results of this study shed light on several overlapping hypotheses that potentially explain this conundrum. First, while it is clear that native perennial grass have lost the most ground as measured by both frequency and percent cover, exotic annual grasses have also declined. As such, the results generally support Minnich's theory that forbs, and not bunchgrasses, were the original cover in California's valleys. However, this logic raises the question of why were there large patches of native grasses in LJV in 1981, approximately 13 years after at the end of the ranching era.

In sum, the body of evidence presented here suggests a more complicated picture for Southern California's coastal mountain valleys. Recent evidence suggests that prior to the introduction of exotic species, shrub cover was greater than was found in the present study. Grazing management included frequent efforts to reduce shrubs, and this involved a regime of disturbances that included burning and mechanical disturbances as well as the planting of exotic grasses. It is not know how these activities, along with grazing, may or may not favored native bunchgrasses, but at least one study suggests *S. pulchra* would have benefitted from such a disturbed landscape (Bartolome and Gemmill 1981). At present it is clear that the vegetation cover of LJV is in flux; shrubs and forbs are both increasing at the expense of native and exotic grasses. This suggests that native cover in LJV may indeed have been a mix of shrubs, forbs, and a variety of grasses at the time of Spanish arrival. Clearly shrub cover was higher when the ranching commenced in the valley as evidence of shrub removal is well documented (Hobbs 1983, Engelberg et al. 2013, and Laris, Brennan, and Engelberg 2016). The question remains as to why perennial grasses were common in the valley at the end of the ranching period. It may be that bunchgrasses compete well in a shrub-dominated landscape. Indeed, the research found that native grasses had higher percentages in plots on the valley edges where shrubs are also more common. Recent research on shrub recovery shows that native perennials, such as *S. pulchra*, are in the process of increasing beneath an encroaching shrub canopy (Brennan, Laris, and Rodrigue 2017).

This study has made it apparent that scientists still do not have a clear understanding of the relationships native grasses have with exotic grasses and/or exotic forbs. From a holistic point of view, it is unreasonable to expect to find a single cause for the persistence of an exotic plant species. While it is important for researchers and academics to look at specific hypotheses regarding exotic plant invasion, persistence, and subsequent native recovery, it is equally important to bring multiple hypotheses together to gain a holistic understanding.

With that in mind, the results of this study's specific hypotheses show support for, and are supported by, multiple hypotheses. The results show a definite decrease in native grasses, although the disturbance hypothesis would suggest an increase in the population of natives (grasses or forbs) over time. This confounding result may stem from the large amount of time having passed since anthropogenic disturbance ceased (circa 1965). Perhaps there was an increase in native grasses immediately following the removal of cattle and an unknown factor came into play between then and the first data collection in 1981. The disturbance hypothesis tells us that following the removal of a disturbance (cattle ranching, in this case) exotic grass species would decrease.

Future Research and Applications

A greater understanding of the measures the California Park Service has taken against the spread of certain exotic grass species is required to better understand the changes in the species composition of the valley. Specifically, such information is vital with regard to the upcoming *S. pulchra* seeding in the valley. Future iterations of this study should expand from passively marking changes over time, to also include data on the success or failure of projects such as the seeding in order to actively direct and inform the Park Service on restoration projects. Additionally, experiments with types of disturbance—such as fire, grazing, and/or disking—might shed light on the reasons for which *S. pulchra* cover was higher in 1981 when those disturbances were removed.

Studies such as those presented in this thesis are important to the future of LJV as efforts continue toward restoring the land to its original state. Other areas of California dealing with decreasing populations of native grasses may benefit from any insights gained. Additionally, the rare and endangered species that inhabit California's grassland ecosystems (e.g., Kangaroo Rat and Western Meadowlark) benefit as well. Research should stop looking to humans for answers to the question of bunchgrasses versus forbs, and instead look at the native species that inhabit (or previously inhabited) California's grasslands. It may be through their needs that a best environment can be determined.

APPENDICES

APPENDIX A

QUADRAT LOCATION DATA

APPENDIX A

Coordinates of each quadrat's corners.

	Upper-left	Upper-right	Lower-left	Lower-right
Quadrat 1	34.100318, -119.050387	34.100120, -119.050371	34.100333, -119.050571	34.131569, -119.091563
Quadrat 2	34.104232, -119.043858	34.168739, -118.984915	34.104358, -119.043883	34.104136, -119.044170
Quadrat 3	34.105474, -119.038024	34.105370, -119.038282	34.105545, -119.038091	34.105478, -119.038328
Quadrat 4	34.105632, -119.055078	34.105609, -119.054796	34.105479, -119.055010	34.105474, -119.054793
Quadrat 5	34.100723, -119.054223	34.100746, -119.054451	34.100868, -119.054183	34.100927, -119.054423
Quadrat 6	34.107069, -119.035331	34.106861, -119.035402	34.107104, -119.035451	34.106930, -119.035609
Quadrat 7	34.095498, -119.050682	34.095420, -119.050529	34.095415, -119.050778	34.095274, -119.050623
Quadrat 8	34.094377, -119.049799	34.094191, -119.049578	34.094210, -119.049546	34.133370, -119.070453
Quadrat 9	34.097148, -119.046896	34.097150, -119.046766	34.096913, -119.046945	34.096897, -119.046814
Quadrat 10	34.132799, -119.070059	34.107717, -119.052777	34.107874, -119.053073	34.107705, -119.052950
Quadrat 11	34.105971, -119.040681	34.105748, -119.040535	34.105870, -119.040808	34.105683, -119.040663
Quadrat 12	34.109381, -119.032427	34.109217, -119.032520	34.109442, -119.032547	34.109278, -119.032652
Quadrat 13	34.101822, -119.048342	34.101762, -119.048156	34.111793, -119.055444	34.101635, -119.048207
Quadrat 14	34.106791, -119.049892	34.106859, -119.049591	34.106629, -119.049856	34.106716, -119.049555
Quadrat 15	34.102848, -119.053277	34.102658, -119.053348	34.102836, -119.053504	34.125661, -119.066123

How the researcher should orient him or herself to assure proper assignment of corners as upper-left, et cetera.

	Orientation:
Quadrat 1	Back to main streambed
Quadrat 2	Back to trail
Quadrat 3	Back to trail

Quadrat 4	Back to trail
Quadrat 5	Back to trail connection/shady lunch spot
Quadrat 6	Front to trail
Quadrat 7	Back to trail
Quadrat 8	Front to trail
Quadrat 9	Back to trail
Quadrat 10	Back to stream bed
Quadrat 11	Back to downhill
Quadrat 12	Back to stream bed
Quadrat 13	Back to oak ditch
Quadrat 14	Back to trail
Quadrat 15	Back to trail

Corner markers for each quadrat.

	Upper-left	Upper-right	Lower-left	Lower-right
Quadrat 1	At least rocks	Rebar	At least rocks	Rebar
Quadrat 2	Rocks, maybe angle iron		At least rocks	
Quadrat 3	Only rocks	Angle Iron, metal pole	Angle Iron	Only rocks
Quadrat 4	Only rocks	Only rocks	Only rocks	Only rocks
Quadrat 5	Rebar	Angle Iron	Angle Iron	Angle Iron
Quadrat 6	At least rocks	At least rocks	Metal Pole	Rebar
Quadrat 7			Rebar	
Quadrat 8	Rebar	Rebar	Rebar	Rebar
Quadrat 9	Angle iron		Rebar	Rebar
Quadrat 10	Rebar	At least rocks	Rebar	Rebar, white rocks
Quadrat 11		Only rocks	Only rocks	Angle Iron
Quadrat 12	Angle iron	Angle Iron	Only rocks	Angle iron/metal pole
Quadrat 13		At least rocks	At least rocks	Angle iron
Quadrat 14	At least rocks	At least rocks	At least rocks	At least rocks
Quadrat 15	Angle iron, white rocks	Angle iron, white rocks	Angle iron	Angle Iron

APPENDIX B

COVER DATA BY QUADRAT

APPENDIX B

Cover Data by Quadrat: Grass Species

Quadrat 1	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	2.00	28.67	1333.33	95.24	40.78	42.26	2.11
Bromus diandrus	11.00	0.42	-96.21	-6.87	0.00	-100.00	-5.00
Bromus hordeaceus	1.00	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Bromus madritensis	1.00	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Festuca perennis	42.00	45.67	8.73	0.62	2.84	-93.79	-4.69
Hordeum murinum	2.00	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Stipa lepida	0.00	0.00	n/a	n/a	1.06	Undef.	n/a
Stipa pulchra	42.00	19.00	-54.76	-3.91	1.42	-92.53	-4.63
Vulpia myuros	0.25	0.08	-66.80	-4.77	0.00	Still Zero	n/a

Quadrat 2	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	5.00	4.67	-6.67	-0.48	0.00	-100.00	-5.00
Bromus diandrus	5.00	6.00	20.00	1.43	0.00	-100.00	-5.00
Bromus hordeaceus	11.00	0.42	-96.21	-6.87	0.00	-100.00	-5.00
Bromus madritensis	0.00	4.08	Undef.	n/a	0.00	-100.00	-5.00
Festuca perennis	7.00	17.33	147.62	10.54	0.00	-100.00	-5.00
Phalaris aquatica	18.00	21.00	16.67	1.19	3.08	-85.35	-4.27
Stipa lepida	0.00	0.00	n/a	n/a	1.92	Undef.	n/a
Stipa pulchra	40.00	19.67	-50.83	-3.63	3.85	-80.44	-4.02

Quadrat 3	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	2.00	22.33	1016.67	72.62	61.02	173.23	8.66
Bromus diandrus	0.00	1.33	Undef.	n/a	0.00	-100.00	-5.00
Bromus hordeaceous	11.00	0.08	-99.25	-7.09	0.00	-100.00	-5.00
Bromus madritensis	7.25	0.42	-94.25	-6.73	0.00	-100.00	-5.00
Festuca perennis	14.00	50.00	257.14	18.37	0.32	-99.36	-4.97
Stipa pulchra	54.00	22.00	-59.26	-4.23	15.34	-30.29	-1.51
Vulpa myuros	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a

