Vegetation Change in Rancho Sierra Vista, Santa Monica Mountains

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1 ABSTRACT

Rancho Sierra Vista, which lies in the eastern extent of the Santa Monica National Recreation Area, is dominated by five major vegetation alliances: Coastal Sage Scrub (CSS), Chaparral, Oak Woodland, Grassland, and Willow Riparian. Though existing within an ecologically important ecozone, these vegetation communities are threatened due to changes in the historic fire regime, changing land use practices, and misadvised management. This project aims to supplement data regarding the current extent of these vegetation communities in Rancho Sierra Vista, including data on the relative stability of the vegetation boundaries, and further advise the National Park Service on areas best suited for restoration of Coast Live Oak Woodlands.

Aerial imagery from 1959 and 2010 were analyzed and classified to produce two vegetation distribution maps. On site fieldwork was conducted to validate accuracy of current map, and to advise in lab classification. The 1959 and 2010 vegetation maps were compared to determine areas of increasing, decreasing, and stable vegetation. Chaparral had the largest increase (81%) in area, with a major shift coming from the transition of CSS to Chaparral as a result of the 1955 Ventura Park fire. Grasslands on site were the most stable vegetation alliance, and were subject to only 18% loss, reflecting the aggressive nature of the non-native species that dominate this alliance. Oak Woodlands grew 260%, and Willow Riparian grew 413%. Both of these changes are likely attributed to the removal of grazing pressure from past ranching practices as a significant land use.

A Habitat Suitability Model (HSM) was created to map the ideal potential distribution of the Coast Live oak, based on specific physical parameters (cited in literature), and field verification.

2 INTRODUCTION

Rancho Sierra Vista (RSV), located in the northwestern portion of the Santa Monica Mountains, is currently managed by the National Park Service as part of the greater Santa Monica Mountains Recreation Area. It consists of a diverse composition of vegetation communities, including coastal sage scrub (CSS), chaparral, annual grasslands, willow riparian, and oak woodland. While a detailed map of the current distribution of vegetation communities does exist for the Santa Monica Mountains, information about changes that have occurred between historical and current vegetation coverage in RSV is not available. Without this information, there is no means of comparing the modern state of vegetation boundaries with historical boundaries, both during and prior to human disturbances of grazing, fire and land clearance. This information is key to surveying and establishing the current state of vegetation, and understanding the relative stability of vegetation communities. This project focused on comparing existing vegetation boundaries with the boundaries present in a map of the vegetation boundaries present in 1959. Therefore, the current vegetation map was analyzed to the same level of detail as the historical vegetation map so that the two maps would be comparable. This will provide the National Park Service with an understanding of long-term vegetation dynamics in order to improve their management, restoration, and weeding practices.

3 LITERATURE REVIEW

3.1 HISTORICAL BACKGROUND

RSV, located in the northwestern portion of the Santa Monica Mountains, has had a long history of human settlement, division of property, and modern ranching and farming practices ("Map" 2012). Prior to settlement by ranchers in the 1800s, the area was occupied by the Chumash and Tongva Native Americans ("Map" 2012). Spanish arrival in the late 1770s radically changed the human dynamics on the land. Portuguese explorers laid claim to an area they named Conejo Valley, which includes a portion of modern southeastern Ventura County and northwest Los Angeles County, encompasses the entirety of modern day RSV (Allen 1976, Rasson 2000). Conejo Valley became a part of the 1803 El Conejo Spanish land grant that was sold and distributed to various private interest groups throughout the 19th century (Allen 1976). During this time, Conejo valley underwent various grazing and agricultural operations, which included cattle, horse, and sheep grazing, and planting of wheat, alfalfa and various fruits (Rasson 2000). The land had been continually disturbed by land clearance (for agriculture and construction of buildings and roads), occasional fires in 1955, 1988, 1993, and construction of reservoirs and wells for irrigation of orchards and fields in an area now referred to as Satwiwa. The land clearing and agriculture impacts were likely concentrated at lower elevations and on flatter terrain, which is the area that is both currently and historically characterized by extensive grassland. Modern ranching and building construction began in 1937 after acquisition of a portion of the land grant by Carl Beal, who christened the area *Rancho Sierra Vista* (Rasson 2000). The National Park Service, managing the Santa Monica Mountains National Recreation Area, obtained the property in 1980 and has maintained mostly passive restoration of the local vegetation and wildlife landscape (Rasson 2000, "Map" 2012). Passive restoration involves the "cessation of those anthropogenic activities that are causing degradation or preventing recovery" of an ecosystem (Kauffman *et al.* 1997). Active restoration can involve a variety of practices, such as planting programs and streambank reconfigurations, and is generally used to help restore an ecosystem either in addition to passive restoration or in cases where the ecosystem is unlikely to recover with passive restoration alone (Kauffman *et al.* 1997). In RSV, some active restoration has occurred in the form of spraying and mowing of non-native vegetation, and planting of native vegetation.

3.2 CURRENT ENVIRONMENT AND CLIMATE

With high rates of endemism, Mediterranean ecosystems rival tropical ecosystems in terms of their vegetation diversity (Vogiatzakis *et al.* 2006). Worldwide, the five Mediterranean-climate regions boast a total of over 48,000 vascular plant species. This is about 20% of the world total, but the regions occupy only 1.2% of the Earth's surface (Cowling *et al.* 1996, Vogiatzakis *et al.* 2006). In southern California, high biodiversity and endemism occur in shrublands, which also provide habitat for rare, endangered, and threatened species (Stow *et al.* 2008). The coastal sage scrub community is the most endangered shrubland habitat type in Southern California (Stow *et al.* 2008). Mediterranean ecosystems of North America, situated mostly along the western-southern coast of California and northern Baja California, are distinguished by their warm, dry summers and cool, wet winters. The Santa Monica Mountains Recreation Area (SMMRA) is a Mediterranean-climate dominated region containing evergreen and deciduous shrublands, including coastal sage scrub, oak woodland, riparian woodland, grasslands, and woody chaparral (Radtke *et al.* 1982). The current landscape of RSV consists of mostly non-native annual grasses, including mustard, barley, wild oats, some native chaparral, coastal sage scrub, oak and riparian woodland. A description of chaparral, coastal sage scrub, riparian, annual grassland, and oak woodland communities, which are five main vegetation communities found in the SMMNRA, is included below.

3.3 CHAPARRAL

Chaparral communities represent the most widespread vegetation type in California with a range that extends from northern Mexico to southern Oregon (Keeley 1989). Chaparral is typically found in relatively mesic areas with a precipitation range of 250-1,200 millimeters annually and elevations of 300-500 meters (Poole 1975, Shmida 1981). The most favorable conditions for chaparral growth include north facing aspects due to reduced evapotranspiration losses (Bauer 1936). Furthermore, a study by Odion (2000) suggests that north facing slopes are the last hit during a typical fire event and, therefore, undergo less heating effects, which promotes the survival of sprouting plants. A study found that the average biomass per area (in g/m2) of chaparral ranged from 6,500 to 7,500 (Gray 1982).

The vegetation is characterized by broad, evergreen, schlerophyllus leaves and a short canopy (1.5-2 meters), which is generally over ninety percent closed (Bauer 1936). Schlerophyllus leaves are those with a "leathery texture due to presence of sclerenchyma with large amounts of lignin and cellulose in their tissues" (Rundel 2007). Lignin and cellulose allow for a thicker leaf, which provides a mechanism against complete desiccation in the summer months and allows for increased water capacity during the winter months (Rundel 2007, Poole 1975). During winter months, plants exhibit increased primary production, and require a greater amount of water (Poole 1975). Species show a variety of adaptations to prevent water loss, including leaf adaptations, seasonal functional changes in plant metabolism, and adaptations to acquiring water (Poole, 1975). *Ceanothus, Adenostoma, Arctostaphylos,*and *Quercus* are primary dominant genera and *Adenostoma fasciculatum* is the most common species found in chaparral communities (Shmida 1981).

3.4 COASTAL SAGE SCRUB

The coastal sage scrub (CSS) is the second most widespread vegetation community in California (Keeley 1989). It is most common on steep, south facing slopes in relatively xeric areas with elevations between 0 and 300 meters above sea level and average annual precipitation ranges of 250-440 mm (Poole 1975, Shreve 1927, Kirkpatrick 1980). Dominance patterns are similar to those found in chaparral communities. Most communities exist as almost pure stands of one species, although co-dominance and herbaceous elements are more common in CSS than chaparral communities (Kirkpatrick 1980). The most common genus are *Rhus* and *Salvia,* and the most common species, from which the plant community as a whole derives its name, is *Artemisia californica* (common name: coastal sagebrush) (Kirkpatrick 1977).

The vegetation is characterized by possessing facultatively-deciduous leaves, subligneous tubers, mesophytic leaf structures, a deep root structure, and a relatively open canopy that is typically about 60 percent closed (Kirkpatrick 1980). Facilitatively-deciduous leaves allow plants to reduce the potential effects of water loss through evapotranspiration during dry summer months by shedding their leaf structures (Shmida 1981, Poole 1975, Westman

1981). CSS species are adapted to compensate for the loss of sugars that comes from the significant drop in photosynthesis rates during the summer months (when the plants have shed their leaves). One such adaptation is green stems, or "retamoid syndrome", which allows for photosynthesis in the cellulose rich stems without significant water loss through leaf stomata (Shmida 1981). The *Ceanothus leucodermis* is an example of a CSS species exhibiting this adaptation (Shmida 1981). CSS species also require rapid and efficient photosynthetic rates during the winter months in order to compensate for the significant drop in photosynthetic rates of summer (Kirkpatrick 1980). This is accomplished by maximizing the amount of mesophyll tissue, the leaf tissue that is associated with photosynthetic chloroplasts and which, therefore, increases photosynthetic rates and primary production in the winter (Gray 1982, Westman 1981). The food and sugars that are created during the winter months are then stored in lignotubers which are associated with many CSS species (Kirckpatrick 1980). Most CSS species use deeply embedded root systems that contain the lignotubers used for food storage and post-fire regeneration (Kirckpatrick 1980). Though this pattern is widespread, exceptions do exist. Deep root systems also allow for the efficient acquisition of moisture in both the porous sandstone sediment, and the deeper water tables found in clay substrates (Kirckpatrick 1977).

3.5 RIPARIAN WOODLAND

Riparian ecosystems in the arid and semiarid southwest of the United States make up only about 1-3% of the landscape and show significant diversity in structure and composition as a result of the disparate conditions in which they occur (Patten 1998, Gregory *et al.* 1991). Riparian woodlands provide several ecosystem services to people, including "ground water recharge, flood-flow mediation, recreation, cultural resources, and aesthetic resources" as well as many wildlife uses, which include "forage, water, thermal and escape cover, nesting/breeding, migration and dispersal corridors" (Barbour 2007, Naiman & Decamps 1997). Furthermore, in California, "over 225 species of birds, mammals, reptiles, and amphibians depend on riparian habitats" (Barbour 2007). Barbour defined the riparian woodland as encompassing "the stream channel between low and high water as well as the adjacent terrestrial landscape influenced by flooding, elevated water tables, and increased soil-water holding capacity" (Barbour 2007, Nilsson & Svedmark 2002). Furthermore, riparian woodlands are characterized by an abundance of phreatophytic trees and shrubs, which are dependent on the water table to supplement local rainfall. *Salix* spp. (common name: willows) are an example of phreatophytic trees found in riparian woodlands in southern California (Rood *et al.* 2003, Patten 1998).

Two of the key factors that influence the extent, density, and composition of riparian woodlands are the volume and timing of local stream flows. These two factors are determined by precipitation patterns, watershed characteristics, and climatic factors (Patten 1998). In the southern United States, a sandy and coarse river bottom is common and sediment often moves downstream in pulses (Patten 1998). The receding of winter floods (between March and April in arid, southwestern regions) is when most native riparian species disperse seeds. The flooding and high runoff events of winter are important for successful seedling establishment because the high flows can cause both the scouring and redeposit of sediments, leaving bare sandbars that have no established plants to compete with the germinating seedlings (Patten 1998). Furthermore, the receding flows may continue to keep the soil moist as the seedlings germinate and begin to grow (Rood & Mahoney 1995). It is estimated that "three-quarters of the riparian woodlands in the southwestern United States have been lost during the past two centuries," with a significant part of that loss resulting directly or indirectly from the damming, diversion, and channeling of rivers (Patten 1998).

Grazing and agricultural practices represent two additional major sources of riparian woodland degradation resulting from human activities. It is estimated that 70% of the western United States is used for grazing land, including "wilderness areas, wildlife refuges, national forests, and even some national parks" (Fleischner 1994). In arid and semiarid regions, livestock are attracted by the relatively rich water, food, and shade of riparian habitats and so tend to congregate in them, especially during hot or dry periods when the forage production elsewhere is low (Warner 1984, Fleischner 1994, Patten 1998). The congregation of livestock in these areas magnifies the impact that grazing has on riparian areas relative to other vegetation types (Patten 1998, Jansen & Robertson 2001). The impacts of grazing on riparian woodlands include: disruption of the reproductive cycle of trees, destruction of ground cover, destabilization of streambanks, increases in the sediment loads to streams and rivers, altering of habitat structure, changes to the biogeochemistry of the floodplain habitats and to the geomorphology of the area (Patten 1998, Jansen & Robertson 2001). These impacts cause a "pattern of gradual decline of ecological diversity and quality" that is commonly seen throughout the arid and semiarid regions of California (Warner 1984). Agricultural practices have similarly detrimental impacts on riparian woodlands. Irrigation for agricultural lands has historically been the greatest consumptive use of water in the western United States (Patten 1998). Diversion of stream water for irrigation "may reduce surface flows to a level insufficient to maintain riparian vegetation, while ground-water pumping lowers local and regional water tables and reduces stream flow, either of which can eliminate or weaken riparian vegetation" (Patten 1998). Riparian woodlands are also cleared to create agricultural fields, which results in direct loss of both the riparian woodland and the water- and sediment-buffering that the woodland provided (Patten 1998).

3.6 ANNUAL GRASSLAND

California's annual grasslands occupy extensive areas along the coast and in the Central Valley and consist largely of non-native species. At most sites non-native species make up the major vegetation cover, and statewide nearly 400 non-native species have been recorded (McNaughton 1968). The soil is a reservoir of a variety of species that can potentially grow each new growing season depending on conditions. Therefore, the vegetation can vary considerably annually if there are changes in site conditions, including the occurrence of "fire, grazing or climatic oscillations," (McNaughton 1968). The annual grasslands become green and can undergo considerable growth during fall if there are favorable conditions. During the winter months (December through February) the minimum temperatures may drop to near freezing, resulting in little growth at this time of year (Biswell 1956). Around March warmer weather returns and significant growth rates resume. By April and May annual species will mature and dry until rain comes again in the fall (Biswell 1956). Perennial grasses and forbs have similar growth patterns to annual herbaceous species: they grow when moisture is plentiful and become dry during the hot summer months (Biswell 1956).

3.7 OAK WOODLAND

Oak communities, including riparian oak forests, oak woodlands and oak savannas, cover over ten percent of California's overall land area and occupy one quarter of California's woodlands (Davis *et al*. 1998). The upper canopy is largely composed of trees of the Beech family in the genus *Quercus.* The understory generally includes a combination of non-native annual grasses, native perennial bunchgrasses and woody shrubs. The distribution and abundance of oak communities depend upon variable microclimate and terrain conditions. In southern California, oak communities trend towards north-facing slopes and areas with accessible water tables. At higher elevations, oaks tend to occur alongside chaparral and conifer forests, while at lower altitudes, oaks will occur with non-native grasses, annual forbs, and native perennial grasses (Brooks *et al.* 2008). *Quercus agrifolia,* also known as Coast Live Oak, dominates southern California oak woodlands (Steinberg 2002) and is discussed more extensively in the species profile subsection.

Urban development and intensive agriculture have contributed to the dramatic decline in oak woodlands. Since European settlement in the 18th century, many oak habitats have been converted to rangelands, vineyards, and agriculture (Brooks *et al.* 2008). The accompanying matrix of native grasses, forbs and shrubs has also been type-converted into invasive, non-native annual grasses and forbs (Raven 1977, Heady *et al.* 1992). Consequently, a third of California's oak woodlands have been lost to exhaustive human displacement and only approximately seven million acres remain today. While four percent of the current population of oak woodlands is protected from development, these areas still experience a continual loss (CalPIF 2002). In addition, factors that affect the regeneration and succession of oak trees are not completely understood. Dynamic habitat-changing events, such as fire suppression and overgrazing, may encourage invasion by non-native annual grasses and alter ecological conditions that inhibit oak woodland re-growth and oak tree recruitment. Invasive annual grasses may displace native perennial vegetation and oak seedlings by competing for soil water. Cattle grazing may also stump oak sapling growth (CalPIF 2002).

