Current and Historical Distribution of Vegetation Communities at Paramount Ranch, Santa Monica Mountains National Recreation Area

by

Ross Bernet
Morgan Fahlman
Kevin Kawakami
Charles Le
Jessica Savio
Karly Wagner

June 2011
Institute of the Environment & Sustainability, UCLA
Environment 180 – Senior Practicum
Advisor: Travis Brooks
Program Coordinator: Dr. Travis Longcore
Client: National Park Services
Santa Monica Mountains National Recreation Area

Table of Contents

ABSTRACT

Vegetation boundaries change naturally over time, but native vegetation communities are especially at risk following the introduction of exotic species and changes in land use patterns from human urbanization. This study is aimed at understanding the historical trends in the distribution of native and non-native vegetation communities in the Santa Monica Mountains, including Coastal Sage Scrub (CSS), native perennial grassland, non-native annual grassland, oak woodland and riparian, within the protected area of Paramount Ranch. By using two approaches – historical photo analysis and vegetation mapping – we assessed which communities have undergone an increase, decrease, or remained stable in their area coverage through the past few decades. We observed that the vegetation has largely remained stable overall, with the exception of a few areas. Additionally, the study added detail to previous vegetation map efforts by providing further classification of the grassland areas into native and non-native communities.

INTRODUCTION

A mosaic of vegetation communities occurs within the Santa Monica Mountains National Recreation Area (SMMNRA) where Paramount Ranch is located. The area is largely dominated by native vegetation, but non-native communities are present and the stability of these exotic communities is not fully understood. Certain vegetation communities are particularly susceptible to type-conversion by non-native species. The most common example of type-conversion is between communities such as coastal sage scrub (CSS), chaparral and native perennial bunchgrass dominated by *Nassella pulchra* that have been converted to non-native annual grassland communities. The vegetation boundaries do not only change from native to exotic species, but under certain conditions other native plant communities, such as chaparral, can also succeed coastal sage scrub communities. Mediterranean grasses were first introduced to Southern California as early as the 17th century and many new species have been introduced as recently as the 1950's. These non-native annual grassland communities are often able to out-compete the native vegetation and represent the largest threat to their survival.

Human land use patterns are also a major influence to the vegetation communities at Paramount Ranch. Before being a National Recreation Area, Paramount Ranch was owned by Paramount Movie Studios, which altered the vegetation to suit their needs for various movie sets. More recently, external suburban development has lead to an increase in landscape irrigation runoff that alters the water availability to the vegetation communities. Anthropogenic factors resulting from direct land use changes and the introduction of non-native plants dramatically influences the present vegetation. The long-term stability of boundaries between these communities is not always clear.

It is important to understand these vegetation dynamics in order for the National Park Service to effectively manage Paramount Ranch to preserve and restore native vegetation communities. The SMMNRA is in fact a biodiversity hotspot, hosting a large number of flora and wildlife species including some endangered ones such as the California Gnatcatcher (*Polioptila californica)*. This fact allows for special consideration and increased interest in protection and preservation of the native vegetation for its ability to house these species. CSS and chaparral are crucial part of this ecosystem, and the type-conversion to non-native vegetation would endanger both plant and wildlife communities.

LITERATURE REVIEW

Historical Background

Coastal Sage Scrub (CSS) is a vegetation community, which is native to the coastal foothills of California and is characterized by species that exhibit drought-deciduous adaptations to summer drought. The same climatic conditions that CSS vegetation communities occur in are found in the Mediterranean region of Europe, which has been the source of the majority of the non-native annuals and forbs that have been introduced to Mediterranean-type climate California. In some cases following disturbance, these Mediterranean species have successfully displaced, or type-converted native vegetation, including CSS, into what are referred to as annual grasslands, composed of Mediterranean grasses and forbs (Mooney, 1977, DeSimone & Burk, 1992). Even intact CSS habitat is subject to invasion in the open canopy between shrubs, and in some cases, some non-native species are now considered naturalized and permanent components of California’s flora (Eliason, 1997). Invasive species tend to reduce light, soil surface and soil moisture, which makes it difficult for native species to compete (Cox, 2008). These effects greatly hinder the ability of most native coastal sage scrub species to survive because of the abundant competition as well as increasing risks of landslides or fires.

Description of CSS Boundaries and Location

The coastal sage scrub (CSS) community is found in a Mediterranean biome. Mediterranean ecosystems are found at the mid latitudes in both the Southern and Northern Hemispheres. There are five major locations of the Mediterranean ecosystems: the Mediterranean Basin, Southern Australia, Southern Africa, Chile, and California. CSS has been classified into floristic associations. Three of these associations occur in Southern California: Ventura (Ventura Area), Riverside (Riverside Area), and Diegan (San Diego Area) (O'Leary and Westman 1986). In each stand you can expect to find variation in species makeup and domination.

The dominant native plant types to the CSS ecosystem are short shrubs, generally one to ten feet tall, with light green waxy leaves (Hutchinson and Kirkpatrick 1977). Some indicator species are the California sagebrush, the California buckwheat, Laurel Sumac, and bottlebrush (WWF). Coastal sage scrub (CSS) is generally defined as a collection of drought-deciduous, aromatic, shallow-rooted, shrubby plant species that occur along the coastal mountains of southern California below 300 meters (Gray 1981). CSS usually occurs in close proximity to chaparral but on soil less moist due to various factors such as average rainfall, slope, and aspect factors. Above 300 meters and in slightly more moist conditions, CSS often transitions into evergreen chaparral, although many of the same species occur in both. The most commonly cited species of CSS vary slightly in the literature but always include California Sagebrush *(Artemisia californica)* and California Buckwheat (*Eriogonum fasciculatum*) (Keeley 1984, Minnich 1998, Zedler 1983, Westman 1986).

Disturbances

Anthropogenic

Later research, seemingly done in the 1990s and beyond, addresses issues of human impact on the status of coastal sage scrub. Davis's 1995 study utilizing gap analysis presents an early study of anthropogenic effects on the status of coastal sage scrub. Gap analysis is a method of risk assessment for ecosystem conservation that evaluates community planning as well as animal and vertebrate species richness by means of superimposing biological distributions over a map of existing biological reservations. From the gap analysis study, Davis established that coastal sage scrub is at considerable risk with a majority of its land already type converted to agricultural or urban use and the remaining threatened with future urbanization. Davis's methodology of gap analysis, unfortunately, does face some disadvantages that warrant question as to the accuracy of his results. While gap analysis is able to provide a local summary of the ownership and distribution of major plant species and populations, this method is not well suited to examine most wetlands, dune communities, or other populations that are restricted to environments confined to a small area.

Eliason (1997) similarly cites human disturbances as the initial causes that have secondary impacts in reducing the coastal sage scrub population. Invasive grass density was examined in experimental plots in the Santa Monica Mountains National Recreation Area, and native shrubs were seeded and planted to determine the species' response to this invasive grass density. Eliason ultimately determined that the coastal sage scrub community suffered as water use was diverted from this community for use by the invasive grass species, which is associated with overgrazing by livestock, increased fire frequency, and removal of natural vegetation by machinery.

Much of the literature on human impact on coastal sage scrub relates to the human influence on fire regimes. Using United States Forest Service National Fire Reports, Keeley and Fotheringham (2003) determined that humans are responsible for fire ignitions approximately seven times as much as natural lightning. Therefore, human population increase is positively related with an increase in fire frequency. In a later 2006 study, Keeley investigated the historical impacts that Native Americans had on fire regimes of California shrub land in comparison to the natural impact of lightning. From examining historical documents, ethnographic accounts, records of archaeology, and modern land management standards, Keeley developed models of potential Native American burning patterns. He disputes Eliason (1997)'s claims that poor moisture availability in the soil are responsible for habitat loss of coastal sage scrub, concluding that all previous ecological research has failed to prove that there are any factors related to climatology or soil quality that can explain for the distribution of coastal sage scrub. Keeley also disputes claims by Vale (1998, 2000) that, of the annual average of 5125 ignitions caused by lightning, any additional burning started by Native Americans would have been in the immediate area surrounding villages. Keeley goes on to explain fire as a pre-Columbian tool for land management needs: increasing seed, bulb, and fruit production, increasing the habitat size for mammal resources, increasing water resources by means of seasonal streams, reducing health hazards such as rattlesnakes and grizzly bears, and facilitating travel by foot.

Aside from providing quantitative analyses of anthropogenic ignitions and observations of historical records and documentation regarding human-influenced fire regimes, with improving technology, research has also digitally modeled potential conditions for the future. In 2006, Syphard, Clarke, and Franklin developed a landscape simulation model of disturbance and succession (LANDIS) with an urban growth model (UGM) for the Santa Monica Mountains National Recreation Area. From this simulation model, they supported previous research (Keeley, 2003 & 2006) that human-caused ignitions have increased to the point such that coastal sage scrub succession is endangered due to the resulting expansion of non-native annual grasses. Syphard, Clarke, and Franklin additionally concluded that the risk of fire ignition is much higher at intermediate levels of urbanization due to the manner in which ignition sources and fuel are spatially arranged.

Aside from human-initiated fires that destroy large areas of vegetation, including coastal sage scrub, other anthropogenic forces are also responsible for the decreasing coastal sage scrub population. A study conducted by Talluto and Suding (2008) examined the historical change of southern California vegetation type map plots from the 1930s to determine if fire frequency and nitrogen deposition resulting from air pollution are positively associated with the conversion of coastal sage scrub to exotic grasslands. Over the course of 76 years of United States Forest Service records, the population of coastal sage scrub has decreased by 49 percent in size, being replaced primarily by non-native, invasive grass species. While it is agreed that increased fire frequency contributes to non-native grassland encroachment, in areas with low fire frequency, Talluto and Suding determine that this exotic plant invasion is positively associated with nitrogen deposition, a result of air pollution from anthropogenic combustion of fossil fuels. Another study conducted by Westman (1985) also examined the effects of air pollution injury to coastal sage scrub in the Santa Monica Mountains National Recreation Area. The qualitative and quantitative study included a field study of coastal sage scrub species in the area, observing particularly for 26 various types of foliar damage. Pollution levels at the selected sites in the Santa Monica Mountains National Recreation Area were estimated from ten weeks of readings by seven nearby air quality monitoring stations. Ultimately, Westman resolved that 40 percent of injury symptoms found in coastal sage scrub samples were positively matched with control species exposed to controlled fumigation.

Nitrogen (N) deposition just recently became a topic of interest in the past few years. Concerns with the effects of atmospheric pollution on vegetation have heightened sensitivity toward these emitted gases. Nitrogen deposition is excess nitrogen added to vegetation due to atmospheric pollution. In Riverside County, California a survey showed that nitrogen is four times higher at these locations than rural areas (Cione, Padgett, and Allen 2002). The same study in 2002 also states, "increased nitrogen deposition or fertilization supports grassland growth (Cione, Padgett, and Allen). CSS has very little nitrogen fixing species and with an increase in nitrogen deposition this may cause a change in vegetation (Padgett, Allen, Bytnerowicz and Minnich 1999).

Invasive Species

There are roughly 50,000 invasive species that have been brought to the United States both intentionally, for agriculture or landscaping purposes, and unintentionally, as stowaways on ships, planes, and human travelers. These plant species have been estimated to cost the United States economy 120 billion dollars each year (Morrison *et al.* 2005; Lundquist 2003). It is estimated that 42% of the species on the endangered and threatened species list are there primarily because of threats to their habitat from non-native species (Morrison *et al.* 2005). Identifying the invasive species, its evolution history, natural habitat, and native competition are the main components of background research on the alien species.

Invasive species also increased ecosystem carbon storage in litter because when present non-native grass litter decomposed more slowly than native shrub litter. Invasive species facilitate growth of their litter and the density of the invasive species is directly related to the litter success causing a positive feedback loop and significantly affecting the competitiveness of the seedlings (Wolkovich, 2009). The growth and survival of CSS seedlings were also significantly reduced in the presence of invasive annual grasses. Grasses can persist adjacent to and expand into coastal sage scrub by inhibiting shrub recruitment (Eliason 1997). By inhibiting shrub recruitment, invasive species are able to outcompete the native species and drain the soil's nutrients. "Grass invasion into shrub habitats can intensify belowground competition for limited resources, especially nitrogen and water, to the detriment of the native shrubs (D'Antonio *et al.*, 1998)." In many invaded systems, invasive grasses take up resources before the resources reach the deeper roots of shrubs, or share shallow rooting depths with native shrubs (Melgoza *et al.* 1990)

In some instances, the introduction of non-native species cannot be avoided. There must be methods in place to remove the invaders. One method that has been used in California is prescribed burning; this involves purposely burning an area to rid it of invasive plant species (Stephens and Potts 2009). The major drawback with this method is that the burning gets rid of all species in an area and generally lowers the species diversity. Another method includes creating gaps between vegetation types and altering the height of the different species. This isolates the invasive species from the native species and prevents the plant from spreading further (Burke and Grime 1996). One final effective strategy for the removal of invasive species is to mechanically remove the non-native plants. This process is both costly and labor intensive, but ultimately effective. In mechanical removal, the invasive species are manually removed and disposed of away from the study site. This leaves the native plants alone in the environment, and they are able to grow and reproduce without competition from the alien species. These are several of the leading methods in identification and removal of non-native species. Each method has its drawbacks, and there is always the chance that the same non-native species will get re-introduced.

Fire

A major component of the Mediterranean and CSS ecosystems are the plants' adaptation to fire. The two typical ways of studying fire are longitudinal studies and simulation models of fire. Simulation models map an area's response to fire using ecological, geological, and environmental factors. When studying an area's response to fire, the models are usually run on low, medium, and high intensity. The intensity of the fire takes into account both the duration (time) and the extent (area burned) of the fire.