Quadrat 4	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	0.25	27.67	10966.67	783.33	53.19	92.26	4.61
Bromus diandrus	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Festuca perennis	66.00	56.67	-14.14	-1.01	4.56	-91.95	-4.60
Stipa pulchra	34.00	7.00	-79.41	-5.67	11.55	65.00	3.25
Vulpia myuros	0.00	0.08	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 5	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	0.25	3.67	1366.67	97.62	0.00	-100.00	-5.00
Bromus diandrus	12.00	0.75	-93.75	-6.70	0.00	-100.00	-5.00
Bromus hordeaceous	1.00	2.00	100.00	7.14	0.00	-100.00	-5.00
Bromus madritensis	1.00	3.33	233.33	16.67	0.00	-100.00	-5.00
Festuca perennis	4.00	23.33	483.33	34.52	0.00	-100.00	-5.00
Hordeum murinum	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Phalaris aquatica	20.00	36.00	80.00	5.71	17.62	-51.05	-2.55
Stipa lepida	0.00	0.00	n/a	n/a	0.82	Undef.	n/a
Stipa pulchra	57.00	18.33	-67.84	-4.85	6.56	-64.23	-3.21
Vulpia myuros	0.00	1.33	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 6	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	13.00	26.00	100.00	7.14	66.93	157.41	7.87
Bromus diandrus	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus hordeaceus	4.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	4.00	3.33	-16.67	-1.19	0.00	-100.00	-5.00
Festuca perennis	1.00	43.67	4266.67	304.76	8.56	-80.40	-4.02
Stipa pulchra	25.00	19.00	-24.00	-1.71	11.28	-40.61	-2.03
Vulpia myuros	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a

Quadrat 7	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	0.25	21.67	8566.67	611.90	0.00	-100.00	-5.00
Bromus diandrus	1.00	0.42	-58.30	-4.16	0.00	-100.00	-5.00
Bromus hordeaceus	2.00	2.33	16.67	1.19	0.00	-100.00	-5.00
Bromus madritensis	1.25	14.00	1020.00	72.86	0.00	-100.00	-5.00
Festuca perennis	0.00	1.67	Undef.	n/a	0.00	-100.00	-5.00
Phalaris aquatica	0.00	0.00	n/a	n/a	0.35	Undef.	n/a
Stipa lepida	13.00	15.33	17.95	1.28	0.00	-100.00	-5.00
Stipa pulchra	45.00	6.33	-85.93	-6.14	1.74	-72.59	-3.63
Vulpia myuros	0.25	4.33	1633.33	116.67	0.00	-100.00	-5.00

Quadrat 8	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	8.00	31.67	295.83	21.13	1.11	-96.49	-4.82
Bromus carinatus	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus diandrus	1.00	3.33	233.33	16.67	0.00	-100.00	-5.00
Bromus hordeaceus	14.00	3.33	-76.19	-5.44	0.00	-100.00	-5.00
Bromus madritensis	24.00	15.75	-34.38	-2.46	0.00	-100.00	-5.00
Festuca perennis	0.00	0.08	Undef.	n/a	0.00	-100.00	-5.00

Stipa pulchra	33.00	19.33	-41.41	-2.96	1.85	-90.42	-4.52
Vulpia myuros	0.25	3.33	1233.33	88.10	0.00	-100.00	-5.00

Quadrat 9	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	3.00	8.00	166.67	11.90	0.00	-100.00	-5.00
Bromus hordeaceous	0.25	0.13	-50.00	-3.57	0.00	-100.00	-5.00
Bromus madritensis	0.25	0.13	-50.00	-3.57	0.00	-100.00	-5.00
Elymus condensatus	0.25	1.50	500.00	35.71	0.00	-100.00	-5.00
Phalaris aquatica	0.00	0.00	n/a	n/a	5.04	Undef.	n/a
Stipa lepida	25.00	20.00	-20.00	-1.43	2.52	-87.41	-4.37
Stipa pulchra	0.00	0.50	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 10	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus hordeaceus	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	3.25	2.00	-38.46	-2.75	0.00	-100.00	-5.00
Festuca perennis	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Gastridium phleoides	0.00	0.33	Undef.	n/a	0.00	-100.00	-5.00
Stipa lepida	0.00	0.00	n/a	n/a	1.35	Undef.	n/a
Stipa pulchra	64.00	36.67	-42.71	-3.05	4.05	-88.94	-4.45
Vulpia myuros	0.00	0.67	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 11	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	15.00	20.00	33.33	2.38	55.97	179.85	8.99
Bromus carinatus	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus diandrus	1.00	2.00	100.00	7.14	0.00	-100.00	-5.00
Bromus hordeaceus	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	0.00	2.50	Undef.	n/a	0.00	-100.00	-5.00
Festuca perennis	6.00	39.50	558.33	39.88	1.12	-97.17	-4.86
Melica imperfecta	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Phalaris aquatica	0.00	0.13	Undef.	n/a	0.00	-100.00	-5.00
Stipa lepida	4.00	0.50	-87.50	-6.25	0.00	-100.00	-5.00
Stipa pulchra	17.00	15.50	-8.82	-0.63	26.87	73.33	3.67

Quadrat 12	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	23.00	36.67	59.42	4.24	56.48	54.03	2.70
Bromus hordeaceus	25.00	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Bromus madritensis	0.25	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Festuca perennis	2.00	39.00	1850.00	132.14	15.95	-59.11	-2.96
Stipa pulchra	33.00	22.67	-31.31	-2.24	3.32	-85.34	-4.27

Quadrat 13	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	0.00	12.67	Undef.	n/a	25.78	103.49	5.17
Festuca perennis	99.00	67.00	-32.32	-2.31	15.53	-76.82	-3.84
Phalaris aquatica	0.25	16.67	6566.80	469.06	0.00	-100.00	-5.00

Quadrat 14	1981	1990s	% Change	%/Year	2015	%Change	%/Year
Avena sp.	0.25	53.50	21300.00	1521.43	78.41	46.57	2.33
Bromus diandrus	59.00	7.00	-88.14	-6.30	0.00	-100.00	-5.00
Bromus hordeaceous	0.25	0.00	-100.00	-7.14	0.00	Still Zero	n/a
Bromus madritensis	0.00	10.00	Undef.	n/a	0.00	-100.00	-5.00
Festuca perennis	0.00	0.50	Undef.	n/a	0.00	-100.00	-5.00
Hordeum murinum	0.25	0.00	-100.00	-7.14	0.00	Still zero	n/a
Phalaris aquatica	1.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Stipa lepida	0.00	0.00	n/a	n/a	4.41	Undef.	n/a
Stipa pulchra	39.00	7.50	-80.77	-5.77	0.00	-100.00	-5.00
Vulpia myuros	0.00	11.00	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 15	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	1.30	0.00	-100%	-7.14%	0.00	Still Zero	n/a
Bromus diandrus	62.5	0.00	-100.00	-7.14%	0.00	Still Zero	n/a
Bromus hordeaceous	0.20	0.00	-100.00	-7.14%	0.00	Still Zero	n/a
Hordeum murinum	0.10	0.00	-100.00	-7.14%	0.00	Still Zero	n/a

Cover Data by Quadrat: Shrub Species

Quadrat 1	1981	1994	1995	1996	2015
Grindelia camporum	0.25	1.00	1.00	0.25	0.00
Hazardia squarrosa	0.00	0.00	0.00	0.00	0.35
Salvia leucophylla	0.00	0.00	0.00	0.00	1.77

Quadrat 2	1981	1994	1995	1996	2015
Artemisia californica	2.00	2.00	2.00	2.00	3.08
Corethrogyne filaginifolia	7.00	0.00	0.00	0.00	0.00
Grindelia camporum	2.00	0.00	1.00	0.00	0.00
Hazardia squarrosa	0.00	0.25	0.00	0.00	0.00
Malmosa laurina	0.00	0.00	0.00	0.00	0.38
Salvia leucophylla	0.00	6.00	7.00	15.00	1.54
Solanum xanti	0.00	0.00	0.00	0.00	1.15

Quadrat 3	**1981**	**1994**	**1995**	**1996**	**2015**
Corethrogyne filaginifolia	1.00	0.00	0.00	0.00	0.00
Grindelia camporum	0.00	0.25	0.00	0.00	0.00
Hazardia squarrosa	2.00	1.00	0.25	1.00	0.00
Salvia leucophylla	0.00	1.00	0.00	0.00	0.00

Quadrat 4	**1981**	**1994**	**1995**	**1996**	**2015**
Baccharis pilularis	0.00	0.00	1.00	1.00	0.00
Grindelia camporum	0.25	0.00	0.00	0.00	0.00

Quadrat 5	**1981**	**1994**	**1995**	**1996**	**2015**
Baccharis pilularis	0.00	0.25	1.00	1.00	3.28

Quadrat 6	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	3.00	0.00	0.00	0.00	0.00
Corethrogyne filaginifolia	2.00	0.00	0.00	0.00	0.00
Grindelia camporum	1.00	0.00	0.00	0.00	0.00
Hazardia squarrosa	16.00	3.00	2.00	5.00	1.17

Quadrat 7	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	8.00	0.00	0.00	1.00	0.00
Baccharis pilularis	0.00	0.00	0.00	0.00	1.04
Eriogonum cinereum	2.00	0.25	1.00	0.25	4.51
Hazardia squarrosa	1.00	0.00	0.00	0.25	0.00
Malmosa laurina	0.25	1.00	1.00	1.00	0.00
Opuntia	0.25	0.00	0.25	0.00	0.35
Salvia leucophylla	12.00	1.00	3.00	4.00	3.13

Quadrat 8	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	11.00	0.25	0.25	1.00	0.00
Corethrogyne filaginifolia	2.00	0.00	0.00	0.00	0.00
Eriogonum cinereum	2.00	7.00	1.00	1.00	1.85
Hazardia squarrosa	0.25	0.00	0.00	0.25	0.00
Malmosa laurina	0.00	0.00	0.00	(blank)	5.93
Quercus	0.00	0.00	0.00	0.00	1.11
Salvia leucophylla	0.25	0.00	0.00	0.00	1.11

Quadrat 9	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	13.00	n/a	1.00	0.25	0.72
Corethrogyne filaginifolia	0.25	n/a	0.00	0.00	0.00

Encelia californicum	0.00	n/a	0.25	0.00	1.80
Eriogonum cinereum	10.00	n/a	10.00	9.00	6.12
Grindelia camporum	0.25	n/a	0.00	0.00	0.00
Hazardia squarrosa	0.25	n/a	0.00	0.00	0.00
Malmosa laurina	5.00	n/a	2.00	4.00	2.16
Salvia leucophylla	14.00	n/a	1.00	0.25	1.08