Species Profile: Quercus agrifolia

Quercus agrifolia, also known as coast live oak, occurs throughout California, ranging from Mendocino County to Baja California (Barbour & Johnson 1977). It is a native, drought-tolerant, evergreen tree that ranges in height from 6 to 25 meters and in diameter from 0.3 to 1.2 meters (Hickman 1993, Plumb & Gomez 1983). The trees may exhibit deep main root systems if there is accessible groundwater within 11 meters of the soil surface (Canadell *et al.* 1996). Coast live oaks typically occur in Mediterranean climate regions consisting of hot, dry summers and mild, wet winters. The trees prefer to grow on mesic sites including north-facing slopes, alluvial terraces, valleys, shady ravines and swales and stream banks (Steinberg 2002, Davis *et al.* 1998). While coast live oaks tend to occur in areas with access to adequate soil moisture, many trees have extensive root systems that allow them to grow in drier terrains (Knops & Koenig 1994). For coast live oak populations that grow in lower elevations, the trees prefer loam, while higher-elevated oaks prefer shaley clay-loam soil (Clark *et al.* 1990). Their abundance is most strongly correlated with water availability—

they occur with the highest density in riparian forests with deep loamy soil and lowest in porous, sandy soils (Brooks *et al.* 2008).

Coast live oak is well adapted to fire because of its evergreen leaves, thick bark and efficient sprouting. Evergreen leaves support efficient re-growth and help conserve energy better than deciduous trees, thus favoring them in environments with high fire frequency. Even after severe burning, coast lives oaks are still able to sprout from the main trunk and upper crown. Sprouting ranges from 2 months to 3 years after initial burning, and the the prefire crown size is usually recovered in approximately 10 years (Steinberg 2002).

3.8 DISTURBANCES

3.8.1 HISTORICAL

The existence of non-native vegetation is not a recent phenomenon of southern California ecosystems as its roots may be traced back to Native American and colonial agricultural practices. Native American peoples had traditionally practiced burning of “unproductive” shrublands, potentially disturbing the land and promoting succession of non-native, annual species, when they were introduced during contact with Europeans. Spanish settlers and livestock holders may have introduced many of the exotic plants observed today through imported livestock and vegetation transplanting. The Mediterranean environment also promulgated the quick expansion of the alien vegetation, most of Mediterranean origin (Cox & Allen 2008). The combination of climate, overgrazing, and past burning has facilitated the conversion of perennial grasses into nonnative annual grassland (Keeley 2001).

3.8.2 GRAZING

The effects of grazing on vegetation composition have been analyzed on two scales – on a small scale for short-term effects and on the landscape scale for long-term effects (Carmel & Kadmon 1999). The majority of studies have focused on a small spatial scale and in short time frames, often less than a decade (Carmel & Kadmon 1999). In Mediterranean ecosystems, grazing has an adverse affect on the growth and development of woody vegetation, with more intensive grazing having greater effects (Callaway & Davis 1993, Carmel & Kadmon 1999, Kadmon & Harari-Kremer 1999a). A study by Carmel and Kadmon on the combined effects of topography and grazing on vegetation dynamics over 28 years in the Mediterranean region of Israel supports this view. They found that as grazing intensity increased, herbaceous cover also increased while tree cover decreased (Carmel & Kadmon 1999). An eleven year study on the effects of cattle grazing at different intensities on vegetation composition in a Mediterranean oak scrub forest found that under both moderate and heavy grazing herbaceous cover steadily increased (Gutman *et al.* 1990). It was more difficult to find clear trends for changes in woody vegetation cover. There was generally higher herbaceous cover and lower woody cover where there was heavy grazing (Gutman *et al.* 1990). A study of Mediterranean grassland in Israel found a significant relationship between a plant species’ growth form and its response to grazing: plants which grow erect and tall (greater than 50 cm) were more abundant in areas protected from grazing and less abundant in areas with moderate or heavy grazing whereas prostrate and small erect (less than 20 cm at maturity) plants showed the opposite pattern and increased in abundance under moderate to heavy grazing conditions (Noy-meir, Gutman, & Kaplan 1989).

3.8.3 TOPOGRAPHY

In their study on the effects of grazing and topography, Carmel and Kadmon found that tree cover increased most on north-west facing slopes and was positively correlated with increasing slope angle, while herbaceous cover had the opposite pattern and increased the most on south-east facing slopes (Carmel & Kadmon 1999). The pattern along the north-south gradient is generally accepted to be due to differences in the amount of solar radiation received, with south-facing slopes receiving more solar radiation in the northern hemisphere (Carmel & Kadmon 1999). While the east-west gradient is not as well understood, it is probable that wind direction and precipitation differences account for it (Carmel & Kadmon 1999). A similar 32 year study that looked at a Mediterranean marquis habitat following the cessation of grazing found that while recovery occurred everywhere in the site, north-facing slopes returned to conditions closer to those prior to grazing than south-facing slopes did (Kadmon & Harari-Kremer 1999). Furthermore, they estimated that full recovery to closed marquis habitat (meaning tree cover over 66.6% or more of the area) would take approximately 320 years on north-facing slopes and 960 years on south-facing slopes. This indicates both the significant affect that slope can have on the rate of vegetation change in Mediterranean ecosystems and that grazing can have effects on vegetation composition long after it has been stopped.

3.8.4 AIR POLLUTION

Nitrogen deposition associated with air pollution from vehicle exhaust is considered to be the most important mechanism by which pollution influences increased success for alien species in Mediterranean habitats (Keeley *et al.* 2005). Studies of CSS habitats in the Los Angeles Basin have found that total cover by native CSS species decreased and alien species cover increased with increases in annual air pollution (Westman 1979, Westman 1985). Furthermore, low precipitation and frequent temperature inversions in regions with Mediterranean climates support the build-up of relatively high levels of air pollution, making vegetation injury from pollutants a greater concern in these regions (Westman 1985). This theory has been criticized because the areas within the Los Angeles region which have received the most air pollution, and therefore nitrogen deposition, have also received extensive disturbances from urbanization, grazing, and increased fire frequency. Further studies are needed to explore the possibility of compounding variables and to show that pollution is capable of significantly favoring alien invasion in the absence of disturbance (Keeley *et al.* 2005).

3.8.5 FIRE

Long considered as natural processes that are fundamental to the functioning, maintenance, and restoration of various wildland ecosystems, wildfires are still controversially debated on their impacts to terrestrial and atmospheric health, humans, and surrounding wildlife and vegetation. In the United States, prescribed fire, or controlled burning, is a common method used to manage ecosystem health by simulating historical patterns of burning and post-fire succession conditions. However, fire may have greater implications of facilitating growth of alien invasive plant species and suppressing development of native plants, especially in Mediterranean climate communities. Invasive plants may displace native vegetation and alter traditional wild land conditions, potentially changing historical fire regimes and vegetation distribution.

Fires are a historical, natural component of the Santa Monica Mountains ecosystem, and both wildlife and vegetation have tailored to resisting and recovering quickly from fire disturbance. However, frequent fires threaten the reproduction of native plants, which require sufficient time to reproduce and establish seeds before the next fire (Wise & McGuire 2009). While natural fire regimes may decrease populations of nonnative, invasive plant species in some cases, current literature on the effects of fire in the Mediterranean-climate region of Southern California indicate that frequent fires have contributed to a propagation of invasive vegetation.

CHAPARRAL AND RELATIONSHIP TO FIRE

Fire plays a pertinent role in characterizing the vegetative dynamics of the chaparral community. Specific roles that fire plays within the chaparral community include nutrient cycling, facilitation of reproduction, and restructuring dominance patterns within the communities (Keeley 1986). In response to fire, two main adaptive categories exist: obligate seeders and obligate sprouters (Keeley 1986). The term “obligate seeder” refers to an individual whose post fire regenerative strategies include sexual reproduction by means of seed germination in the period after a fire (Keeley 1978, Keeley 1986). Obligate seeders exhibit high mortality during and after fire events (Keeley 1978). The term “obligate sprouter” refers to an individual whose post fire regenerative strategies include basal re-sprouting of lignotubers within the plant's root structure, associated with low mortality of the individual (Keeley 1978, Keeley 1986). Though many authors categorize the chaparral as strictly of the obligate sprouting type, because so much regenerative variation exists between individuals and species, such a generalization is not possible. For example, *Adenostoma fasciculatum,* widely known as the most common individual within this plant community, exhibits both sprouting and seeding types (Zedler 1983). Whereas the *Ceanothus oliganthus,* another dominant chaparral shrub, strictly exhibits seeding patterns (Zedler 1983). Therefore, generalizations cannot be made among the regenerative strategies within this vegetation community. Since the chaparral is dominated by only several individuals, these individuals can be analyzed, and with this in depth context of which traits these species display, a broader portrait of regenerative strategies of the complex chaparral environment can be created. What can be generalized within chaparral's relationship to fire is a broad time-line of altering species dominance. The time-line begins with an almost pure stand of a dominant species, which is burned. The burning causes medium to high mortality of the dominant species, allowing annual species of herbs and sub-shrubs to enter the ecosystem. After several years, the once dominant species begins to regain dominance, and the cycle is repeated (Keeley 1978). Though rudimentary, these patterns can be applied to a broad range of sub-communities within the chaparral.

COASTAL SAGE SCRUB AND RELATIONSHIP TO FIRE

Fire plays a pertinent role in characterizing the vegetative dynamics of the coastal sage community. Much like in the chaparral, fire plays specific roles within the coastal sage scrub community that include nutrient cycling, facilitation of reproduction, and restructuring dominance patterns within the communities (Keeley 1986). Unlike the chaparral, though, the regenerative processes associated with post fire rehabilitation can be broadly categorized within the obligate sprouting type (Westman 1981). Data that Westman produced suggests that of the 25 most common shrubs in the coastal sage community, all exhibited basal resprouting capabilities as a primary means of regeneration (Westman 1981). Though there are some contradictions to this information, such as the research published by Hanes, the authors Zelder and Keeley have reported data that support Westman's article (Hanes 1971, Keeley 1986, Zedler 1983). Malanson suggests that the basal resprouting is well suited to the coastal sage scrub: “In a community in which evapotranspirative stress reduces the growth of plants, maintains an open canopy, and...

indirectly causes shrub mortality, the fittest individuals will reproduce continuously" (Malanson 1982).

Time scales of burns of coastal sage scrub species are similar to those of the chaparral, beginning with an almost pure stand of a dominant species, which is burned. The burning causes high mortality of the dominant species, allowing annual species of herbs and subshrubs to enter the ecosystem. After several years, the once dominant species begins to regain dominance, and the cycle is repeated (Keeley 1978).

NON-NATIVE ANNUAL GRASSES AND RELATIONSHIP TO FIRE

Introduced species, particularly aggressive annual grasses, have affected fire regimes by making increased fire frequency more likely (Zedler *et al.* 1983). Additionally, increasing fire frequency makes habitats more susceptible to invasion by exotic species and promotes the further spread of invasives into adjacent stands of native vegetation (Keeley *et al.* 2005, Moyes *et al.* 2005). A study found that it is more likely for areas to experience repeated burnings if they are populated with introduced grasses (Zedler *et al.* 1983). Furthermore, the repeated burns aid the expansion of coastal sage scrub (CSS) into areas that were previously covered by chaparral scrub (Zedler *et al.* 1983). Chaparral habitats in California are most susceptible to invasion in the first few years following a fire event and annual grasses and forbs are the most likely species to invade (Keeley *et al.* 2005). A study looking at 90 sites in both chaparral and CSS habitats over a five year period following fire events recorded the presence of 75 alien plant species. In both the chaparral and CSS habitats, the species richness of non-natives peaked during the second year following the fire event and decreased in the following years. Therefore, the results support that many alien species take advantage of disturbance events such as fires to displace native vegetation, but the majority of the alien species persist for a relatively short time and displacement is not permanent (Keeley *et al.* 2005). Because much of the diversity of Mediterranean shrub lands consists of endemics that grow in the first post-fire year, more research is needed to explore possible long-term cascading effects on the seed production of native species (Keeley *et al.* 2005). Other studies have found that Mediterranean scrub habitats near urban development are particularly vulnerable to invasion by non-native grass species which often dominate in areas that have been cleared as firebreaks (Swenson & Franklin 2000).

3.9 HABITAT SUITABILITY MODELING

Habitat Suitability Models (HSM) were developed initially as a part of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures to assess the efficacy of land management practices on wildlife populations (Roloff 1999). These models evaluate idealized habitat conditions based on environmental parameters most influential in the occurrence, distribution, and abundance of a specific species. (Uhmann *et al.* 2001). They play an integral role in conservation management, prediction of relative species distribution, analysis of influences of different ecological factors, and the risk of species invasions and endangerment (Hirzel *et al.* 2006). Even though HSM models may only incorporate a limited number of factors, they help identify species' responses to its environment, its niche requirements and its prospective distribution. Relative values are assigned to habitats depending on the magnitude of influence on the growth and stability of the given species. Geographic Information Systems (GIS) also provide terrain data useful for modeling and for digitizing the application of HSM (Donovan *et al.* 1987).

3.10 Remote Sensing Techniques

3.10.1 Aerial and Orthographic Photography

Orthographic photos are a specialized form of aerial photography. These photographs are taken from a “straight down” view and are geometrically corrected to preserve even scale throughout the entire image (Anderson 2010). “Orthorectified” or uniformly scaled images are similar to a photographic map and can be analyzed through the science of Photogrammetry, or the ability to take accurate measurements from an aerial photograph. Potential variables of measurement include object height, object length, area of a polygon, and perimeter of a polygon (Habib *et al.* 2007). Orthophotos are advantageous for the study of “medium- to long-term vegetation change” (Carmel & Kadmon 1998). According to Carmel and Kadmon (1998), “high quality panchromatic (black and white) photos can be found for the last 50-60 years for many parts of the world.” This was stated 10 years ago. Today 60-70 year old orthorectified photographs are available. Non-corrected aerial photography can also be used to better understand past landscapes and cover types. UCLA’s Department of Geography houses the Benjamin and Gladys Thomas Air Photo Archives also known as the Spence and Fairchild Collection. This archive is comprised of oblique (angled not straight down view), black and white, aerial photographs taken between 1918 and 1971. These photographs extensively cover Ventura County, Los Angeles County, and Orange County (UCLA Geography). Although photogrammetry cannot be directly applied to these photographs, they still offer valuable information regarding the change experienced by Southern California’s Mediterranean ecosystems.

3.10.2 Multispectral Remote Sensing through the Landsat Series

There are many moderate resolution satellite platforms providing similar multispectral data, but the volume of published work tied to Landsat series is by far the most extensive. The National Aeronautics & Space Administration (NASA) began the Earth Resource Technology Satellite program in 1967. This gave rise to the Multispectral Scanners (MSS) onboard the first of the Landsat series satellites (Jenson 2007). MSS is a passive remote sensing system capturing 5 discrete “bands” of reflected electromagnetic radiation at a resolution (pixel size) of 79m x 79m (Jenson 2007). These bands are equivalent to the blue, green, red, near infrared, and thermal wavelengths of the electromagnetic spectrum. Each image covers a swath size, or area of 185 km x 185 km (Jenson 2007). The Landsat series has been acquiring United States environmental data since 1972 (Huang et. al 2009). The Landsat Thematic Mapper (TM) launched in 1982, and Enhanced Thematic Mapper Plus (ETM+) launched in 1999, are the predecessors of MSS. Both of these sensors have an increased resolution of 30m x 30m, but ETM+ captures 8 spectral bands including a 15m x 15m panchromatic or purely black and white image (Huang et. al 2009). All Landsat images can be acquired free of charge providing 40 years of imagery at medium spatial resolution.

3.11 Accurate Map Assessment

Accuracy assessment of a map derived from remotely sensed information is necessary to ensure project success and reliability for future studies. Global application of GIS has made accuracy assessment a crucial component of remote sensing data analysis. Map validation allows for self-evaluation and self-correction, quantitative comparison of methods, and the usage of resulting maps for decision-making processes (Congalton 2004). Different ways of identifying accuracy and error in spatial data include “visual inspection, non site-specific analysis, error budget analysis and quantitative accuracy assessment” (Congalton 2004). Map accuracy assessment protocols need to address both statistical rigor and practical application. Two criteria are necessary to assure reliable statistics: probability sampling and consistent measurement. Practical application depends on cost, which is directly correlated with assessment quality. A probability-based validation that infers the entire map population creates a practical and statistically rigorous accuracy assessment. While practical constraints are inherent in map validation, efficient and novel sampling designs may help overcome these problems (Stehman 2001).

