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MANAGEMENT STRATEGIES FOR CENTRAL MARITIME CHAPARRAL

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Tami Reiko Nakahara

May 2004

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ABSTRACT

MANAGEMENT STRATEGIES FOR CENTRAL MARITIME CHAPARRAL

by Tami R. Nakahara

Central maritime chaparral (CMC) is a rare endemic plant community along California's central coast. Habitat loss and fragmentation from residential development threaten the survival of CMC. The California Coastal Commission is lacking comprehensive information on ecological requirements and management strategies for CMC. To assist this agency, information on CMC was gathered through an extensive literature review, vegetation surveys of conservation easements on residential parcels, and interviews with various agencies. Correlation analysis was used to determine if there was a correlation between the percent cover of non-native species and easement size, shape, and spatial arrangement. Presence of non-natives can be an indicator of the health of an ecosystem, since these species tend to thrive in disturbed areas. Results showed a significant correlation only between percent cover and easement shape. Recommendations for management strategies included protecting larger intact habitat areas, conducting prescribed burns, undertaking weed control, and improving monitoring and enforcement.

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CHAPTER 1

INTRODUCTION

Background

The central maritime chaparral (CMC) community in the Elkhorn Slough Watershed, North Monterey County, California is classified by various federal, state, and local agencies as a rare type of native plant community. According to the California Department of Fish and Game (DFG): "Rare plant communities are those communities that are of highly limited distribution. These communities may or may not contain rare, threatened, or endangered species" (Skinner and Pavlik 1994, 29). The DFG defines a plant as "rare" when, "although not presently threatened with extinction, the species, subspecies, or variety is found in such small numbers throughout its range that it may be endangered if its environment worsens" (Skinner and Pavlik 1994, 29). The U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (DFG), the California Coastal Commission (CCC), the Monterey County Planning and Building Inspection Department (MCPBID), and the California Native Plant Society (CNPS) all consider the CMC community in the Elkhorn Slough Watershed to be sensitive because of the rarity of some of its constituent plant species (Mercurio 1998; Monterey County Planning Department 1981). Rare species that are not currently listed under the Federal Endangered Species Act (FESA) as threatened or endangered are not protected under the FESA. Development in these habitats could push these rare species and entire communities toward extinction if not protected. As a result, effective strategies for the

protection and management of rare plants, their habitats, and their communities need to be developed.

It is predicted that approximately 25% of the estimated 250,000 species of vascular plants in the world may become extinct within the next 50 years (Schemske et al. 1994). In the United States, the populations of approximately 22% of the vascular plants are currently declining (Schemske et al. 1994). California has high natural diversity with over 5000 species of vascular plants (Barbour et al. 1993). This diversity exceeds that of Alaska, a state 4 times the size of California and the areas of central and northeastern United States and adjacent Canada combined. Small areas with a large diversity of plant species are likely to have the largest number of species that are rare and endangered (Dallman 1998). Approximately, 30% of all of California's native plants are endemic, meaning they are found nowhere else in the world (Barbour et al. 1993; Scott 1995). In the past 200 years, approximately 857 of California's native plant species have become rare or endangered and another 34 have become extinct (Barbour et al 1993).

Along the Central Coast of California, in North Monterey County, CMC communities are found in the uplands around Elkhorn Slough (Mercurio 1998) and the former Fort Ord military base (Jones & Stokes Associates, Inc. n.d.). The CMC community in the Elkhorn Slough uplands is considered rare because of the limited distribution of several plant species that are located here. For example, Eastwood's goldenbush (*Ericameria fasciculata*) (also called Eastwood's golden fleece and Eastwood's goldenweed) is endemic to Monterey County. It is ranked by the California Native Plant Society (CNPS) as extremely rare (Tibor 2001) and is a federal species of

concern (Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001). Monterey ceanothus (*Ceanothus cuneatus* var. *rigidus*) is endemic to Monterey, Santa Cruz, and San Luis Obispo counties, and is on the CNPS watch list for plants of limited distribution (Tibor 2001). Pajaro manzanita (*Arctostaphylos pajaroensis*) and Hooker's manzanita (*Arctostaphylos hookeri* ssp. *hookeri*) are both native endemic species of California. Pajaro manzanita is ranked by the CNPS as very rare (The CalFlora Database 2002). Its original distribution was confined to Santa Cruz County and Monterey County, but it is now extinct in Santa Cruz County. Hooker's manzanita is also ranked by CNPS as very rare and it is currently found only in Santa Cruz and Monterey counties (The CalFlora Database 2002). These species, which are indicative of CMC, have the potential of becoming extinct in their home ranges if protective measures are not taken now.

The main threat to the survival of CMC appears to be fragmentation and the loss of habitat, due to development pressures associated with California's growing human population. In California, more than 6 million people live in wildland areas and another 4 million live along the wildland-urban interface (Ainsworth and Doss 1995). In addition, 80% of California's human population lives within 30 miles (48 km) of the coast (The Resources Agency 1997). Habitat destruction not only causes the direct loss of organisms, but it promotes invasions by non-native species, causes changes in community structure, and declines in species diversity.

Various federal, state, and local agencies are involved in the protection of rare plants. The U.S. Fish and Wildlife Service (USFWS) is the main agency responsible for

administering the FESA. In California, the Department of Fish and Game (DFG) cooperates with other agencies to protect and manage rare plants and natural plant communities and is the jurisdictional agency for the California Endangered Species Act (CESA). The California Native Plant Society (CNPS) is a local non-profit organization of amateurs and professionals who work together to increase the understanding and preservation of the diversity of native plant species in California. They have developed a system for classifying rare plants that is used by the DFG. All these groups have various publications and guidelines used in the protection of rare, threatened, and endangered plants in California.

The California Coastal Commission (CCC) is charged with protecting and managing the coast's natural resources. It is given this responsibility and granted the authority to regulate coastal development, in cooperation with local governments, pursuant to the California Resources Code sections 30000-30900, also known as the California Coastal Act (CCA) of 1976. The CCA policies mandate that, among other things, the CCC review and decide on permits for new development in areas where the CCC has permitting authority, and hear and decide appeals from coastal development permit decisions of local governments (California Coastal Commission n.d.).

The CCC must also review and authorize the approval of local coastal programs (LCPs) submitted by local governments. One such LCP, in Monterey County, allows the County to process coastal development permits. Through the Monterey County Planning and Building Inspection Department, private landowners have been applying for permits to develop portions of their land that contain central maritime chaparral. Due to the lack

of comprehensive scientific data currently available to the CCC for use in evaluating impacts to these sensitive habitats, there is concern that improper planning decisions will be made regarding the issuance of development permits. Such permits could lead to the further decline of rare habitats and lead to the extinction of some of their species. The result would not only be a violation of the mandates of the CCA, but would contribute to the global extinction crisis.

One management strategy currently being used by the Monterey County Planning and Building Inspection Department is the requirement of a permanent "conservation easement" for proposed developments. In established developments, the County recommends a voluntary conservation easement for CMC (Monterey County Planning Department 1981). These easements are meant to set aside land that will not be developed in order to preserve rare species habitat. However, there are no guidelines regarding the parameters used to establish an easement, such as the size, shape, location, and biotic and abiotic components. In addition, there is no monitoring or enforcement of the easements.

The implementation of effective management strategies is necessary for the protection of rare plant communities such as CMC. Potential and current strategies, such as the use of conservation easements, must be assessed as to their ability to preserve the ecological functioning of maritime chaparral communities. Regulatory agencies such as the CCC, the DFG, and the USFWS need this type of scientific evidence on which to base their management decisions.

Purpose

The purpose of this research is to gather comprehensive scientific and regulatory information on CMC and to make recommendations on the types of strategies that could be used to manage the CMC community in the Elkhorn Slough watershed in North Monterey County. In particular, the current use of conservation easements for developments in CMC was examined to determine if and what guidelines could be implemented to ensure that easements will help protect CMC from further decline due to the impacts of residential development.

Objectives

The specific objectives of this research are as follows:

1. To conduct an extensive literature review and interview various federal, state, and local agencies and organizations to collect comprehensive information on the ecology of CMC as well as strategies and recommendations for the management of this sensitive plant community. This study addressed the following research questions:
 - What are the ecological requirements of CMC?
 - What are current and potential management issues for CMC?
 - What are current and potential management strategies for CMC?
 - What are the policies, strategies, and recommendations for managing CMC that are currently being used by federal, state, local agencies, and

other organizations involved in natural resource management along the central coast of California?

2. To examine established conservation easements to determine if there is a correlation between the dimensions of easements and the percent cover of non-native species. Since the size, shape, and spatial arrangement of a reserve have been shown to directly affect the survival of fragmented populations (Yahner 1988; Loney and Hobbs 1991; Fahrig and Merriam 1994; Shafer 1995), this research measured these parameters for established easements. Invasive non-native plants can be used as an indicator species of the health of an ecosystem since these species tend to thrive in areas that have been disturbed (Zedler and Scheid 1988; Hobbs and Huenneke 1992; Zink et al. 1995; Bossard, Randall, and Hoshovsky 2000). This research tested the following null hypothesis:

- H_0 : There is no significant correlation between the size, shape, and spatial arrangements of conservation easements and the percent cover of non-native plant species present.

CHAPTER 2

RELATED RESEARCH

Central maritime chaparral is a type of chaparral vegetation, located along the central coast of California in the maritime fog zone. According to the literature, the majority of information available on chaparral vegetation and its various types is on chaparral in general. In California, most of the research studies on chaparral have concentrated on chaparral in southern California. Little research has been done on the chaparral vegetation type maritime chaparral and even less on its subtype CMC. As a result, the majority of information on management issues and management strategies in the literature also pertain to chaparral in general.