Quadrat 10	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	1.00	0.00	1.00	2.00	0.00
Baccharis pilularis	7.00	0.00	1.00	1.00	0.00
Encelia californicum	0.00	0.00	0.00	0.00	0.45
Eriogonum cinereum	0.00	7.00	4.00	5.00	4.50
Hazardia squarrosa	7.00	0.00	0.00	0.00	1.35
Malmosa laurina	0.00	1.00	4.00	2.00	11.71
Mimulus aurantiacus	0.00	0.00	2.00	5.00	2.25
Salvia leucophylla	1.00	0.25	0.00	0.00	0.00
Salvia mellifera	0.00	0.00	0.00	1.00	0.00

Quadrat 11	**1981**	**1994**	**1995**	**1996**	**2015**
Ademostoma fasciculatum	0.25	n/a	0.00	0.00	0.00
Artemisia californica	0.25	n/a	0.00	0.00	0.00
Corethrogyne filaginifolia	5.00	n/a	0.25	0.00	0.00
Grindelia camporum	1.00	n/a	2.00	0.00	0.00
Hazardia squarrosa	3.00	n/a	2.00	3.00	1.87
Malmosa laurina	1.00	n/a	0.00	0.25	0.00
Quercus	0.25	n/a	4.00	10.00	0.00
Ribes malvaceum	1.00	n/a	0.00	0.00	0.00
Ribes speciosum	0.25	n/a	0.00	0.00	0.00
Salvia leucophylla	1.00	n/a	0.00	0.00	0.00
Toxicodendron diversiloba	0.25	n/a	pr	pr	0.00

Quadrat 12	**1981**	**1994**	**1995**	**1996**	**2015**
Grindelia camporum	6.00	0.25	0.00	0.25	0.00
Hazardia squarrosa	1.00	0.00	0.00	0.00	0.00

No shrubs in quadrat 13.

Quadrat 14	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	1.00	n/a	0.25	1.00	0.00
Eriogonum cinereum	0.00	n/a	0.00	3.00	0.88

Hazardia squarrosa	0.00	n/a	1.00	2.00	0.00
Malmosa laurina	0.00	0.00	0.00	0.00	1.76

Quadrat 15	1981	1994	1995	1996	2015
Artemisia californica	0.10	n/a	n/a	n/a	0.00
Baccharis pilularis	n/a	n/a	n/a	n/a	1.74
Malmosa laurina	n/a	n/a	n/a	n/a	1.74
Nicotiana glauca	1.50	n/a	n/a	n/a	0.00
Sambucus nigra	0.60	n/a	n/a	n/a	2.17

Cover Data by Quadrat: Forb Species

Quadrat 1	1981	1994	1995	1996	2015
Acmispon glaber	0.00	0.00	0.00	0.00	1.77
Anagallis arvensis	0.00	0.00	1.00	0.25	0.00
Calochortus catalinae	0.25	0.25	0.00	0.00	0.35
Calystegia macrostegia	0.25	0.00	1.00	0.00	6.38
Centaurea melitensis	0.25	0.00	0.00	0.00	7.09
Daucus pusilus	0.00	0.00	0.00	0.00	0.35
Deinandra fasiculata	0.25	3.00	5.00	0.00	14.89
Dichelostemma capitatum	0.00	0.00	0.00	0.00	2.13
Erodium cicutarium	0.25	0.00	0.00	0.00	16.31
Hypochaeris glabra	0.00	0.00	0.25	0.00	0.00
Medicago polymorpha	0.25	0.00	0.00	0.00	0.00
Pseudognaphalium californicum	0.25	0.00	0.00	0.00	0.00
Sanicula arguta	0.25	0.00	0.00	0.00	0.00
Silene gallica	0.25	0.00	0.00	0.00	0.00
Sisyrinchium bellum	0.25	0.25	3.00	4.00	0.00

Quadrat 2	1981	1994	1995	1996	2015
Acmispon glaber	0.00	0.00	0.00	0.00	3.46
Anagallis arvensis	0.00	0.00	0.00	0.25	0.00
Astragalus trichopodus	0.25	0.00	0.00	0.00	0.00
Calochortus catalinae	0.00	6.00	0.00	0.00	1.15
Calystegia macrostegia	0.00	0.00	0.00	0.00	3.46
Castilleja affinis	0.00	0.00	0.00	1.00	0.00
Centaurea melitensis	0.00	2.00	0.25	1.00	6.15
Deinandra fasiculata	0.25	4.00	0.00	0.00	55.38
Dichelostemma capitatum	0.00	0.00	0.25	0.00	5.77

Galium nuttallii	0.00	0.00	1.00	1.00	1.15
Lupinus succulentus	0.00	0.00	0.00	0.00	1.15
Medicago polymorpha	0.00	0.00	0.00	0.00	1.54
Sanicula arguta	0.25	1.00	1.00	3.00	0.00
Silene gallica	0.25	0.00	0.00	0.00	0.00
Silybum marianum	1.00	0.00	0.00	0.00	0.00
Sisyrinchium bellum	0.00	0.00	0.25	1.00	0.00
Sonchus apser/oleraceus	0.00	0.00	0.00	0.00	1.92

Quadrat 3	**1981**	**1994**	**1995**	**1996**	**2015**
Anagallis arvensis	0.25	0.00	0.00	0.00	0.00
Calochortus catalinae	0.25	0.25	0.25	0.00	0.32
Calystegia macrostegia	0.25	3.00	2.00	2.00	19.17
Centaurea melitensis	1.00	0.00	0.00	0.00	0.00
Deinandra fasiculata	0.25	1.00	0.00	0.00	0.96
Dichelostemma capitatum	0.25	0.00	0.00	0.00	0.00
Erodium cicutarium	1.00	0.00	0.00	0.00	2.56
Galium nuttallii	0.00	0.00	0.00	0.00	0.32
Medicago polymorpha	1.00	0.00	0.00	0.00	0.00
Plantago erecta	0.25	0.00	0.00	0.00	0.00
Sanicula arguta	0.25	1.00	0.25	1.00	0.00
Sonchus apser/oleraceus	0.25	0.00	0.00	0.00	0.00
Stebbinsoseris hertocarpa	0.25	0.00	0.00	0.00	0.00

Quadrat 4	**1981**	**1994**	**1995**	**1996**	**2015**
Calochortus catalinae	0.25	0.00	0.00	0.00	0.00
Convulvus simulans	0.00	0.00	0.00	0.00	16.72
Cynara cardunculus	0.00	11.00	10.00	3.00	0.00
Deinandra fasiculata	0.00	2.00	0.00	0.00	0.00
Dichelostemma capitatum	0.25	0.00	0.00	0.00	7.60
Euphorbia spathulata	0.00	0.00	0.00	0.00	0.30
Sonchus apser/oleraceus	0.00	0.00	0.00	0.00	5.78

Quadrat 5	**1981**	**1994**	**1995**	**1996**	**2015**
Anagallis arvensis	0.00	0.00	0.00	0.00	0.41
Brassica nigra	0.00	1.00	1.00	0.00	0.00
Calystegia macrostegia	0.25	0.00	0.00	0.00	0.00
Centaurea melitensis	0.25	0.00	0.00	0.00	0.00
Deinandra fasiculata	0.00	10.00	6.00	1.00	51.23
Dichelostemma capitatum	0.25	0.00	0.00	0.00	0.00

Emmenanthe peduliflora	0.00	0.00	0.00	0.00	0.41
Erodium cicutarium	0.00	4.00	0.00	0.00	9.02
Medicago polymorpha	0.25	0.00	0.25	0.00	0.00
Sanicula arguta	0.25	0.00	0.00	0.00	0.00
Silene gallica	0.25	0.00	0.00	0.00	0.00
Sonchus apser/oleraceus	0.00	0.25	0.00	0.00	1.23

Quadrat 6	**1981**	**1994**	**1995**	**1996**	**2015**
Bloomeria crocea	2.00	1.00	1.00	0.25	1.95
Brassica nigra	1.00	0.00	0.00	0.00	0.00
Calochortus catalinae	0.25	0.00	0.00	1.00	0.39
Calystegia macrostegia	0.25	4.00	2.00	2.00	1.56
Centaurea melitensis	0.00	0.00	0.00	0.00	2.33
Chorizanthe staticoides	0.00	0.00	0.25	0.00	0.00
Convulvus simulans	0.00	0.00	0.00	0.00	1.56
Daucus pusilus	0.00	0.00	0.00	1.00	0.00
Deinandra fasiculata	0.25	0.25	0.00	0.00	1.56
Emmenanthe peduliflora	0.00	0.00	0.00	0.00	0.00
Erodium cicutarium	0.25	4.00	0.00	0.00	0.00
Lupinus succulentus	0.25	0.00	0.25	0.00	1.17
Sisyrinchium bellum	0.25	0.00	0.00	1.00	0.00
Sonchus apser/oleraceus	0.25	0.00	0.00	0.00	0.00

Quadrat 7	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0.25	0.00	0.00	0.25	1.39
Apiastrum angustifolium	0.00	0.00	0.25	0.00	0.00
Brassica nigra	0.00	0.25	0.00	0.00	0.00
Calochortus catalinae	0.25	4.00	3.00	0.25	3.47
Calystegia macrostegia	0.25	11.00	13.00	7.00	11.81
Castilleja affinis	0.00	0.00	1.00	2.00	0.00
Chlorogalum pomeridianum	1.00	0.00	0.00	0.00	0.00
Daucus pusilus	0.00	0.25	1.00	2.00	0.35
Deinandra fasiculata	0.25	13.00	6.00	0.25	22.57
Dichelostemma capitatum	0.00	0.25	0.25	0.00	4.51
Dichondra occidentalis	1.00	0.25	1.00	2.00	1.39
Erodium cicutarium	0.00	1.00	2.00	0.00	28.47
Galium aparnine	0.00	0.00	2.00	2.00	0.00
Galium nuttallii	0.00	1.00	1.00	1.00	0.69
Lupinus succulentus	0.00	0.25	0.00	0.00	2.43
Medicago polymorpha	0.00	0.00	1.00	0.25	0.00