3.12 CONCLUSION

RSV has undergone a history of anthropogenic disturbances, including settlement, grazing, and agriculture, that has influenced the distribution of vegetation. Fire, climate, and topography also play a role in determining how vegetation boundaries have developed at the site. Analysis using remote sensing provides greater understanding of the natural and anthropogenic disturbances that shape this habitat. Incorporating aerial photography allows for observation of data within a longer time frame. There is a lack of data and published literature on the composition and distribution of vegetation change at RSV. This literature review provides a historical and scientific background on factors that influence vegetation conditions, and explores technology available for analyzing vegetation cover.

4 RESEARCH QUESTIONS

After meeting with the National Park Service (NPS) and visiting RSV, we established three guiding questions that framed the foundation of our research.

RESEARCH QUESTION #1

What is the current distribution of vegetation within RSV?

Our client is primarily concerned with developing a keen understanding of the vegetation communities that populate the modern day site. We are providing baseline data for the NPS and future research endeavors.

RESEARCH QUESTION #2

Have the vegetation boundaries been stable or dynamic over the past century?

Addressing this research question will provide insight into the last century of vegetation community history within RSV. This includes an understanding of the succession patterns of native and invasive species after multiple disturbances ranging in type and scale.

RESEARCH QUESTION #3

Where are the best onsite locations for the active restoration of Coast Live Oak?

The NPS is concerned with future management of specific native species within RSV. Answering this research question will provide better management for future active restoration of the Coast Live Oak.

5 METHODS

A 3-band color aerial orthographic image (1-m resolution) of our site in Summer 2010 was acquired from the California Department of Fish and Game (CDFG) Map Service in order to determine the current vegetation cover of RSV. Trimble eCognition Developer software was used to segment the aerial image into homogenous units based on characteristics of shape, color and texture, resulting in 5,844 polygons within the park boundary. Using ArcMap, we classified these polygons into nine different mapping classes: Buildings, CSS, Chaparral, Eucalyptus, Grassland, Oak Woodland, Riparian Woodland, Roads and Trails, and Seasonal Ponds. Mapping classes were determined by identifying homogenous mapping units indicating specific communal distributions. Other imagery was used in conjunction with the 2010 color aerial to help classify the polygons, including a 2010 color-infrared and 2010 NDVI image from the CDFG Map Service, and ESRI's high resolution World Imagery layer (60 cm resolution). Through the Editor tool bar in ArcMap, the classified polygons were simplified into 906 contiguous polygons and thematically colored to clearly indicate individual groupings.

We then ground-truthed the results of our classified current vegetation map using Map Accuracy Assessment (AA) methods (CDFG Vegetation Classification and Mapping Program). To begin this process, we used the random number generator function on Microsoft Excel to randomly select 30 field ID's that equate to 30 polygons from our five main alliance types (CSS, Chaparral, Grassland, Oak Woodland, Riparian Woodland). We then checked the accessibility of each of these polygons based on the layout of roads and trails and where we would be able to hike, and acquired 15 polygons from each alliance type that we would assess the accuracy of in the field (**Appendix A-2**). Using the RSV Field Assessment data sheets (**Appendix B-1 to B-5**), we assessed 15 polygons from the five main alliances (75 polygons total) by determining the vegetation type and percent cover of each type and including information on topography and additional observations. In the field, we interpreted the polygons from a mapper's point of view to determine what the dominant vegetation is from an aerial vantage. A polygon was considered to be accurate if the majority of the vegetation within the polygon met the key definitions for the vegetation type that the polygon was classified as. For example, a polygon that was classified as chaparral and consisted of 60% ceanothus species and had a closed canopy was considered to be accurately classified. In order to meet the expected map accuracy of the State of California CNPS-CDFG mapping standards, we had to have at least 80% accuracy in each of the alliance types (12 out of the 15 assessed polygons). After the Map AA was completed, we returned to the lab to integrate the field data into our classified image and to increase the detail of our final map. With the data collected from our fieldwork and our developed knowledge of what each vegetation type looks like in the field and from an aerial vantage, we corrected our draft to account for incorrect classifications and added detail such as buildings and roads and trails.

The historic image was a raw aerial image of 1959 from Cal State University Northridge (original source: Fairchild Aerial Surveys, Inc.) that we had to orthorectify and mosaic before classification. It was divided into homogenous units in the same way as the current aerial image and classified with the same approach, except without the use of the infrared and NDVI layers to assist. We did not include Eucalyptus and Seasonal Ponds as alliance types in the historic vegetation map as these were only included in the current image because of direct field observations. Due to the lack of historic field study data, we were not able to confirm an accuracy of at least 80% for our classified 1959 vegetation map, but we applied the same knowledge of how each vegetation type looks from an aerial vantage to the classification process of the 1959 aerial image to be as accurate as possible.

The classification effort for the 2010 vegetation map was focused on broad community groups, at a hierarchical level that could be also completed with the historic 1959 image, to characterize the stability of vegetation over a 60-year period. However, the resulting 2010 current vegetation map is not classified to the same level of detail as the existing SMMNRA Mapping (SMMNRA Photo Interpretation Report 2007). **Table 5-1** identifies the mapping classes used for this project and the corresponding mapping classes identified at RSV in the SMMNRA vegetation map.

Table 5-1 Our mapping classes compared to the SMMNRA final mapping classification names for our main vegetation types.

Map Class:	Chaparral	Coastal Sage Scrub	Grassland	Oak Woodland	Riparian Woodland
SMMNRA Final Mapping Classification:	Greenbark Ceanothus - Bigpod Ceanothus Association	California Sagebrush - Purple Sage Superassociation Mapping Unit	Native and Non-Native Herbaceous Superallliance Mapping Unit	Coast Live Oak Superassociation Mapping Unit	Red Willow and Arroyo Willow Superallliance Mapping Unit
	Bigpod Ceanothus - Laurel Sumac Association	Laurel Sumac - Ashy Buckwheat - Black Sage Phase		California Sycamore - Coast Live Oak South Coast Association	Mulefat - Riparian Association
	Greenbark Ceanothus and Bigpod Ceanothus and Birchleaf Mountain-mahogany Superalliance Mapping Unit	Coast Prickly Pear - Mixed Coastal Sage Scrub Association		Coast Live Oak / Greenbark Ceanothus Association	
	Bush Mallow-Greenbark Ceanothus Association	Black Sage Superassociation Mapping Unit			
	Chamise - Black Sage - Laurel Sumac Association	California Sagebrush - Bush Monkeyflower Association			
	Bigpod Ceanothus - Chamise Association				

We developed our visual classification key (**Appendix A-3 and A-4**) with the help of the 2010 color-infrared and 2010 NDVI layers, as well as the high resolution World Imagery layer. The NDVI image contained a color infrared band and a normalized difference vegetation index (NDVI), which allowed us to differentiate between vegetation types while classifying because green vegetation has much larger variation within the infrared region of the electromagnetic spectrum. This was helpful mainly for differentiating between areas of chaparral and oak woodland and areas of chaparral and CSS, with oak having the highest infrared reflectance and CSS having the lowest of the three vegetation types. Some nonnative grassland species showed a similar reflectance to CSS which made classification of some areas difficult, but it was generally easy to identify CSS as regions with sparse shrubbery and an open canopy. Chaparral was differentiated from CSS by its higher infrared reflectance, obviously more dense vegetation communities, and its closed canopy. The high resolution of the World Imagery layer allowed us to see the difference between the tree crowns of oak woodland and the closed canopy of chaparral, as well as shadows that indicated the dominant height of oak woodland over other vegetation. Grassland and riparian woodland had very identifiable aerial signatures; grassland was noticeably flat (and mowed in some regions) and lacked the sparse shrubbery that is characteristic of CSS regions, and riparian woodlands grew in corridors following alongside stream beds throughout the site. Since we did not have the assistance of the color-infrared, NDVI, and World Imagery layers during the classification of the 1959 aerial image, we had to rely on the expertise we had gained thus far. The classification of our current vegetation map and our extensive field observations helped us train our eye to identify each vegetation type from an aerial vantage.

We created an intersect map as an overlay and union of the historic and current vegetation maps using Tools in ArcGIS Editor to compare chronological change within the vegetation community boundaries present in Rancho Sierra Vista. This comparison showed us where vegetation boundaries expanded, diminished, and remained stable in the 50 years between 1959 and 2010. With ArcMap we employed spatial statistics to determine changes in area, direction of movement, and relative abundance of each main alliance type. We used a summarizing tool to determine the relative concentration of each specific change, and the zonal statistics tool to calculate the modal direction for dynamic and stable alliances. We took a close look at the top ten specific alliance changes by acreage to analyze the biggest changes that occurred on site, and ran statistics on alliance changes using Excel.

The habitat suitability model (HSM) was created based on the physical parameters of the habitat preferences of Coast Live Oak, which we determined from direct field observations and literature research. Our HSM was based on four physical parameters: aspect, slope, canyon proximity, and soil type. All these parameters were combined through map algebra to produce a single output where each individual pixel represents a range of values indicating degree of favorability of Coast Live Oak in RSV. These values ranged from zero to fourteen, with zero being least favorable and fourteen being most favorable. The mathematical equation used to generate the HSM was decided on what gave us the highest mean zonal output value out of fourteen. We employed zonal statistics comparing the current distribution of oak woodlands and our HSM output to test the accuracy of our model. The combined parameters provided a spatial analysis of where Coast Live Oak would best be suited in RSV, providing insight for potential active restoration sites.

6 RESULTS

Our 2010 vegetation map (**Figure 6-1**) was classified with at least 80% accuracy (**Appendix C-1 to C-5**). The 2010 vegetation map can be seen in **Figure 6-1**. The 1959 vegetation map can be seen in **Figure 6-2**. At over 60%, the majority of vegetation on our site remained stable from 1959 to 2010, depicted in **Figure 6-5.** We identified the top ten biggest changes that occurred amongst the alliances from 1959 to 2010 based on acreage (**Table 6-2, Figure 6-6**). These major changes include a shift from CSS to chaparral (by far the largest, at 231 acres of transformation), a shift from chaparral to CSS (55 acres), and a shift from grassland to CSS (46 acres). These increases and decreases are illustrated in a bar graph in **Figures 6-3** and **6-4**, which compare the vegetation cover in U.S. acres from 1959 to 2010 for each vegetation type.

Chaparral saw the largest increase in acreage of all the alliances at 259 acres, which calculates to an 81% increase from 1959 cover (**Table 6-1**). Of the 259 acres, 231 acres were attributed to a shift from CSS to chaparral, which equates to 89% of the total alliance increase (**Table 6-2**). The remainder of the increase was almost entirely due to a shift from grassland to chaparral, totaling to another 17 acres (**Table 6-2**). Chaparral was the second-most stable alliance after grassland, with a total of 241 acres that remained stable between 1959 and 2010 (**Figure 6-3 and 6-4, Table 6-2**). Chaparral also had the second-least amount of relative decrease in acreage after grassland at 25% (**Table 6-1**). About 55 of the 78 acres of chaparral loss is due to a shift from chaparral to CSS, which is mostly evident in the western region of our site (**Figure 6-7**).

CSS saw the largest decrease in acreage of all the alliances at 264 acres, which is 66% of the total CSS cover in 1959 (**Table 6-1**). A significant 58% of the CSS cover in 1959 shifted to chaparral by 2010 (**Table 6-2**). This shift occurred mostly on western slopes and in the eastern region of RSV, with a notable amount in the southwestern region as well (**Figure 6-7**). Even though CSS saw a 66% decrease in acreage, the net percent change was equivalent to -40% which indicates that regions of the site did gain CSS since 1959 (**Table 6-1**). CSS saw an increase of 104 acres, which is equivalent to 26% of 1959 cover (**Figure 6-4**). About 138 acres of CSS remained stable from 1959 to 2010 (**Figure 6-4**).

Grassland was our most stable alliance, with about 325 stable acres (**Figure 6-4, Table 6-2**). Grassland had a net 18% loss of acreage on site since 1959, with only a 4% increase of cover (**Table 6-1**). About 55% of the 19 acres of increased grassland cover is due to a shift from CSS to grassland. There was a total decrease of 97 acres, about half of which transitioned to CSS. The grassland loss is mostly evident on the boundaries of the grassland and expanding riparian corridors (**Figure 6-8**). Development of park trails since 1959 contributed to a decrease of 12 grassland acres (**Table 6-2**).

Oak woodland saw a relatively significant increase in cover of 47 acres since 1959, which equates to about 260% of the 1959 cover (**Table 6-1**). This large increase is due to the removal of grazing and to restoration projects on site. About half of this acreage increase is from a shift from CSS to oak, and the other half from a shift from chaparral to oak. The fourth and fifth largest alliance changes were chaparral to oak and CSS to oak, respectively (**Table 6-2**). These shifts are mainly concentrated in the northeastern region of the park, with a notable amount in the southwestern corner as well (**Figure 6-7**). Approximately nine acres of oak woodland remained stable, while another nine acres were lost from 1959 to 2010 (**Figure 6-9**). Since there were only 18 acres of oak woodland in 1959, the 9-acre loss makes oak woodland the alliance with the second-largest percent decrease in cover relative to its 1959 cover, with the first being CSS (**Table 6-1**). This also means that about half of the 1959 oak woodland cover remained stable over the 50 years until 2010. Currently in RSV, 1.509 acres are allotted for active oak restoration by the National Park Service (**Figure 7-1**).

Riparian vegetation saw the largest relative percent increase in cover out of all the alliances by far, at about 413% (**Table 6-1**). With only about four total acres in 1959, this equates to a 16-acre increase in riparian vegetation since 1959 (**Figure 6-3 and 6-4**). About 88% of this increase in riparian cover is due to a shift from grassland to riparian, which can be attributed to the removal of ranching as previously stated (**Table 6-2**). This expansion is mostly evident in regions of riparian corridors in RSV (**Figure 6-8**)**.** About 2.5 of the original four acres from 1959 remained stable between 1959 and 2010, while there was a 34% decrease in the 1959 riparian cover, which equals about 1.3 acres (**Figure 6-4**). This gives riparian vegetation a net percent increase of 380%, which is the highest net percent increase of all the alliances (**Table 6-1**).

To give the National Park Service an expert-guided model of regions suitable for coast live oak restoration, we created a habitat suitability model (HSM). We based our HSM on four physical parameters: aspect, slope, canyon proximity, and soil type. The HSM assessment that correlated best with existing oak woodland communities at RSV was produced by weighting slope and aspect on scales of five and canyon proximity and soil type on scales of two (**Figure 6-10 and 6-11**). All these parameters were combined through addition, giving a maximum, or perfect suitability value, of fourteen. To test the predictive power of our model, we employed zonal statistics comparing the current distribution of oak woodlands and our HSM output. Our highest scoring model produced a mean zonal output of 8.012, which indicates that our mathematical equation correlates with previously existing coast live oak on our site while also providing locations for future active restoration (**Table 6-3**).