However, since CMC is a type of chaparral vegetation, it does share some of the same general characteristic as chaparral as well as general biological and ecological requirements. The main differences between CMC and chaparral involve their geographic locations, local climatic conditions, and key species. In the case of CMC, the California Coastal Commission (CCC) is lacking comprehensive information regarding the various factors that affect the survival of this rare plant community. This extensive literature review will examine these factors as well as relevant management strategies. It will begin with a discussion on the general biology and ecology of chaparral vegetation.

Chaparral

Chaparral is a vegetation community found in Mediterranean climates in Europe, Africa, Asia, Australia, Chile, Mexico, and the United States (Rundel 1986; Radtke 1992). The climate is characterized by hot, dry summers and moderate, wet winters (Miller and Hajek 1981; Rundel 1986; Radtke 1992; Hanes 1995). Annual air temperatures range from below 32°F to above 104°F (0°C to above 40°C) and total annual precipitation ranges from 10-31 inches (250-800mm) (Miller and Hajek 1981; Rundel 1986; Radtke 1992; Hanes 1995). In California, chaparral is the most widespread vegetative type, covering approximately 5% of the state (Rundel 1986; Hanes 1995; Dallman 1998), or approximately 10 million acres (4 million hectares) (Barbour et al. 1993). It ranges from 155 miles (250 km) south of the Baja California border of Mexico northward into southern Oregon, from coastal areas to mountain regions to desert floors (Hanes 1995; Holland and Keil 1995). Chaparral is usually found on steep slopes or ridgelines with rocky or sandy, low nutrient soils (Holland and Keil 1995; Johnson 1997; Dallman 1998).

The general characteristics that define chaparral vegetation are the presence of mainly evergreen, woody shrubs that are drought-tolerant and fire-adapted. The drought-tolerant adaptations include sclerophyllous leaves that are small, thick, leathery, and have a waxy cuticle (Rundel 1986; Radtke 1992; Hanes 1995; Dallman 1998). The stomata of sclerophyll leaves, which regulate water loss on the surface of the leaves, are smaller than those of softer deciduous leaves. Some species have stomata in sunken pits and grooves covered by hair or wax tubules and are located on the shaded underside of leaves (Hanes

1995; Dallman 1998). Leaves of some species are oriented vertically to reduce the surface area exposed to evaporation by the sun (Barbour et al. 1993; Hanes 1995; Dallman 1998). Other leaf adaptations to reduce water loss include a hairy leaf surface and a gray-green color to reflect light (Dallman 1998). The shrubs are usually winter active and summer dormant, which allows the plants to reduce their metabolic functions during summer droughts (Radtke 1992; Hanes 1995; Dallman 1998).

Chaparral vegetation has a dual root system with rapidly growing deep taproots to reach moisture deep in the soil during dry months and shallow lateral roots to reach nutrients and moisture from light rains and coastal fog (Rundel 1986; Hanes 1995; Holland and Keil 1995; Dallman 1998). In areas with the longest periods of summer drought, the root mass accounts for more than half the weight of woody plants (Dallman 1998). Some species, such as deerweed (*Lotus scoparius*), have nitrogen-fixing bacteria associated with their roots that convert mineralized soil nitrogen into an organic form that can be utilized by the host plant as well as other plants (Radtke 1992). Nitrogen is the nutrient that is usually lost during fires (Radtke 1992).

Many chaparral shrub species, especially members of the Ericaceae such as manzanitas, have mycorrhizal associations with their roots (Kummerow and Borth 1986). Studies of mycorrhizal associations in softwood and hardwood forests have indicated that mycorrhizae enhance nutrient uptake by the roots, but few studies have been done on chaparral shrubs (Kummerow and Borth 1986). This ability is important in chaparral habitats where phosphorous, a necessary mineral for growth, is frequently in low amounts or inaccessible in the soil because of droughts. Studies of mycorrhizal associations in

scrub oak (*Quercus berberidifolia*) seedlings indicate that mycorrhizae can help the seedlings recover more quickly from wilting (Kummerow and Borth 1986). This function is important for the establishment of shrub seedlings in low moisture chaparral soils. In addition, resprouting shrubs that have roots with mycorrhizae grow deeper into the soil than roots without mycorrhizae, which may provide them with better insulation from the heat of fires (Kummerow and Borth 1986).

This sclerophyll type vegetation forms dense, sometimes impenetrable stands that lack an understory of shrub seedlings, annual herbs, or grasses (Barbour et al. 1993; Hanes 1995; Holland and Keil 1995). In areas where the shrub cover is incomplete, there may be a sparse herbaceous understory (Holland and Keil 1995). Several factors may account for this lack of herbaceous undergrowth in a continuous chaparral canopy. A dense shrub canopy (Westman 1979; Hanes 1995; Holland and Keil 1995; Dallman 1998) or thick litter layer may make seedling establishment difficult by limiting the amount of light that reaches the soil surface (Holland and Keil 1995). Waxes and resins released from decomposing litter may coat the surface of soil particles, causing them to become water resistant and reducing the amount of water absorbed into the soil (Hanes 1995; Holland and Keil 1995). Herbivores may reduce the survival of herb seedlings through their foraging activities (Barbour et al. 1993; Hanes 1995; Holland and Keil 1995). Small rodents, especially, forage for grains and young shoots most intensively near their nest sites beneath the dense shrub cover (Barbour et al. 1993). When chaparral burns, the cover is lost and these animals either move or die. Their absence allows the herbs to re-

establish. As the shrub canopy returns, the herbivores move back in and resume grazing on the herb layer.

Herb seedling establishment may also be reduced as a result of certain shrub species and/or their litter layer leaching allelopathic substances, that inhibit germination, into the soil during rain or volatilizing them into the air during warm weather (Westman 1979; Keeley and Keeley 1987; Radtke 1992; Barbour et al. 1993; Holland and Keil 1995; Dallman 1998). Allelopathy may function as a defense mechanism for these plants, reducing competition with other plants for the limited moisture and nutrients in chaparral soils (Radtke 1992). In chamise (*Adenostoma fasciculatum*), only the leaves accumulate allelopathic chemicals during summer droughts, not the roots or leaf litter (Hanes 1995). Fog condensation and rain transport the chemicals to the soil where they inhibit herb germination. The allelopathic effects last only as long as chamise remains intact. Removal of the live above ground portions of the plant, either manually or by fire, allows the herbs to sprout during the next growing season. In other shrub species such as manzanitas (*Arctostaphylos* spp.), their roots, fallen fruit, fallen bark, leaf litter, and freshly fallen leaves release chemicals into the soil, which inhibit the germination and root growth of most herbs and shrub seedlings (Hanes 1995). The chemicals from manzanitas can persist in the soil for long periods, even beyond the second growing season after the shrubs have been removed. In general, fire removes the sources of inhibition by burning the live leaves and leaf litter of these shrubs (Radtke 1992; Barbour et al. 1993; Hanes 1995) and the heat breaks down the inhibitors present in the soil (Radtke 1992; Holland and Keil 1995). This inhibition does not return until the shrub

canopy closes over again. However, the importance of allelopathy in herb seedling inhibition has been questioned due to findings that in areas where fencing is used to prevent grazing by herbivores, seedlings do develop and survive in significant numbers (Dallman 1998).

Typical chaparral communities are often referred to as "hard chaparral" because the dominant species have stiff, woody branches and sclerophyllous leaves (Rundel 1986; Hanes 1995; Holland and Keil 1995). Common hard chaparral species include manzanitas (*Arctostaphylos* spp.), ceanothus (*Ceanothus* spp.), and chamise (*Adenostoma fasciculatum*) (Rundel 1986; Hanes 1995; Holland and Keil 1995). Chamise is the dominant species on dry, south-facing slopes, while on wetter north-facing slopes mixed dominance stands of manzanitas and ceanothus species are more common (Rundel 1986). Shrub heights range from 3 to 12 feet (1 to 4 m) (Head 1972; Rundel 1986; Holland and Keil 1995).

In contrast, coastal sage scrub, another type of vegetation community often associated with chaparral, is referred to as "soft chaparral" because the dominant species are mostly herbaceous plants with relatively soft textured stems and leaves (Rundel 1986; Radtke 1992; Hanes 1995; Holland and Keil 1995). Common coastal sage scrub species include California sagebrush (*Artemisia californica*), coyote brush (*Baccharis pilularis*), sage (*Salvia* spp.), and deerweed (*Lotus scoparius*) (Rundel 1986; Radtke 1992; Hanes 1995; Holland and Keil 1995). Coastal sage scrub communities are closely associated with chaparral communities from central California to northwestern Baja California (Rundel 1986). Coastal sage scrub vegetation is smaller than chaparral, ranging from 1.5

to 5 feet (0.5 to 2 m) tall, and has shallower root systems (Rundel 1986; Radtke 1992; Hanes 1995; Holland and Keil 1995). In addition, coastal sage scrub is drought-deciduous while chaparral species are mostly evergreen (Rundel 1986; Radtke 1992; Hanes 1995; Holland and Keil 1995; Dallman 1998). This life strategy allows coastal sage scrub to grow in more xeric habitats than chaparral because many coastal sage scrub species are able to drop their leaves and go dormant during droughts. The shrub layer is less dense than chaparral, but coastal sage scrub has a dense understory of grasses and herbs (Barbour et al. 1993; Holland and Keil 1995; Dallman 1998). In contrast to hard chaparral, which tends to germinate in the winter, coastal sage scrub tends to germinate after the first fall rain (Radtke 1992). Most of its shrubs germinate from seeds so there are usually various age classes present (Dallman 1998). Coastal scrub is also considered to be a pioneer type of vegetation that is able to establish in disturbed areas in other plant communities (Da Silva and Bartolome 1984). Without frequent fire or grazing, coastal sage scrub can invade coastal grasslands and start community succession, which eventually leads to chaparral, evergreen forest, or oak woodland (Barbour et al. 1993).