Oxalis albicans	0.25	0.00	0.00	0.00	0.00
Silene gallica	0.25	0.00	1.00	0.00	0.00
Sonchus apser/oleraceus	0.25	0.25	1.00	1.00	0.69
Trifolium gracilentum	0.00	0.00	0.25	0.00	0.00
Yabea microcarpa	0.25	0.00	0.00	0.00	0.00

Quadrat 8	**1981**	**1994**	**1995**	**1996**	**2015**
Achillea millefolium	0.25	0.00	0.00	0.00	0.00
Acmispon glaber	0.00	0.00	0.00	0.00	0.37
Anagallis arvensis	0.00	0.00	0.00	0.00	0.74
Calochortus catalinae	0.25	0.00	0.00	0.00	0.00
Calystegia macrostegia	2.00	6.00	9.00	5.00	30.37
Daucus pusilus	0.00	0.00	2.00	1.00	0.00
Deinandra fasiculata	0.25	8.00	1.00	0.25	3.70
Dichelostemma capitatum	0.25	0.00	0.00	0.25	4.44
Erodium cicutarium	0.25	9.00	4.00	0.00	31.11
Galium aparnine	0.00	0.00	0.25	4.00	0.00
Galium nuttallii	0.25	0.00	0.25	1.00	0.00
Lupinus succulentus	0.00	0.00	0.00	0.25	0.00
Malacothrix saxatilis	0.00	0.00	0.00	0.25	0.74
Medicago polymorpha	0.25	0.00	0.00	0.00	0.37
Oxalis albicans	0.00	0.00	0.25	0.25	0.00
Pseudognaphalium californicum	1.00	0.00	0.00	0.00	0.00
Sanicula arguta	0.25	0.00	1.00	0.25	0.74
Silene gallica	0.00	0.00	0.00	0.25	0.00
Silybum marianum	0.25	0.00	0.00	0.00	0.00
Sonchus apser/oleraceus	1.00	3.00	0.00	1.00	0.00
Yabea microcarpa	0.25	0.00	0.00	0.00	0.00

Quadrat 9	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	1.00	n/a	9.00	22.00	6.12
Acmispon maritimus	0.00	n/a	0.00	0.00	0.36
Astragalus trichopodus	0.25	n/a	2.00	14.00	0.00
Calochortus catalinae	0.00	n/a	0.00	0.00	0.36
Calystegia macrostegia	1.00	n/a	26.00	18.00	29.14
Castilleja affinis	0.25	n/a	0.00	0.00	0.00
Cryptantha intermedia	0.00	n/a	0.25	0.00	0.00
Daucus pusilus	0.00	n/a	4.00	22.00	3.24
Deinandra fasiculata	0.25	n/a	0.00	20.00	6.47
Dichelostemma capitatum	0.00	n/a	2.00	0.00	1.08

Dichondra occidentalis	0.25	n/a	0.25	4.00	0.00
Emmenanthe peduliflora	0.00	n/a	0.25	0.00	0.00
Erodium cicutarium	0.00	n/a	0.00	4.00	0.00
Galium nuttallii	4.00	n/a	7.00	22.00	0.36
Lactuca serriola	0.00	n/a	0.00	0.00	4.68
Lupinus succulentus	0.00	n/a	2.00	0.00	11.87
Malacothrix saxatilis	0.00	n/a	0.00	4.00	0.00
Marah macrocarpa	0.00	n/a	2.00	0.00	0.00
Oxalis albicans	0.25	n/a	0.25	0.00	0.00
Sanicula arguta	0.25	n/a	0.25	0.00	0.00
Sonchus apser/oleraceus	0.00	n/a	0.00	0.00	2.16
Stephanomaria virgata	0.00	n/a	0.00	8.00	0.00

Quadrat 10	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0.00	3.00	12.00	20.00	4.05
Acmispon maritimus	0.00	2.00	0.00	0.25	11.26
Acmispon strigosus	0.00	1.00	0.00	0.25	0.00
Anagallis arvensis	0.00	3.00	9.00	1.00	0.00
Calochortus catalinae	0.25	0.00	0.00	0.00	0.00
Calystegia macrostegia	0.00	15.00	18.00	47.00	3.60
Centaurea melitensis	0.00	0.00	0.00	1.00	0.90
Crassula connata	0.00	0.00	0.25	1.00	0.00
Cryptantha microstacys	0.00	0.00	0.00	0.00	0.45
Cryptantha muricata	0.00	0.00	1.00	0.00	0.00
Daucus pusilus	0.00	0.00	0.00	0.25	0.00
Deinandra fasiculata	0.00	1.00	2.00	0.25	5.41
Dichelostemma capitatum	0.00	1.00	0.00	0.00	9.01
Emmenanthe peduliflora	0.00	0.00	0.00	0.00	0.45
Eremocarpus setigerus	0.00	2.00	0.00	0.00	0.00
Erigeron canadensis	0.00	0.00	1.00	0.00	0.00
Erodium cicutarium	0.00	2.00	5.00	1.00	9.46
Eulobus californicus	0.00	0.00	0.00	0.00	0.45
Lupinus succulentus	0.00	0.00	0.00	0.00	0.45
Phacelia viscida	0.00	0.00	0.00	0.00	0.45
Pseudognaphalium californicum*	0.25	0.00	0.25	0.25	0.00
Sanicula arguta	0.25	0.00	0.00	0.00	0.00
Solanum xanti	0.00	0.25	1.00	3.00	0.00
Sonchus apser/oleraceus	0.25	0.00	0.00	4.00	0.45

Quadrat 11	**1981**	**1994**	**1995**	**1996**	**2015**
Bloomeria crocea	0.25	n/a	0.00	0.00	0.00
Brassica nigra	0.25	n/a	2.00	0.00	1.49
Calochortus catalinae	0.00	n/a	1.00	0.00	2.24
Calystegia macrostegia	0.25	n/a	0.00	0.00	0.00
Deinandra fasiculata	0.25	n/a	0.00	0.00	0.00
Dichelostemma capitatum	0.25	n/a	0.25	0.00	5.22
Galium nuttallii	1.00	n/a	1.00	1.00	0.00
Hypochaeris glabra	0.00	n/a	0.25	0.00	0.00
Marrubium vulgare	0.25	n/a	0.00	0.00	0.00
Medicago polymorpha	0.25	n/a	0.00	0.00	0.00
Melilotus albus	0.00	n/a	0.25	0.00	0.00
Pseudognaphalium californicum*	0.25	n/a	0.00	0.25	0.00
Silene gallica	0.00	n/a	0.25	0.00	0.00
Sisyrinchium bellum	2.00	n/a	3.00	5.00	0.00
Solidago confinis	8.00	n/a	0.00	0.00	0.00
Sonchus apser/oleraceus	0.00	n/a	0.00	0.25	0.37
Stachys bullata	0.25	n/a	3.00	3.00	0.00
Vicia sp.	0.00	n/a	1.00	0.00	0.00

Quadrat 12	**1981**	**1994**	**1995**	**1996**	**2015**
Brassica nigra	1.00	2.00	0.25	8.00	1.33
Calochortus catalinae	0.25	0.25	1.00	10.00	2.66
Calystegia macrostegia	0.25	0.25	0.25	6.00	0.00
Centaurea melitensis	0.00	0.00	0.00	0.00	0.66
Convulvus simulans	0.00	0.00	0.00	0.00	17.28
Deinandra fasiculata	0.25	0.00	0.00	0.00	0.00
Dichelostemma capitatum	0.25	0.00	0.00	4.00	1.33
Sonchus apser/oleraceus	0.25	0.00	0.00	8.00	0.00

Quadrat 13	**1981**	**1994**	**1995**	**1996**	**2015**
Brassica nigra	1.00	8.00	1.00	0.25	0.00
Convulvus simulans	0.00	0.00	0.00	0.00	30.12
Dichelostemma capitatum	0.00	0.00	0.00	0.00	1.86
Erodium cicutarium	0.00	0.00	0.00	0.00	0.62
Euphorbia spathulata	0.00	0.00	0.00	0.00	4.66
Medicago polymorpha	0.00	0.00	0.00	0.00	0.62
Nicotiana glauca	0.00	0.00	0.25	0.00	0.00
Sonchus apser/oleraceus	0.00	0.00	0.00	0.00	19.88

Quadrat 14	**1981**	**1994**	**1995**	**1996**	**2015**
Astragalus trichopodus	0.00	n/a	0.00	0.25	0.00
Brassica nigra	0.25	n/a	1.00	0.00	0.00
Calystegia macrostegia	0.00	n/a	2.00	2.00	8.37
Deinandra fasiculata	0.00	n/a	3.00	0.25	1.32
Dichelostemma capitatum	0.00	n/a	0.00	0.25	0.00
Eremocarpus setigerus	0.00	n/a	0.25	0.00	0.00
Mirabilis laevis	0.00	n/a	0.00	1.00	0.00
Oxalis albicans	0.00	n/a	0.00	0.25	0.00
Sanicula arguta	0.00	n/a	0.25	0.00	0.00
Silene gallica	0.00	n/a	0.00	0.25	0.00
Sonchus apser/oleraceus	0.00	n/a	1.00	1.00	0.44
Stephanomaria virgata	0.00	n/a	0.25	1.00	0.00
Vicia sp.	0.00	n/a	0.00	1.00	0.00

Quadrat 15	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0.00	n/a	n/a	n/a	0.43
Brassica nigra	3.84	n/a	n/a	n/a	0.00
Calystegia macrostegia	0.00	n/a	n/a	n/a	2.61
Centaurea melitensis	0.00	n/a	n/a	n/a	3.04
Emmenanthe peduliflora	0.00	n/a	n/a	n/a	8.70
Erodium cicutarium	0.00	n/a	n/a	n/a	6.96
Malva parviflora	0.00	n/a	n/a	n/a	25.65
Marrubium vulgare	23.59	n/a	n/a	n/a	0.00
Medicago polymorpha	0.00	n/a	n/a	n/a	10.00
Melilotus indicus	0.00	n/a	n/a	n/a	0.43
Rumex crispus	0.00	n/a	n/a	n/a	0.87
Silybum marianum	6.47	n/a	n/a	n/a	0.00
Sonchus apser/oleraceus	0.00	n/a	n/a	n/a	13.48

*= includes other psuedognaphalium species

Cover Data by Quadrat: Bare Ground

	1981	**1995**	**2015**
Quadrat 1	0.00	0.00	2.48
Quadrat 2	2.00	0.33	3.85
Quadrat 3	6.00	0.33	0.00
Quadrat 4	0.25	0.00	0.30
Quadra t5	5.00	3.00	9.43