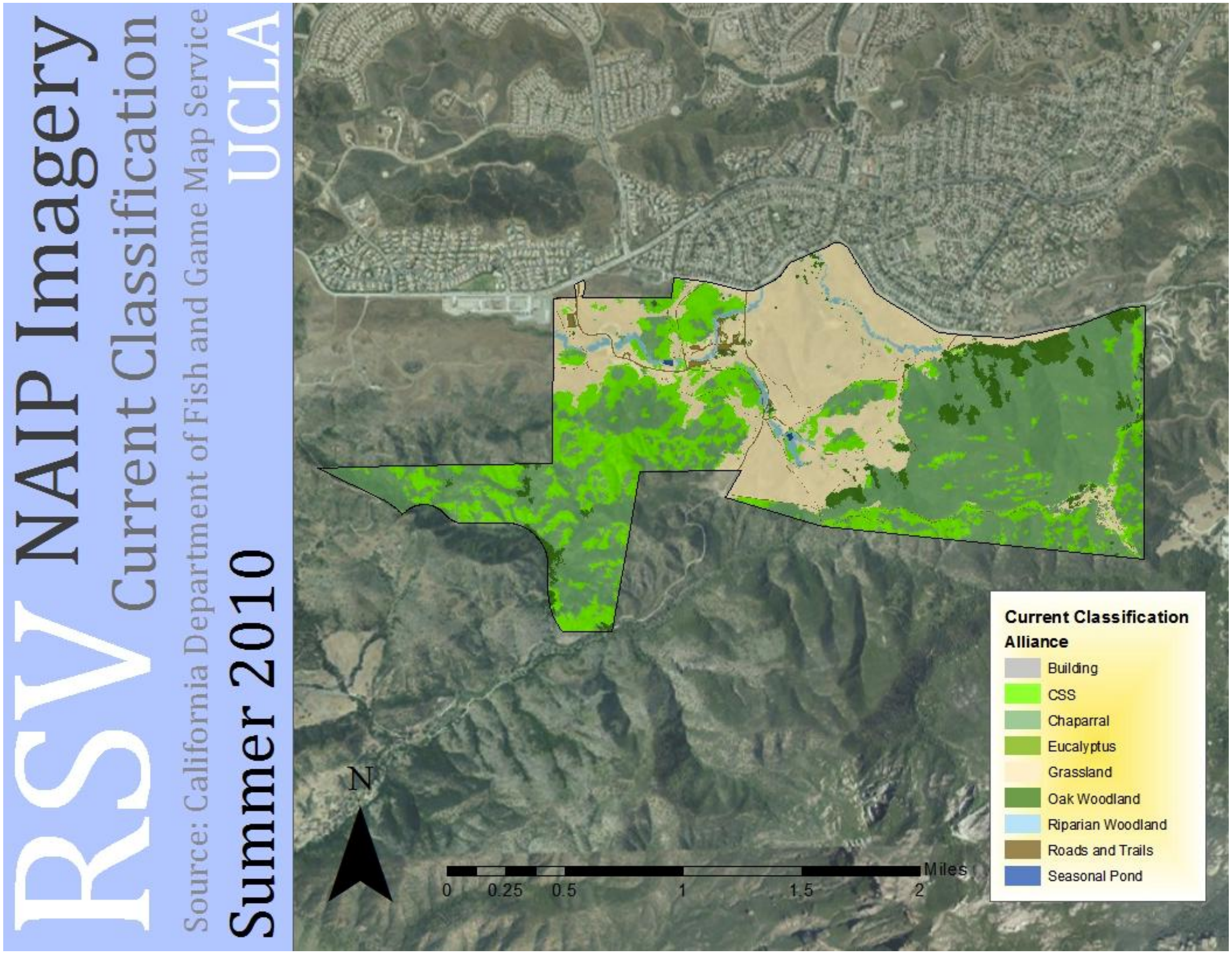

Figure 6-1 **Classification of current vegetation from a 2010 aerial image of RSV.**

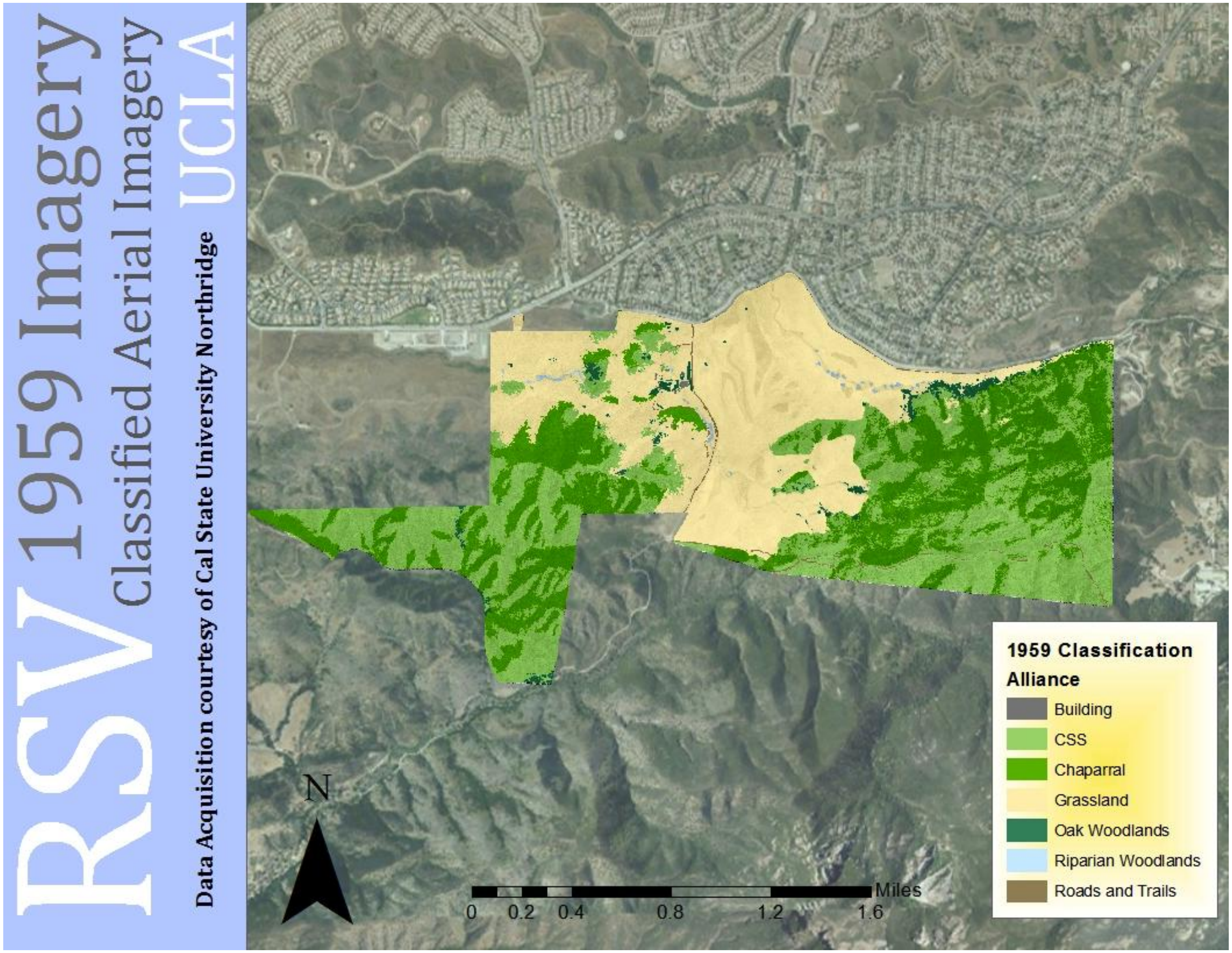

Figure 6-2 **Classification of historic vegetation from a 1959 aerial image of RSV.**

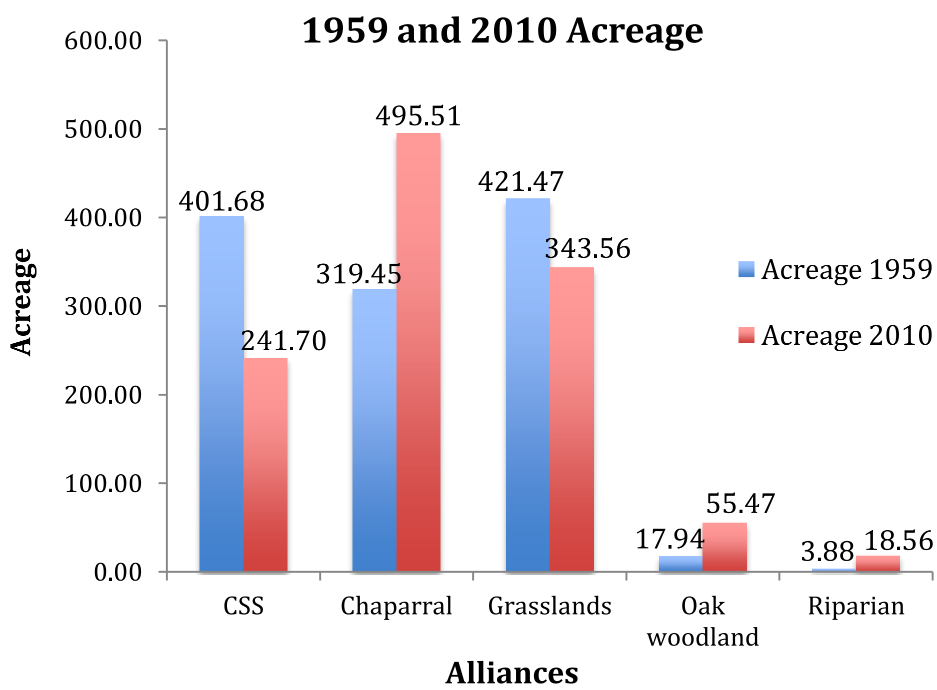

Figure 6-3 **Vegetation acreage in 1959 and 2010.**

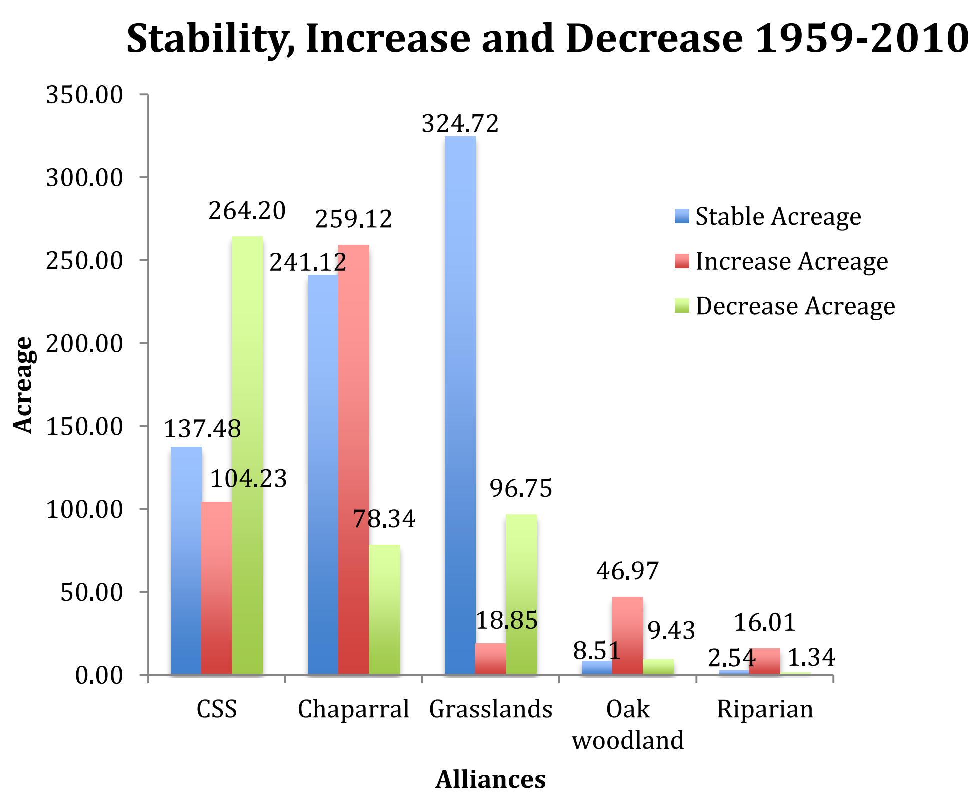

Figure 6-4 **Change in vegetation cover in U.S. acres from 1959 to 2010.**

Table 6-1 **Percentage of increase, decrease, and net change in respect to 1959 acreage.**

Alliances	Increase (Acres)	Decrease (Acres)	Net Change (Acres)
CSS	26% (104.23)	66% (264.20)	-40% (-159.97)
Chaparral	81% (259.12)	25% (78.34)	57% (180.78)
Grasslands	4% (18.85)	23% (96.75)	-18% (-77.90)
Oak woodland	262% (46.97)	53% (9.43)	209% (37.54)
Riparian	413% (16.01)	34% (1.34)	378% (14.68)

Table 6-2 **Vegetation alliance, 1959 to 2010, in percentage and U.S. acres.**

Vegetation Alliance 1959 to 2010	Change within Alliance (1959)	Mode of Direction Change
Change		
CSS to Chaparral	57.58% (231.27 ac)	W
Chaparral to CSS	17.09% (54.60 ac)	S
Grasslands to CSS	10.83% (45.65 ac)	N
Chaparral to Oak	6.16% (19.67 ac)	N
CSS to Oak	4.86% (19.54 ac)	N
Grasslands to Chaparral	4.00% (16.84 ac)	N
Grasslands to Riparian	3.26% (13.74 ac)	N
Grasslands to Park Trails	2.75% (11.57 ac)	N
CSS to Grasslands	2.58% (10.38 ac)	N
Grasslands to Oak	1.83% (7.73 ac)	N
Stable		
Stable Grasslands	77.04% (324.72 ac)	N
Stable Chaparral	75.48% (241.12 ac)	N
Stable CSS	34.23% (137.48 ac)	S
Stable Oak Woodlands	47.43% (8.51 ac)	N
Stable Riparian Woodlands	65.55% (2.54 ac)	N

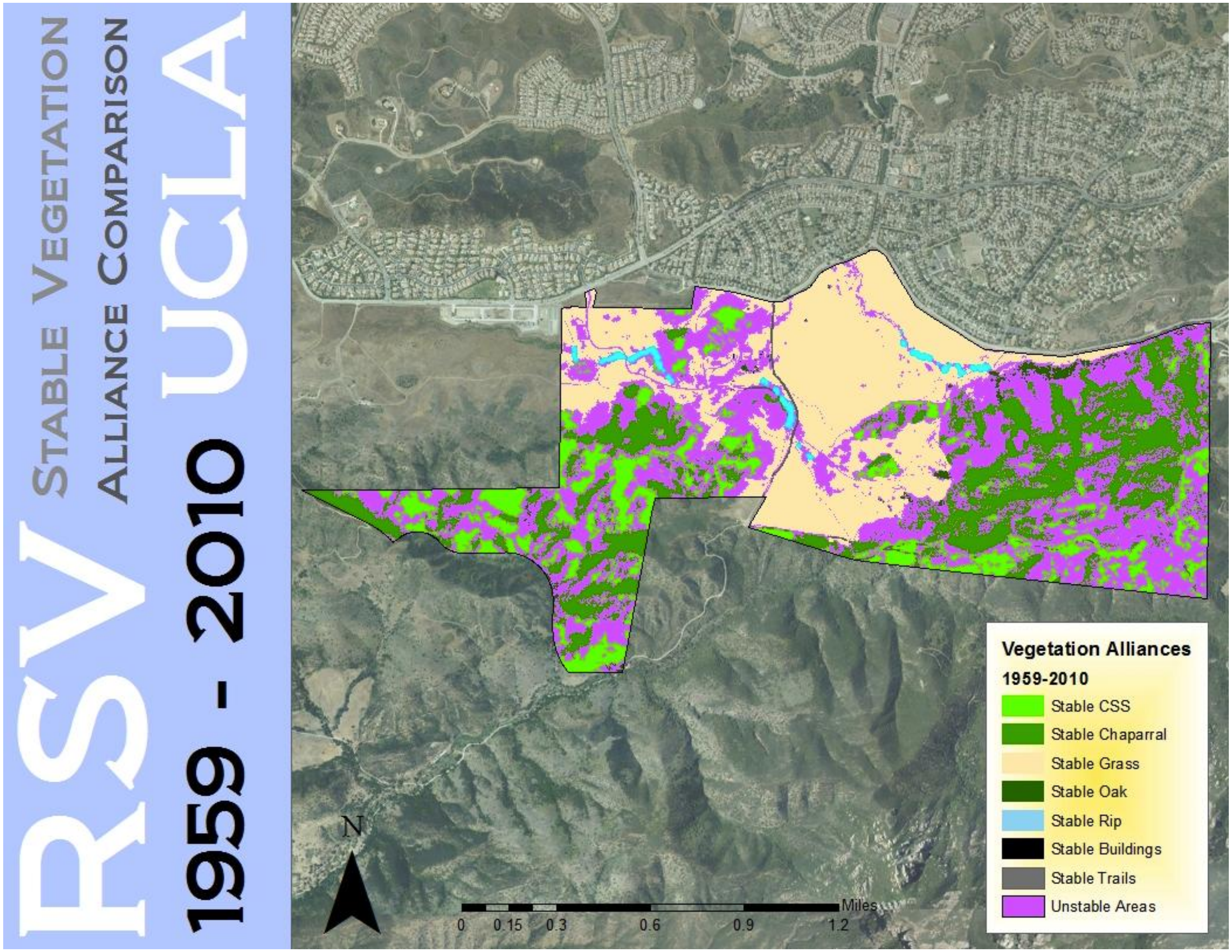

Figure 6-5 **Regions of each vegetation alliance that remained stable between 1959 and 2010.**