LANDIS (landscape Disturbances and Succession) is arguably the most widely used model for simulating fire in Mediterranean regions. LANDIS incorporates all aspects of the ecological region, giving an accurate picture of the effects of fire over a long time scale (Deutschman*et al.* 2001; Franklin *et al.* 2007).

A fire that risks the health of humans or threatens property destruction is unacceptable for those responsible for fire management. This human motivation is not very compatible with the many plants that depend or partially depend on fire to create their next generation (Barro 1991, Keeley 1984). In addition to the direct destruction of human property, fire negatively affects humans in at least two other significant ways. First, fire destroys hillside plants, which can increase soil runoff. This soil runoff can result in the secondary problems affecting water supply and decreasing slope stability leading to more damaging mudslides (Beyers 2004). Secondly, the smoke produced by large fires impacts air quality (Barro 1991). Although fire can be a naturally occurring phenomenon, humans have also been the source of these costly disasters. A long-term management plans for predicting and dealing with them is vital to the economic well being of Southern California.

Studies that examined fire patterns found that there was an initial spike in the species abundance roughly two years after the occurrence of fire. The species then declined back to pre-fire densities around the fifth year (O'Leary and Westman 1986). The LANDIS model bases its simulations on interactions between species. Information is gathered from the species' history: the conditions at the specific site, disturbances at a particular site, and the type of land management that is practiced in that region (Deutschman *et al.* 2001; Franklin *et al.* 2007). Although each community has different responses to fire, many plant species in both communities have seeds that will re-sprout only after a fire or that have structures that burn easily but allow for basal re-sprouting (Keeley 1984). Hanes (1971) even suggested a new term to describe this process: auto succession, which makes clear that recovery comes from the individuals already present on the site before the fire. The danger to plants from fire is when it occurs too frequently. This exhausts their resources and does not allow them a chance to recover and prepare for the next fire (Zedler 1983).

Native and non-native plants have different responses to fire. When compared in a longitudinal study, non-native plants have been found to do better with very high levels of fire while native plants tend to suffer with too much fire (Keeley 2001). The plants that are classified as coastal sage scrub thrive with moderate levels of fire. They have historically declined when there is no incidence of fire (Franklin *et al.* 2006). These species in the CSS community are not only dependent on fire but also deteriorate when the fire intensity is too high or too frequent. They need a balance between periods of fire and periods without fire in order to be most successful. Finding that balance in Southern California today has proven to be difficult. Each native species within the ecosystem has its own slightly different response to fire; these differences must also be noted when looking at fire in the CSS ecosystem. The ability of native plants to quickly re-sprout following a fire has a direct effect on the density of non-native species that are able to colonize the region (Keeley 2001). Invasive species are very competitive in the CSS community because of their ability to quickly re-sprout and dominate after a disturbance. Once non-natives have established themselves as the primary species in the region, the native species lack the adaptations to compete for the space and nutrients they need for survival (Eiswerth *et al.* 2009).

Some invasive species even have adapted their leaves to fuel the fires. Their leaves have evolved to be more flammable, thus increasing the duration of the fire and removing native plants that are less adept at dealing with high intensity fires (Keeley 2001). Fire is a traditional part of the Mediterranean ecosystems; however, too much fire has been proved to have negative effects on the CSS (Franklin *et al.* 2006; Keeley 2002; O'Leary and Westman 1986). One exotic grass, *Ampelodesmos,* heightens the intensity of a fire. The grass has evolved to be very flammable and have a large above ground biomass to facilitate the fire (Lloret *et al.* 2001). These adaptations are very useful for the grass. Once the fire has burned through, the non-native species have an advantage because of their ability to re-sprout quickly. These species repopulate more quickly than other natives and establish themselves as the primary species in an area, out competing the native species (Lloret *et al.* 2001; Franklin *et al.* 2007).

Many of the studies that look at an ecosystem's response to fire need to be executed over a long time period. Because CSS conservation is a relatively new topic of interest, there is no long-term analysis of the coastal sage scrub habitat's response to fire. One must make do with simulations that project the specific areas and species and their response to fire (Franklin *et al.* 2006; Allen and Cox 2008). While these simulations are adequate at predicting fire patterns and responses, they are not able to take into account anthropogenic changes to the environment (Franklin *et al.* 2007). This is one area where no model can give accurate predictions. More studies are necessary to both prevent new invasive species from being introduced into the CSS and to stop the expansion of existing invasive species.

GIS

Understanding how and why vegetation cover changes over time is of critical importance to the ecologist and conservationist. Historically, one of the biggest challenges to overcome has been the limited spatial resolution of older data, which had to be measured and drawn by hand and is generally only detailed enough to provide a broad view of landscape changes (Talluto 2008). The increasing ease of accessibility to high quality satellite imagery is dramatically changing this problem and redefining how we are able to track landscape changes with increasing spatial resolution. NASA's Landsat program started to become widely available to the public in the 1980s and marks the beginning of useful high-resolution imagery being made available. Now the problem is the lack of temporal resolution.

Still, the older maps provide a basis, and along with other areas of special interest, the Santa Monica Mountains have a fair share of aerial photography, which does widen the time scale with which we can track vegetation changes. Furthermore, both of our sites within the Santa Monica Mountains have a record of black and white photographic images, which can be compared to new photographs from the same viewpoint to provide information on coverage changes. GIS allows for greater processing power of the available image in the form of layers and vegetation indexes that make it possible to compare places of interest with accuracy limited only by the images (Davis 1994).

METHODS

In order to answer the question of vegetation boundary dynamics we utilized two main techniques, which allow us to view past records of vegetation and compare them with the present state. The first approach capitalized on the fact that our study location was previously under the ownership of the cinematography company Paramount Studios and consequently a rich archive of historical photos dating back to the 1950s exists as a research tool. The documentation of the vegetation was a resulting consequence of the photographs taken for various movie sets or other purposes. Present data photographs from identical vantage points allow us to compare directly the vegetation of the past and the present. The second technique compared vegetation boundaries visible from aerial and satellite images to assess the stability or change in vegetation over a 21-year period.

2010 Vegetation Map

The vegetation map was created upon an ArcGIS base layer. The National Park Service provided the map boundaries for the Paramount Ranch National Park Site. By first examining the satellite images from the ESRI Web Service Imagery, National Cartography and Geospatial Center, we tried to identify the various vegetation types and boundaries in the area based upon areas of similar color, texture and pattern. The vegetation types that were delineated include woodland, chaparral, coastal sage scrub, riparian, and grassland. With the location of these vegetation boundaries estimated and the park boundaries provided, the Paramount Ranch National Park Site was separated into several smaller and more manageable areas for purposes of a field survey.

The first step to the process of conducting the field survey was to locate and visit potential boundaries between different vegetation types that were identified from visual interpretation of the aerial photos. A GPS (Garmin eTRex) unit was used to record location of vegetation surveyed, along with attributes about the vegetation cover (see Appendix A for a sample field data sheet) and photos.

Because native bunchgrass dominated grassland cannot be detected from the aerial imagery, special field surveys were conducted with the GPS to document the boundary between areas of significant *N. pulchra* cover (>10%) and areas dominated by non-native annual grasses with no native grass cover.

The field data was added to a geodatabase, and was used to develop a refined visual key of what the different vegetation communities looked like on the aerial image. This improved both the delineation of vegetation boundaries and in the classification of vegetation type. When each polygon was mapped, the attribute table that was completed in the field was also input into ArcGIS. Additionally, certain areas of the park were not accessible by foot, and therefore, surveys of the boundaries could not be performed. For these regions, the areal images were examined and compared to the conjectured polygons on the developing map so that we could better establish the locations of the vegetation boundaries.

<u>1989 Vegetation Map</u>

Following the completion of the 2010 vegetation map, the next phase was to create a vegetation map for the 1989 aerial image of the Paramount Ranch National Park Site. The delineation of vegetation boundaries and classification of vegetation types was informed by our field surveys of present day vegetation and by examining the historical photos collected from the Rocky Oaks Museum. Native bunchgrass and different associations of CSS could not be detected from the 1989 aerials, with the information available.

<u>Vegetation Change: 1989 to 2010</u>

Once both the 2010 and the 1989 vegetation map were completed, an intersection of the two maps was created in ESRI ArcGIS. This way, areas of increasing, decreasing, and stable vegetation types could be seen determined. Multiple intersect maps were created for each vegetation type (riparian, woodland, coastal sage scrub, grassland, and chaparral).

One of the severe limitations when comparing the resulting vegetation maps is the confidence with which we were able to map vegetation from the 1989 aerial and the disparities we faced when viewing the 2010 satellite image versus our ground GPS points.

<u>Historical Photos</u>

The National Parks Service has an archive of photos from the 1950s, located at the Rocky Oaks Museum, in Thousand Oaks, CA. Approximately twenty photos from the Paramount Ranch National Park were selected. The photos were selected based on the amount of vegetation that was present in the photo. They were also selected based on distinct landmarks (such as buildings, road, mountains) the landmarks were necessary in order to be able to find same vantage point that the original photo was taken from. The next step in this process was to visit Paramount Ranch to determine the vantage points from which the photos were taken. This was done by observing unique features of the landscape, including mountain ranges, buildings in the movie set, telephone poles, trees, and trails. Several photos were taken from each vantage point to ensure that the same view of the landscape was included in the present day oblique. GPS points were also taken to track and catalogue the locations where each photo was obtained.

Once all of the photos were taken, the next step was to change some of the photos to a gray scale filter. This was only done to the photos in which it made the distinction of the vegetation changes more clear. For the rest of the photos they were kept in their original color. With the original color intact on these photos it was still possible to detect the vegetation changes. There were slight differences in the scale and content of the historic and present day oblique photos. To fix this problem, the program Adobe Photoshop was used to adjust the size and crop the images so that they have the exact same vantage point. With the adjusted photos, we analyzed and examined similarities and differences between the historic and present day photos. Areas of vegetation that seemed to have experienced change between the two times were outlined in red to better display the vegetation change that has occurred. For some photos, insignificant change was observed, and in these cases, only a qualitative analysis was completed to describe areas that changed over time or remained stable.

A website was created for the display of the historic and present day photos. A slider tool on the website allows one to swipe back and forth between the present day image and the historical photo. This aids in the visual analysis, with each area of significant change outlined on each of the photos.

RESULTS

Vegetation Maps

After completing fieldwork we created the 2010 vegetation map, which can be seen in figure 1. Figure 2 shows the 1989 vegetation map based off of the 1989 aerial image. There are three types of classifications that could be mapped in the 2010 map, but not in the 1989 map. These include bunchgrass, rye grass, and disturbed areas. We were unable to distinguish these classifications in the 1989 map due to the quality of the aerial image and the lack of field study data. These areas are all classified under grassland in the 1989 vegetation map. One clear change from the 1989 to the 2010 vegetation map is the increase of a large community of CSS in the central east part of the maps within a chaparral community. Although this is a significant change, we are skeptical to accept this as true. We were able to complete a field survey of this area that we determined to be coastal sage scrub. When analyzing the 1989 aerial image, we could not identify this area with 80% confidence as CSS due to the resolution. The coloring in this area is similar to other known chaparral areas in 1989.

The intersect map of total area change indicated the percent increase or decrease of each vegetation type, which can be seen in figure 3 and table 1. There are small changes in percent increase or decrease and it is difficult to say with confidence that these numbers are correct. For example, we know from historical photograph analysis that the riparian zone has in fact grown, but on this graph it shows that the riparian zone has remained stable. This is due to the fact that there was not a significant amount of total

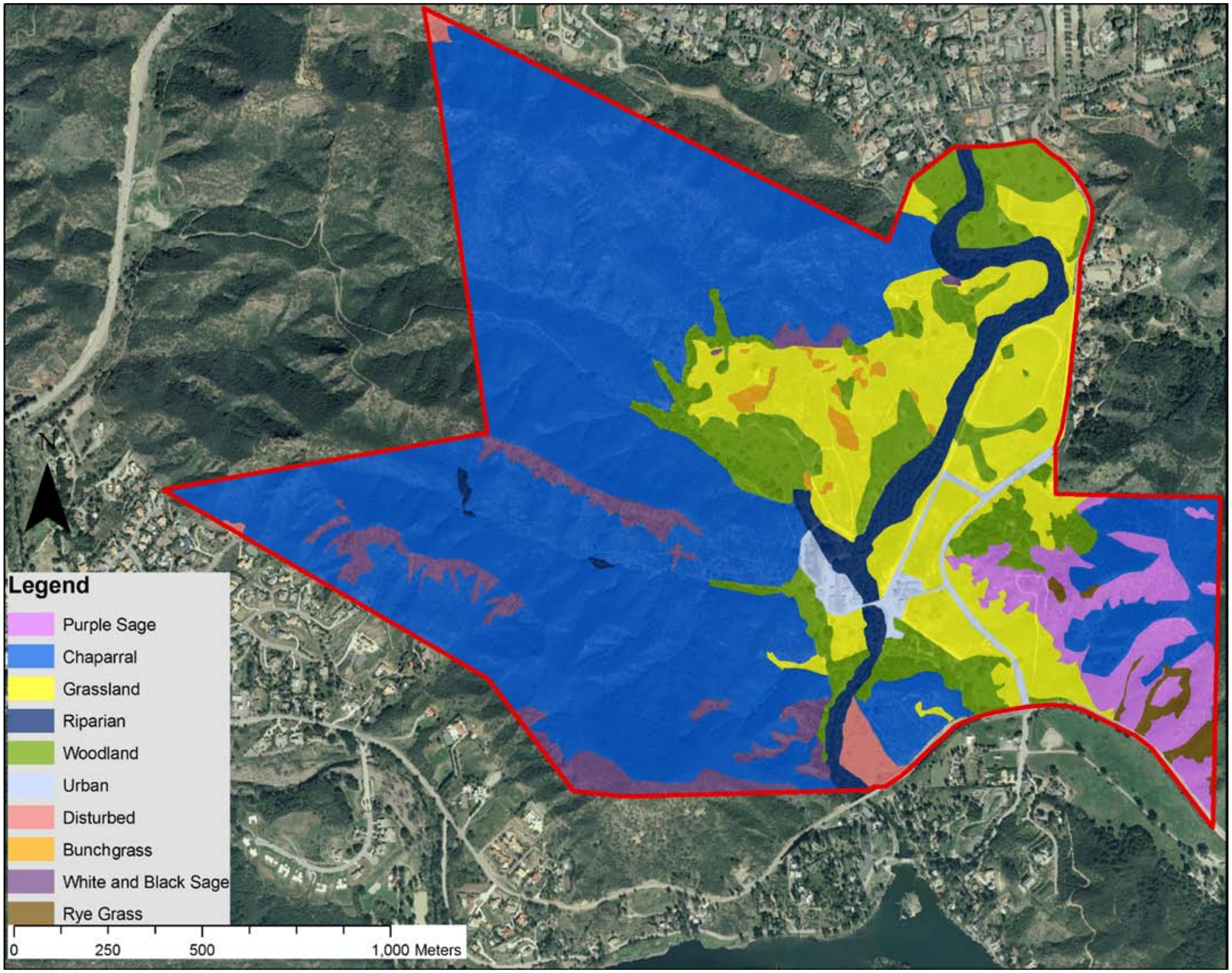


Figure 1. 2010 vegetation map depicting the vegetation types and associations found in Paramount Ranch based off of field surveys and an aerial image.