Quadrat 6	32.00	0.67	1.56
Quadrat 7	12.00	1.00	11.11
Quadrat 8	1.00	0.67	14.44
Quadrat 9	24.00	0.00	14.75
Quadrat 10	13.00	8.67	27.93
Quadrat 11	30.00	0.00	4.85
Quadrat12	9.00	0.33	1.00
Quadrat 13	0.00	0.67	0.93
Quadrat 14	0.00	0.00	4.41
Quadrat 15	0.00	n/a	22.17

APPENDIX C

FREQUENCY DATA BY QUADRAT

APPENDIX C

Percent Frequency by Quadrat: Grass Species

Quadrat 1	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	26.00	71.33	174.36	12.45	78.00	9.35	0.47
Bromus diandrus	60.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus hordeaceus	34.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	4.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Festuca perennis	78.00	91.33	17.09	1.22	16.00	-82.48	-4.12
Stipa lepida	0.00	0.00	n/a	n/a	8.00	Undef.	n/a
Stipa pulchra	82.00	58.00	-29.27	-2.09	18.00	-68.97	-3.45

Quadrat 2	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	40.00	6.67	-83.33	-5.95	0.00	-100.00	-5.00
Bromus carinatus	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus diandrus	84.00	18.67	-77.78	-5.56	0.00	-100.00	-5.00
Bromus hordeaceus	38.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	2.00	6.00	200.00	14.29	0.00	-100.00	-5.00
Festuca perennis	40.00	18.00	-55.00	-3.93	2.00	-88.89	-4.44
Phalaris aquatica	18.00	29.33	62.96	4.50	14.00	-52.27	-2.61
Stipa lepida	0.00	4.00	Undef.	0.00	4.00	0.00	0.00
Stipa pulchra	68.00	46.00	-32.35	-2.31	10.00	-78.26	-3.91
Vulpia myuros	0.00	0.67	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 3	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	67.00	85.33	27.36	1.95	96.00	12.50	0.63
Bromus diandrus	3.00	8.00	166.67	11.90	0.00	-100.00	-5.00
Bromus hordeaceous	86.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	74.00	1.33	-98.20	-7.01	0.00	-100.00	-5.00
Festuca perennis	37.00	92.67	150.45	10.75	4.00	-95.68	-4.78
Stipa pulchra	91.00	64.67	-28.94	-2.07	40.00	-38.14	-1.91
Vulpa myuros	9.00	0.00	-100.00	-7.14	0.00	Still zero	n/a

Quadrat 4	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	26.00	74.00	184.62	13.19	96.00	29.73	1.49
Bromus diandrus	8.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Festuca perennis	100.00	96.00	-4.00	-0.29	26.00	-72.92	-3.65
Phalaris aquatica	2.00	2.67	33.33	2.38	0.00	-100.00	-5.00
Stipa pulchra	84.00	24.00	-71.43	-5.10	14.00	-41.67	-2.08

Quadrat 5	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	10.00	16.00	60.00	4.29	0.00	-100.00	-5.00
Bromus diandrus	76.00	2.67	-96.49	-6.89	0.00	-100.00	-5.00
Bromus hordeaceous	14.00	10.67	-23.81	-1.70	0.00	-100.00	-5.00
Bromus madritensis	6.00	4.00	-33.33	-2.38	0.00	-100.00	-5.00
Festuca perennis	42.00	32.67	-22.22	-1.59	0.00	-100.00	-5.00
Hordeum murinum	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Phalaris aquatica	24.00	56.67	136.11	9.72	38.00	-32.94	-1.65
Stipa pulchra	86.00	47.33	-44.96	-3.21	2.00	-95.77	-4.79
Vulpia myuros	0.00	4.00	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 6	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	88.00	86.67	-1.52	-0.11	96.00	10.77	0.54
Bromus diandrus	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus hordeaceus	62.00	0.67	-98.92	-7.07	0.00	-100.00	-5.00
Bromus madritensis	56.00	2.67	-95.24	-6.80	0.00	-100.00	-5.00
Festuca perennis	26.00	97.33	274.36	19.60	32.00	-67.12	-3.36
Stipa pulchra	80.00	70.67	-11.67	-0.83	30.00	-57.55	-2.88
Vulpia myuros	4.00	0.00	-100.00	-7.14	0.00	Still zero	n/a

Quadrat 7	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	8.00	46.00	475.00	33.93	0.00	-100.00	-5.00
Bromus diandrus	6.00	5.33	-11.11	-0.79	0.00	-100.00	-5.00
Bromus hordeaceus	20.00	14.00	-30.00	-2.14	0.00	-100.00	-5.00
Bromus madritensis	48.00	41.33	-13.89	-0.99	0.00	-100.00	-5.00
Festuca perennis	2.00	8.00	300.00	21.43	0.00	-100.00	-5.00
Stipa lepida	28.00	22.00	-21.43	-1.53	0.00	-100.00	-5.00
Stipa pulchra	74.00	25.33	-65.77	-4.70	8.00	-68.42	-3.42
Vulpia myuros	6.00	7.33	22.22	1.59	0.00	-100.00	-5.00

Quadrat 8	**1981**	**1990s**	**% Change**	**%/Year**	**2015**	**% Change**	**%/Year**
Avena sp.	58.00	65.33	12.64	0.90	0.00	-100.00	-5.00
Bromus diandrus	12.00	19.33	61.11	4.37	0.00	-100.00	-5.00
Bromus hordeaceus	76.00	2.67	-96.49	-6.89	0.00	-100.00	-5.00
Bromus madritensis	88.00	40.00	-54.55	-3.90	0.00	-100.00	-5.00
Festuca perennis	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Stipa pulchra	64.00	42.67	-33.33	-2.38	8.00	-81.25	-4.06
Vulpia myuros	4.00	4.00	0.00	0.00	0.00	-100.00	-5.00

Quadrat 9	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	20.00	5.00	-75.00	-5.36	0.00	-100.00	-5.00
Bromus madritensis	14.00	1.00	-92.86	-6.63	0.00	-100.00	-5.00
Elymus condensatus	0.00	1.00	Undef.	n/a	0.00	-100.00	-5.00
Phalaris aquatica	0.00	0.00	n/a	n/a	4.00	Undef.	n/a
Stipa lepida	86.00	45.00	-47.67	-3.41	14.00	-68.89	-3.44

Quadrat 10	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	18.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus diandrus	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus hordeaceus	44.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	48.00	4.67	-90.28	-6.45	0.00	-100.00	-5.00
Festuca perennis	6.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Stipa lepida	10.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Stipa pulchra	84.00	60.67	-27.78	-1.98	16.00	-73.63	-3.68
Vulpia myuros	4.00	0.67	-83.33	-5.95	0.00	-100.00	-5.00

Quadrat 11	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	54.00	63.00	16.67	1.19	94.00	49.21	2.46
Bromus diandrus	2.00	7.00	250.00	17.86	0.00	-100.00	-5.00
Bromus hordeaceus	4.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Festuca perennis	42.00	88.00	109.52	7.82	4.00	-95.45	-4.77
Melica imperfecta	2.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Stipa lepida	4.00	1.00	-75.00	-5.36	0.00	-100.00	-5.00
Stipa pulchra	54.00	36.00	-33.33	-2.38	42.00	16.67	0.83

Quadrat 12	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	92.00	96.67	5.07	0.36	80.00	-17.24	-0.86
Bromus diandrus	0.00	0.67	Undef.	n/a	0.00	-100.00	-5.00
Bromus hordeaceus	82.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Bromus madritensis	24.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Festuca perennis	34.00	74.67	119.61	8.54	58.00	-22.32	-1.12
Stipa pulchra	42.00	43.33	3.17	0.23	42.00	-3.08	-0.15
Vulpia myuros	4.00	0.00	-100.00	-7.14	0.00	Still zero	n/a

Quadrat 13	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	0.00	42.67	Undef.		0.00	-100.00	-5.00
Festuca perennis	100.00	94.00	-6.00	-0.43	64.00	-31.91	-1.60
Phalaris aquatica	2.00	15.33	666.67	47.62	54.00	252.17	12.61

Quadrat 14	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	26.00	88.00	238.46	17.03	96.00	9.09	0.45
Bromus diandrus	94.00	8.00	-91.49	-6.53	0.00	-100.00	-5.00
Bromus madritensis	0.00	23.00	Undef.	n/a	0.00	-100.00	-5.00
Hordeum murinum	18.00	0.00	-100.00	-7.14	0.00	Still zero	n/a
Lamarchia aurea	0.00	1.00	Undef.	n/a	0.00	-100.00	-5.00
Stipa lepida	0.00	0.00	n/a	n/a	12.00	Undef.	n/a
Stipa pulchra	64.00	31.00	-51.56	-3.68	4.00	-87.10	-4.35
Vulpia myuros	0.00	20.00	Undef.	n/a	0.00	-100.00	-5.00

Quadrat 15	1981	1990s	% Change	%/Year	2015	% Change	%/Year
Avena sp.	22.00	n/a	n/a	n/a	0.00	n/a	n/a
Bromus diandrus	76.00	n/a	n/a	n/a	0.00	n/a	n/a
Bromus hordeaceous	8.00	n/a	n/a	n/a	0.00	n/a	n/a
Hordeum murinum	26.00	n/a	n/a	n/a	0.00	n/a	n/a

Percent Frequency by Quadrat: Shrub Species

Quadrat 1	1981	1994	1995	1996	2015
Baccharis pilularis	2	0	0	0	0
Corethrogyne filaginifolia	2	0	4	2	0
Grindelia camporum	0	0	0	4	0
Hazardia squarrosa	0	0	2	0	0
Salvia leucophylla	0	0	0	0	8

Quadrat 2	1981	1994	1995	1996	2015
Artemisia californica	2	0	12	0	20
Corethrogyne filaginifolia	30	0	0	0	0
Eriogonum cinereum	6	0	0	0	0
Grindelia camporum	8	0	0	0	0
Hazardia squarrosa	0	0	2	2	0
Lupinus longifolius	0	4	0	0	0
Malacothamnus fasciculatus	0	2	0	0	0
Malmosa laurina	0	0	0	0	2
Ribes malvaceum	0	0	2	0	0
Salvia leucophylla	4	14	22	12	14

Quadrat 3	1981	1994	1995	1996	2015
Corethrogyne filaginifolia	0	2	0	1	0
Hazardia squarrosa	0	0	2	0	0

Quadrat 4 contained no shrub species.