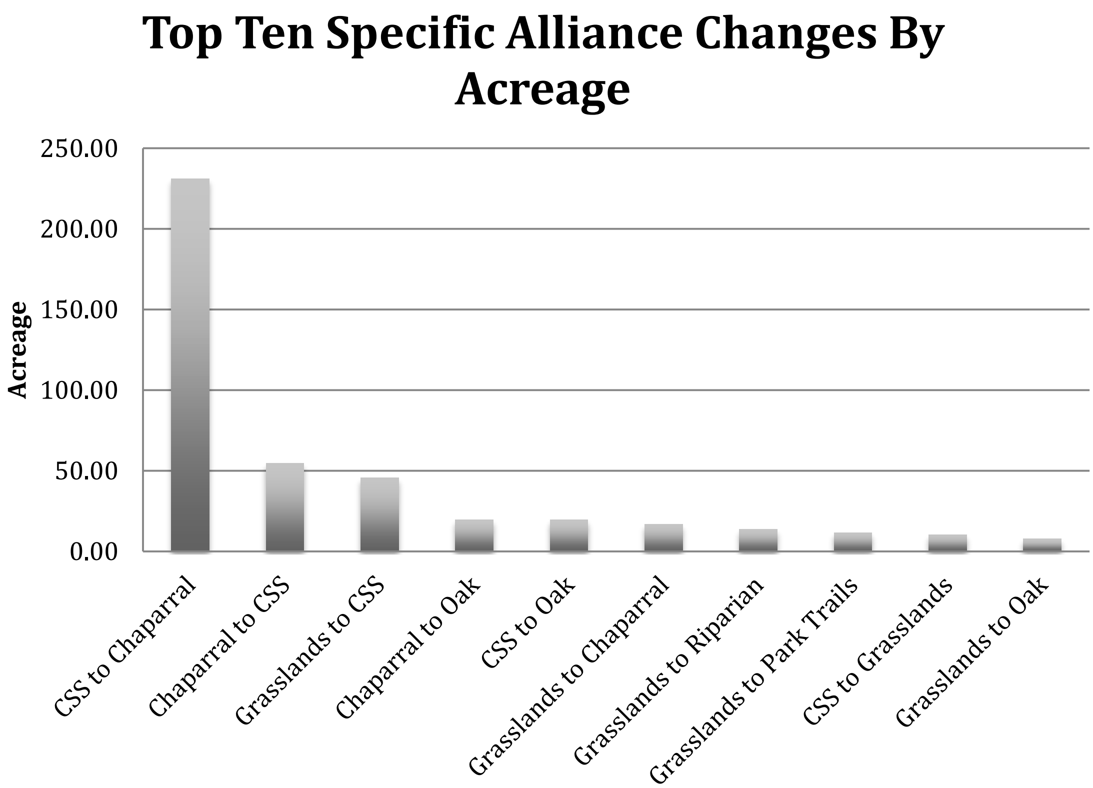

Figure 6-6 **Specific transitions between vegetation types from 1959 to 2010, in U.S. acres.**

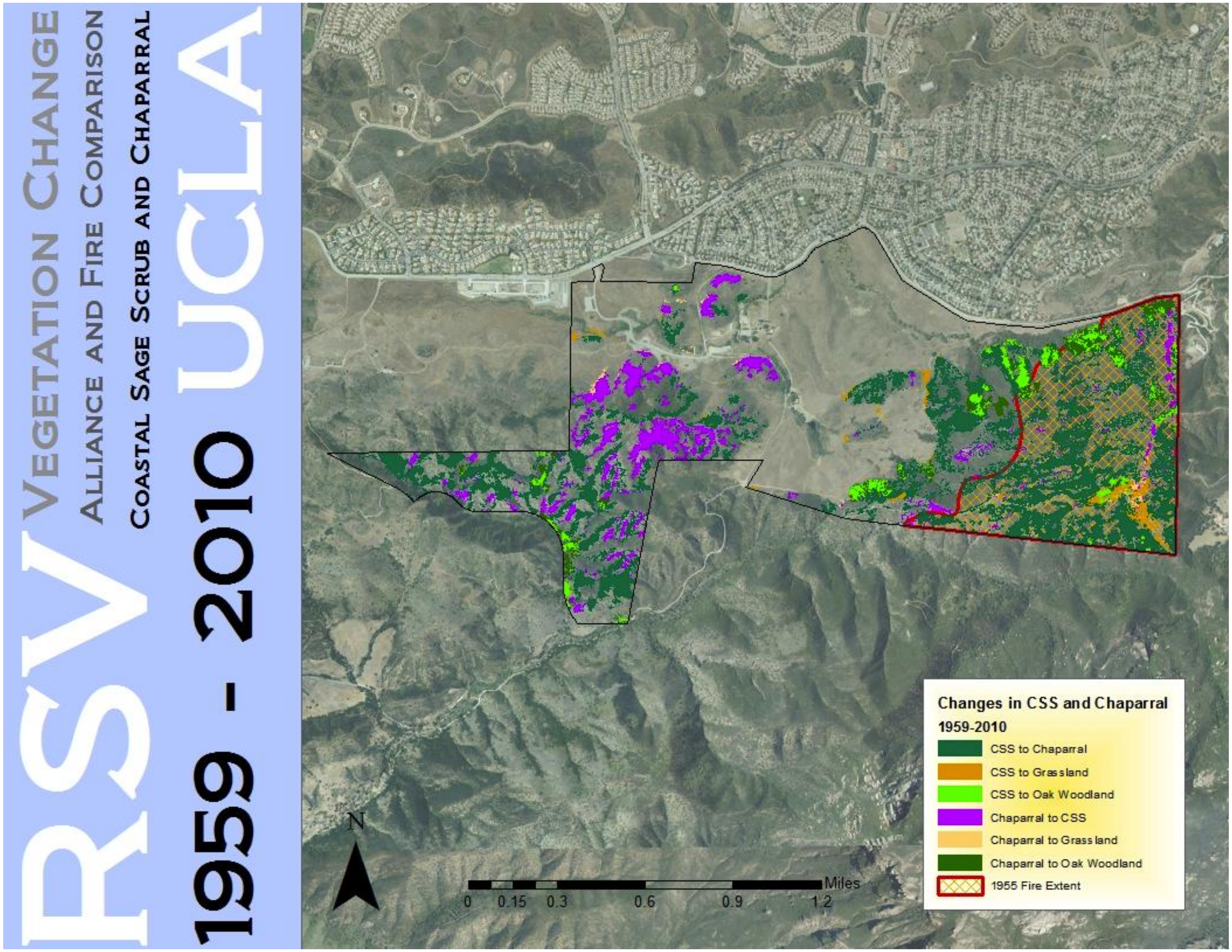

Figure 6-7 **Changes in CSS and chaparral cover from 1959 to 2010, including 1955 fire extent.**

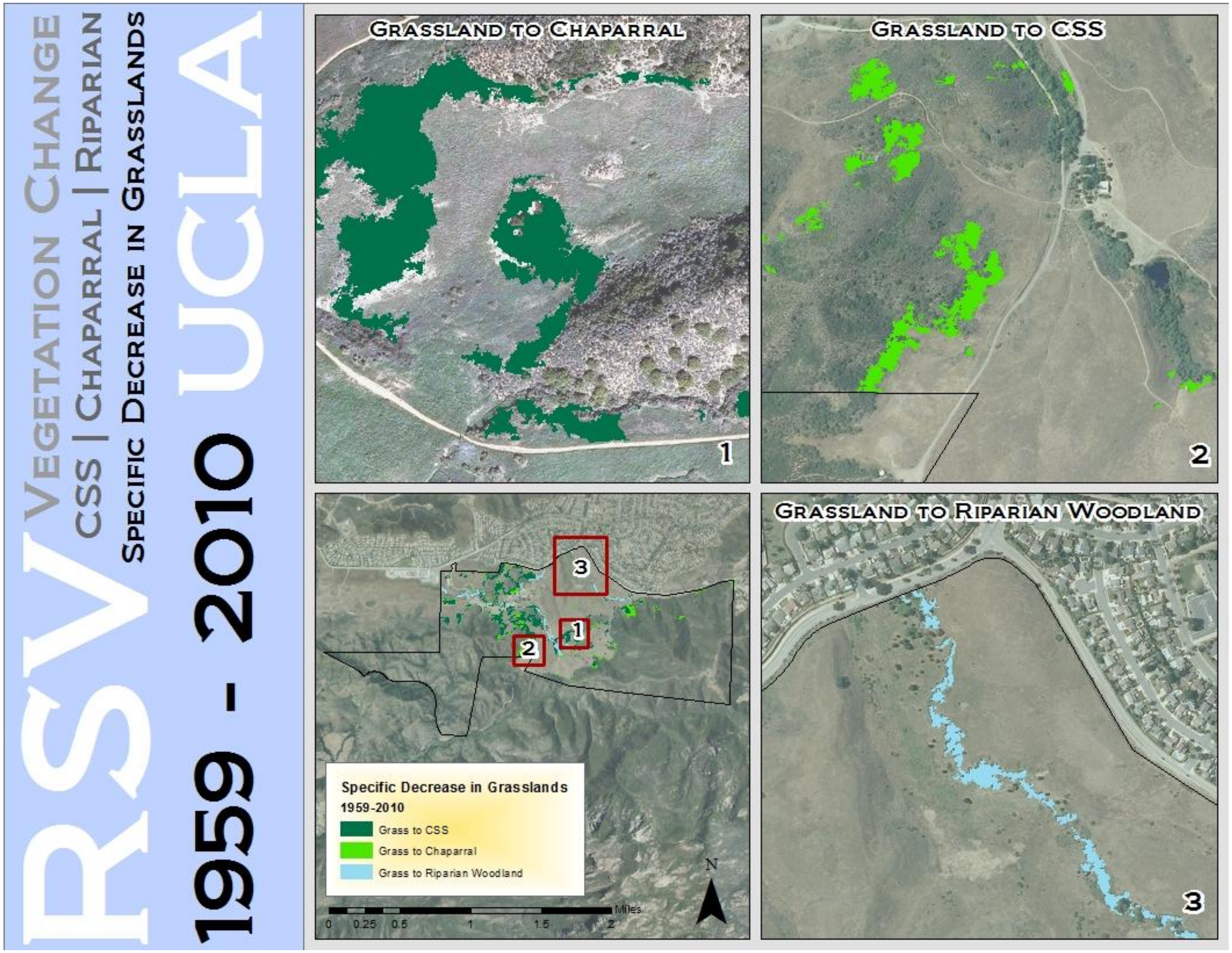

Figure 6-8 **Shifts from grassland to other alliances from 1959 to 2010.**

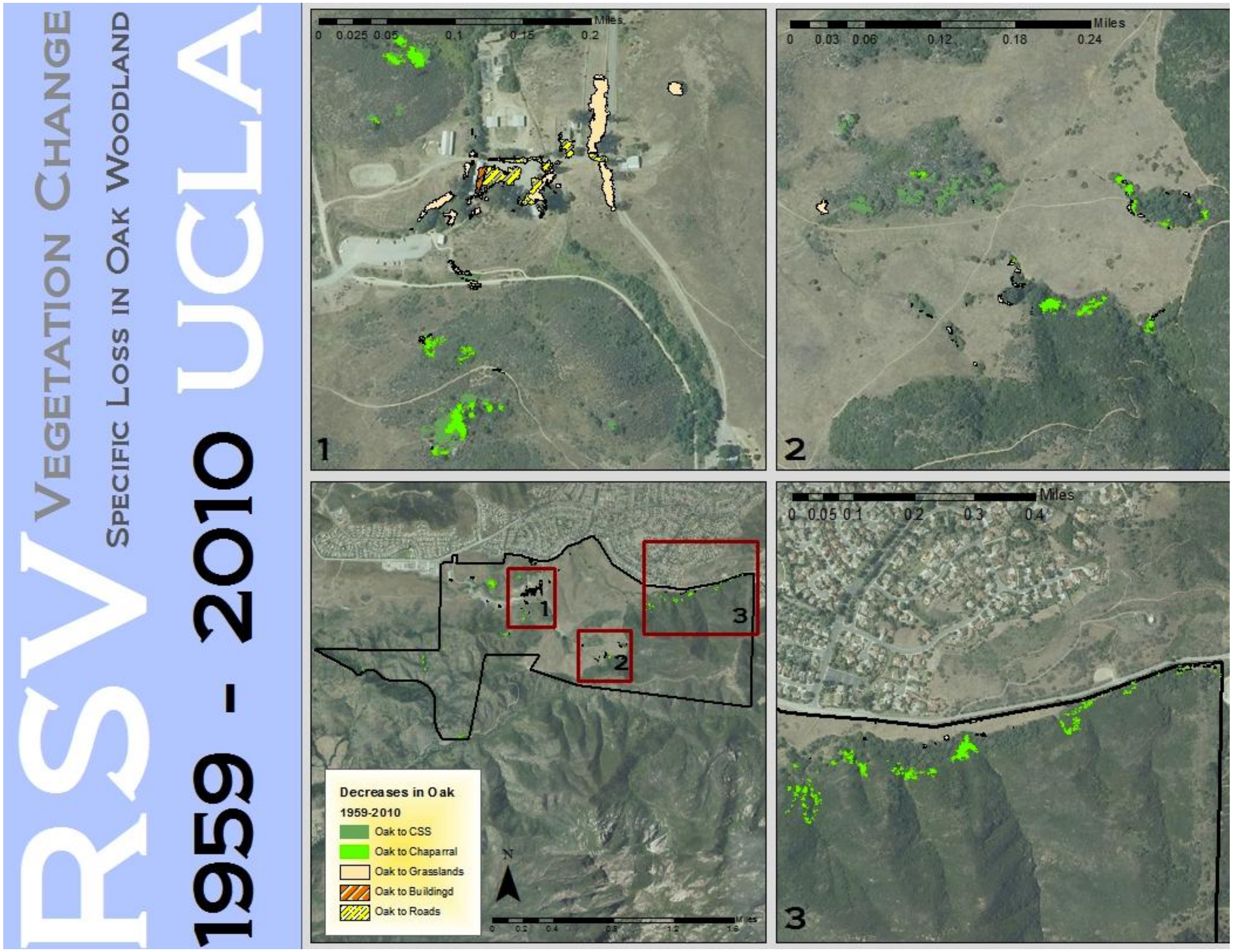

Figure 6-9 **Shifts from oak woodland to other alliances from 1959 to 2010.**

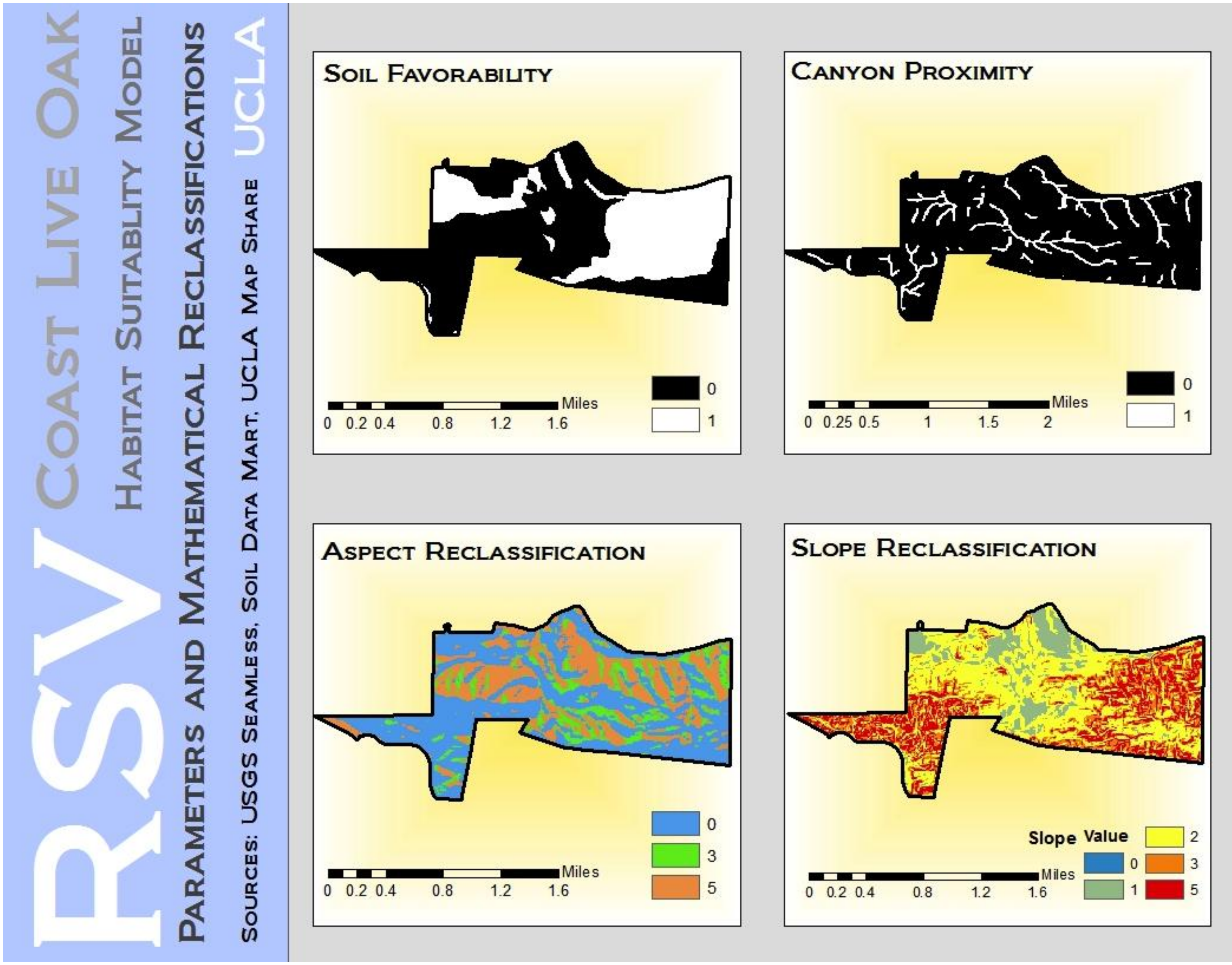

Figure 6-10 **Parameters and reclassifications for the Coast Live Oak habitat suitability model.**