Since coastal sage scrub is found near or adjacent to chaparral habitats, it may act as an important source of seeds for the herbs that germinate in chaparral after fires.

There is a large increase in the growth of annuals, perennial herbs, and short-lived suffrutescents (sub-shrubs) during the first 3 to 6 years after fire in chaparral (Westman 1979). Over 200 of these temporary post-fire species have been recorded (Keeley and Keeley 1987). A study found that out of 111 herb species present on recently burned sites of chaparral in southern California, 58 % were found in the understories of southern

coastal sage scrub stands that had not burned for 7 years or more (Westman 1979). This finding suggests that the seeds of these post-fire chaparral herbs species are dispersed from nearby coastal sage scrub communities each year (Westman 1979). The conditions created during and after fires are the stimuli that cause the germination of the post-fire herb seeds on chaparral sites (Westman 1979; Barbour et al. 1993).

This hypothesis of seed dispersal from coastal sage scrub to chaparral each year challenges the idea that post-fire herbs germinate from seeds that have remained viable in the chaparral soil for 40-90 years since the previous burn (Westman 1979). This dispersal theory is also supported by evidence from a study by Went (1969) on the seed viability of southern California chaparral and desert species that were stored in dry cabinets. Results indicated that very few seeds remained viable after 20 years (Westman 1979). This potential partial dependence of chaparral species richness on dispersal from coastal sage scrub provides another reason for the conservation of coastal sage scrub communities, which are also currently threatened by development pressures (Westman 1979).

Coastal sage scrub and chaparral communities are also both adapted to fire. Three types of fire-adaptations include sprouting from root-crown burls, the production of seeds at an early age, and the production of fire resistant seeds (Radtke 1992; Hanes 1995). About half of the California chaparral species can sprout from root-crown burls or lignotubers, which are swollen, woody structures at the base of the trunk, that have been protected underground from fires (Barbour et al. 1993; Hanes 1995). Sprouting is stimulated when the above ground portion of these plants is killed, consumed by fire, or

removed manually (Radtke 1992; Hanes 1995). Since sprouts grow around the perimeter of the previous trunk, the width of the new crown and burl expands with each successive sprouting (Hanes 1995). Advantages of sprouting include the ability of these plants to retain their established position in the habitat and to start growing immediately after fire by using food and water stored in their fully developed root systems (Hanes 1995). In contrast to seed germination, which requires rain, sprouting can occur during summer droughts when there is little competition from other species. Sprouting species grow faster than seedlings, during their first year. They can produce new growth without having to go through the seedling stage. The new growth can suppress other seedlings by growing faster and shading them out and by producing allelopathic substances (Hanes 1995). Sprouting species include chamise (*Adenostoma fasciculatum*), toyon (*Heteromeles arbutifolia*), coffeeberry (*Rhamnus californica*), and some manzanitas (*Arctostaphylos* spp.) (Dallman 1998). For them, reproduction by seed is facultative, compared to nonsprouting species, where reproduction by seed is obligatory (Hanes 1995).

Obligate seeders produce seeds at an early age in order to build up a large seed stock in the soil (Radtke 1992). In California, these species include most manzanitas (Hickman 1993) and some ceanothus (*Ceanothus* spp.) (Dallman 1998). The thick seed coats of fire-resistant seeds protect the endosperm from drying out and from being destroyed in fires, so that the seeds will remain viable for decades (Radtke 1992; Barbour et al. 1993). Burls and seeds 3 inches (8 cm) below the soil surface survive during fires because of the insulating properties of the earth. Although surface temperatures can

reach 1,000° F (518° C) for up to 20 minutes, temperatures 3 inches deep only reach 150° F (66° C) for about 10 minutes (Barbour et al. 1993). Burls, seeds, and animals in burrows deeper than 3 inches experience even lower temperatures for a shorter amount of time (Barbour et al. 1993). In the seed zone, which is the top 0.5 inches (1.3 cm) of the soil, air-dried seeds can tolerate temperatures higher than 302° F (150° C) for 5 minutes, but tolerance to high temperatures decreases as the seed moisture level increases (Radtke 1992).

Fire may actually be necessary for altering tough seed coats so that the chaparral seeds are able to germinate (Keeley and Keeley 1987; Radtke 1992; Barbour et al. 1993). However, it is not known exactly how fire enhances the germination of seedlings. There are two theories for explaining the dependence on fire for seed germination in chaparral. The first theory is that herb seeds are inhibited from germinating by the allelopathic effects of mature chaparral species, and fire releases the seeds from inhibition (Keeley and Keeley 1987; Barbour et al. 1993; Holland and Keil 1995; Hanes 1995). Many studies have investigated the allelopathic inhibition of seed germination by chaparral, but it is still unclear how this inhibition is accomplished.

The second theory is that seeds require a stimulus from fire for germination (Keeley and Keeley 1987; Barbour et al. 1993; Hanes 1995). There are several studies that have provided strong evidence to support this theory. The germination behavior of post-fire herbs and sub-shrubs can be divided into two categories: species with no seed dormancy, except for the requirement of cold temperatures to break dormancy; and species with various levels of seed dormancy that can be only be broken by fire-related

stimuli (Keeley and Keeley 1987). For some species in the second category, germination is stimulated by heat shock from fire that ruptures the seed coat (Keeley and Keeley 1987; Barbour et al. 1993; Holland and Keil 1995; Hanes 1995). For other species, germination is stimulated by a chemical, which is leached from wood that is charred, but not turned to ash, by fire (Keeley and Keeley 1987; Barbour et al. 1993). These charred wood stimulated species also respond in a similar way to smoke stimulation (Keeley and Fotheringham 1998).

In a study to test the response of 57 herbaceous and sub-shrub species common after fire in chaparral to charred wood and heat shock, over half the species germinated without either treatment (Keeley and Keeley 1987). The species with non-dormant seeds include all of the herbaceous perennial monocots (both bulb-forming plants and bunch grasses), most of the herbaceous perennial dicots, and several annuals (Keeley and Keeley 1987).

In Keeley and Keeley's study (1987), species with dormant seeds stimulated by heat shock from fire include only one: coastal lotus (*Lotus salsuginosus*). Other species that have been reported to have heat-stimulated germination include: the annuals wild celery (*Apiastrum angustifolium*), black mustard (*Brassica nigra*), and primrose (*Camissonia hirtella*); the sub-shrubs rush-rose (*Helianthemum scoparium*) and deerweed (*Lotus scoparius*); and shrubs such as ceanothus (*Ceanothus* spp.) (Keeley and Keeley 1987). These species have heavily sclerified seed coats and smooth thick cuticles that block water uptake. It is believed heat melts or cracks the cuticle enough to stimulate germination because artificially scarring the seed coat also stimulates germination the

same way. High soil temperatures may also produce the same effect as heat shock, so germination may be stimulated in gaps in shrub canopy and on disturbed sites (Keeley and Keeley 1987).

Species with dormant seeds that have a nearly complete dependence on charred wood for germination are found in 10 plant families: Asteraceae, Boraginaceae, Brassicaceae, Caryophyllaceae, Hydrophyllaceae, Onagraceae, Papaveraceae, Polemoniaceae, Rubiaceae, and Scrophulariaceae (Keeley and Keeley 1987). These species have seeds with rough reticulate seed coats and thin cuticles. The chemical leached from charred wood may either affect gas permeability of membranes or act as a stimulant for embryo development. Studies have shown that the application of gibberellic acid can cause the same reaction as charred wood (Keeley and Keeley 1987).

Smoke may also work in a similar manner as charred wood to stimulate germination since the charred wood stimulated species react as strongly or more strongly to smoke and vapors from charred wood (Keeley and Fotheringham 1998). Smoke can induce germination by directly penetrating the seed or indirectly by being absorbed into the soil and then releasing chemicals in vapors or water (Keeley and Fotheringham 1998). Studies on some of the smoke stimulated species indicate that different species require different concentrations of smoke generated chemicals for germination and have different tolerances to the length of smoke exposure (Keeley and Fotheringham 1998). These species do have similar responses to both direct and indirect exposure to water soluble and gaseous forms of smoke. They differ from heat-stimulated species in that they are not hard-seeded and smoke does not alter the seed coat to stimulate water uptake as heat

does for other species. Instead, smoke stimulated species have a sub-dermal cuticle that blocks solute uptake and smoke alters the cuticle's permeability. However, different smoke stimulated species have different numbers and types of barriers to germination, which suggests that the mechanism for smoke-induced germination may differ among these species (Keeley and Fotheringham 1998). Thus, fire behavior may affect the structure of the post-fire vegetation community through the amount of smoke produced and the length of time the smoke is present (Keeley and Fotheringham 1998). Dry fuels in high winds will produce different smoke exposure than moist fuels and smoldering fires in low winds.