Quadrat 5	**1981**	**1994**	**1995**	**1996**	**2015**
Baccharis pilularis	0	2	2	12	0

Quadrat 6	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	2	0	0	0	0
Corethrogyne filaginifolia	6	0	0	0	0
Grindelia camporum	6	0	0	0	8
Hazardia squarrosa	36	12	6	8	14

Quadrat 7	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	28	4	0	6	2
Baccharis pilularis	0	0	0	0	4
Eriogonum cinereum	6	2	6	8	0
Hazardia squarrosa	8	2	4	14	0
Opuntia	2	2	0	2	0
Salvia leucophylla	12	1	0	6	4

Quadrat 8	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	16	6	0	10	8
Corethrogyne filaginifolia	14	0	0	0	0
Eriogonum cinereum	4	0	0	0	4
Malmosa laurina	0	0	2	4	2
Salvia leucophylla	4	0	0	0	2

Quadrat 9	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	18	n/a	0	6	0
Encelia californicum	0	n/a	0	0	8
Eriogonum cinereum	32	n/a	28	28	34
Malmosa laurina	6	n/a	6	2	2
Salvia leucophylla	18	n/a	2	0	4

Quadrat 10	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	10	2	10	10	4
Baccharis pilularis	2	4	12	16	0
Encelia californicum	0	0	0	0	6
Eriogonum cinereum	2	8	8	18	64
Hazardia squarrosa	10	0	0	0	0
Malmosa laurina	0	22	16	16	18

Mimulus aurantiacus	0	0	44	36	0
Ribes malvaceum	0	0	0	0	6
Salvia leucophylla	6	0	0	2	0
Salvia mellifera	0	6	2	2	4

Quadrat 11	**1981**	**1994**	**1995**	**1996**	**2015**
Baccharis pilularis	0	n/a	0	2	0
Corethrogyne filaginifolia	32	n/a	4	0	0
Grindelia camporum	4	n/a	8	14	0
Hazardia squarrosa	12	n/a	12	4	2
Malmosa laurina	4	n/a	0	0	0
Quercus	4	n/a	4	2	0
Ribes malvaceum	2	n/a	0	0	0
Ribes speciosum	2	n/a	0	0	0
Toxicodendron diversiloba	0	n/a	0	2	0

Quadrat 12	**1981**	**1994**	**1995**	**1996**	**2015**
Grindelia camporum	18	0	2	2	0
Hazardia squarrosa	4	0	2	0	0

Quadrat 13	**1981**	**1994**	**1995**	**1996**	**2015**
Grindelia camporum	2	0	0	0	0

Quadrat 14	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	2	n/a	2	2	0
Eriogonum cinereum	0	n/a	2	6	2
Hazardia squarrosa	0	n/a	2	6	4

Quadrat 15	**1981**	**1994**	**1995**	**1996**	**2015**
Malmosa laurina	0	n/a	n/a	n/a	6
Nicotiana glauca	2	n/a	n/a	n/a	0
Sambucus nigra	0	n/a	n/a	n/a	4

Percent Frequency by Quadrat: Forb Species

Quadrat 1	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	0	0	0	2
Anagallis arvensis	0	14	12	4	0
Calochortus catalinae	2	0	0	0	2
Calystegia macrostegia	0	2	2	0	14

Centaurea melitensis	0	4	0	0	44
Daucus pusilus	0	0	0	0	6
Deinandra fasiculata	6	48	58	2	84
Dichelostemma capitatum	0	0	0	0	10
Erigeron canadensis	0	0	2	0	0
Erodium cicutarium	0	6	0	0	62
Hypochaeris glabra	0	0	2	0	0
Pseudognaphalium californicum	0	0	0	6	0
Sanicula arguta	0	0	4	0	0
Silene gallica	4	0	0	0	0
Sisyrinchium bellum	0	0	2	6	0
Sonchus apser/oleraceus	0	0	16	2	8

Quadrat 2	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	0	0	0	16
Anagallis arvensis	0	0	0	4	2
Bloomeria crocea	0	6	10	0	0
Brassica nigra	0	0	0	0	10
Calochortus catalinae	0	28	8	0	4
Calystegia macrostegia	2	2	0	2	8
Castilleja affinis	0	2	2	12	0
Centaurea melitensis	0	0	0	0	42
Daucus pusilus	0	0	8	4	12
Deinandra fasiculata	0	18	14	0	94
Dichelostemma capitatum	0	0	0	0	46
Dodecatheon clevelandii	0	0	0	2	0
Emmenanthe peduliflora	0	0	0	0	10
Erodium cicutarium	4	0	0	0	22
Galium nuttallii	0	6	6	4	0
Lupinus succulentus	0	0	0	0	2
Medicago polymorpha	10	0	0	0	4
Sanicula arguta	12	8	8	14	0
Silybum marianum	2	0	0	0	0
Sisyrinchium bellum	0	4	0	2	0
Sonchus apser/oleraceus	0	0	2	0	24

Quadrat 3	**1981**	**1994**	**1995**	**1996**	**2015**
Calochortus catalinae	14	4	0	2	12
Calystegia macrostegia	0	8	10	2	38
Deinandra fasiculata	6	4	0	0	10

Erodium cicutarium	11	12	0	0	4
Galium nuttallii	0	0	0	0	4
Lactuca serriola	0	0	0	0	4
Medicago polymorpha	17	0	0	0	0
Sanicula arguta	0	6	14	16	0
Sonchus apser/oleraceus	9	0	6	0	10

Quadrat 4	**1981**	**1994**	**1995**	**1996**	**2015**
Convulvus simulans	0	0	0	0	64
Cynara cardunculus	0	12	22	6	0
Deinandra fasiculata	0	4	4	2	0
Dichelostemma capitatum	0	0	0	0	44
Euphorbia spathulata	0	0	0	0	8
Medicago polymorpha	0	0	0	0	4
Pseudognaphalium californicum (sp)	0	0	2	0	0
Sonchus apser/oleraceus	0	0	6	0	46

Quadrat 5	**1981**	**1994**	**1995**	**1996**	**2015**
Anagallis arvensis	0	0	0	0	2
Brassica nigra	0	12	8	0	0
Calochortus catalinae	0	0	2	0	0
Calystegia macrostegia	0	0	0	0	2
Daucus pusilus	0	0	0	0	2
Deinandra fasiculata	0	40	66	24	96
Erodium cicutarium	0	26	0	0	26
Medicago polymorpha	0	0	2	0	0
Oxalis albicans	0	0	0	0	2
Pseudognaphalium californicum	0	0	0	4	0
Sanicula arguta	0	6	2	0	0
Silene gallica	0	0	8	0	0
Sonchus apser/oleraceus	0	2	16	8	32

Quadrat 6	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	0	0	2	0
Bloomeria crocea	0	0	8	2	8
Brassica nigra	2	0	0	0	0
Calochortus catalinae	0	8	4	2	14
Calystegia macrostegia	2	0	0	0	4
Centaurea melitensis	0	0	0	0	8
Convulvus simulans	0	0	0	0	12

Deinandra fasiculata	2	0	0	0	6
Dichelostemma capitatum	0	0	0	0	6
Erodium cicutarium	4	0	0	0	0
Lactuca serriola	0	0	0	0	2
Lupinus succulentus	0	0	0	0	8
Sonchus apser/oleraceus	2	0	0	0	2

Quadrat 7	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	0	0	0	6
Calochortus catalinae	0	0	14	2	28
Calystegia macrostegia	10	18	18	14	42
Castilleja affinis	0	0	2	6	2
Daucus pusilus	0	0	14	22	0
Deinandra fasiculata	0	0	0	6	84
Dichelostemma capitatum	0	0	0	0	40
Dichondra occidentalis	2	4	0	6	10
Emmenanthe peduliflora	0	0	0	0	2
Erodium cicutarium	0	0	14	0	92
Galium aparnine	0	0	12	8	0
Galium nuttallii	0	0	4	2	2
Hypochaeris glabra	0	0	4	0	0
Lupinus succulentus	0	0	14	0	14
Medicago polymorpha	0	0	0	0	2
Oxalis albicans	0	0	0	2	0
Silene gallica	0	0	0	4	0
Sonchus apser/oleraceus	10	4	12	6	12

Quadrat 8	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	0	0	0	8
Acmispon maritimus	0	0	0	0	12
Bloomeria crocea	0	0	8	0	0
Calystegia macrostegia	20	20	58	34	76
Daucus pusilus	0	0	4	6	4
Deinandra fasiculata	4	2	0	18	48
Dichelostemma capitatum	4	0	2	0	42
Erodium cicutarium	10	26	44	6	98
Galium aparnine	0	0	2	2	0
Galium nuttallii	0	0	2	2	0
Lactuca serriola	0	0	0	0	12
Lupinus succulentus	0	0	0	0	18

Malacothrix saxatilis	0	0	0	2	0
Oxalis albicans	0	0	2	0	0
Pseudognaphalium californicum	4	0	0	2	0
Sanicula arguta	4	0	2	6	4
Silene gallica	0	0	0	2	0
Sonchus apser/oleraceus	10	6	0	20	4

Quadrat 9	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	n/a	2	0	26
Acmispon maritimus	0	n/a	10	0	0
Astragalus trichopodus	0	n/a	0	0	6
Calochortus catalinae	0	0	0	0	2
Calystegia macrostegia	14	n/a	42	0	88
Daucus pusilus	0	n/a	34	0	28
Deinandra fasiculata	14	n/a	22	0	38
Dichelostemma capitatum	0	n/a	14	0	18
Dichondra occidentalis	4	n/a	0	0	14
Emmenanthe peduliflora	0	n/a	0	0	2
Erodium cicutarium	0	n/a	4	0	0
Galium nuttallii	18	n/a	18	0	8
Lupinus succulentus	0	n/a	24	0	50
Malacothrix saxatilis	0	n/a	2	0	0
Sanicula arguta	0	n/a	2	0	0
Sonchus apser/oleraceus	0	n/a	2	0	18
Trifolium gracilentum	0	n/a	4	0	0