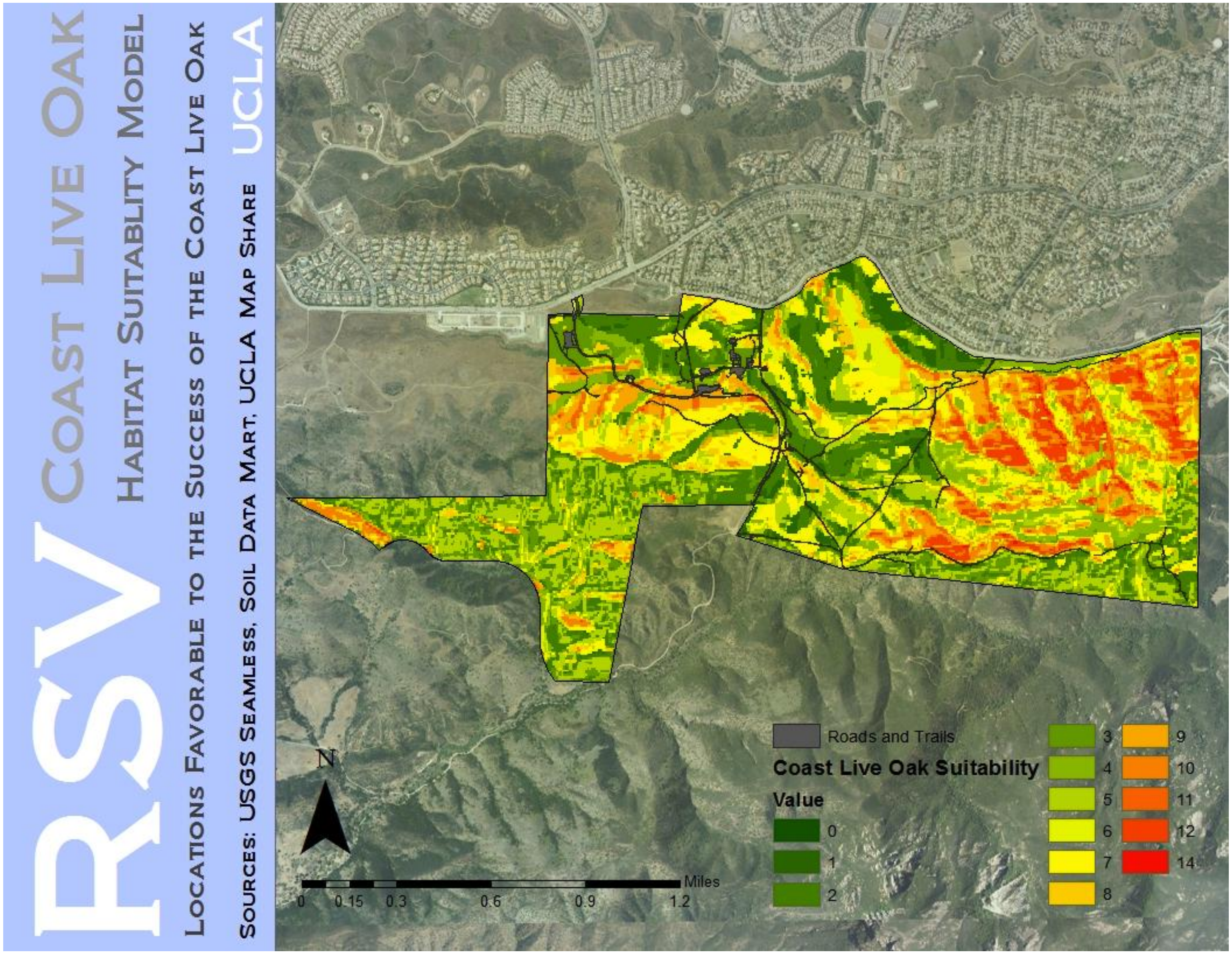

Figure 6-11 **Coast Live Oak habitat suitability model.**

Table 6-3 Mathematical equation comparison and accuracy assessment for HSM.

Slope Value	Aspect Value	Canyon Value	Soil Value	Max Value	Mean Zonal Output
3	5	5	3	16	6.706
5	5	2	2	14	8.012
5	5	3	1	14	7.324
2	5	5	2	14	6.814
3.5	3.5	3.5	3.5	14	7.686
3	4	5	2	14	6.786
4	4	2	2	12	6.752

7 DISCUSSION

7.1 CHAPARRAL

The majority of Chaparral acres gained (57%) were from previously classified CSS regions, specifically in the eastern region. This growth is likely explained by the 1955 fire event (**Figure 6-7**). The eastern section 1959 map contains a portion of classified CSS, that had burned for the first time in over 100 years, according to the Fire and Rescue Assessment Program. Keeley (1989) states in the first few post-fire years, species typical of the CSS may occupy the openings in the landscape between re-sprouting Chaparral shrubs and young seedlings of other evergreen Chaparral shrubs. This explains the dominance of Coastal Sage Scrub in the 1959 imagery. If the regions are favorable for Chaparral (i.e. northerly slope, elevation of 300-500 m, etc.), these evergreen shrubs get large enough to close the canopy and eliminate gaps between shrubs, and therefore, effectively crowd out the CSS sub-shrubs (Keeley 1989). At the site this pattern was observed to happen on the mesic north facing slopes. Though the Green Meadows Fire burned the site in 1993, the 19 year gap is long enough fire free period to allow chaparral species to dominate.

The western region saw the opposite: a shift from chaparral to CSS. These regions primarily occurred on steep south facing slopes. This region was not subject to the 1955 Ventura Park Fire (**Figure 6-7**), and is localized within an area that had not previously burned for over 100 years (FRAP 2012). In areas that have long absences of fire (over a century), evergreen Chaparral species common to both alliances (Ceanothus, Laurel Sumac), are able to able to slowly close the canopy and dominate over deciduous CSS species that must regenerate a new crown annually (Keeley 1992). This phenomenon is even known to occur on xeric south facing slopes if there is no nutrient limitation (Keeley, 1992). This explains the 1959 extent of Chaparral in the western edge of the region, as seen in purple in **Figure 6-7.** The 1993 Green Meadows Fire that burnt the entire extent of the park allowed CSS to recolonize the xeric steep south facing slopes, controlling the growth of the dominating Chaparral species. The 19 year post fire period was not long enough to allow chaparral to recolonize, which explains the present extent of CSS on south facing slopes in the western extent of the site.

The regions of stable chaparral (primarily eastern extent of park) existed on a northward modal direction of stability. This supports the literature that cites a mesic northward slope as the most favorable slope for chaparral to exist (Bauer, 1936).

7.2 COASTAL SAGE SCRUB

CSS experienced the largest loss in acreage (264 acres, 66%), with a majority of the shift coming from the shift from CSS to Chaparral (over 200 acres). This large shift can be explained in the previous section, due to natural post fire recovery.

The acreage gains in CSS (104 acres, 26%), were largely attributed to the transition from Chaparral to CSS. This shift can be explained in the previous section.

The regions of stable CSS (southwestern edge of park, **Figure 6-5**) existed on a southward modal direction of stability. This supports the literature that cites the most favorable slope of coastal sage scrub to exist upon is a xeric southward slope (Bauer 1936).

7.3 RIPARIAN WOODLAND

Riparian woodlands saw a 378% net increase from 1959 to 2010, from 3.88 to 18.56 acres. Almost 14 acres of the 16 acre increase came from conversion of grasslands into riparian woodlands (**Table 6-2**). This occurred along drainages running through relatively low elevations of RSV (**Figure 6-8**). This increase likely resulted from the cessation of both agriculture and grazing on site. Degradation from grazing practices is often magnified in riparian woodlands (Patten 1998, Jansen & Robertson 2001). This is due to livestock congregating in these areas for the relatively abundant access to water, food, and shade they provide, especially during hot or dry periods (Warner 1984, Fleischner 1994, Patten 1998). Livestock have various direct impacts on riparian corridors, ranging from consumption of the vegetation to increasing the sediment loads in the rivers and streams, all of which result in reduction of the riparian areas (Warner 1984). Agricultural practices have similarly detrimental impacts on riparian woodlands, mostly due to impacts of irrigation (Patten 1998).

7.4 GRASSLAND

Grassland saw a net decrease of about 97 acres, or 18%, from 1959 to 2010, with conversions to every other vegetation type in RSV (**Table 6-1**). These changes occurred in the central region of RSV, which is where the majority of the grasslands are located (**Figure 6-8**). The conversion of grassland into CSS accounted for nearly half of the total loss of grassland, at 46 out of the 97 acre decrease, and overall was the third largest change in alliance by acreage (**Table 6-2**). The conversion of grassland to CSS tended to occur on north facing slopes, which are characterized by having more moisture available (**Figure 6-8**). The wetter conditions may have reduced the competition between shrubs and non-native grasses, making expansion of CSS into these areas easier than it would have been on drier, south facing slopes. A typical area of change from grassland to CSS can be seen in section 2 of **Figure 6-8**. On the lower left area of section 2 conversion is happening along the borders of previously established CSS communities (**Figure 6-8**). Spread at the edges of previous CSS communities was common, often occurring on the lower portion of a slope and stopping at the slope break, after which point grassland usually remained dominant. Grassland shifting to chaparral represents another significant change in RSV and was the sixth largest type of alliance shift by acreage seen between 1959 and 2010 (**Figure 6-6**). Section 1 of **Figure 6-8** shows an area typical of change from grasslands to chaparral. The change occurred on a slope, adjacent to areas that were already either CSS or chaparral in 1959. However, the changes did not only occur along the borders of the previously established communities of chaparral. Instead, the shifts occurred both along borders and in larger groupings and generally occurred on hills. The change was likely due mostly to the removal of grazing from the RSV (Carmel & Kadmon 1999). In section 3 of **Figure 6-8**, grassland conversion to riparian woodland can be seen. The expansion of riparian woodlands occurred along drainages (**Figure 6-8**). This type of alliance shift was likely due to the removal of grazing and agricultural practices, both of which are detrimental to riparian woodlands (Patten 1998). Grassland also saw a decrease due to the construction of roads, trails, and buildings. Conversion of grassland into park trails (including dirt trails and paved roads) accounted for 11.57 acres of grassland loss (**Table 6-2**).

7.5 Oak Woodland

The establishment, growth and distribution of oak trees depends on a number of ecological factors, including the availability of soil water, sunlight and shade tolerance, fire disturbance, and soil type. The 208% relative increase in oak woodlands can be attributed to favorable ecology and to the discontinuance of grazing and drainage projects, and active plant restoration. Oak trees sprout efficiently after fire (Hanes 1971) and prefer to grow on northern-facing slopes with adequate access to water (USDA Forest Service). The northeastern section of RSV, which experienced the 1955 Ventura Park fire and features northern facing slopes adjacent to a running stream, create favorable conditions for growth of oak woodlands. It is known that adequate soil moisture is required for stable recruitment of oak saplings and growth of adult trees (Brooks *et al.* 2008). Human disturbances have prevented the development of streams and stream drains (Tom Young), which in turn has limited access to soil water for potential oak saplings. With the discontinuation of human activity, streams have been allowed to develop in the north and northeast section of the site. These streams have encouraged the increase of riparian land, which supports efficient recruitment and growth of oak trees. In addition, direct field observations of tree shelters around young oak trees along the northern center riparian strip indicate active planting of oak trees.

The decrease in oak woodland, which occurs in the northwest section of RSV, may be attributed mostly to fire disturbance and human development of trails and buildings. The 1993 Green Meadows fire, which burned throughout the entire site, may explain the slight decline in oak trees in the northeast region of RSV. In addition, recreational inputs of parking lots, culture centers and offices may have directly displaced oak woodland habitat, or altered site conditions in a way that no longer supports oak tree growth. These changes may include shifts in soil water patterns and soil types.

7.6 Restoration

The northwest region of the recreation area has been identified as a restoration area (**Figure 7-1**). Six types of restoration are planned to take place in summer 2012: CSS, native grass, active oak restoration, restoration buffer, riparian, and riparian Marsh. These areas were previously classified in the 2010 imagery as nonnative grassland communities. The National Park Service is planning active restoration on site for the designated CSS, native grass, oak, riparian, and riparian marsh via chemical weeding to remove nonnative species (such as nonnative grass and invasive thistle) and active seeding. Different seeds will be distributed based on designated alliance type. The restoration buffer is an area where the NPS has actively sprayed and mowed nonnative species to prevent re-dominance.

Two different oak restoration sites have been designated by the NPS on site. The favorability of these oak restoration sites are analyzed in the discussion of the oak habitat suitability model.

7.7 HABITAT SUITABILITY MODEL

The accuracy of our Habitat Suitability Model was assessed through zonal statistics. Specifically, we utilized the current distribution of classified Oak Woodlands within RSV as our vector of comparison. Our statistic of choice was the mean HSM value associated with oaks on site. This style of statistic was employed to test the accuracy of 13 different mathematical combinations of our defining parameters. We chose the equation that yielded the highest mean zonal statistic. This value was equivalent to 8.012 out of 14 (**Table 6-3**).

Potential errors could have resulted from multiple sources. We utilized a Digital Elevation Model with a spatial resolution of a third arc second or 10m by 10m. This was acquired from the USGS seamless viewer, and this initial data was utilized to generate 3 of our 4 parameters. Because our site is relatively small (~1170 acres), a third arc second resolution may have homogenized acute variations within the terrain. Our classified oak layer also could have contained potential errors. It is important to note that both Valley and Coast Live Oak were classified as Oak Woodland and used as our vector of comparison. This could have potentially skewed the mean zonal statistic for our Coast Live Oak Habitat Suitability Model. We also did not remove single oak trees from our Oak Woodland classification before employing zonal statistics. These single oaks definitely dropped the mean zonal value because most of them are located in “unfavorable” locations around RSV. Overall, the oak groves on site lined up with the higher scoring regions of our HSM.

Currently Recon Ecology is actively restoring Coast Live Oak along the Northwestern entrance into RSV. To test the favorability of these specific areas of interest, we statistically compared the defined restoration areas with our Coast Live Oak HSM. The first region (left) scored 5.4 while the second region (right) yielded a score of 8.9 (**Figure 7-1**). From this, we expect to see greater proliferation of Coast Live Oak within the second region of active restoration. Overall, we hope the National Park Service utilizes our HSM to advise future active restoration of Coast Live Oak within RSV.