Species with charred wood stimulated germination and smoke stimulated germination are strongly associated with burns. They are true pyrophyte endemics, which are species that are abundant during the first few years after a burn then disappear until the next burn. Some of these species may grow in the shrub gaps and produce a few seeds that germinate each year, but a larger amount of the seeds remain dormant until stimulated by charred wood or smoke after fires (Keeley and Keeley 1987). After the first rains following a fire, pyrophyte endemics germinate from seeds that have been dispersed from nearby areas or from seeds that have been dormant in the soil for many years (Radtke 1992; Hanes 1995; Holland and Keil 1995; Dallman 1998). Fire-dependent annuals and perennials produce the wide array of wildflowers that are seen after a fire and provide a natural vegetative cover to temporarily reduce erosion on steep slopes after the shrub cover has been burned away (Radtke 1992). Rains cause the ashes from the burned shrubs and leaf litter to release minerals and organic nutrients into the

soil (Hanes 1995; Dallman 1998). The pyrophyte endemics convert the mineral nutrients to organic form, reducing the amount of nutrients lost to leaching and erosion (Radtke 1992). More bacteria and fungi are present in burned than unburned chaparral soil (Hanes 1995). Fire removes mature vegetation, which eliminates competition with seedlings for light, water, and nutrients (Hanes 1995; Dallman 1998).

The chaparral plant community structure changes in the years following a fire (Rundel 1986; Hanes 1995; Holland and Keil 1995; Dallman 1998). During the first year after a fire, the pyrophyte endemics, generalist herbs, and short-lived subshrubs are abundant while sprouter and seeder shrubs begin to slowly reestablish. Many of the subshrubs support nitrogen-fixing bacteria on their roots (Hanes 1995). In the second to fourth years, herbaceous perennial shrubs and annual grasses become more prominent, while the pyrophyte endemics decline to a dormant seed bank. The fifth to ninth years, the shrub canopy has closed and almost all the herbaceous species have died. The tenth to fiftieth years, shrub growth continues at a slower pace and subshrubs and shrubs with shorter lifespans die off because they only reproduce from seeds and are not able to stump sprout. The plant community becomes less diverse and gradually succeeds to one that only includes resprouting shrubs. The seeds of previously present species lie dormant in the soil until the next fire cycle. During this stage, the fuel load increases as a result of the accumulation of dead vegetation from herbaceous layer, and the death of lower branches of shrubs (Dallman 1998) resulting from bark stripping, an adaptation of some shrub species where living tissue of lower shaded branches is minimized in order to provide support to the growth of upper branches and new leaves in full sunlight (Davis

1973). Extremely destructive fires are those that occur in cycles of 35 to 50 years, when there is a drought right after several wet years, resulting in the accumulation of large amounts of dead vegetation (Dunn 1986; Dallman 1998).

In most cases, animals living in chaparral respond to the structure of the plant community and physical features of the environment, rather than certain plant species (Quinn 1990). Habitat preferences of animals depend on such factors as the age of the plant community, the amount of cover, proximity to openings in the vegetation, proximity to sources of water, ecotones, and physical features such as rocky slopes.

Seeds, fruits, and young vegetation are important food sources for chaparral animals (Quinn 1990). In mature chaparral seeds and fruits are produced by the shrubs. In the first 2 to 5 years after a fire, short-lived herbaceous and sub-shrub species produce large seed crops (Quinn 1990). Seeds and fruits are an important part of the diets of rodents, which may explain why rodents comprise fifty percent of the mammal species found in chaparral (Quinn 1990). Mature shrubs have sclerophyllous leaves that are unpalatable to herbivores due to oils, terpenes, and other substances (Quinn 1990). In addition, these leaves have high fiber content and are low in nutritional value (Dallman 1998). As a result, mature chaparral leaves are only eaten by a few animal species such as the dusky-footed woodrat (*Neotoma fuscipes* ssp.) and the mule deer (*Odocoileus hemionus* ssp.) (Quinn 1990). Mature chaparral also usually lacks an herbaceous understory for herbivores to eat. New herbaceous growth and crown sprouts that appear after fires are important food sources for rabbits (*Sylvilagus* sp.), mule deer, and rodents (Quinn 1990).

The effects of fire are the most important factors that affect the distribution and abundance of animal populations in chaparral, by causing various changes such as altering the structure of the plant community and the availability of food, shelter, and breeding grounds (Quinn 1990). Some animals survive the direct effects of fire by either fleeing, such as deer, or hiding in burrows underground, such as kangaroo rats (*Dipodomys* sp.) (Quinn 1990; Hanes 1995). Other species that are physically or behaviorally incapable of escaping the fire, such as brush rabbits (*Sylvilagus bachmani*), will die (Quinn 1990). In the years following the fire, animal population densities and distributions shift according to the mosaic of vegetation age classes and ecotones, created by the fire (Quinn 1990). The mosaic of vegetation occurs because chaparral fires do not burn uniformly over large areas, since chaparral usually grows on hills and large fires are driven by gusty winds. Within the fire boundaries there will be unburned patches, patches burned with varying intensities, and the ecotones between them. Unburned patches of chaparral act as a refuge and center of dispersal for animals recolonizing burned areas. The ecotones are used by mammals, such as deer and rabbits, that forage in the open areas and take cover in the unburned shrubs. Predators are attracted to the ecotones because of the increased number of prey species (Quinn 1990). Animal species abundant in recently burned chaparral will be absent in mature chaparral, and vice versa (Quinn 1990).

Insect species, such as beetles, ants, bumble bees, flies, moths, and butterflies are abundant in California chaparral and some function as important pollinators for the flowering species. Ground-inhabiting beetles consist of species from the Carabidae and

Staphylinidae families, which prey on small arthropods and other organisms, and species from the Tenebrionidae family, which are mostly scavengers (Force 1990). Seed-gathering ants are an important part of the chaparral ant population (Force 1990). The flower-visiting insects consist of the bees, flies, moths, butterflies, and some beetles (Force 1990). Since the variety and abundance of chaparral plant species is highest during the first couple of years after a fire, it would be logical to assume that the variety and abundance of flower-visiting insects would be highest at this time too. However, a study determined that species richness of flower-visiting insects in shrubland vegetation is not correlated with plant species richness (Force 1990). Numbers of flower-visiting insects were actually higher in mature chaparral (Force 1990).

Not all flower-visiting insects are good pollinators. The most important and abundant insect pollinators in California chaparral are the bees. Bees pollinate about 95 % of the insect-pollinated plants in California (Force 1990). Of the approximate 1200 species of native bees in the state, the important pollinators in chaparral include the larger bees such as bumble bees and *Anthophora* spp. (Anthophoridae), halictine bees, and bee flies (Bombyliidae) (Force 1990). Almost all vegetation types have been invaded by the introduced honey bee (*Apis mellifera*), which has caused the extinction of many native bees through competition (Force 1990). Bees are extremely abundant in chaparral because of the ideal habitat chaparral provides: nonwindy areas and the lack of understory vegetation provides ample bare ground for ground-nesting bees in mature chaparral and periodic fires provide dead branches for wood-nesting bees in burned areas (Force 1990). Halictine bees are common in chaparral, are generalist and opportunistic

feeders, and are effective pollinators in mature chaparral from early spring to late summer (Force 1990). The larger social bees, such as bumble bees, may be important pollinators in cold weather, such as in the early spring (Force 1990). In southern California, bees are the most abundant flower-visiting insect, in terms of species richness and abundance, in both burned and mature chaparral. In northern California, the species richness is highest for bees but the number of individual beetles is much more abundant (Force 1990).

The other flower-visiting insects account for only a relatively small percentage of the pollination in chaparral. In California, bee flies are both species rich and abundant. They pollinate about 10 to 20% of chaparral flowers (Force 1990). Wasps are species rich but low in abundance, and pollinate about 5% (Force 1990). Butterflies, muscoid flies, syrphid flies, and moths are all low in species richness and abundance. Butterfly and moth pollination is common in chaparral (Force 1990). Beetle pollination is poorly understood, but most flowers that are pollinated by beetles are also pollinated by other insects. Tumbling flower beetles (Mordellidae), long-horned beetles (Cerambycidae), and metallic woodborers (Buprestidae) are important pollinators, but other beetles cause more damage than good by feeding on the flower parts (Force 1990).

Due to the large variety and abundance of insect pollinators in chaparral, it has been suggested that there must be a lot of competition between pollinators for plant species. In fact, many of the dominant chaparral plants have specialist insect pollinators (Force 1990). For example, the genus *Aesculus* is only pollinated by butterflies and sphingid moths (Force 1990). Specialization is a strategy that reduces competition while allowing more effective pollination. Many chaparral plants also bloom at different times,

which is another way to improve pollination (Force 1990). Since pollinators are so abundant, almost all chaparral shrubs are not able to self-pollinate (Force 1990). However, many of the annuals abundant after fires can self-pollinate, so they are not dependent on pollinators (Force 1990).

Since CMC is a type of chaparral, CMC has similar general characteristics to chaparral such as climate, topography, soils, plant genera/species, plant adaptations, animal species, and pollinators. As a result it is possible to make general inferences from the biological and ecological requirements of chaparral to CMC. The main factors that distinguish CMC communities from other types of chaparral are geographic location, maritime conditions, and key indicator species. Various vegetation classification systems have been designed to distinguish different types of vegetation communities according to such factors. The following is a brief discussion on some common vegetation classification systems that can be used to distinguish CMC from other types of chaparral.