Quadrat 10	**1981**	**1994**	**1995**	**1996**	**2015**
Acmispon glaber	0	6	0	20	42
Acmispon maritimus	0	4	0	0	22
Acmispon strigosus	0	4	0	0	0
Anagallis arvensis	0	6	22	10	0
Calochortus catalinae	0	2	0	8	4
Calystegia macrostegia	2	16	8	12	36
Camissonia sp.	0	0	2	0	0
Centaurea melitensis	0	0	0	6	10
Chaenactis artemsisifolia	0	0	0	0	4
Chamaesyce polycarpa	0	0	0	0	4
Cryptantha microstacys	0	0	0	0	12
Daucus pusilus	0	0	4	0	4
Deinandra fasiculata	0	0	10	2	28

Dichelostemma capitatum	2	2	0	0	14
Emmenanthe peduliflora	0	0	0	0	2
Eremocarpus setigerus	0	4	0	0	0
Erigeron canadensis	0	0	0	2	0
Erodium cicutarium	0	2	18	6	40
Eulobus californicus	0	0	0	0	6
Lactuca serriola	0	0	0	0	4
Phacelia viscida	0	0	0	0	4
Pseudognaphalium californicum*	2	0	2	6	0
Solanum xanti	0	0	2	0	0
Sonchus apser/oleraceus	0	0	4	2	0

Quadrat 11	**1981**	**1994**	**1995**	**1996**	**2015**
Bloomeria crocea	0	n/a	0	0	30
Brassica nigra	2	n/a	4	2	0
Calochortus catalinae	0	n/a	2	0	18
Centaurea melitensis	0	0	0	0	2
Convulvus simulans	0	0	0	0	4
Deinandra fasiculata	0	n/a	0	0	8
Dichelostemma capitatum	0	n/a	0	0	32
Galium nuttallii	14	n/a	2	8	0
Lactuca serriola	0	0	0	0	6
Marrubium vulgare	2	n/a	0	0	0
Pseudognaphalium californicum*	4	n/a	0	0	0
Silene gallica	0	n/a	2	0	0
Sisyrinchium bellum	38	n/a	6	6	0
Solidago confinis	4	n/a	0	0	0
Sonchus apser/oleraceus	0	n/a	2	0	0
Stachys bullata	0	n/a	4	4	0
Toxicodendron diversiloba	0	n/a	0	2	0

Quadrat 12	**1981**	**1994**	**1995**	**1996**	**2015**
Anagallis arvensis	0	0	2	0	0
Brassica nigra	20	34	16	8	8
Calochortus catalinae	6	2	2	10	28
Calystegia macrostegia	4	0	8	6	12
Centaurea melitensis	0	0	0	0	26
Convulvus simulans	0	0	0	0	62
Deinandra fasiculata	0	0	0	0	2
Dichelostemma capitatum	0	0	0	4	30

Pseudognaphalium californicum	2	0	0	0	0
Sisyrinchium bellum	2	0	0	0	0
Sonchus apser/oleraceus	4	0	6	8	2

Quadrat 13	**1981**	**1994**	**1995**	**1996**	**2015**
Brassica nigra	24	30	14	2	0
Calochortus catalinae	0	0	0	0	4
Convulvus simulans	0	0	0	0	76
Deinandra fasiculata	0	0	0	0	6
Dichelostemma capitatum	0	0	0	0	6
Euphorbia spathulata	0	0	0	0	30
Lactuca serriola	0	0	0	10	0
Medicago polymorpha	0	0	10	0	4
Sonchus apser/oleraceus	0	0	0	0	44

Quadrat 14	**1981**	**1994**	**1995**	**1996**	**2015**
Brassica nigra	0	n/a	0	10	0
Calystegia macrostegia	2	n/a	4	0	8
Deinandra fasiculata	0	n/a	32	12	4
Dichelostemma capitatum	0	n/a	0	0	4
Eremocarpus setigerus	0	n/a	24	0	0
Erodium cicutarium	0	n/a	4	0	0
Mirabilis laevis	0	n/a	0	2	0
Oxalis albicans	0	n/a	0	2	0
Pseudognaphalium californicum	0	n/a	0	4	0
Silene gallica	0	n/a	12	8	0
Sonchus apser/oleraceus	0	n/a	4	14	4
Stephanomaria virgata	0	n/a	0	6	0

Quadrat 15	**1981**	**1994**	**1995**	**1996**	**2015**
Brassica nigra	32	n/a	n/a	n/a	0
Calochortus catalinae	22	n/a	n/a	n/a	0
Calystegia macrostegia	0	n/a	n/a	n/a	8
Centaurea melitensis	0	n/a	n/a	n/a	8
Dichelostemma capitatum	0	n/a	n/a	n/a	2
Dienandra fasciculate	2	n/a	n/a	n/a	0
Emmenanthe peduliflora	0	n/a	n/a	n/a	16
Erodium cicutarium	0	n/a	n/a	n/a	18
Malva parviflora	0	n/a	n/a	n/a	58
Marrubium vulgare	22	n/a	n/a	n/a	0

Medicago polymorpha	0	n/a	n/a	n/a	28
Sonchus apser/oleraceus	0	n/a	n/a	n/a	44

*= includes other psuedognaphalium species

APPENDIX D

SHRUB DENSITY BY QUADRAT

APPENDIX D

Shrub Density by Quadrat

Quadrat 1	**1981**	**1994**	**1995**	**1996**	**2015**
Adenostoma fasiculatum	0	0	0	0	0
Artemisia californica	0	0	0	0	6
Baccharis pilularis	1	2	3	6	0
Corethrogyne filaginifolia	0	0	4	7	0
Grindelia camporum	2	0	0	23	1
Hazardia squarrosa	0	10	6	12	12
Malmosa laurina	0	0	0	0	2
Salvia leucophylla	0	3	7	8	88
Salvia mellifera	0	0	0	0	1

Quadrat 2	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	43	91	49	55	484
Baccharis pilularis	0	0	0	0	3
Corethrogyne filaginifolia	221	0	0	0	0
Encelia californica	0	0	0	0	0
Eriogonum cinerium	14	0	0	0	0
Grindelia camporum	110	27	0	0	0
Hazardia squarrosa	6	10	7	15	3
Heteromeles arbutifolia	0	0	0	0	0
Lupinus longifolius	0	0	0	0	0
Malmosa laurina	0	8	1	3	4
Ribes malvaceum	0	0	4	3	0
Salvia leucophylla	18	154	98	149	164
Solanum xanti	0	0	0	0	12

Quadrat 3	**1981**	**1994**	**1995**	**1996**	**2015**
Corethrogyne filaginifolia	39	1	0	0	0
Hazardia squarrosa	9	9	13	9	0

Quadrat 4	**1981**	**1994**	**1995**	**1996**	**2015**
Baccharis pilularis	0	27	22	13	0

Quadrat 5	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	0	0	0	0	1
Baccharis pilularis	0	9	4	30	19
Hazardia squarrosa	0	0	0	0	1

Quadrat 6	1981	1994	1995	1996	2015
Artemisia californica	59	3	7	4	11
Corethrogyne filaginifolia	30	0	0	0	0
Hazardia squarrosa	370	259	152	1	98
Malacothamnus fasciculatus	0	0	0	0	7
Salvia leucophylla	1	1	1	161	2

Quadrat 7	1981	1994	1995	1996	2015
Artemisia californica	207	22	41	66	2
Baccharis pilularis	7	0	1	1	24
Corethrogyne filaginifolia	0	1	1	2	0
Eriogonum cinerium	30	20	16	121	38
Hazardia squarrosa	112	50	56	91	0
Malmosa laurina	1	1	2	2	5
Opuntia	3	0	2	7	0
Quercus	0	0	0	0	10
Salvia leucophylla	95	4	82	76	98

Quadrat 8	1981	1994	1995	1996	2015
Artemisia californica	146	11	15	40	63
Baccharis pilularis	0	0	0	0	1
Corethrogyne filaginifolia	151	3	0	3	0
Eriogonum cinerium	10	1	1	1	13
Grindelia camporum	1	0	0	0	0
Hazardia squarrosa	6	4	3	5	13
Malmosa laurina	0	1	6	20	16
Mimulus Aurantiacus	8	0	0	0	2
Quercus	0	0	0	0	1
Salvia leucophylla	46	4	3	6	9

Quadrat 9	1981	1994	1995	1996	2015
Artemisia californica	160	n/a	7	15	33
Corethrogyne filaginifolia	4	n/a	0	0	0
Encelia californica	0	0	0	0	16
Eriogonum cinerium	199	n/a	105	131	173
Hazardia squarrosa	4	n/a	1	0	0
Lupinus longifolius	0	0	0	1	0
Malmosa laurina	10	n/a	10	7	15

Opuntia	2	n/a	0	0	1
Salvia leucophylla	115	n/a	10	15	44
Salvia mellifera	2	n/a	0	0	0

Quadrat 10	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	38	11	205	17	8
Baccharis pilularis	12	24	489	14	0
Corethrogyne filaginifolia	1	0	0	0	0
Encelia californica	0	0	0	0	10
Eriogonum cinerium	21	34	83	25	1532
Hazardia squarrosa	132	15	3	2	17
Malacothamnus fasciculatus	0	5	1	2	128
Malmosa laurina	1	187	182	52	91
Mimulus Aurantiacus	0	9	33	93	37
Opuntia	2	0	0	0	0
Salvia leucophylla	35	5	182	8	10
Salvia mellifera	0	21	14	9	19
Solanum xanti	0	0	0	13	1

Quadrat 11	**1981**	**1994**	**1995**	**1996**	**2015**
Adenostoma fasiculatum	5	n/a	0	0	0
Artemisia californica	7	n/a	0	0	0
Baccharis pilularis	1	n/a	2	4	0
Corethrogyne filaginifolia	251	n/a	0	19	0
Grindelia camporum	47	n/a	pr	0	8
Hazardia squarrosa	129	n/a	58	41	26
Heteromeles arbutifolia	0	0	3	3	0
Malmosa laurina	43	n/a	2	2	0
Quercus	107	n/a	47	46	0
Rhus integrifolia	0	n/a	0	1	0
Ribes malvaceum	11	n/a	0	0	0
Ribes speciosum	8	n/a	0	0	0
Salvia leucophylla	13	n/a	2	1	0
Toxicodendron diversiloba	4	n/a	4	9	0

Quadrat 12	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	1	0	0	0	0
Baccharis pilularis	0	0	0	0	3
Grindelia camporum	256	1	pr	1	6

Hazardia squarrosa	16	6	5	7	4
Opuntia	0	0	0	0	1

Quadrat 13	**1981**	**1994**	**1995**	**1996**	**2015**
Grindelia camporum	3	0	0	0	0

Quadrat 14	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	2	n/a	7	1	1
Eriogonum cinerium	0	0	35	46	30
Grindelia camporum	0	0	pr	0	1
Hazardia squarrosa	0	0	19	20	22
Malmosa laurina	0	0	0	0	1

Quadrat 15	**1981**	**1994**	**1995**	**1996**	**2015**
Artemisia californica	0	n/a	n/a	n/a	6
Baccharis pilularis	0	n/a	n/a	n/a	1
Malmosa laurina	0	n/a	n/a	n/a	71
Sambucus nigra	0	n/a	n/a	n/a	4

APPENDIX E

FORB SPECIES PRESENCE

APPENDIX E

Number of forb species present in cover data.