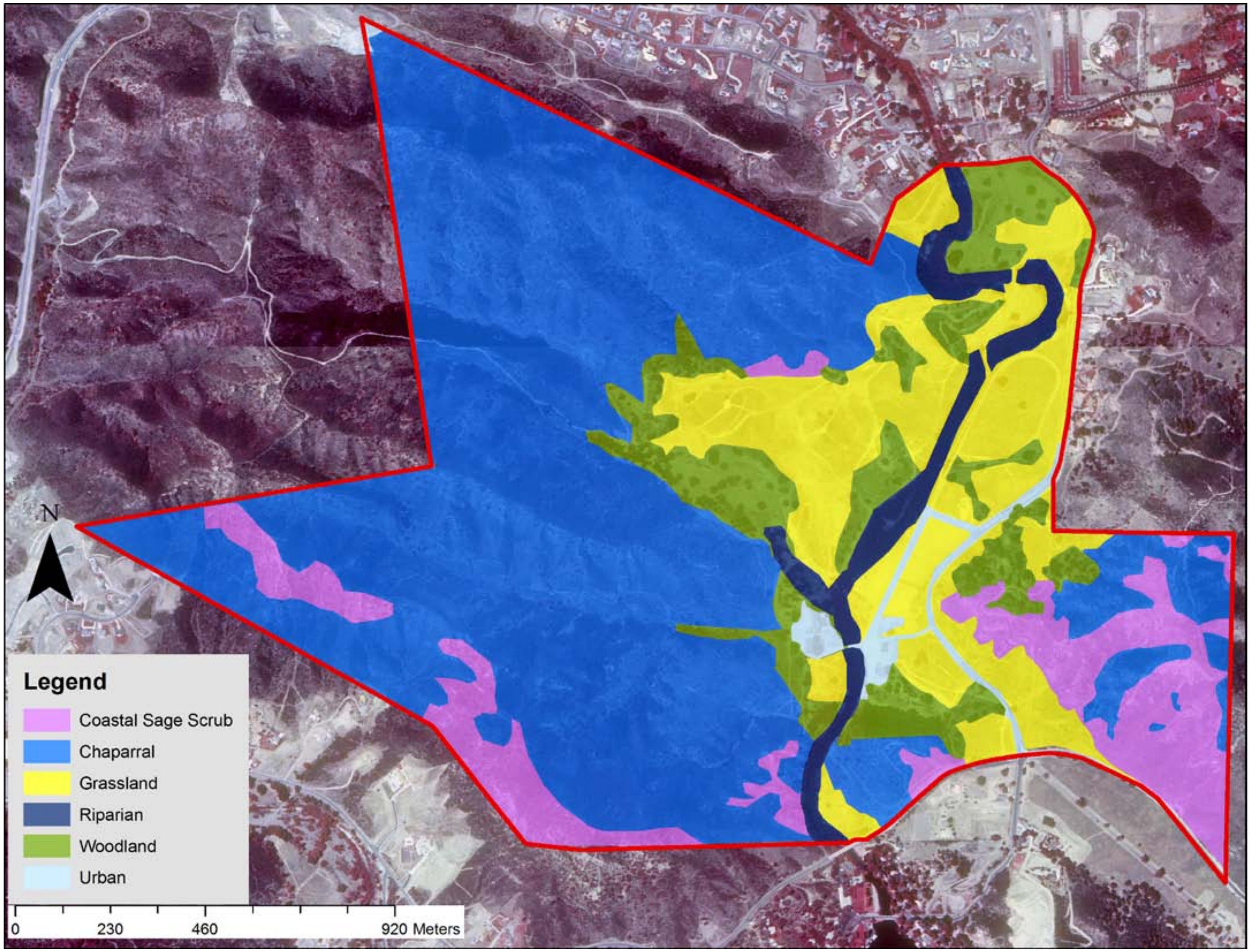


Figure 2. 1989 vegetation map created using ArcGIS from a 1989 aerial image.

change of area defined as riparian between the 1989 aerial and the 2010 satellite image, so this change in cover is not reflected in figure 3. This could also be due to the more limited ability to be confident about the specific location of boundaries in 1989 because that was entirely based on aerial image interpretation whereas the 2010 vegetation map was created with the use of extensive field surveys. In figure 3 grassland increases by 2%, which may also be a combination of the inherent error in using ArcGIS as well as the better aerial image used for the 2010 map. In the southeast corner of figure 1 there is a large ryegrass community mapped that is not present in the 1989 map (figure 2). We believe that this area has most likely expanded since 1989, but could also be due to the poor quality of the 1989 aerial. Based on figure 3 woodland has decreased by 4%. This is most likely due to error in delineating exact boundaries on ArcGIS. Delineating the boundaries in the 1989 aerial between woodland, chaparral and grassland was particularly difficult, which explains the decrease in woodland.

One of the clearest examples of chaparral boundary change can be seen in the southeastern corner of Paramount Ranch (Figure 4). This area, which is also magnified in figures 6a, 6b, and 7, consists mainly of south facing slopes and is consequently largely purple sage dominated coastal sage scrub. Rye grass dominates down the middle of the valleys while the tops of some of the slopes are more densely vegetated by laurel sumac (*Malosma laurina*) dominated chaparral. Although the resolution for the 1989 aerial image (Figure 6a) has a resolution of 1m, which is far poorer than the 2010 satellite image with a 30 cm resolution (Figure 5b), vegetation boundaries can still be quite

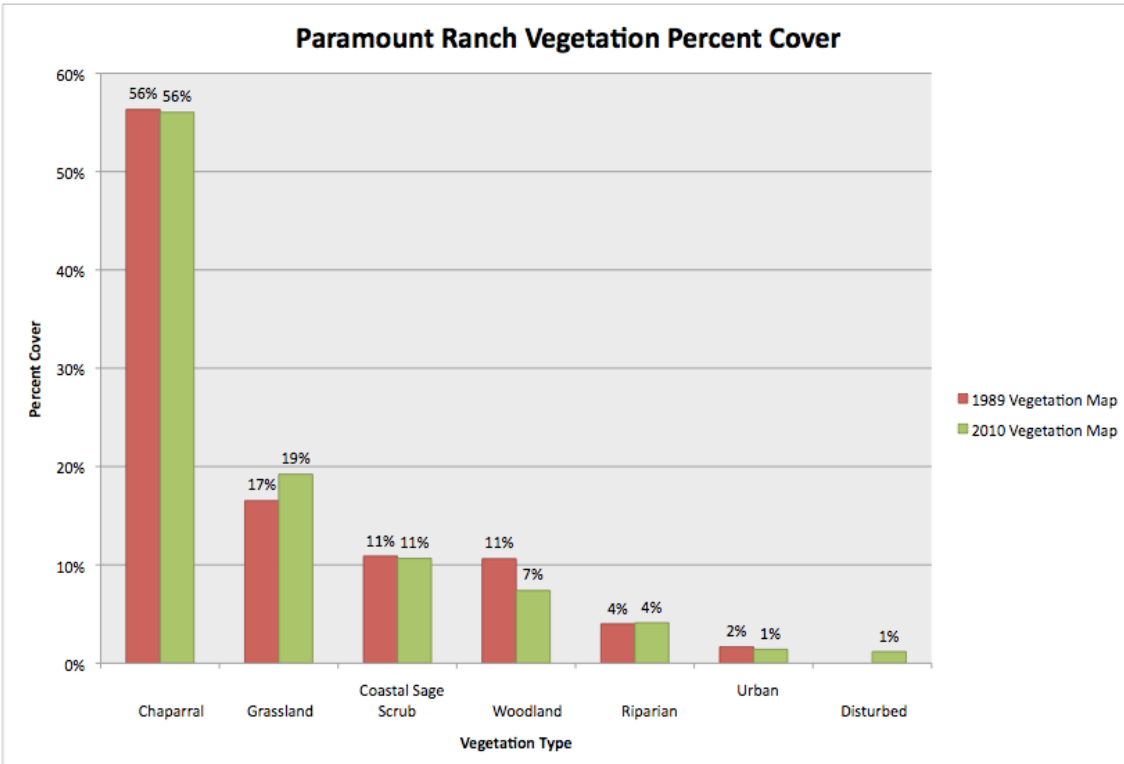


Figure 3. Change in total percent of vegetation cover from 1989 to 2010 in Paramount Ranch.

Table 1. Total area cover and percent cover for each vegetation type in the 1989 and 2010 vegetation maps.

	Vegetation Area Cover					
1989 Vegetation Map			2010 Vegetation Map			
	Area Cover (km^2)	Percent Cover		Area Cover (km^2)	Percent Cover	
Chaparral	1744.682884	56.31%	Bunchgrass	18.72462134	0.61%	
Coastal Sage Scrub	337.4507501	10.89%	Chaparral	1764.517184	57.32%	
Grassland	511.8624719	16.52%	Coastal Sgae Scrub	281.0937699	9.13%	
Riparian	123.8898201	4.00%	Disturbed	25.06673472	0.81%	
Urban	51.23143271	1.65%	Grassland	463.3613624	15.05%	
Woodland	328.9936546	10.62%	Riparian	159.9308962	5.20%	
Total	3098.111014	100.00%	Urban	49.32146908	1.60%	
			Woodland	316.3498959	10.28%	
			Total	3078.365934	100.00%	

distinct. The boundary between the oak woodland and the chaparral is in fact much more clear in the 1989 aerial because the shrubs appear much smaller. The boundary between the chaparral and the coastal sage scrub is slightly more difficult to detect, but in some areas the boundary is fairly sharp. The intersection between the 1989 and 2010 map (Figure 4) reveals where the total area of chaparral is expanding, shrinking, or is stable over the 21-year period. Figure 6 shows a close-up of the southeast corner of chaparral boundary dynamics. This approach was done for the entire study site, but the change is most visible in this region and the zoomed in images included in figures 6a, 6b, and 7.