Vegetation Classification Systems

Several systems have been developed to classify California vegetation types and plant communities. All classification systems are subjective in that they are designed to meet a specific need: resource inventory, land use planning, conservation, identification of ecological relationships, or explanation of vegetation dynamics (Sawyer and Keeler-Wolf 1995). These classification systems vary depending on their scale, philosophy, and main purpose; some classify vegetation according to ecosystem type or forest cover type, while others are based on physiognomy or floristics. In addition, the vegetation in

California is very diverse, so it is extremely difficult to classify every local assemblage of plants into an exact category. Thus, a name given to a particular vegetation community may differ depending on the vegetation classification system used.

There are several different vegetation classifications systems that categorize chaparral communities into various types. For example, Hanes (1995) has categorized California hard chaparral communities into 10 distinct types based on dominant or indicator species and geographical factors. In order of decreasing abundance, they are Chamise (Figures 1 and 2), Ceanothus, Scrub oak, Manzanita, Montane, Red shanks, Serpentine, Desert, Woodland, and Island (Hanes 1995). In this classification system, central maritime chaparral (CMC) would appear to fall under the category of Manzanita chaparral (Figures 3 and 4) in which manzanitas (*Arctostaphylos* spp.) are the dominant species. Several recognized forms of manzanita chaparral including manzanita-chamise, oak-manzanita, pine-manzanita, and pure manzanita (Hanes 1995) are mentioned, but no specific category for maritime chaparral is identified. Manzanita chaparral communities form dense stands over uniform slopes and lack an understory. About half of the manzanitas are obligate seeders. Other species associated with these manzanitas are ephemerals and short-lived perennials that sprout a few years after a fire. Manzanita chaparral develops at a moderate rate, and lives long, with 50% cover after 10 years, 80% cover after 25 years, and 100% cover after 50 years (Hanes 1995).

Another classification system divides hard chaparral communities into 11 different categories, with a specific one for maritime chaparral (Holland and Keil 1995). Maritime chaparral is not further subdivided into more specific categories such as

northern, central, or southern maritime chaparral. However, in this classification maritime chaparral is described as occurring in windswept coastal areas of central and northern California, such as in Monterey and Santa Cruz Counties. Here maritime chaparral grows best on the sandy soils of old stabilized sand dunes, but can also be found on fine grained clay and serpentine soils. These communities form a mosaic with closed-clone coniferous forests, coast live oak woodlands, coastal scrub, and coastal prairie. Species of manzanita and ceanothus are often the dominants, some of which have very localized distributions. The dominant plants range in height from shrubs a few inches tall to large bushes 5 to 12 feet (2 to 4 m) tall. Herbaceous species grow best in sites where the shrub cover is incomplete and can be absent in dense patches of chaparral (Holland and Keil 1995).

The California Department of Fish and Game's California Natural Diversity Data Base (NDDDB) has an even more detailed classification system for hard chaparral, using 27 different categories, based on species composition and geographic location. Here maritime chaparral is subdivided into Northern maritime chaparral, Central maritime chaparral, and Southern maritime chaparral (Holland 1986). In this classification system, CMC is described as "A variable sclerophyll scrub of moderate to high cover (50-100%) dominated by forms of *Arctostaphylos tomentosa* plus one or more other narrowly distributed manzanita" (Holland 1986, 31). The site factors include well-drained sandy soils within the summer coastal fog zone and periodic fires appear necessary for reproduction (Holland 1986). This conservation-based classification system was designed for inventorying plant communities, especially rare ones.

The California Native Plant Society Plant Communities Committee, composed of 32 individuals from academia, conservation organizations, environmental consulting companies, and state and federal agencies, published their own vegetation classification system: *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995). The purpose of this manual was to establish a uniform vegetation classification system that could be used by various land management agencies as a way to consistently identify and protect rare, threatened, or endangered plant communities. This system classifies vegetation into either a set of series, unique stands, or habitats. These categories provide more narrowly defined definitions of specific vegetation stands than are given in the NDDb.

According to the *Manual*, CMC is categorized in the Woollyleaf manzanita series (Sawyer and Keeler-Wolf 1995). In this series, forms of woollyleaf manzanitas (*Arctostaphylos tomentosa*) are dominant or are important shrubs with one or more rare ceanothus (e.g. *Ceanothus cuneatus* var. *rigidus*) or manzanita species (e.g. *Arctostaphylos hookeri* ssp. *hookeri* or *Arctostaphylos pajaroensis*) in the canopy (Sawyer and Keeler-Wolf 1995). Shrubs are less than 3 m in height and the canopy is continuous. This type of vegetation is found in upland areas such as bluffs, dunes, mesas, outcrops, slopes, and terraces. The soils are derived from sand, sandstone, shale, or volcanic origins. The distribution is inland or montane areas of the central coast, from sea level to 1500 m. According to the *Manual*, this series is comparable to the NDDb/Holland type for Central maritime chaparral (Sawyer and Keeler-Wolf 1995).

For the purposes of this research study, the name Central maritime chaparral (Holland 1986) is used to describe the type of chaparral vegetation community found in the Prunedale hills in North Monterey County, California. Maritime chaparral is the most common name used to identify this plant community in botanical surveys for development permits in North Monterey County (Vandevere and Associates 1994; Kephart 1998). It is also the name used by the County in the *North County Land Use Plan* (Monterey County Planning Department 1981). However, Central maritime chaparral is a more specific name for the type of maritime chaparral that occurs along the central coast of California, which differs from maritime chaparral communities that occur in northern and southern California (Holland 1986; Sawyer and Keeler-Wolf 1995). Central maritime chaparral is the name used in some recent botanical reports for development permits in North Monterey County (Mercurio 1998) as well as in the US Army Corps of Engineers vegetation clearance study at Fort Ord, California (Harding ESE, Inc. 2002a and 2002b).

Central Maritime Chaparral

The mixtures of plant species in chaparral are determined by various local factors such as climate, soils, elevation, slope, and fire frequency (Radtke 1992; Hanes 1995). Along the central coast of California, the maritime conditions reduce extreme fluctuations in the climate. This is accomplished through the influence of thick fog that forms over the cold waters upwelling from the Monterey Bay submarine canyon, and the constant onshore flow of marine air currents (Mercurio 1998). The common occurrence of fog

during the summer dry season reduces the amount of evaporation and increases the amount of moisture present through condensation and fog drip (Griffin 1978; Mercurio 1998). The average yearly rainfall for North Monterey County is about 15 inches (380 mm) per year (Mercurio 1998).

In this part of the county, the sandy soils are developed from the underlying Aromas red sands, which are well-drained and nutrient poor (Griffin 1978; Mercurio 1998). The general topography of this area is characterized by rolling hills. The northern and eastern slopes tend to be more heavily forested due to greater moisture levels (Figure 5), while the southern and western slopes are more brushy with a few patches of grasslands (Figure 6). The flatter areas are dominated by grasslands, or grasslands with scattered coast live oaks (Figure 6) (Mercurio 1998). All of the ridgelines are covered with CMC and some of this extends along southern slopes (Figure 7) (Mercurio 1998; Scharffenberger et al. 1999). The distribution of CMC in these locations is a result of thin soils [10-20 inches (25 to 50 cm) of the Arnold-Santa Ynez complex], which creates a shallow root penetration zone (Mercurio 1998). Central maritime chaparral thrives only in shallow, well-drained, sandy soils within the cool summer fog zone. On lower elevations, the deeper sandy soils (Arnold loamy sand) are preferred by coast live oak (*Quercus agrifolia*) (Figure 8), which eventually develops as the mature community (Mercurio 1998).

According to various botanical surveys in North Monterey County, CMC is primarily found in the Prunedale hills of the Elkhorn Slough watershed (Vandevere and Associates 1994; Mercurio 1998; Kephart 1998). Only a few other isolated patches exist

in Monterey County and a small patch is found in Santa Cruz County (Mercurio 1998). These patches are composed of highly localized plant communities, with a large number of endemic species. In the Prunedale hills, CMC is the mature community along the ridgelines and upper elevations (Mercurio 1998). Components of CMC are also present in the successional stage preceding coast live oaks on lower elevations (Mercurio 1998).

Characteristic native plant species that are present in the CMC community in the Prunedale hills include: chamise (*Adenostoma fasciculatum*) (Figure 9), Hooker's manzanita (*Arctostaphylos hookeri* ssp. *hookeri*) (Figure 10), Pajaro manzanita (*Arctostaphylos pajaroensis*) (Figure 11), brittle-leaf manzanita (*Arctostaphylos tomentosa* ssp. *crustacea*) (Figure 12), coast sagebrush (*Artemisia californica*) (Figure 13), coyote brush (*Baccharis pilularis* var. *consanguinea*) (Figure 14), golden yarrow (*Eriophyllum confertiflorum*) (Figure 15), rush-rose (*Helianthemum scoparium*) (Figure 16), toyon (*Heteromeles arbutifolia*) (Figure 17), deerweed (*Lotus scoparius*) (Figure 18), sticky monkey flower (*Mimulus aurantiacus*) (Figure 19), western bracken fern (*Pteridium aquilinum* var. *pubescens*) (Figure 20), California coffeeberry (*Rhamnus californica*) (Figure 21), black sage (*Salvia mellifera*) (Figure 22), and poison oak (*Toxicodendron diversilobum*) (Figure 23) (Mercurio 1998; Kephart 1998; Vandever and Associates 1994).

Pajaro manzanita and Hooker's manzanita are both native species that are endemic only to California (The CalFlora Database 2002) and are ranked on the California Native Plant Society's (CNPS) Inventory of Rare and Endangered Plants of California List 1B, as very rare (Table 1) (Tibor 2001; The CalFlora Database 2002).