Quadrat	**1981**	**1994**	**1995**	**1996**	**2015**
1	10	3	5	2	8
2	5	4	5	6	10
3	12	4	3	2	5
4	2	2	1	1	4
5	6	4	3	1	5
6	9	4	4	5	7
7	10	11	15	11	11
8	13	4	8	12	9
9	9	n/a	13	10	11
10	4	10	10	13	13
11	12	n/a	10	5	4
12	6	3	3	5	5
13	1	1	2	1	6
14	1	n/a	7	10	3
15	3	n/a	n/a	n/a	10

REFERENCES

Baker, H.G. 1974. The evolution of weeds. *Annual Review of Ecology and Systematics* 5:1-24.

Baker, Herbert G. 1976. Invasion and Replacement in Californian and neotropical grasslands. In *Plant Relations in Pastures*, ed. J.R. Wilson, 368-383. Australia: CSIRO Publishing.

Brennan, Sean, Paul S. Laris, and Christine M. Rodrigue. 2017. Coyote brush as facilitator of native California plant recovery, in the Santa Monica Mountains. In progress.

Burcham, L.T. 1957. *California Rangeland*. California Forestry: Sacramento, California.

California Department of Forestry and Fire Protection. 2015. Fire and resource assessment program. http://frap.ca.gov/ (last accessed 18 December 2016).

California Native Grasslands Association. Grass Facts. http://cnga.org/page-1633090 (last accessed 27 July 2015).

Christian, Janice M. and Scott D. Wilson. 1999. Long-term ecosystem impacts of an introduced grass in the northern Great Plains. *Ecology* 80 (7):2397-2407.

Clements, Frederic E. 1934. The Relict Method in Ecology. *Journal of Ecology* 22 (1):39-68.

D'Antonio, Carla M., Carolyn Malmstrom, Sally A. Reynolds, and John Gerlach. 2007. Ecology of Invasive Non-Native Species in California Grassland. In *California Grasslands: Ecology and Management*, eds. Mark R. Stromberg, Jeffrey D. Corbin, and Carla D'Antonio, 67-83. Berkeley: University of California Press.

D'Antonio, Carla M. and Peter Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. *Annual Review of Ecology and Systematics* 23:63-87.

Darwin, Charles 1859. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*. London: John Murray.

Dyer, Andrew R. and Kevin J. Rice. 1999. Effects of competition on resource availability and growth of a California bunchgrass. *Ecology* 80 (8):2697-2710.

Elton, C.S. 1958. *The Ecology of Invasions by Animals and Plants*. London: Mentheun.

Engelberg, Kyra, Paul S. Laris, Brian Nagy, and Scott Eckardt. 2014. Comparing the Long-Term Impacts of Different Anthropogenic Disturbance Regimes on California Sage Scrub Recovery. *The Professional Geographer* 66 (3):468-479.

Evans, A.A. and J.A. Young. 1972. Competition within the grass community. In *The Biology and Utilization of Grasses*, eds. V.B. Younger and C.M. Kell, 230-246. New York: Academic Press.

Farquhar, F.D. 1966. *Up and down California in 1860-1864: the Journal of William H. Brewer*. Berkeley: University of California Press.

Fleming, G.M., J.E. Diffendorfer, and P.H. Zedler. 2009. The relative importance of disturbance and exotic-plant abundance in California coastal sage scrub. *Ecological Applications* 19 (8):2210-2227.

Fowler, S.V. et al. 1996. Comparing the population dynamics of broom, *Cytisus scoparius*, as a native plant in the United Kingdom and France, and as an invasive alien weed in Australia and New Zealand. In *Proceedings of the Ninth International Symposium of Biological Control of Weeds*, eds. V.C. Moran and J.H. Hoffman, 19-26. University of Cape Town.

Gale, Carole. A Quantitative Baseline of Native Grass Stands in La Jolla Valley, Point Mugu State Park. M.A. Thesis, California State University, Los Angeles, 1983.

Gandon, S. 1998. Local adaptation and hot-parasite interactions. *Trends in Ecology and Evolution* 13:214-216.

Garnier, Eric. 1991. Resource capture, biomass allocation and growth in herbaceous plants. *Trends in Ecology and Evolution* 6 (4):126-131.

Goldingay, R.L., P.A. Kelly, and D.F. Williams. 1997. The kangaroo rats of California: endemism and conservation of keystone species. *Pacific Conservation Biology* 3 (1):47.

Goode, Suzanne. The Vegetation of La Jolla Valley. M.A. Thesis, California State University, Long Beach, 1981.

Gray, A. 1879. The predominance and terinacity of weeds. *American Journal of Science and Arts* 118:161-167.

Grime, J. Phillip and Roderick Hunt. 1975. Relative growth-rate: Its range and adaptive significance in a local flora. *Journal of Eco*logy 63 (2):393-422.

Hamilton, Jason G. 1997. Changing Perceptions of Pre-European Grasslands in California. *Madroño* 44 (4):311-333.

Hamilton, Jason G., Claus Holzapfel, and Bruce E. Mahall. 1999. Coexistence and interference between a native perennial grass and non-native annual grasses in California. *Oecologia* 121:518-526.

Heady, H.F., J.W. Bartolome, M.D. Pitt, G.D. Savelle, and M.C. Stroud. 1991. California Prairie In *Ecosystems of the world, natural grasslands*, ed. R.T. Coupland, 313-335. Amsterdam: Elsevier.

Hierro, Jose L., John L. Maron, and Ragan M. Callaway. 2005. A biogeographical approach to plant invasions: the importance of studying exotics in their introduced and native range. *Journal of Ecology* 93 (1):5-15.

Higgs, Eric. 2003. *Nature by Design: People, Natural Process, and Ecological Restoration*. Cambridge, MA: The MIT Press.

Hobbs, E.R. 1983. Factors controlling the form and location of the boundary between coastal sage scrub and grassland in Southern California. Ph.D. diss., University of California, Los Angeles.

Holmes, T.H. and K.J. Rice. 1996. Patterns of growth and soil-water utilization in some exotic annuals and native perennial bunchgrasses of California. *Annals of Botany* 78 (2):233-243.

Hosking, J.R. 1995. The impact of seed- and pod-feeding insects on *Cytisus scoparius*. In *Proceedings of the Eighth International Symposium on Biological Control of Weeds*, eds. E.S. Delfosse and R.R. Scott, 45-51. Australia: CSIRO Publishing.

Jackson, Louise E. 1985. Ecological Origins of California's Mediterranean grasses. *Journal of Biogeography* 12:349-361.

Jackson, Louise E. and J. Roy. 1986. Growth patterns of Mediterranean annual and perennial grasses under simulated rainfall regimes of southern France and California. *Oecologia plantarum* 7 (2):191-212.

Jackson, L.E., R.B. Strauss, M.K. Firestone, and J.W. Bartolome. 1988. Plant and soil nitrogen dynamics in California annual grassland. *Plant and Soil* 110:9-17.

Jepson, W.L. 1925. *A manual of the flowering plants of California*. Berkeley: Sather Gate Bookshop.

Julien, M.H. and M.W. Griffiths. 1998. *Biological Control of Weeds: a World Catalogue of Agents and Their Target Weeds*. Oxford: CABI International/Oxford University Press.

Keane, Ryan M. and Michael J. Crawley. 2002. Exotic plant invasions and the enemy release hypothesis. *Trends in Ecology and Evolution* 17 (4):164-170.

Laris, Paul S., Sean Brennan, and Kyra Engelberg. 2016. The coyote brush invasion of Southern California grasslands and the legacy of mechanical disturbance. *Geographical Review*:1-20.

Leiva, M.J., F.S. Chapin, and R. Fernandez Ales. 1997. Differences in species composition and diversity among Mediterranean grasslands with different history- the case of California and Spain. *Ecography* 20 (2): 97-106.

Mack, Richard N., Daniel Simberloff, W. Mark Lonsdale, Harry Evans, Michael Clout, and Fakhri A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications* 10 (3):689-710.

Minnich, Richard A. 2008. *California's Fading Wildflowers- Lost Legacy and Biological Invasions*. Berkeley: University of California Press.

Robinson, R.H. 1971. An analysis of ecological factors limiting the distribution of a group of *Stipa pulchra* associations. *Korean Journal of Botany* 14:61-80.

Schiffman, P. M. 2000. Mammal burrowing, erratic rainfall and the annual lifestyle in the California prairie: Is it time for a paradigm shift? In *2nd Interface between Ecology and Land Development in California*, eds. J. E. Keeley, M. Baer-Keeley, and C.J. Fotheringham, 75-78. U.S. Geological Survey Open File Report 00-62.

Seabloom, Eric W., W. Stanley Harpole, O.J. Reichman, and David Tilman. 2003. Invasion, competitive dominance, and resource use by exotic and native California grassland species. *Proceedings from the National Academy of Sciences of the USA* 100 (23):13384-13389.

Strassforth, Margaret. 1996. Monitoring Native Grass Stands in La Jolla Valley After the October, 1993, Green Meadow Wildfire.

Wester, L. 1981. Composition of native grasslands in the San Joaquin Valley, California. *Madroño* 28:231-241.

Western Regional Climate Center. 2009. Climatological Summary *for* Station: Oxnard Airport (KOXR), CA. http://www.wrcc.dri.edu/summary/oxr.ca.html (last accessed 22 July 2015).

Williams, J.R. 1954. The biological control of weeds. In *Report on the Sixth Commonwealth Entomological Congress*, 95-98. London, United Kingdom.