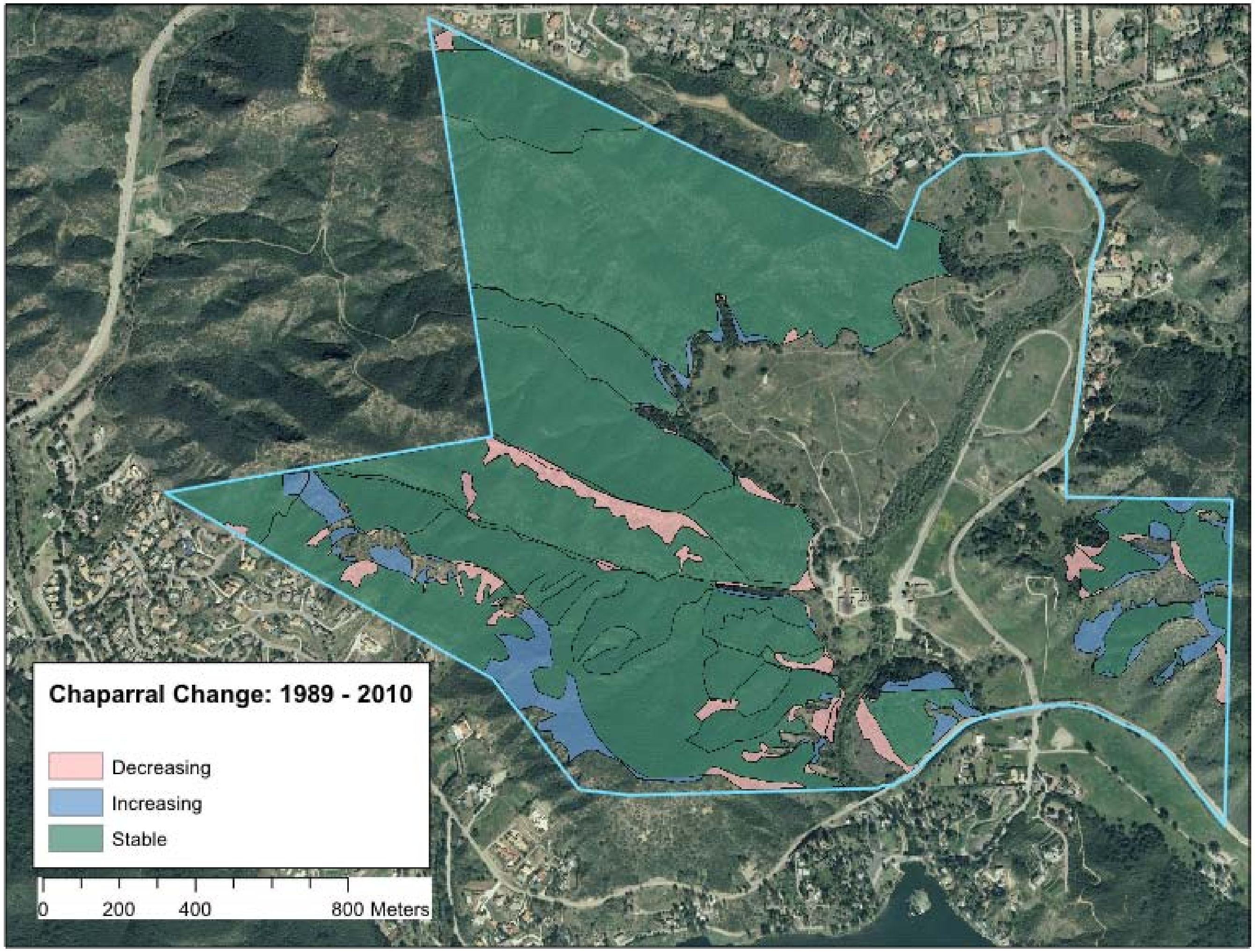


Figure 4. Intersect map showing where chaparral is decreasing, increasing, or stable.

1989 Aerial Image Chaparral Vegation Boundary

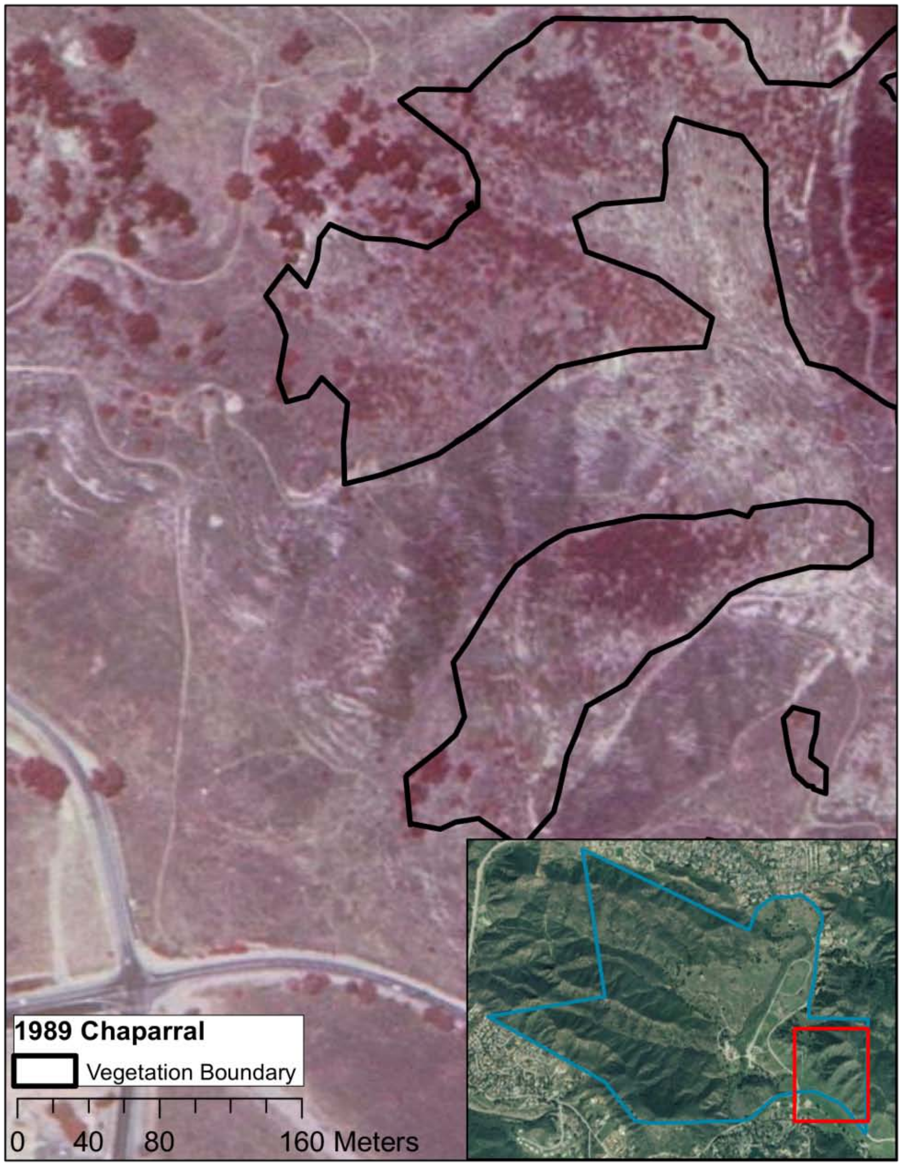


Figure 5a shows the outlined chaparral community based off of the 1989 vegetation map with an insert showing the area within Paramount Ranch.

2010 Satellite Image Chaparral Vegation Boundary

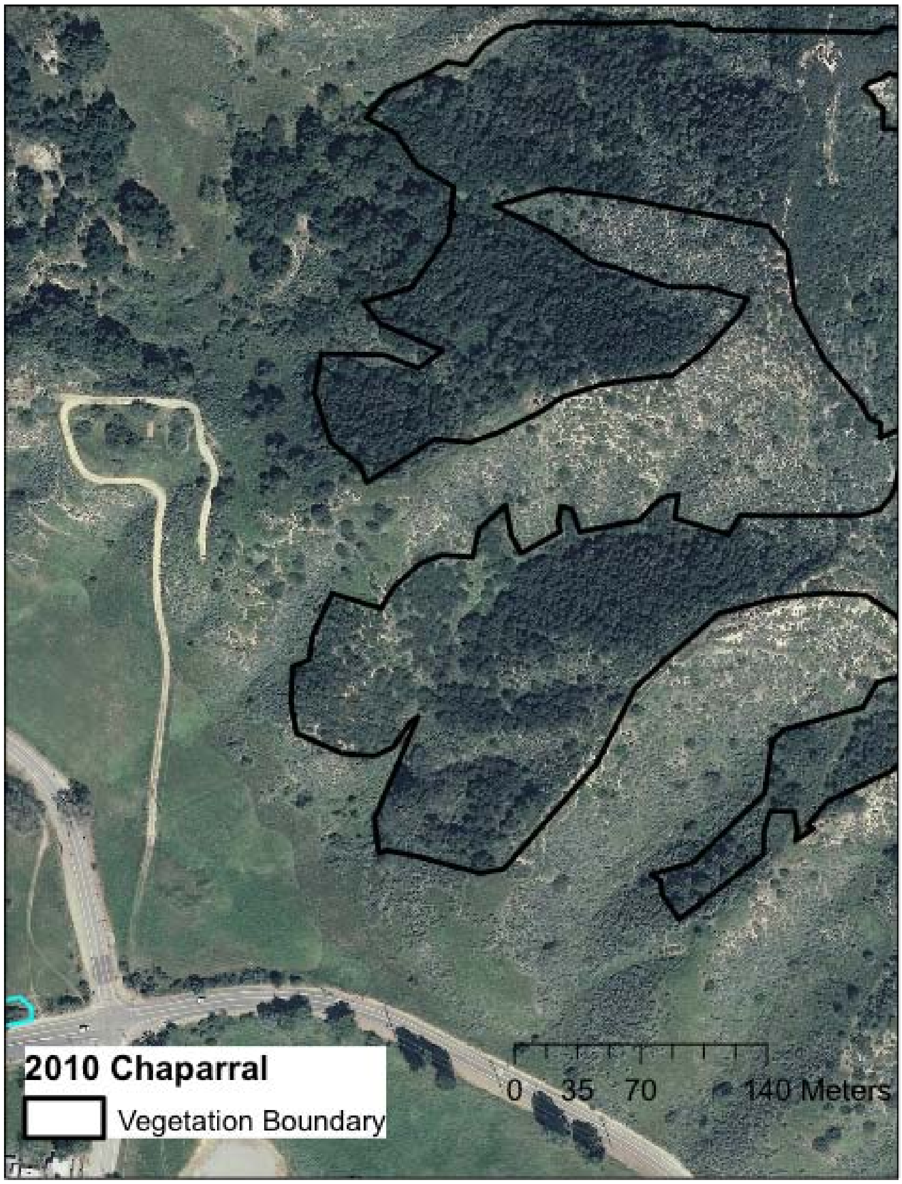


Figure 5b shows the outlined chaparral community taken from the 2010 vegetation map.

Chaparral Boundary Changes between 1989 and 2010

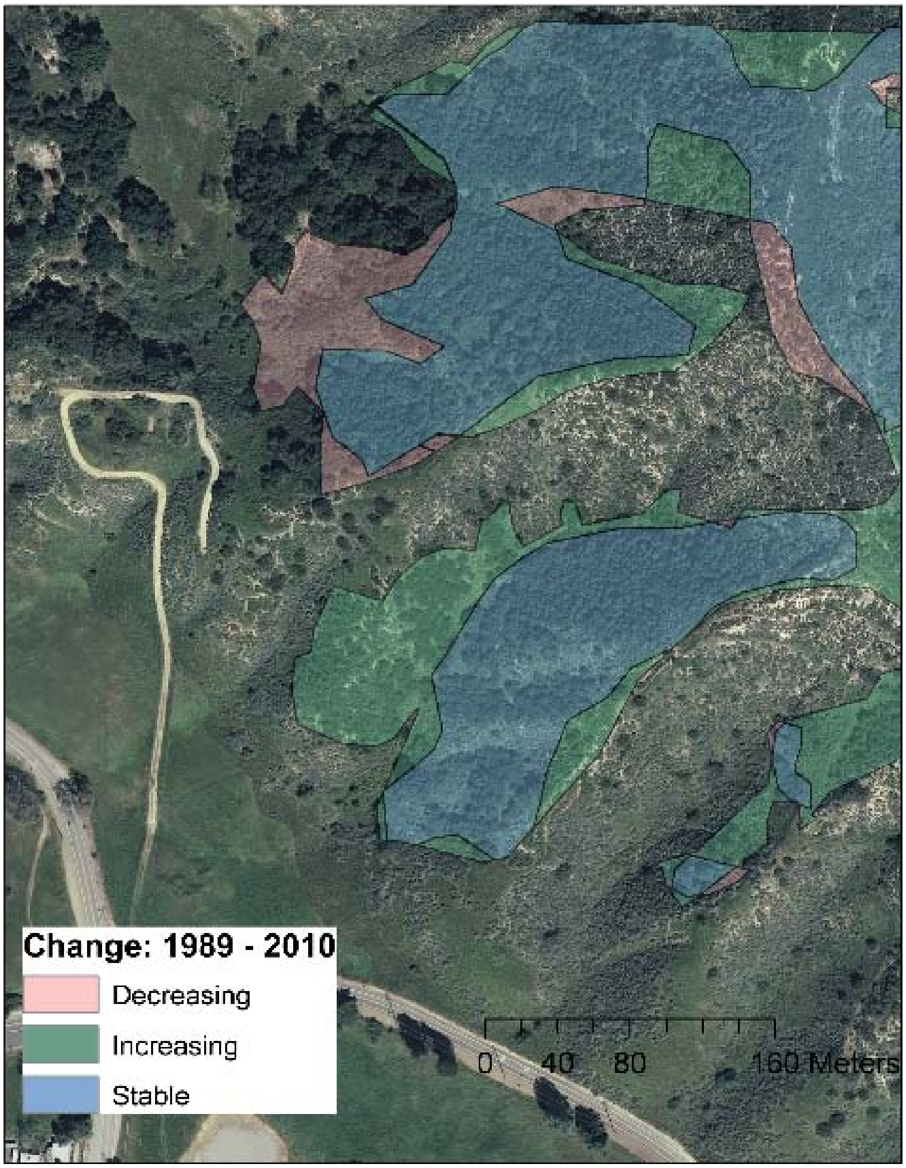


Figure 6 shows a zoomed in view of the intersect map between figures 6a and 6b, which is in the southeast corner of Paramount Ranch.

Discussion

<u>Vegetation Maps</u>

Overall, between 1989 and 2010 the vegetation community boundaries were stable; however, there are a few places with some significant change (Figure 7). The fact that much of the vegetation did remain stable is a significant outcome in itself, although perhaps not incredibly surprising due to the short time period of 21 years. The few places where change is evident are revealing of broader activity.