Pajaro manzanita's distribution is confined to the Prunedale hills in North Monterey County, because it is now extinct from the rest of its former range in Santa Cruz County (Mercurio 1998; Tibor 2001). Hooker's manzanita is currently found only in Santa Cruz and Monterey counties (Tibor 2001; The CalFlora Database 2002).

Other rare plant species associated with CMC include Eastwood's goldenbush (*Ericameria fasciculata*), also called Eastwood's golden fleece or Eastwood's goldenweed, and Monterey ceanothus (*Ceanothus cuneatus* var. *rigidus*). Eastwood's goldenbush is endemic to Monterey County, ranked on the CNPS Inventory List 1B as extremely rare (Tibor 2001), and is a federal species of concern (Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001). Monterey ceanothus (Figure 24) is endemic to Monterey, Santa Cruz, and San Luis Obispo counties, and is on the CNPS Inventory List 4, a watch list for plants of limited distribution (Tibor 2001).

The California Department of Fish and Game (DFG) recognizes that plants on the CNPS Inventory Lists 1A, 1B, and 2 may qualify for state listing as rare, threatened, or endangered and may recommend that they are addressed in California Environmental Quality Act (CEQA) projects (Morey and Ikeda 2001). DFG also recommends protection of plants on the CNPS Inventory Lists 3 and 4 (Morey and Ikeda 2001). The Bureau of Land Management considers plants on the CNPS Inventory List 1B, that are not already federally or state listed, as sensitive and these sensitive species receive the same level of protection as Federal candidate species (Willoughby 2001). Central maritime chaparral is considered to be a sensitive plant community by the Monterey

County Planning and Building Inspection Department, the California Coastal Commission, the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and the California Native Plant Society (Skinner and Pavlik 1994; Mercurio 1998).

There is little information on the specific biology and ecology of the rare CMC plant species. Most information available pertains to the genera. For example, manzanitas (*Arctostaphylos* spp.) in the Ericaceae are generally very drought tolerant, do well on rocky or sandy low nutrient soils, and are fairly easy to grow in landscaping (Johnson 1997). Manzanitas can germinate from seeds or sprout from root crown burls (Johnson 1997; Dallman 1998). They usually require at least half a day of direct sunlight (Johnson 1997). Manzanitas range in size from trees to low growing mats and form dense, impenetrable stands with no understory. Pure stands of manzanitas are the densest of all types of chaparral (Dallman 1998). The tall growing manzanitas, such as Pajaro manzanita, are the most drought-tolerant (Johnson 1997). The low growing types, such as Hooker's manzanita, require more moisture, are more shade tolerant, and grow faster than the tall types (Johnson 1997). Many of these low growing species sprout roots wherever the stems touch the ground and form circular shaped mounds (Smith 1988).

Manzanitas flower in the winter from December to March, rather than in the spring or summer like most other plants. Their flowers have several adaptations to surviving winter conditions. One adaptation is that their tiny flowers grow in dense clusters with their petals fused together in the shape of an urn (Figures 10C, 11B, 12B) (Johnson 1997). This strategy insulates the flowers and protects them from frost. The

flowers also have a waxy coating and hang upside down to allow rain to run down without washing away the pollen (Johnson 1997). Lastly, the flowers can survive longer in the cooler temperatures, from several weeks to months (Johnson 1997). Their flowers are an important winter nectar source for hummingbirds (Johnson 1997). The small red fruit that develops is called a berry (Figures 11B and 12C) and looks like a little apple, hence the Spanish name manzanita, which means "little apple" (Smith 1985; Johnson 1997). They are a favorite food of bears, which explains the scientific name *Arctostaphylos* or bearberry (Johnson 1997).

Neither Pajaro manzanita nor Hooker's manzanita have a burl (Gankin 1999). They are obligate seeders, which require germination from seeds to reproduce. Pajaro manzanita (Figure 11) grows up to 13 feet (4 m) (Hickman 1993), has blue-green, heart-shaped sessile leaves, hairy stems and leaves, produces white to light pink flowers from December to March (Matthews 1997), and exhibits bark stripping (Davis 1973). Hooker's manzanita (Figure 10) is a mounding shrub that ranges from 1 to 4 feet (4-12 dm) tall, has bright green elliptical leaves, smooth stems and leaves, and produces white flowers from February to April (Matthews 1997).

Eastwood's goldenbush is in the Asteraceae (Hickman 1993). The evergreen shrubs are 1 to 3 feet (3-10 dm) tall with thread-like leaves (Hickman 1993; Matthews 1997). The pale yellow flowers bloom from July to October (Matthews 1997; Tibor 2001). It is found in less than 20 locations in the Monterey Bay area (Tibor 2001).

Ceanothus is in the Rhamnaceae (Hickman 1993). Species range from low shrubs to small trees and have a small amount of leaf litter (Holland and Keil 1995; Dallman

1998). Where the shrub cover is dense there is no herbaceous understory (Holland and Keil 1995; Dallman 1998). Clusters of blue, violet, or white flowers bloom in the spring. Ceanothus species have a symbiotic relationship with nitrogen-fixing bacteria living in root nodules, so they are able to live in nitrogen-poor soils (Dallman 1998). Many are short-lived species that only germinate from seeds after fires (Hanes 1995; Dallman 1998). Monterey ceanothus (Figure 24) grows to heights of 3 to 6 feet (1 to 2 m), has toothed sclerophyllous leaves with stomata in sunken pits (Matthews 1997), and also exhibits bark stripping (Keeley 1975). Flowers are lavender-blue or rarely white and bloom from February to April (Matthews 1997).

Animal species that are present in CMC include: Monterey dusky-footed woodrat (*Neotoma fuscipes luciana*) a state species of concern (Table 1), California mouse (*Peromyscus californicus*), brush rabbit (*Sylvilagus bachmani*), California quail (*Callipepla californica*), Heermann kangaroo rat (*Dipodomys heermanni*), California ground squirrel (*Spermophilus beecheyi*), California mule deer (*Odocoileus hemionus californicus*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), red-tailed hawk (*Buteo jamaicensis*), and northwestern fence lizard (*Sceloporus occidentalis occidentalis*) (Vandevere and Associates 1994; Mercurio 1998).

As with CMC plant species, information in the literature on CMC animal species pertains to chaparral in general. The Monterey dusky-footed woodrat, the California mouse, the brush rabbit, and the Heermann kangaroo rat are all endemic to chaparral (Quinn 1990). Compared to other mammals, these species have short generation times

and large numbers of young. They also do not travel large distances so geographic barriers cause them to speciate fairly easily (Quinn 1990).

The Monterey dusky-footed woodrat, the California mouse, the brush rabbit (Quinn 1990), and California quail (Soulé et al. 1988) are found in mature chaparral. The dense chaparral vegetation provides food and cover for these small animals. The Monterey dusky-footed woodrat is one of the few species that thrives in dense, mature chaparral (Quinn 1990). It uses the tall shrubs as a framework for its nest of twigs and branches. The woodrat is an arboreal forager and a generalist herbivore, storing huge quantities of food in its nest. The California mouse's range is restricted to dense chaparral and associated woodlands of California and Baja California (Quinn 1990). It is a part time arboreal mammal, specializing in eating the flowers and seeds of shrubs and trees. The brush rabbit's range coincides with that of California chaparral (Quinn 1990). It uses mature chaparral for cover and feeds in open areas near shrubs. California quail usually feed on or near the ground in scrub vegetation, but will also feed in open or grassy areas adjacent to chaparral, where they return for cover (Soulé et al. 1988). They rarely fly far and require chaparral habitat for breeding.

Burrowing animals, such as the Heermann kangaroo rat and the California ground squirrel, live in disturbed or open chaparral areas with less than 50% cover, where they take shelter underground (Quinn 1990). This burrowing activity also affords them protection underground in the event of a fire (Quinn 1990; Hanes 1995). Heermann kangaroo rats are most abundant in open chaparral habitats that occur 2 to 5 years after a fire, but smaller groups of rats can be found in the limited open areas in mature chaparral

(Quinn 1990). These rodents take dust baths and forage in the open areas between shrubs. California ground squirrel densities are greatest near disturbed areas such as roadsides, old buildings, dumps, agricultural fields, and fuel breaks (Quinn 1990). California mule deer browse the open areas in mature chaparral and, along with other species, are attracted to the abundance of new vegetation that is present during the second and third years after a fire (Quinn 1990; Hanes 1995). The most critical period for deer is during the summer and fall when the moisture and protein content of chaparral shrubs are at their lowest levels. At this time, deer stay within 0.5 to 0.75 miles (0.8 to 1.2 kilometers) of water (Quinn 1990).

Raccoons are omnivorous, opportunistic mammals found in various habitats (Quinn 1990). These mammals require a constant source of water, so their range in chaparral is restricted to larger canyon drainages with permanent surface water. Red-tailed hawks and bobcats hunt the small animals that forage in and around chaparral. Red-tailed hawks nest in woodlands and feed in open areas (Robbins, Bruun, and Zim 1983). Bobcats are most common in canyons and on rocky slopes that have sufficient shrub cover to conceal them while they stalk their prey (Quinn 1990).

The biology and ecology of the plant and animal species present in CMC are important factors that need to be considered in any management plan. Although general information is available on the biology and ecology of the plants and animals in chaparral communities, more research is needed on the requirements and interactions of these species in CMC. This CMC-specific information is needed especially for the rare species, which may have special requirements that account for their rarity. In addition,

information on management issues specific to CMC communities is needed since this will affect the types management strategies that may be implemented.