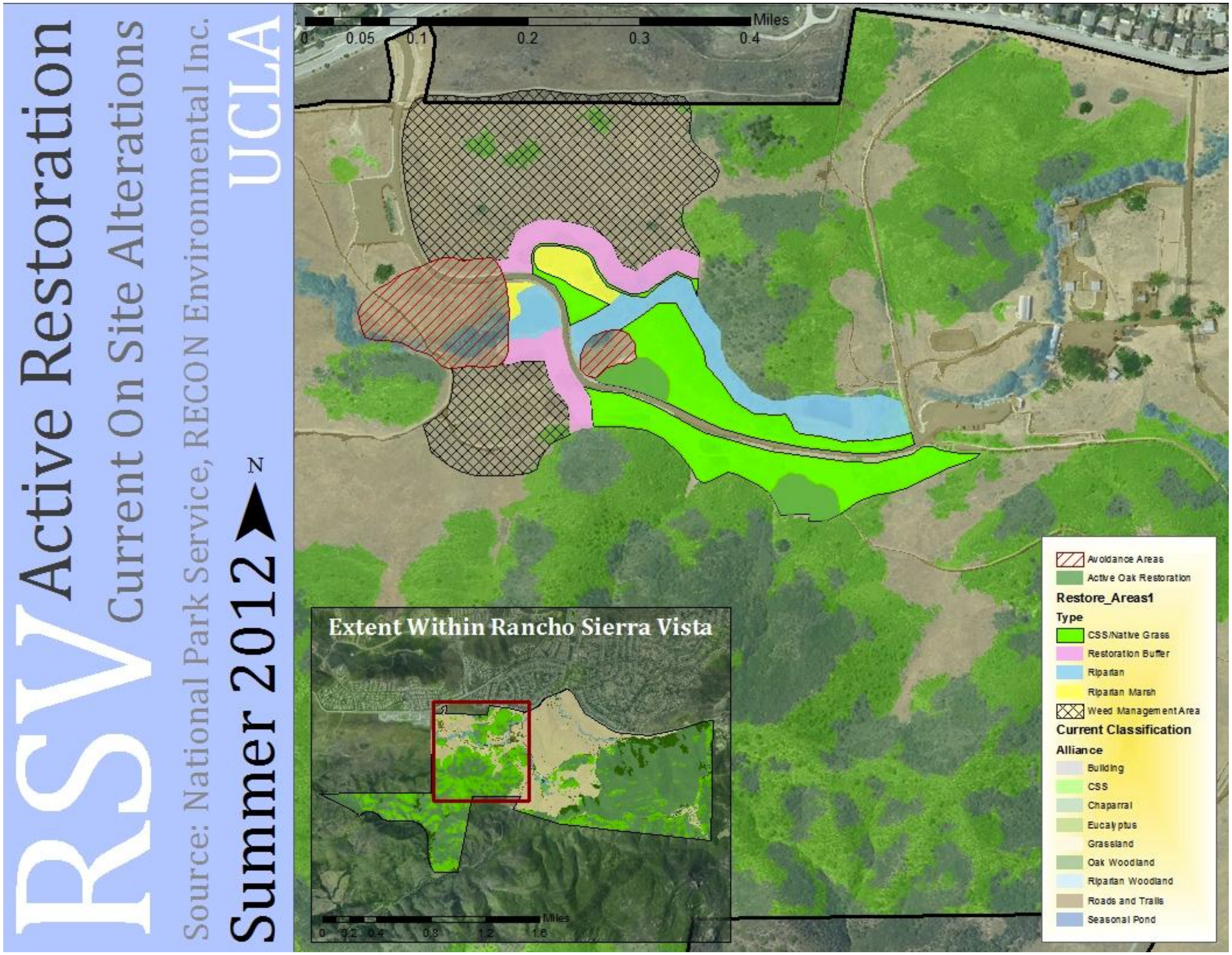

Figure 7-1 Current active restoration in RSV by the National Park Service.

8 CONCLUSION

Each map we created has a very significant purpose. The detailed historic vegetation map provides us with information on what the vegetation boundaries used to look like, in the time before the NPS bought Rancho Sierra Vista and before heavy urbanization. The current map shows us where vegetation boundaries are today, which we detailed with on-site map accuracy assessments to ensure that we were as accurate as possible. The on-site accuracy assessments allow us to optimize the accuracy of available current vegetation maps by providing further vegetation classification and refining vegetation boundaries. Using the historical and current vegetation boundary maps, we created multiple intersect maps using GIS to pinpoint where vegetation boundaries have been stable or dynamic over time. Furthermore, this style of analysis provides quantitative results that illustrate the exact extent and acreage of onsite change. By finding regions of increasing, decreasing, and stable boundaries, we discovered historic trends of vegetation community dynamics and distribution. Identifying areas of changing boundaries will implicate where there have been major disturbances that the original vegetation was not able to fully recover from, where invasive species have taken over areas of native plant communities, and where active restoration has been successful or unsuccessful. The habitat suitability model provides a more in depth look at where active restoration of Coast Live Oak would be successful on site. With all this information, we have a deep understanding of the relative health and stability of the various plant communities at RSV. We are able to provide the NPS with recommendations for better management practices in the form of a guided restoration plan for Coast Live Oak. Our scientific evidence of changing boundaries supports us in instructing further active restoration projects at RSV. It is very important for the NPS to be provided with detailed up-to-date vegetation boundary maps and analyses of vegetation dynamics in order for the NPS to effectively manage the vegetation of RSV and properly conduct active restoration projects.

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SUPPLEMENT MAPS

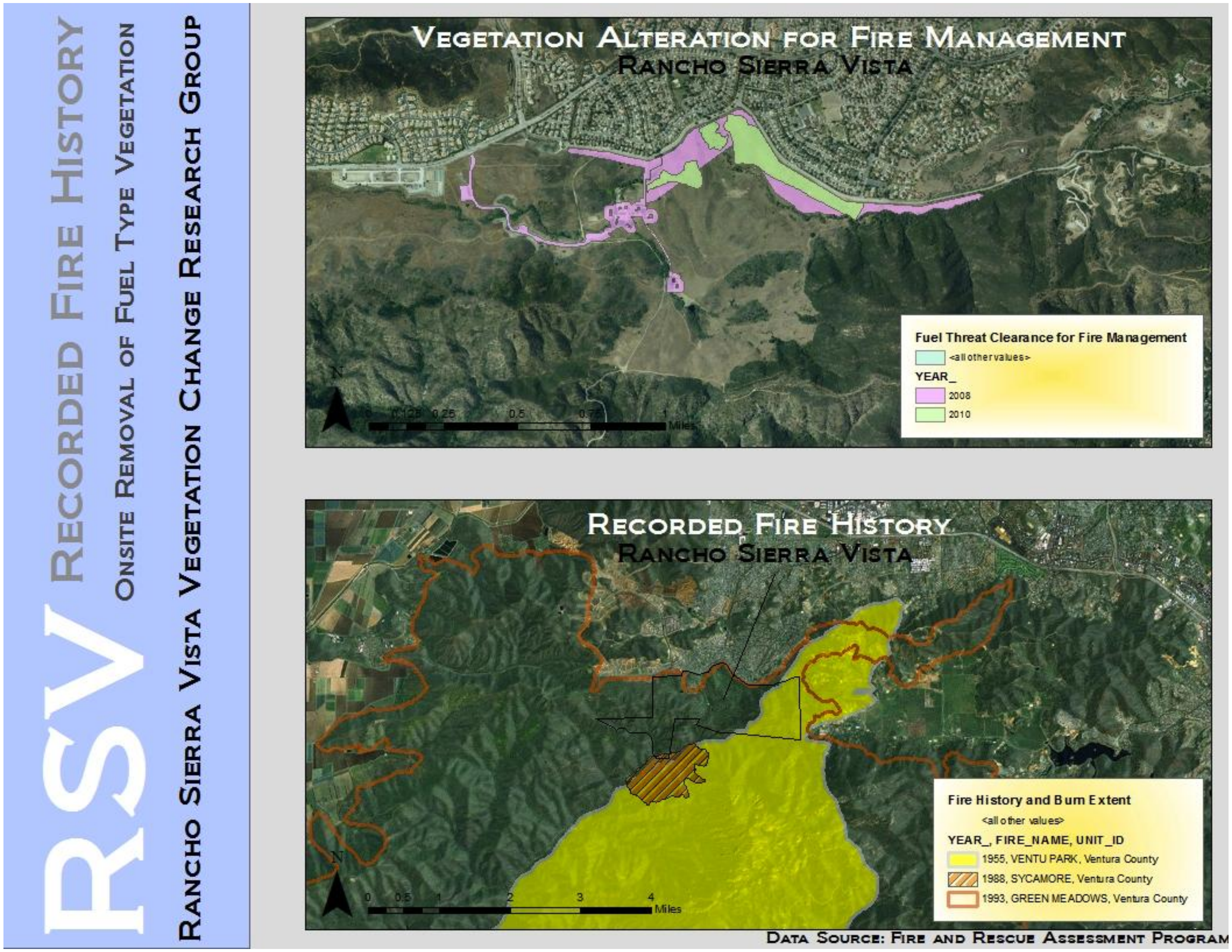

Figure A-1 **Current active restoration in RSV by the National Park Service.**

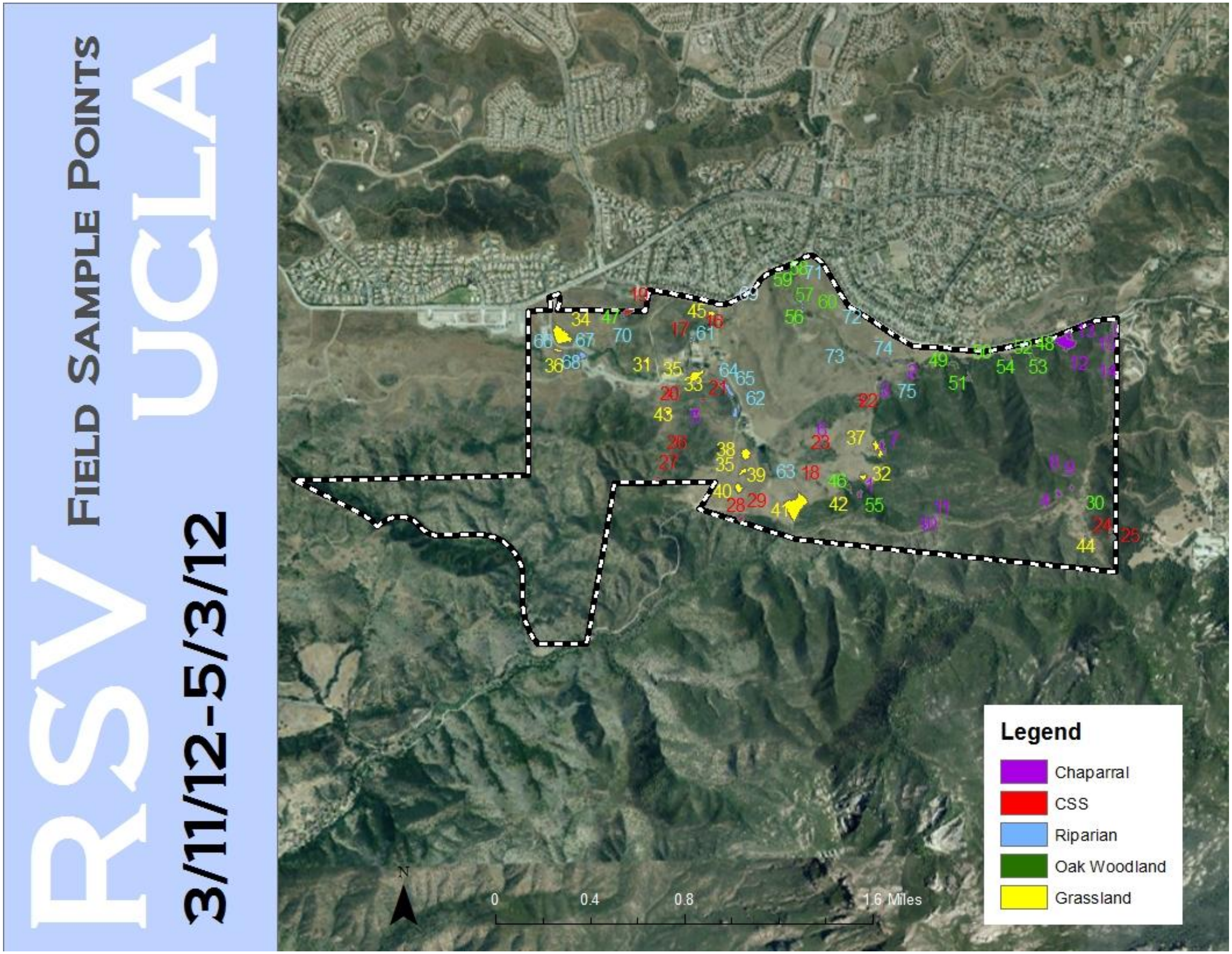

Figure A-2 **Field sample points used for map accuracy assessment.**

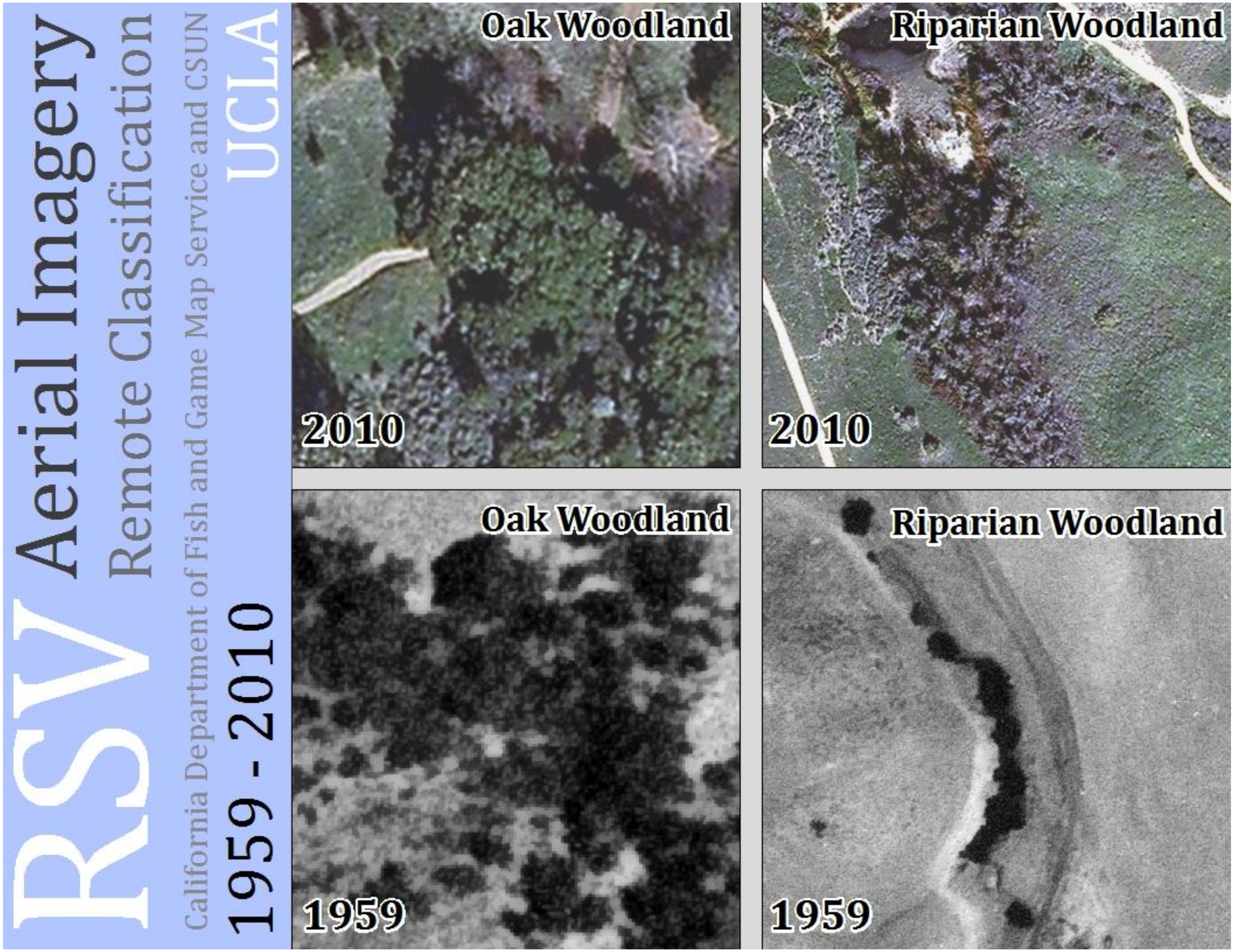

Figure A-3 **Visual key for classification of oak woodland and riparian woodland in 1959 and 2010 images.**