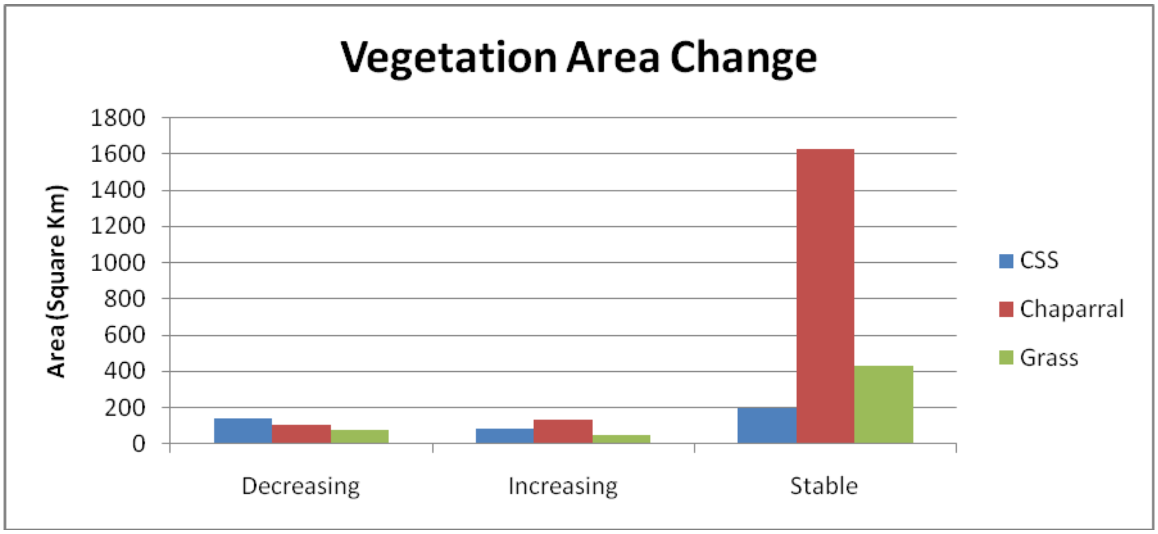


Figure 7 shows the total increasing, decreasing, and stable area of coastal sage scrub, chaparral, and grass between 1989 and 2010.

Riparian

The most definitive change was encountered in the riparian zone vegetation that encases a small stream that spans the park. The stream flows from north of Paramount Ranch through the entire center and exits through the south and drains into Malibu Lake. The 1989 aerial explicitly reveals that the stream was not a continuously flowing river nor entirely encased in vegetation as evident in the two breaks in vegetation in the northern part of the study area (figure 2). The 2010 aerial (figure 1) in addition to our field visits have revealed a dense canopy of riparian vegetation completely encase the river from the point of entry to the point of exit. The explanation for this phenomenon lies in the increased runoff due to increased suburban landscaping. The two images do reveal increase in development and housing and the increased watering of lawns leads to runoff, which allows the stream to have a perennial water flow.

A second large change is this urbanization. Although not within the boundaries of Paramount Ranch, the increase in home building directly adjacent to the Ranch represents the most significant change in land cover and the previously defined relationship this transition represents for the vegetation of Paramount Ranch. The increased Riparian zone and urban zone outside park boundaries represent the two largest, definitive changes. There are other areas of change, but the majority of the park remained stable.

Chaparral

The chaparral remained largely stable for the majority of our study area. In fact, total coverage between our 1989 and 2010 vegetation maps show no change in total cover – remaining 56% of total area covered for both maps. The two images suggest there may be pockets of CSS within the chaparral of the western portion of the study area, but lack of trails prohibited us from confirming this definitively. Of what we could see with our eyes and binoculars, the chaparral vegetation was largely uniform in its coverage of the hillsides and almost the only vegetation type of the west side of Paramount Ranch.

The southeast corner shows some significant change. Most of the upper parts of the slopes remained stable; however there are several areas that decreased around the oak woodland, which appears to be expanding. Something we used as a CSS identifier was the presence of rock outcroppings, which are generally highly associated with CSS cover. The 1989 image reveals a clear rock outcropping that has since turned into chaparral. It is possible that the vegetation intersect could be exaggerating the change, but there seems to be little doubt that a conversion has taken place due to the size of the barren rock outcropping and the lack of vegetation.

The chaparral remained largely stable for the majority of our study area. In fact, total coverage between our 1989 and 2010 vegetation maps show no change in total cover – remaining 56% of total area covered for both maps. The southeastern corner did show some change, but an almost equal increase and decrease. Most of the higher parts of the slopes remained stable. The areas that decreased are around the oak woodland, which appears to be expanding. The parts that increased noticeably are on one of the southern slopes. Something we used as a CSS identifier was the presence of rock outcroppings, which are generally highly associated with CSS cover. The 1989 image reveals a clear rock outcropping that has since turned into chaparral. It is possible that the vegetation intersect could be exaggerating the change, but there seems to be little doubt that a conversion has taken place due to the size of the barren rock outcropping and the lack of vegetation. Beyond this change, the rest is equally likely to be true change or experimental error based on the misclassifying of the 1989 aerial which often proved to be difficult.

Coastal Sage Scrub

Coastal sage scrub was mainly found on southern facing slopes in the south side of Paramount Ranch. The total percent cover for CSS remained the same from 1989 to 2010 at 11%. This does not represent that no change has occurred in the past 21 years. Although most of the CSS community remained stable, 194 km^2, CSS decreased by 139 km^2 and increased by 81 km^2 (*Table 1*).

Figure 8 shows the total change for CSS within Paramount Ranch. The majority of the area decreasing is in the southeast and southwest corners of the park. One area in particular that lends significant information is in the north central part of Paramount Ranch. Figure 9 is zoomed in to this area and shows the total boundary dynamics. The boundary between CSS and grassland in this polygon has been stable for over 50 years, which can be seen in not only Figure 9, but Figure 14 as well. Figure 14was taken in the 1950's and the stable border can clearly be seen. Figure 15 is the present day photo taken from the same vantage point as Figure 14. Although this boundary has not changed, it is vital for understanding boundary relationships.

Grassland

In the past the grassland below the CSS patch in Figure 9 was labeled as non-native grassland. Through field observations we discovered a large community of native bunch grass that comes up to the boundary between CSS and grassland. We believe there are two possible reasons for the stability of this boundary. One is that the nonnative grass below the CSS is inhibiting further development of CSS below the boundary. A second possibility is that this boundary represents a natural boundary between the two communities. Figure 12 shows what this boundary looks like in present day. In Figure 13 a distinct change in slope can be identified. To the left of the trail is a community of CSS with a higher slope angle and to the right of the trail is a community of bunchgrass with a lower slope angle.

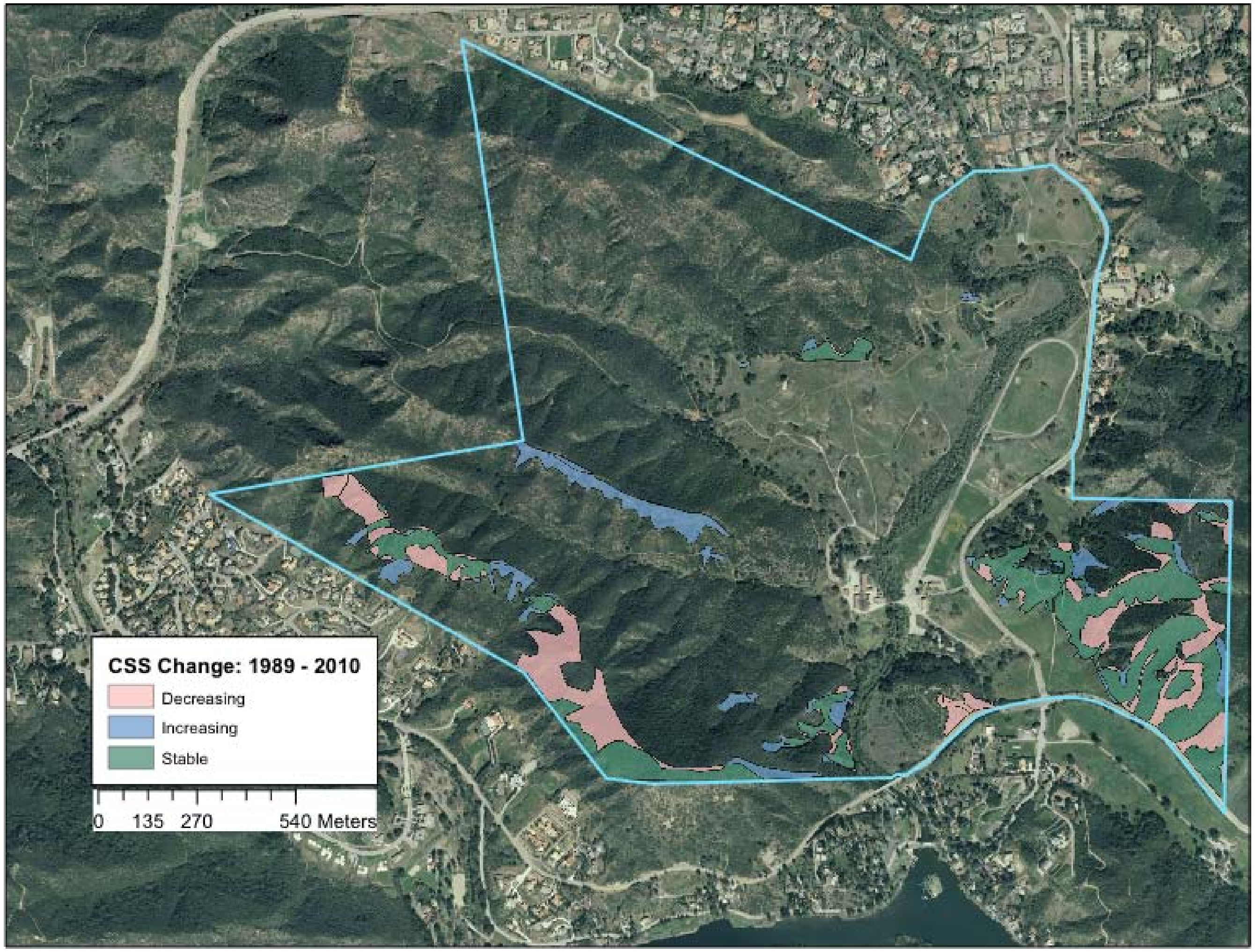


Figure 8 shows the total change in coastal sage scrub boundaries from 1989 to 2010 in Paramount Ranch.

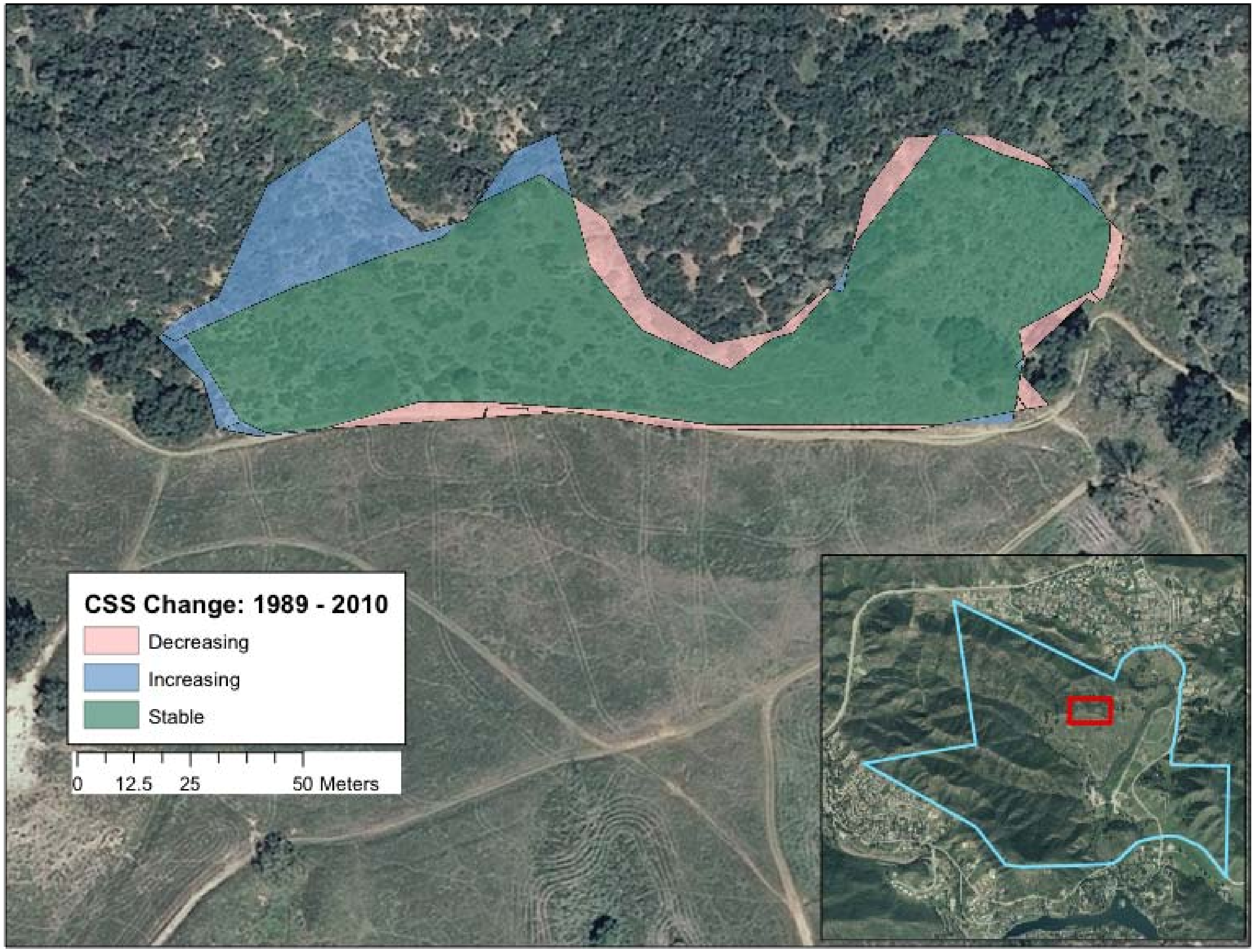


Figure 9 shows the total change in coastal sage scrub from 1989 to 2010 in part of the north central area of Paramount ranch.