Management Issues

Due to the limited amount of information available on CMC communities, information on relevant management issues for CMC was compiled from both the general chaparral literature as well as CMC-specific research. From this information, it was determined that the management issues that should be considered for CMC include: loss of habitat, fire suppression, the fire-flood-erosion cycle, invasive non-native plant species, hybridization, Sudden Oak Death Syndrome (SOD), and interactions with insects, birds, and mammals.

Loss of habitat is the biggest threat to CMC in North Monterey County (Griffin 1978; Mercurio 1998; Scharffenberger et al. 1999; Van Dyke and Holl 2000; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001) as well as species diversity worldwide. Habitat loss can result directly from residential development (Figure 25) and conversion to agricultural uses (Figure 26). Habitat loss can also result indirectly from habitat degradation due to fragmentation and edge effects along roadways and trails (Figure 27). The conversion of CMC habit to another vegetation type can result from succession to oak woodland due to fire suppression (Figure 28) and from the invasion of non-native species (Figures 29-31) (Scott 1995; Scharffenberger et al. 1999; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001).

Central maritime chaparral is a fire-adapted community. The role of periodic moderate fires is essential in maintaining the overall ecology of chaparral communities. The historic fire regime for California chaparral was approximately once every 10 to 50 years (Hanes 1995; Holland and Keil 1995). Under natural conditions, chaparral does not become highly prone to fires for about 15 to 25 years or until some of the shorter-lived species die and increase the dead fuel load (Radtke 1992; Barbour et al. 1993). In contrast, coastal sage scrub can become highly prone to fires after only 5 to 8 years because it has a greater number of shorter-lived and herbaceous species (Radtke 1992).

Fire season for CMC communities differs from other California chaparral communities. In southern California, inner coast ranges, and Sierra Nevada ranges, chaparral occurs in areas that have prolonged droughts and hot summers. Conditions conducive for very hot fires occur frequently during the late summer and fall (Moore 1981; Harding ESE, Inc. 2002b). In CMC communities, humidity levels are higher due to mild summers and the common occurrence of fog. Conditions conducive to hot fires occur infrequently, usually in the late fall, when mild to moderate offshore wind conditions occur (Harding ESE, Inc. 2002b). These wind conditions are milder but similar to the Santa Ana winds of southern California. The dry, warm winds from inland areas reduce moisture levels in the air, soils, and vegetation, making them more prone to hot fires (Harding ESE, Inc. 2002b).

Fire frequency affects the vegetation structure and species composition of CMC communities. Fire suppression regimes create a variety of management problems, such as infrequent intense fires. This is the result of the accumulation of large amounts of

brush and debris, as the years pass (Figure 32). This material creates large fuel loads, which can result in fires that burn hotter and longer and consume everything (Green 1981; Moore 1981; California Department of Forestry and Fire Protection 1981, 1993; Radtke 1992; Barbour et al. 1993). The intense heat can also sterilize the soil, removing nutrients and killing microorganisms that the native plants depend on (Bossard, Randall, and Hoshovsky 2000). The amount of heat produced from fires is measured as BTUs released per second per foot of fire front. Chaparral fires release 12,000 BTUs per second per foot in six mile per hour winds and produce soil surface temperatures of 1,000° F (518° C) (Barbour et al. 1993). In contrast, grassland fires are much cooler, releasing 150 BTUs per second per foot and producing soil surface temperatures of 300° F (149° C) (Barbour et al. 1993). Chaparral fires are so intense, they create local windstorms, such as those in the Oakland Hills firestorm of 1991 (Barbour et al. 1993). The destructiveness of this fire was intensified by the heat from burning homes and eucalyptus trees. These windstorms can blow burning debris past firebreaks, spreading the fire to larger areas. Because of their high temperatures, windstorms, and occurrence on rugged terrain, chaparral fires are very difficult to control. Smaller, more frequent fires, as in prescribed burns, are less destructive since they will not kill everything in their path.

Another problem with fire suppression is community succession from CMC to oak woodland (Scott 1995; Scharffenberger et al. 1999; Van Dyke and Holl 2000; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001) (Figure 28). Fire is essential in maintaining the structure and composition of the CMC

community. As mentioned before, many chaparral plants require periodic fires for the germination of their seeds, such as Pajaro manzanita and Hooker's manzanita, which are both obligate seeders (Matthews 1997). In the first few seasons after a fire, new vegetative growth is abundant in the burned areas and species diversity is highest for both plants and animals (Radtke 1992; Hanes 1995). The new plant growth attracts multiple herbivores, which attract carnivores. As the chaparral matures, the number of native annuals and perennials decrease while the number of shrubs increase in height and density (Green 1981; Radtke 1992; Van Dyke and Holl 2000), blocking access to grazing animals. The older stands of mature chaparral generally have the lowest species diversity and are usually even-aged (Radtke 1992; Van Dyke and Holl 2000). Eventually, the shrubs die off under the shade of the closing tree canopy (Figure 28B). This change in plant community not only results in the loss of rare CMC plant species, it also impacts the animal species that utilize this habitat by altering the availability of food, shelter, and breeding grounds. Populations of rare, chaparral-dependent animal species, such as the Monterey dusky-footed woodrat, may decline further with the loss of their habitat.

Although a lack of fires can cause problems, too frequent fires can also be detrimental to CMC. Different fire regimes may produce different species compositions in post-fire communities because different regimes favor different plant species (Haidinger and Keeley 1993). A study found that, in general, as fire frequency increased, the native plant species decreased dramatically while the non-native weedy species increased dramatically (Haidinger and Keeley 1993). The shrubs *Ceanothus* species, chamise (*Adenostoma fasciculatum*), and black sage (*Salvia mellifera*), the subshrub

deerweed (*Lotus scoparius*), the vine *Marah macrocarpus*, and the native annual *Cryptantha* species were all negatively impacted by frequent fires. Chamise reproduces from seeds and resprouts after fire, but some plants die after each fire, so the number of resprouting plants decreases as fire frequency increases. Non-native species such as black mustard (*Brassica nigra*), *Bromus* species, and schismus (*Schismus barbatus*) were absent or present in low numbers on sites that burned 1 year prior to the study. However, these weedy species increased substantially as fire frequency increased (Haidinger and Keeley 1993). The more often vegetation is burned the more light flammable fuels tend to replace the heavier dense chaparral fuels (Dunn 1986). This favors a higher fire frequency (Dunn 1986).

High fire frequency may be detrimental to obligate seeding shrub species, like ceanothus and manzanita species, that require a period of recovery to establish an adequate seed bank before being subjected to further fires (Keeley and Keeley 1986; Haidinger and Keeley 1993). This recovery period may be 15 to 30 years depending on the requirements of the species and the site (Keeley and Keeley 1986). High fire frequency may also be detrimental to resprouting shrubs, like chamise, since some of these always die during a fire (Keeley and Keeley 1986; Haidinger and Keeley 1993). The study suggests that in California high fire frequency of once every 5 to 10 years is important in the establishment of the weeds and the conversion of shrubland to herb-dominated communities (Haidinger and Keeley 1993; CPIF 2002). Other studies have found that coastal sage and chaparral shrubs have limited ability to reinvade sites dominated by non-native annual grasses and herbs. Part of the reason may be due to the

changes in soil water availability resulting from the annual species and the loss of nitrogen-fixing species such as deerweed and ceanothus (Haidinger and Keeley 1993).

Fire frequency is a main factor in determining vegetation structure and vegetation structure determines fire intensity (Haidinger and Keeley 1993). Fire intensity can in turn affect vegetation structure and fire frequency. Plant species differ in their heat tolerances and germination responses (Borchert and Odion 1995). The germination response to fire for shrub and herbaceous species may be related to their life history strategy. Obligate seeders may be able to withstand greater fire intensity than facultative seeders (Moreno and Oechel 1991). This factor may be important in managing CMC obligate seeding species such as Pajaro and Hooker's manzanitas. Fire-dependent annuals may also be more tolerant of fire intensity than opportunistic annuals (Moreno and Oechel 1991). For chamise, increasing fire intensity increased shrub mortality, reduced the number of resprouts per shrub, and delayed the time until resprouting (Borchert and Odion 1995). Seeds of many herbaceous chaparral species appear to be more sensitive to maximum temperature than the duration of exposure to heat (Borchert and Odion 1995). Moisture levels can affect seed germination since seeds that readily absorb moisture have reduced resistance to high temperatures (Borchert and Odion 1995). The vertical distribution of the seeds may be a more important factor in determining seed survival than seed heat tolerance. Seeds on or near the soil surface in a fire usually suffer high mortality, but seeds located about 1 inch (2 to 3 cm) below the surface may be insulated enough to survive (Borchert and Odion 1995).

Although high intensity fires can cause various management problems, low intensity fires can also cause problems. Prescribed burns can often result in cool burns, where almost no seeds germinate due to high moisture levels in chaparral leaves and stems (live fuel moisture) (Franklin 1993; Smith et al. 2002). This occurs when prescribed burns are conducted out of season in the winter and spring (Stassforth 1997; Smith et al. 2002), but can also occur during years of higher than normal rainfall (Franklin 1993). The result is that there is insufficient heat released during the fire to provide the required temperature to crack seed coats and stimulate germination (Franklin 1993; Stassforth 1997). Therefore, shrubs that reproduce only by seed have low regeneration rates. Chamise burls can also be adversely affected by spring burns, because fire removes leaves needed for photosynthesis and low starch reserves in the burls will limit growth during the spring growing season. Herbaceous species are affected by winter and spring burns, because their seeds absorb water at this time and are usually killed by heat. Thus, low to moderate intensity fires favor resprouter species over obligate seeder species (Stassforth 1997).