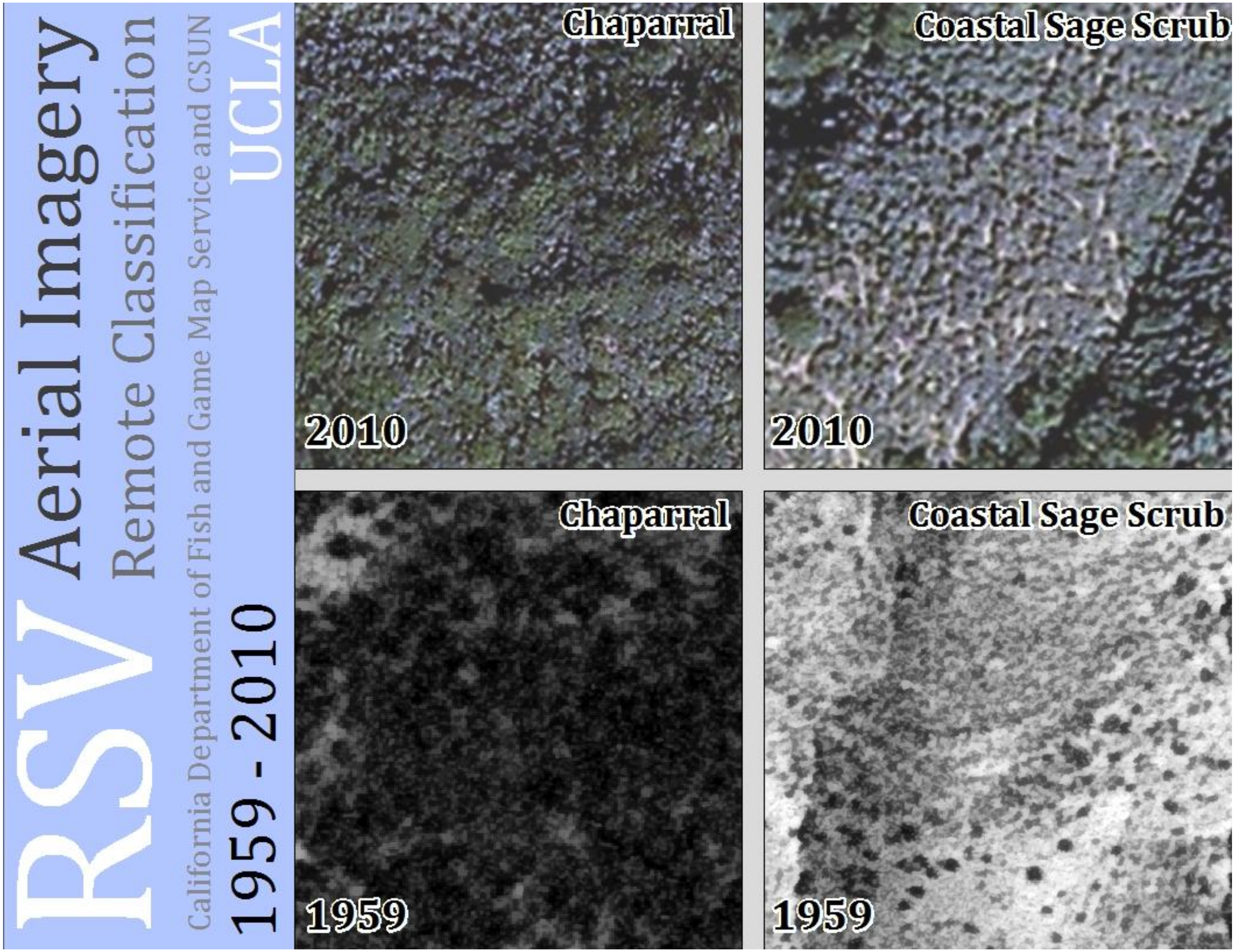

Figure A-4 **Visual key for classification of CSS and chaparral in 1959 and 2010 images.**

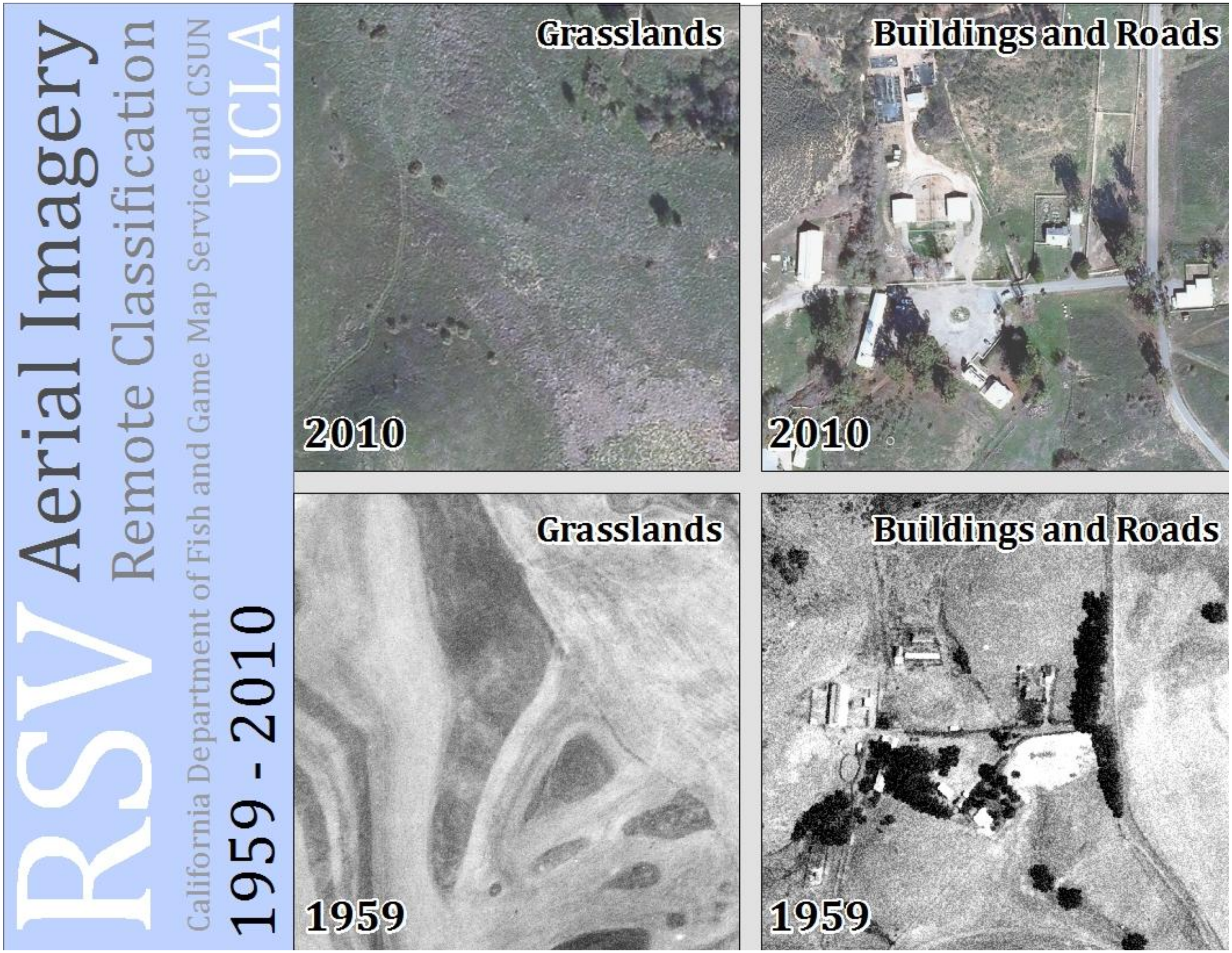

Figure A-5 **Visual key for classification of grassland and buildings and roads in 1959 and 2010 images.**

MAP ACCURACY ASSESSMENT DATA SHEETS

CSSV ✓

RSV Field Assessment

Date: 4/24/12

Field ID: 8639 (red)

GPS Wypt #: 318 (100 m NW)

Photograph #'s from SW Corner → N E S W NE NW

Topography (Convex, flat, concave, undulating,):

convex

Observations (including current and past bioturbation):

could be part of water shed

Vegetation Types:

Vegetation Type	% Cover	Notes
valley oak	~~x~~3%	one tree
coyote bush	30%	
mustard	20%	
NNG	~~x~~40%	
italian thistle	<10%	
cactus	<5%	

Figure B-1 **Field Assessment data sheet for CSS.**

RSV Field Assessment

Date: 4/8

Field ID: 5~~4~~692

GPS Wypt #: 306

Photograph #'s from SW Corner → N E S W NE

Topography (Convex, flat, concave, undulating,):

top of hill and down south slope

Observations (including current and past bioturbation):

circular concrete basin next to polygon, next to parking lot and trail

Vegetation Types: grassland ✓

Vegetation Type	% Cover	Notes
deer weed	40	
thistle	25	
low grasses	20	
"wheat" 4364	10	
mustard	5	

Figure B-2 **Field Assessment data sheet for grassland.**

riparian ✓

RSV Field Assessment

Date: 4/21/12

Field ID: 6176

GPS Wypt #: 314

Photograph #'s from SW Corner → N E S W NE

Topography (Convex, flat, concave, undulating,):

flat, slight slope down to river bed

Observations (including current and past bioturbation):

on right side of dirt trail, slightly more open

Vegetation Types:

Vegetation Type	% Cover	Notes
pompous grass	10%	understory
willow	40%	
unknown A	20%	understory
milk weed?	15%	
coyote scrub	>5%	
mustard	>5%	
NNG	>10%	

Figure B-3 **Field Assessment data sheet for riparian.**

RSV Field Assessment

Date: 4/28

Field ID: 9482

GPS Wypt #: 338

Photograph #'s from SW Corner → N E S W NE 865-866

Topography (Convex, flat, concave, undulating,):

dry streambed

Observations (including current and past bioturbation):

along trail

Vegetation Types: oak ✓

Vegetation Type	% Cover	Notes
~~Oa~~ CLO	70	
poison oak	10	in understory ~~a~~ only
laurel sumac	20	

Figure B-4 **Field Assessment data sheet for oak woodland.**

RSV Field Assessment

Date: 4/28

Field ID: 9889

GPS Wypt #: 339

Photograph #'s from SW Corner → N E S W NE 867

Topography (Convex, flat, concave, undulating,):

flat, some sloping SE. ~20°

Observations (including current and past bioturbation):

trail

Vegetation Types: chap ✓

Vegetation Type	% Cover	Notes
ceanothus	60%	
laurel sum	15	
sticky monkey	15	
NNG	10	

Figure B-5 Field Assessment data sheet for oak chaparral.

MAP ACCURACY ASSESSMENT RESULTS

Table C-1 Map accuracy assessment for chaparral.

Field ID	Way Point	Classified Veg Type	Actual Veg Type	Accuracy Assessment	Comments
1	321	Chaparral	Chaparral	Correct	
2	328	Chaparral	Chaparral	Correct	one oak
3	329	Chaparral	Chaparral	Correct	10% oak
4	339	Chaparral	Chaparral	Correct	majority ceanothus
5	332	Chaparral	Chaparral	Correct	
6	334	Chaparral	Chaparral	Correct	one valley oak
7	336	Chaparral	Chaparral	Correct	majority ceanothus
8	340	Chaparral	Chaparral	Correct	majority ceanothus
9	340	Chaparral	Chaparral	Correct	majority ceanothus
10	342	Chaparral	Chaparral	Correct	dense, majority laurel sumac
11	342	Chaparral	Chaparral	Correct	dense, majority laurel sumac
12	348	Chaparral	Chaparral	Correct	majority ceanothus, some oak
13	348	Chaparral	Chaparral	Correct	majority ceanothus, some oak
14	349	Chaparral	Chaparral	Correct	10% oak
15	349	Chaparral	Chaparral	Correct	10% oak
				Average Accuracy: 100%	

Table C-2 Map accuracy assessment for CSS.

Field ID	Way Point	Classified Veg Type	Actual Veg Type	Accuracy Assessment	Comments
16	305	CSS	CSS	Correct	
17	310	CSS	CSS	Correct	
18	318	CSS	CSS	Correct	one valley oak in polygon
19	296	CSS	CSS	Correct	
20	330	CSS	CSS	Correct	200 ft SW of 330, by restoration area
21	333	CSS	CSS	Correct	50 ft E of 333
22	335	CSS	CSS	Correct	dense but canopy still open
23	337	CSS	CSS	Correct	300 ft S from 337

24	341	CSS	CSS	Correct	100 m S of 341
25	341	CSS	CSS	Correct	100 m S of 341
26	343	CSS	CSS	Correct	
27	343	CSS	CSS	Correct	
28	344	CSS	CSS	Correct	by canyon
29	344	CSS	CSS	Correct	by canyon
30	302	CSS	Oak Woodland	Incorrect	40% coast live oak
				Average Accuracy: 93%	

Table C-3 Map accuracy assessment for grassland.

Field ID	Way Point	Classified Veg Type	Actual Veg Type	Accuracy Assessment	Comments
31	309	Grassland	Grassland	Correct	sparse sage scrub
32	321	Grassland	Grassland	Correct	
33	306	Grassland	Grassland	Correct	
34	293	Grassland	Grassland	Correct	
35	304	Grassland	Grassland	Correct	
36	294	Grassland	Grassland	Correct	
37	315	Grassland	Grassland	Correct	
38	315	Grassland	Grassland	Correct	
39	315	Grassland	Grassland	Correct	200 m south of 7669 and 7765
40	315	Grassland	Grassland	Correct	200 m south of 7669 and 7766
41	317	Grassland	Grassland	Correct	
42	319	Grassland	CSS	Incorrect	50 m south of waypt 319
43	331	Grassland	Grassland	Correct	next to horse trail
44	341	Grassland	Grassland	Correct	
45	300	Grassland	CSS	Incorrect	majority CA sage scrub
				Average Accuracy: 87%	

Table C-4 Map accuracy assessment for oak woodland.

Field ID	Way Point	Classified Veg Type	Actual Veg Type	Accuracy Assessment	Comments
46	320	Oak Woodland	Oak Woodland	Correct	coast live oak
47	296	Oak Woodland	CSS	Incorrect	50 ft south of 296. Mostly laurel sumac
48	322	Oak Woodland	CSS	Incorrect	Mostly laurel sumac, bordered by oak to the SE
49	323	Oak Woodland	Oak Woodland	Correct	coast live oak
50	324	Oak Woodland	Oak Woodland	Correct	coast live oak
51	325	Oak Woodland	Oak Woodland	Correct	border between oak and chaparral, 200 ft south of 325
52	326	Oak Woodland	Oak Woodland	Correct	coast live oak
53	326	Oak Woodland	Oak Woodland	Correct	coast live oak
54	327	Oak Woodland	Oak Woodland	Correct	coast live oak
55	338	Oak Woodland	Oak Woodland	Correct	coast live oak
56	347	Oak Woodland	Oak Woodland	Correct	coast live oak, 10 ft south of 347
57	346	Oak Woodland	Oak Woodland	Correct	coast live oak
58	345	Oak Woodland	Oak Woodland	Correct	oak savannah, not woodland
59	345	Oak Woodland	Oak Woodland	Correct	oak savannah, not woodland
60	345	Oak Woodland	Oak Woodland	Correct	50 m south of waypt 345
				Average Accuracy: 87%	

Table C-5 Map accuracy assessment for riparian woodland.

Field ID	Way Point	Classified Veg Type	Actual Veg Type	Accuracy Assessment	Comments
61	303	Riparian	Riparian	Correct	
62	312	Riparian	Riparian	Correct	
63	316	Riparian	Riparian	Correct	next to man-made lake
64	313	Riparian	Riparian	Correct	
65	314	Riparian	Riparian	Correct	
66	297	Riparian	Riparian	Correct	
67	295	Riparian	Riparian	Correct	
68	295	Riparian	Riparian	Correct	
69	301	Riparian	Riparian	Correct	pipeline along stream bed
70	299	Riparian	Riparian	Correct	
71	287	Riparian	Riparian	Correct	
72	288	Riparian	Riparian	Correct	
73	290	Riparian	Riparian	Correct	
74	291	Riparian	Riparian	Correct	
75	291	Riparian	Riparian	Correct	
				Average Accuracy: 100%	