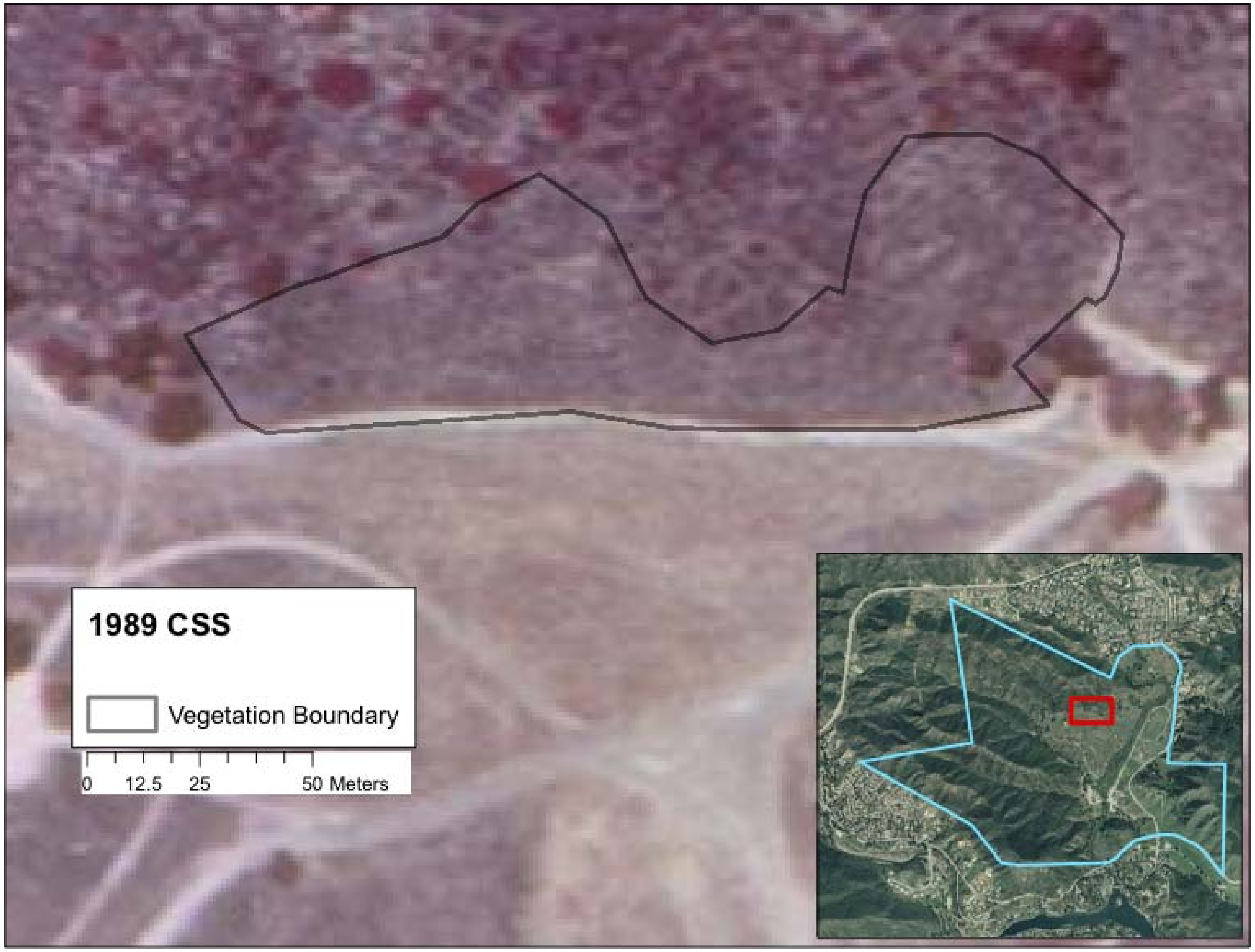


Figure 10 shows the 1989 aerial and boundary of CSS taken from the 1989 vegetation map.

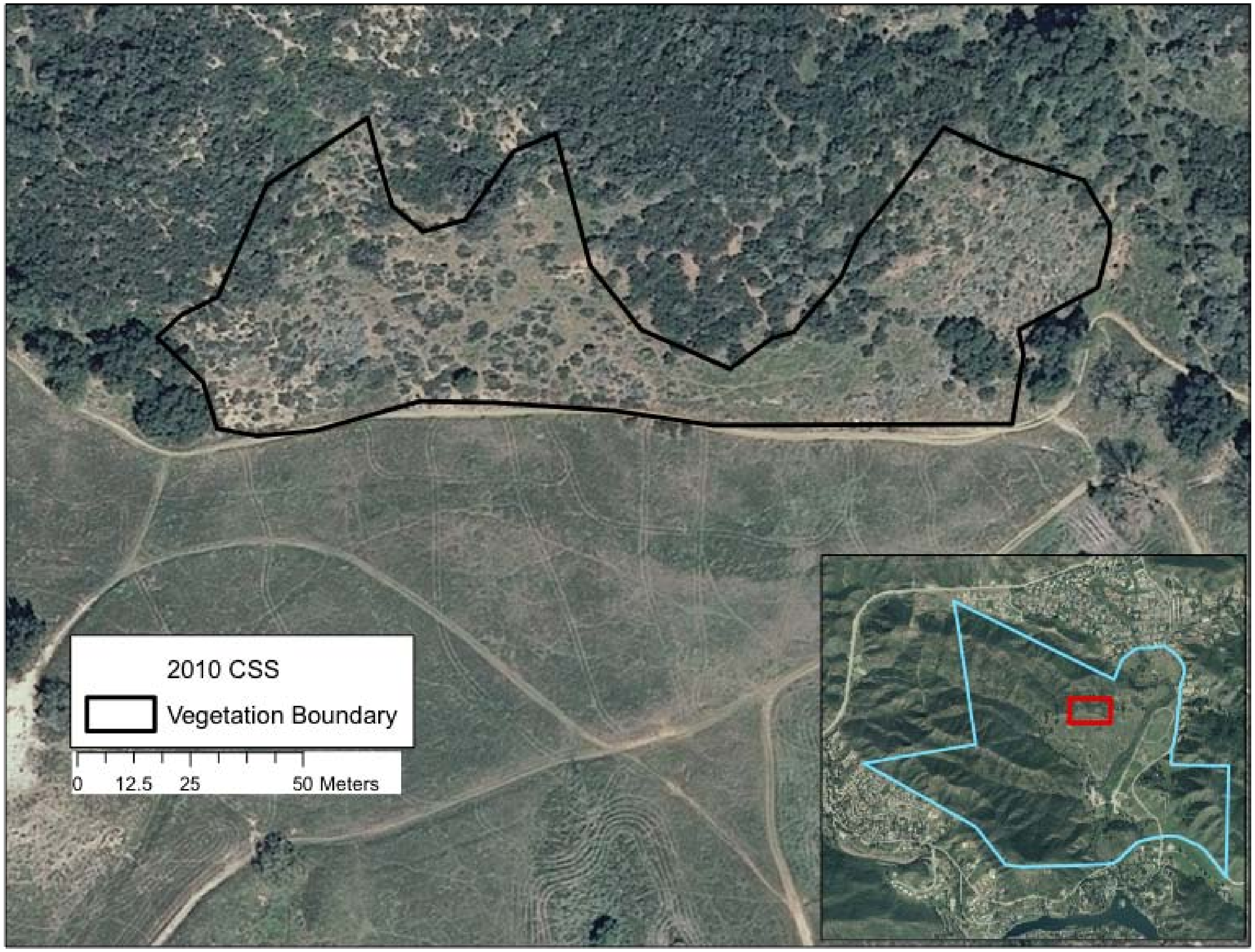


Figure 11 shows the 2010 aerial with the coastal sage scrub polygon taken from the 2010 vegetation map.

Figure 12 shows a distinct change in vegetation from CSS to grassland.

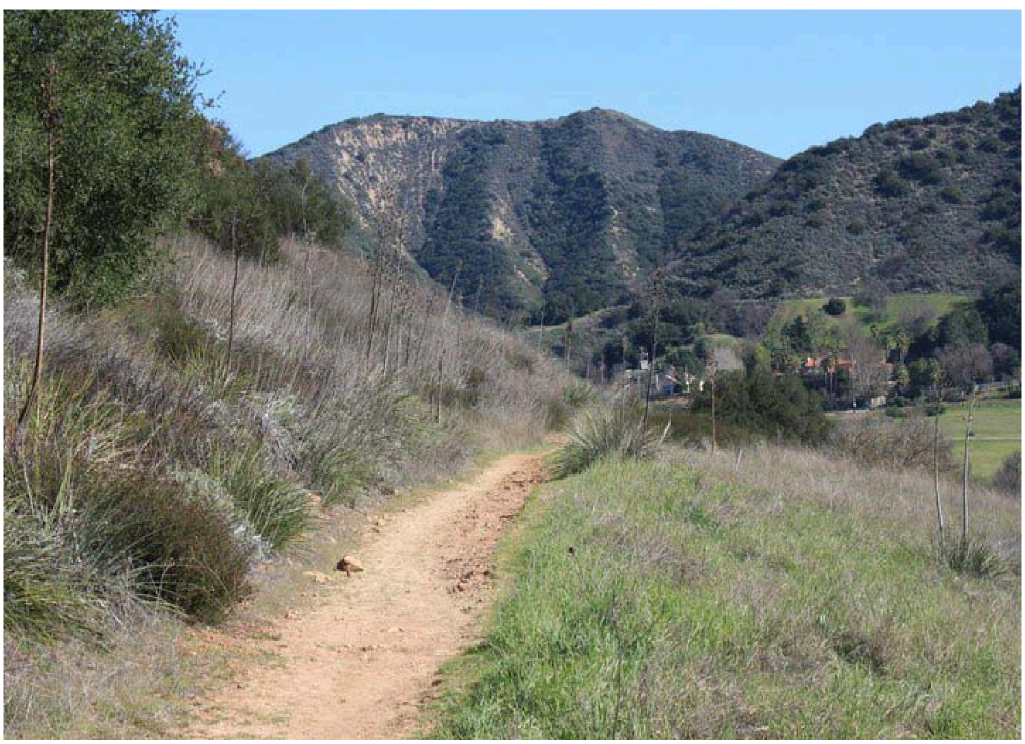


Figure 13 shows the side view of photo 1, which clearly demonstrates the change in slope angle from coastal sage scrub (left of the trail) to grassland (right of the trail).

Figure 14 highlights the boundary between coastal sage scrub above the red line and grassland below the red line in a photo taken in the 1950's.

Figure 15 shows the boundary between coastal sage scrub above the red line and grassland below the red line in a photo taken in 2011.

There are many significant challenges to vegetation map comparison at this kind of spatial and temporal scale. Twenty-one years is enough time for vegetation boundaries to shift; however due to the images available to us over this time period, it is impossible to be very confident on specific boundaries. The images quality is very different between the two images due to the fact that the 1989 was an infrared photograph taken from an airplane whereas the 2010 was a higher resolution satellite image with three times. There are many areas on the 1989 map that would likely have been classified as another vegetation type if we did not have field experience and availability of the 2010 image. Most significantly are areas of the western portion of the study site that appear to be a large mixture of CSS and chaparral (figures 1 and 2). The 1989 is an infrared image that has different thresholds and responds differently to the physical characteristics of the vegetation species. The historical photos reinforces the likelihood that the western half is indeed chaparral and that our classification as such is correct despite what the image suggests. All these considerations make drawing confident conclusion about exact boundary delineations from the map comparison very difficult, and the historical photo analysis of the oblique photos provide a better window into the vegetation of the past and a source of reinforcement for the validity of our 1989 vegetation map.

Historical Photo Analysis

From the analysis of each pair of photos (historic photo and its present day companion), it was determined that there were both areas that had undergone noticeable change and others with less significant or no visible change. A panoramic image comprised of a set of photos taken from a hillside vantage point shows that the riparian area that runs through the center of the park has expanded in both size and cover. This same panoramic image shows that, in the central valley of the park, the woodland areas are now denser and have replaced some of the grassland areas. In each of the panoramic photos, there were also large spans of vegetation on the hillsides that remained unchanged.

Another group of photos was taken from the old movie set in the valley of the park. These photos gave a choice view of a hillside and of the vegetation changes that have occurred since the historic photos were taken. Most of the notable changes in these photos were that the hills are now more densely covered in vegetation, primarily consisting of shrubs. The historic and present day photos also showed a stable vegetation boundary between chaparral and grassland, which remained at the same point on the hillside.

For a more detailed analysis of each photo and side-by-side comparison, please refer to Appendix B. Please also review our webpage that contains a more interactive comparison of the present day and historic photos. The temporary web address for this interactive webpage is <http://jsavio.bol.ucla.edu/NPS/index.php>.

CONCLUSION

The oblique photograph analysis and the aerial image interpretation each provided a unique solution to answering the question of how vegetation boundaries change over time. Over the 21-year period covered by the aerials we found an overall trend of stable vegetation boundaries with a few locations of significant change. Boundary change is better identified in the oblique photographs because they extend further back in time and provide a more clear representation of the vegetation. The aerials indicate larger trends while the oblique analysis yields a more detailed window into certain areas of Paramount Ranch. The use of high-resolution satellite imagery to guide our field surveys produced high accuracy results for the 2010 vegetation map. Our detailed field surveys led us to the discovery that native bunchgrass exists in what appears to be non-native annual grasses at first impression. The use of GPS units in the field allowed us to map the boundaries of this bunchgrass and other vegetation communities with high precision.

REFERENCES

Allen, Edith B. and Cox, Robert D. (2008) Stability of exotic annual grasses following restoration efforts in southern California coastal sage scrub. *Journal of Applied Ecology,* **45,** 495-504.

Barro, S.C. & Conard, S.G. (1991) Fire effects on California chaparral systems: an overview. *Environment International,* 17, 135-149.

Beyers, J. L. (2004) Postfire seeding for erosion control: effectiveness and impacts on native plant communities. *Conservation Biology,* 18, 947-956.

Burke, M. J. W. and Grime, J. P. (1996) An experimental Study of Plant Community Invasibility. *Ecology,* **77,** 776-790.

Cione N.K., Padgett P.E. and Allen E.B. (2002) Restoration of a native shrubland impacted by exotic grasses, frequent fire, and nitrogen deposition in Southern California. *Restoration Ecology* 10:2, p. 376-384.

Cox, R. D., & Allen, E. B. (2008). Stability of exotic annual grasses following restoration efforts in southern California coastal sage scrub. *Journal of Applied Ecology*, *45*(2), 495-504. doi: 10.1111/j.1365-2664.2007.01437.x.

D'Antonio, C.M., Hughes, R.F., Mack, M., Hitchcock, D. & Vitousek, P.M. (1998). The response of native species to removal of invasive exotic grasses in a seasonally dry Hawaiian woodland. *Journal of Vegetation Science* 9: 699–712.

Davis, C. M. (1994). Succession in California shrub communities following mechanical anthropogenic disturbance. M. S. Thesis. San Diego State University, California.

Davis, F. W., *et al.* (1995) Gap analysis of the actual vegetation of California 1. The southwestern region. Center for Remote Sensing and Environmental Optics, and Department of Geography, University of California, Santa Barbara.

DeSimone SA, Burk JH (1992) Local variation in floristics and distributional factors in Californian coastal sage scrub. *Madrono*, 39, 170–188.

Deutschman, Douglas; Franklin, Janet; He, Hong S.; Martin, Ross P.; Mladenoff, David J.; O'Leary, John F.; Simonds, Dena K.; and Syphard, Alexandra D. (2001 Simulating the effects of different fire regimes on plant functional groups in Southern California. *Ecological Modeling,* **142,** 261-283.

Eliason, S. a. (1997). Exotic Grass Competition in Suppressing Native Shrubland Re-establishment. *Restoration Ecology*, *5*(3), 245-255. doi: 10.1046/j.1526-100X.1997.09729.x.

Franklin, Janet; Keeley, Jon E.; and Syphard, Alexandra D. (2006) Simulating Effects of Frequent Fire on Southern California Coastal Sage Shrublands. *Ecological Applications,* **16,** 1744-1756.

Franklin, Janet; He, Hong S.; Keely, Jon E.; Syphard, Alexandera D.; and Jian Yang. (2007) Calibrating a forest landscape model to stimulate frequent fire in Mediterranean-type shrublands. *Environmental Modeling & Software,* **22,** 1641-1653.

Gray, J.T. & Schlesinger, W.H. (1981) Biomass, production, and litterfall in the coastal sage scrub of southern California. *American Journal of Botany,* 68, 24-33.

Hanes, T.L. (1971) Succession after Fire in the Chaparral of Southern California. *Ecological Monographs*, 1, 27-52.

Hutchinson, C.F. and Kirkpatrick, J.B. (1977) The Community Composition of Californian Coastal Sage Scrub. *Vegetatio,* **35,** 21-33.

Keeley, Jon E. (2001) Fire and Invasive Species in Mediterranean-Climate Ecosystems of California. Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species. Fire Conference 2000.

Keeley, J.E. & Keeley, S.C. (1984) Postfire recovery of California coastal sage scrub. *American Midland Naturalist,* 1, 105-117.

Keeley, J.E. (2002) Native American impacts on fire regimes of the California coastal ranges. *Journal of Biogeography*, 29, 303-320.

Keeley J.E. (2006) Fire severity and plant age in postfire resprouting of woody plants in sage scrub and chaparral. *Madrono* 53:4, p.373-379.

Keeley, J. E. & Fotheringham, C. J. (2003) Impact of Past, Present, and Future Fire Regimes on North American Mediterranean Shrublands. In *Fire and Climactic Change in Temperate Ecosystems of the Western Americas*. New York: Springer-Verlag.

Lloret, Francisco; Ogheri, Elena; Terradas, Jaume; and Vila, Montserrat. (2001) Positive fire-grass feedback in Mediterranean Basin woodlands. *Forest Ecology and Management,* **147,** 3-14.

Melgoza, G., Nowak, R.S. & Tausch, R.J. (1990). Soilwater exploitation after fire – competition between Bromus tectorum (cheatgrass) and 2 native species. *Oecologia* 83: 7–13.

Minnich, R.A. & Dezzani, R.J. (1998) Historical decline of coastal sage scrub in the Riverside-Perris Plain, California. *Western Birds*, 29, 366-391.

Mooney HA (1977) Southern coastal scrub. In: Terrestrial vegetation of California (ed. Major J), John Wiley and Sons, New York.

Morrison, Doug; Pimentel, David; Zungia, Rodolfo. (2005) Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics,* **52,** 273-288.

O'Leary, John F. and Westman, Walter E. (1986) Measure of resilience: the response of coastal sage scrub to fire. *Vegetatio,* **65,** 179-189.

Padgett P.E., Allen E.B. and Bytnerowicz A. and Minnich R.A. (1999) Changes in soil inorganic nitrogen as related to atmospheric nitrogenous pollutants in southern California. *Atmospheric Environment* 33:769-781.

Syphard, A. D., Clarke, K. C. & Franklin, J. (2006) Simulating fire frequency and urban growth in Southern Californian coastal shrublands, USA. *Landscape Ecology, 22*(3), 431-445.

Talluto, M. V. & Suding, K. N. (2008) Historical change in coastal sage scrub in southern California, USA in relation to fire frequency and air pollution. *Landscape Ecology 23*(7), 803-815.

Vale, T. R. (1998) The myth of the humanized landscape: an example from Yosemite National Park. *Natural Areas Journal, 18*, 231-236.

Vale, T. R. (2000) Pre-Columbian North America: Pristine or humanized – or both? *Ecological Restoration, 18*, 2-3.

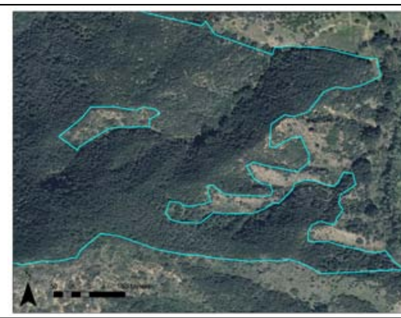
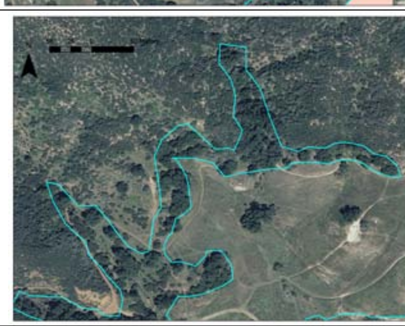
Westman, W. E. (1985) Air pollution injury to coastal sage scrub in the Santa Monica, Mountains, Southern California. *Water, Air, and Soil Pollution, 26*(1), 19-41.

Westman, W.E. & O'Leary, J.F. (1986) Measures of resilience: the response of coastal sage scrub to fire. *Plant Ecology*, 65,179-189.

Zedler, P.H., Gautier, C.R. & McMaster, G.S. (1983) Vegetation change in response to extreme events: the effect of a short interval between fires in California chaparral and coastal scrub. *Ecology,* 64, 809-818.

APPENDIX

VEGETATION STAND EXAMPLES (SCREEN SHOTS)

Coastal Sage Scrub	
Salvia apiana, white sage scrub	
Salvia mellifera, Black sage scrub	
Eriogonum fasciculatum, California Buckwheat	
Chaparral	
Chamise	
Riparian	
Woodland	

Grassland	
Nonnative annual grassland	 
Bunchgrass	
Rye grass	 

APPENDIX B

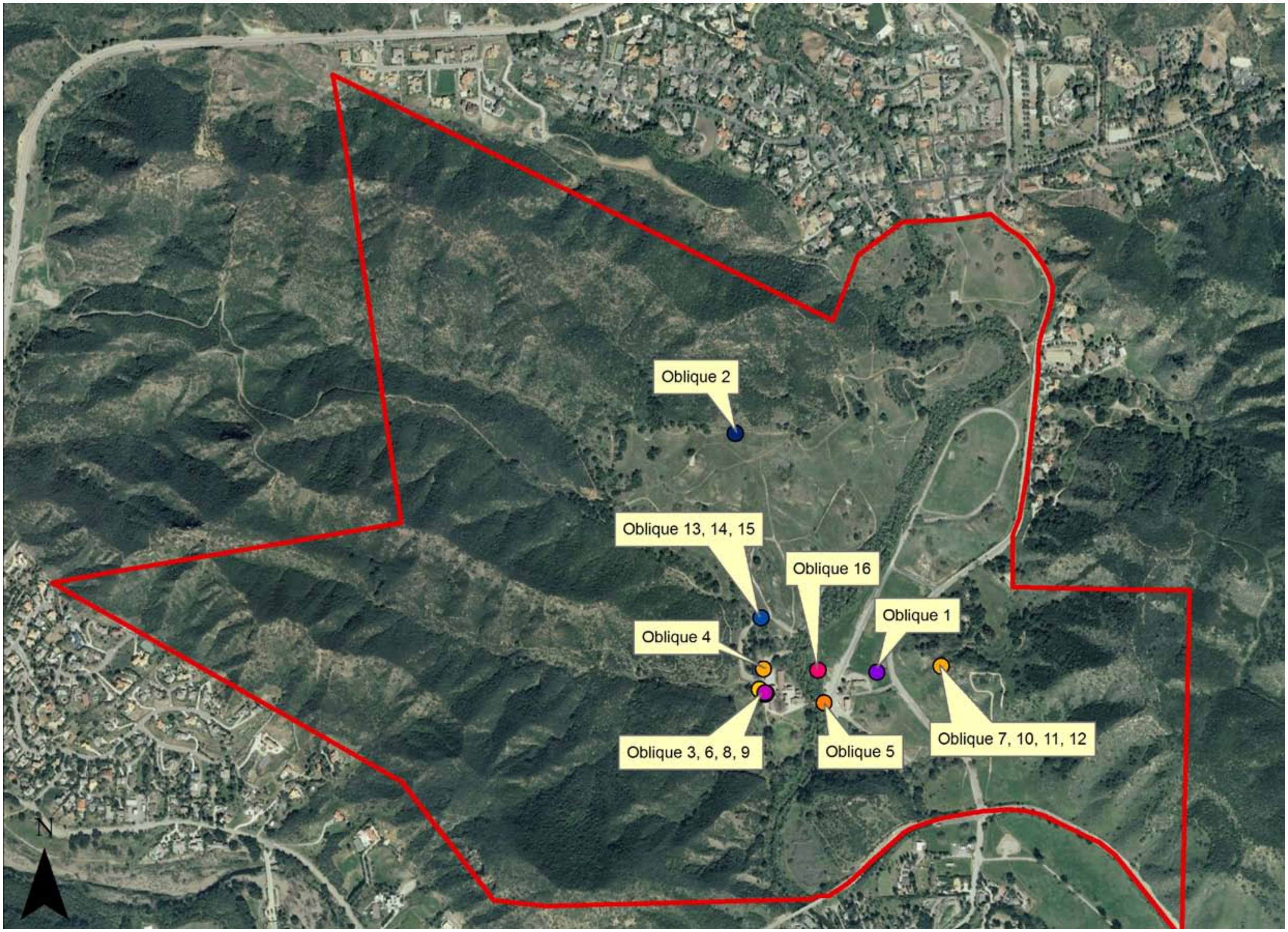


Figure B-1. Location from which present day oblique photos were taken to replicate the historical photo.

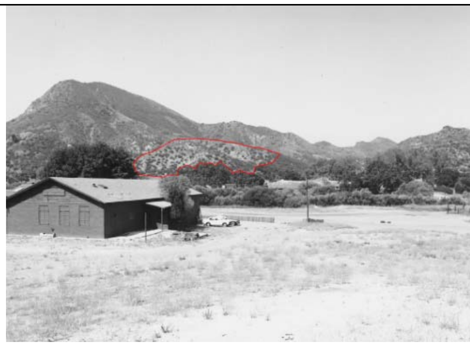
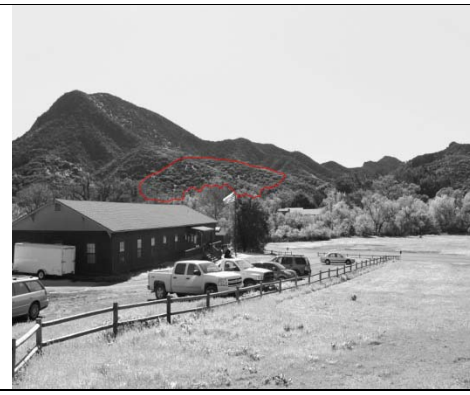
Historical Photo	Present Day Photo
	

Photo Set 1.

The polygon outlined in red on the nearest hillside is an example of an area that was originally coastal sage scrub, but since 1981 has been type converted to chaparral. The canopy cover has increased in percent cover. There is also the possibility of some erosion along the ridge line. This change in ridge line could also be due to a slightly different vantage point in the present day photo.

Historical Photo: Paramount Ranch Longhorn café/commissary, view southwest. Wanamaker, Marc. 1981. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/001.

Present Day Photo: Paramount Ranch landscape, view southwest. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

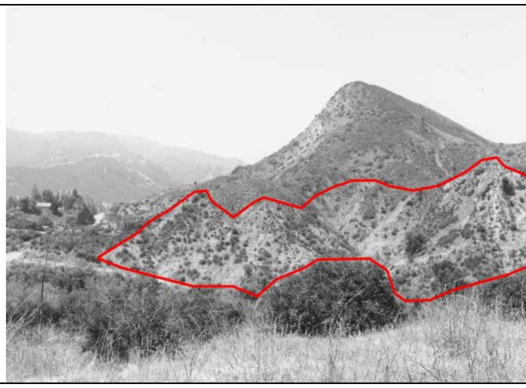
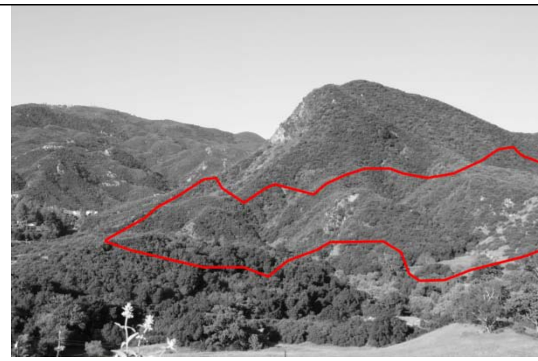
Historical Photo	Present Day Photo
	

Photo Set 2.

The polygon outlined in red on the hillside is an area that has type converted from coastal sage scrub to chaparral. These pictures are taken from slightly different vantage points and thus the ridge lines do not line up exactly. Despite this minimal error, it is still evident that there has been change in the canopy cover.

Historical Photo: Paramount Ranch landscape, "Sugarloaf Peak", view southwest. Wanamaker, Marc, Paramount Pictures. 1981. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/001.

Present Day Photo: Paramount Ranch landscape, "Sugarloaf Peak," view southwest. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 30, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

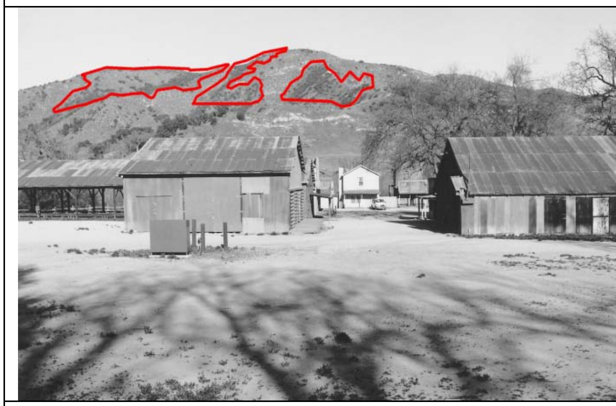
Historical Photo	Present Day Photo
	

Photo Set 3.

This photo was taken from the outskirts of the movie set and gives a view of the facing hill. Each of the polygons outlined in red represent areas that consist of dense chapparal cover in present day. The same areas in 1990 are also chaparral, but they are less densely covered. The now denser canopy cover may be a result of the plants growing or the presence of new plants.

Historical Photo: Paramount Ranch Long Pole barn, left, and horse barn, right. Wanamaker, Marc, Paramount Pictures. 1990. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/001.

Present Day Photo: Paramount Ranch Long Pole barn, left, and horse barn, right. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

Historical Photo	Present Day Photo
	

Photo Set 4.

These photos are taken from slightly different elevations. This is because there is a road in the present day which was not present in 1990. Besides the addition of a road, there is little noticeable change in the vegetation cover. The canopy in the historic photo and the present day photo seem to be relatively the same.

Historical Photo: Paramount Ranch landscape with log cabin set at right. Wanamaker, Marc, Paramount Pictures. 1990. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/001.

Present Day Photo: Paramount Ranch landscape with log cabin set at right, pagoda at center, and horse barn, left. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

Historical Photo	Present Day Photo
	

Photo Set 5.

These photos are taken from slightly different elevations. This is because there is a road in the present day which was not present in 1990. Besides the addition of a road, there is little noticeable change in the vegetation cover. The canopy in the historic photo and the present day photo seem to be relatively the same.

Historical Photo: Paramount Ranch landscape with log cabin set at right. Wanamaker, Marc, Paramount Pictures. 1990. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/001.

Present Day Photo: Paramount Ranch landscape with log cabin set at right, pagoda at center, and horse barn, left. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

<table>
<tr><td>Historical Photo</td><td>Present Day Photo</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Photo Set 6.

The polygon outlined in red is an example of an area where the vegetation has experienced growth between 1989 and 2011. The area below the vegetation outlined in red has remained bare. This may be because the slope at this location is too steep for vegetation to grow on. With time and erosion, this area may grow as the steep slope increases both in surface area and degree of steepness.

Historical Photo: Paramount Ranch. Wanamaker, Marc. September 1989. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/002.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.</td></tr>
</table>

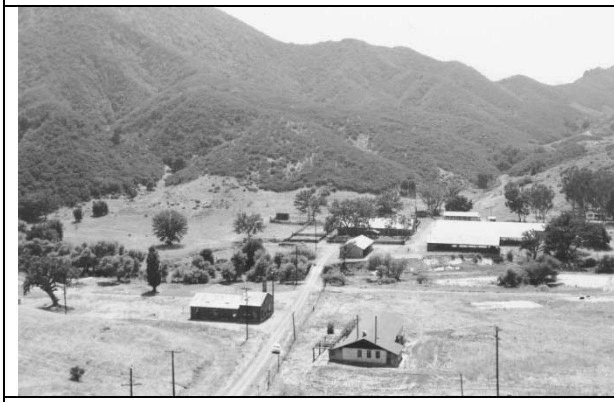
Historical Photo	Present Day Photo
	

Photo Set 7.

In these two photos there is a slight discrepancy in the range of the hill slopes. This is due to new construction in the movie set, which made it impossible to stand at the same vantage point where the historical photo was taken. For the rest of the area outlined, it it possible to see where the vegetation has grown since. As was the case with photo sets 8 and 9 which were taken from this vantage point, the oak tree in the foreground has grown significantly.

Historical Photo: -. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 3071, 102/014.

Present Day Photo: Paramount Ranch, view north. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

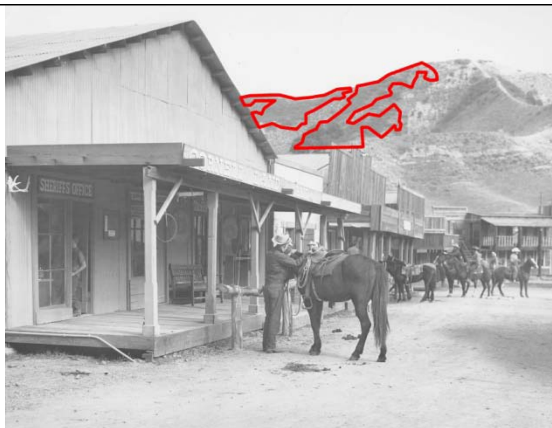
Historical Photo	Present Day Photo
	

Photo Set 8.

This pair of photos is one of a set of panoramic views at an elevated vantage point. The riparian zone in this picture has expanded. The vegetation in the central hill has grown down the slope as it is now present closer to the valley. There also appears to have been some erosion on the leftmost hillside. The recent picture is taken from a slightly different vantage point, but it appears that there has been some remodeling and renovation of the buildings.

Historical Photo: July 1953. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch, view southwest. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 30, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

Historical Photo	Present Day Photo
	

Photo Set 9.

This pair of photos displays a similar view of the area depicted in photo set 3. The polygon outlined in red is an area that has experienced notable growth since the historical photo was taken. It is also noticeable that the oak tree in the foreground has grown.

Historical Photo: -. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

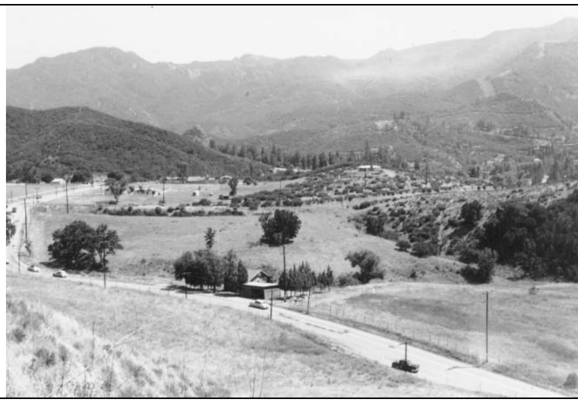
Historical Photo	Present Day Photo
	

Photo Set 10.

This set of photos provides a similar comparison of the growth that has occurred in photo 3. The red polygon outlines each of the patches of chaparral that have grown in. There is one main patch in the center of the hillside that has experienced the most noticeable growth.

Historical Photo: -. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

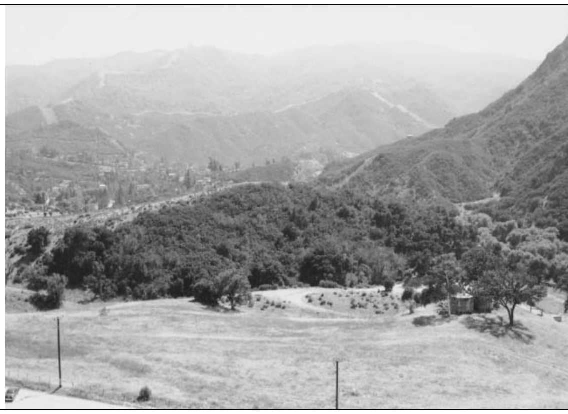
Historical Photo	Present Day Photo
	

Photo Set 11.

This is another photo set from the panoramic view. The hazy quality of the historic photo makes it difficult to determine if there is any change in vegetation cover for the mountain ranges in the background. In the valley of the photos, the woodland, oak, and riparian areas have become more sense,and the height of the canopy is taller. One the hills on the left side of the photo appears to have been cleared since 1953.

Historical Photo: July 1953. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch, view south. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 30, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

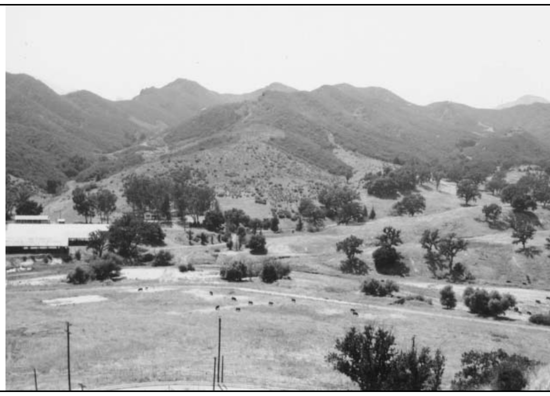
Historical Photo	Present Day Photo
	

Photo Set 12.

This pair of photos is also part of the panoramic photo set. There are several visible trails in the historic photo. Since then, some of these trails have begun to grow back in with vegetation, with chaparral converting to coastal sage scrub. For most of them, there is little visibility of the trail itself, or it has disappeared entirely. The high peak on the right side of the photo has eroded some, and the face is now much steeper. The woodland area in the middle of the photo has grown, resulting in less grassland.

Historical Photo: July 1953. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch, view southwest. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 30, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

Historical Photo	Present Day Photo
	

Photo Set 13.

These photos are of a grove of eucalyptus trees. These trees are not native to the region but grow very well in southern California's Mediterranean climate. Since the historic photo was taken, these trees have grown and expanded their canopy considerably. There was also once a building in this grove of eucalyptus trees. This building was most likely a part of a movie set that was torn down when the ownership of the park changed hands. Although difficult to observe in the present day photo, there is still a cement foundation in this grove of trees.

Historical Photo: -. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 16, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

Historical Photo	Present Day Photo
	

Photo Set 14.

This photo set displays the succession of vegetation following anthropogenic disturbance. In the historical photo, there is a road that runs through the center of the vegetation. Since 1953, non-native grassland has regrown over the road, which is no longer visible. The chaparral patch on the hillside to the left has also filled in. The red polygon outlines a patch of vegetation that has grown in. The shrubs and trees in the background have also grown.

Historical Photo: July 1953. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. May 8, 2011. National Park Service, Santa Monica Mountains National Recreation Area.

<table>
<tr><td>Historical Photo</td><td>Present Day Photo</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Photo Set 16.

Due to the angle at which this photo was taken, it is difficult to compare vegetation change between the two times. These photos do, however, display the stability of the grassland that runs through the center of the park, near the visitor’s center.

Historical Photo: Early 1950s. National Park Service, Santa Monica Mountains National Recreation Area. SAMO 5246.

Present Day Photo: Paramount Ranch. Kawakami, Kevin, Institute of the Environment and Sustainability, UCLA. April 1, 2011. National Park Service, Santa Monica Mountains National Recreation Area.</td></tr>
</table>