The loss of vegetation from any fire can create problems on steep slopes, by causing erosion and sedimentation that is 50 to 100 times greater than on well-vegetated slopes (Radtke 1992). Erosion is affected by 6 factors: soils, climate, vegetation, animals, topography, and humans (Radtke 1992). For example, erosion is more common on sandy soils, on south-facing slopes, and on slopes that range from 25° to 45° (Radtke 1992). After fire has removed the vegetative cover on steep slopes, erosion can occur in the forms of dry creep, dry ravel, and wet-erosion (Radtke 1992). Dry creep and dry

ravel occur during dry weather when soil and debris slide down steep slopes under the force of gravity. This dry erosion can be greatly increased by animal and human activities. During low rainfall years, dry creep and dry ravel rates are often higher than wet erosion rates (Radtke 1992). Wet-erosion occurs when rains cause the barren soil to become supersaturated, resulting in overland runoff, rill and gully erosion, and landslides (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). Waxes and resins released from decomposing litter and burned chaparral, coat soil particles, causing them to become water-resistant and increasing runoff (Moore 1981; Radtke 1992; Hanes 1995; Holland and Keil 1995; Smith et al. 2002). Erosion also causes the loss of the topsoil, which results in the loss of nutrients contained in this layer. The resulting erosion from all forms causes sedimentation into nearby creeks and rivers, which creates scouring of the banks, leading to more erosion, sedimentation, and flooding downstream (Radtke 1992).

The loss of vegetative cover from fires also causes the loss of nutrient cycling from mature vegetation, increases loss of soil moisture, and causes soil temperatures to fluctuate over a greater range, affecting the germination and survival of plants and the animals that depend on them (Hanes 1995; Holland and Keil 1995). Furthermore, as overland runoff increases, infiltration decreases, reducing groundwater recharge (Radtke 1992). The reduced groundwater recharge exacerbates the problem of saltwater intrusion into overdrawn aquifers within the Elkhorn Slough Watershed (Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001).

The CMC community and its fire-flood-erosion cycle also affect and are affected by humans who build their homes there. Urban encroachment accelerates the cycle and adds to the potential for catastrophes. Humans alter the landscape through their development activities, which can lead to fragmentation and loss of habitat (Figures 25 and 26), resulting in the decline of a species. Construction, filling, and grading remove vegetation and may weaken the integrity of the slopes, encouraging more landslides and erosion, damaging habitats and properties (Radtke 1992). Recreational activities such as hiking and biking increase in wildlands adjacent to developments (Scott 1995). These types of activities can be detrimental to sensitive habitats, resulting in soil compaction, trampling of vegetation, disruption of wildlife activities, and the introduction of invasive non-native species via trails and paths (Figure 27) (Scott 1995). Many homeowners are opposed to prescribed burning near their homes because they see fire as a threat to properties and lives. As a result, fire suppression can lead to more catastrophic wildfires in the long run. However, prescribed burning can initiate the fire-flood-erosion cycle, damaging habitats and properties on steep slopes.

Homeowners can also affect the ecosystem by introducing invasive non-native plants into the landscaping around their homes that escape into surrounding native habitats (Figure 29). Invasive species are considered the second biggest threat to biological diversity around the world, right behind direct habitat loss and fragmentation (Bossard, Randall, and Hoshovsky 2000). The invasion of non-native species may alter ecosystem functions such as nutrient cycles, hydrology, and wildfire frequency, and the natural community structure through direct competition for resources and space, the

exclusion of some species through allelopathic affects, and the hybridization of rare, threatened, or endangered species (Radtke 1992; Hobbs and Huenneke 1992; Levin, Francisco-Ortega, and Jansen 1996; Bossard, Randall, and Hoshovsky 2000). Some examples of aggressive non-native species invading CMC include pampas grass (*Cortaderia jubata*) (Figure 33), iceplant (*Carpobrotus edulis*) (Figure 34), eucalyptus (*Eucalyptus globulus*) (Figure 35), and non-native grasses (Figure 36) (Mercurio 1998). The California Exotic Pest Plant Council has included pampas grass, ice plant, and eucalyptus on their A-1 list of Exotic Invasive Plants of Greatest Ecological Concern in California, which means these species are considered among the most invasive and damaging species that are widespread throughout the state (Bossard, Randall, and Hoshovsky 2000). Invasive non-native plant species thrive in areas that have been disturbed, such as by fire or construction activities (Zedler and Scheid 1988; Hobbs and Huenneke 1992; Zink et al. 1995). Disturbance makes a habitat more uniform in its resources and reduces species diversity, in contrast to undisturbed habitat, which has more niches that allow for a wider variety of species to survive (Gankin 1999a). Once established, invasive non-native species are difficult if not impossible to eradicate. Ice plant, pampas grass, and other non-native grasses can out-compete native species for resources (Figures 29 and 30). Eucalyptus, on the other hand, invades by excluding natives through the allelopathic effects of the camphor in its leaves (Figure 31) (Radtke 1992).

Jubata grass (*Cortaderia jubata*) (Figure 33), more commonly referred to as pampas grass, is a perennial grass from South America, 6 to 23 feet (2 to 7 m) tall with

spreading plumes (Bossard, Randall, and Hoshovsky 2000). In California, pampas grass occurs only in the coastal fog zone, from Humboldt County to Santa Barbara County, below 2,600 feet (800m) in elevation (Bossard, Randall, and Hoshovsky 2000). It is common in disturbed areas such as ditches, dirt roads, trails, eroded or exposed soil, forest clearcuts, mudslides, or burned areas. Although it is usually found on sandy soil, pampas grass can occur on other soils such as serpentine (Bossard, Randall, and Hoshovsky 2000).

Pampas grass reproduces asexually; no pollination is required (Bossard, Randall, and Hoshovsky 2000). Since plants produce only female flowers and seeds develop from unfertilized ovules, all offspring are genetically identical to the parent plant. This form of reproduction may explain its aggressive ability to spread, in addition to its limited range. A single flower can produce 100,000 seeds and large clumps of flowers can produce over a million seeds (Bossard, Randall, and Hoshovsky 2000). Seeds are dispersed by the wind and can be blown over 20 miles (30 km). Flowers are usually produced late July to September, and plants can flower twice during the same season. Pampas grass can also reproduce vegetatively from broken pieces of tillers that sprout roots in moist soil. The life span is about 15 years (Bossard, Randall, and Hoshovsky 2000).

Low genetic diversity due to asexual reproduction can also limit its distribution to certain environments (Bossard, Randall, and Hoshovsky 2000). Seed germination in the spring requires a cool foggy climate with temperatures between 55 to 70° F (13 to 21° C), abundant moisture, and light (Bossard, Randall, and Hoshovsky 2000). Seeds do not seem to remain viable in the soil for very long, and seedlings do not survive well in the

shade or in competition with grasses. Pampas grass does not tolerate frost, hot temperatures, intense sunlight, or drought, which may explain why it does not grow in the central valley (Bossard, Randall, and Hoshovsky 2000).

Large infestations of pampas grass can crowd out native plants, outcompeting seedlings, and retarding their establishment and growth (Bossard, Randall, and Hoshovsky 2000). Pampas grass can also create fire hazards due to excessive buildup of dry leaves and flowering plumes (Bossard, Randall, and Hoshovsky 2000). The base of the plants forms impenetrable stands that can impede wildlife and block human access, especially fire and emergency vehicles. The leaves also have razor sharp edges that can cause serious injury to humans.

Hottentot fig (*Carpobrotus edulis*) (Figure 34), more commonly referred to as ice plant, is a South African succulent perennial that roots at the nodes, grows close to the ground, and forms dense mats that covers large areas (Bossard, Randall, and Hoshovsky 2000). In California, ice plant is found in coastal areas from Eureka to Baja, below 500 feet (150 m) in elevation (Bossard, Randall, and Hoshovsky 2000). It has been widely used for erosion control along highways and in landscaping. Seedlings establish quickly in disturbed areas such as along roads and trails, as well as in open sand and burned areas. Fires may actually increase the opportunity for ice plant to establish in burned areas by clearing openings in the shrub canopy for seedlings (Zedler and Scheid 1988).

Ice plant reproduces vegetatively and from seeds (Bossard, Randall, and Hoshovsky 2000). As a result of its ability to sprout roots and shoots at each node, fragmented segments can survive and grow. The segments can grow into plants at least

165 feet (50 m) in diameter (Bossard, Randall, and Hoshovsky 2000). This method of reproduction is necessary for survival on beaches and dunes where sand continuously covers plants. Each fruit produces hundreds of small, hard-coated seeds (Zedler and Scheid 1988; Bossard, Randall, and Hoshovsky 2000). Fruits are eaten by mammalian frugivores such as deer, rabbits, and rodents and seeds are spread through deposition in feces. Seeds have been found in deer feces over half a mile (0.8 km) from the nearest plant (Bossard, Randall, and Hoshovsky 2000). Mammal digestive systems enhance seed germination. Studies have determined seeds in feces had a higher germination rate than seeds not eaten (Bossard, Randall, and Hoshovsky 2000). Flowers bloom throughout the year in California, but peak in the spring and early summer. The yellow and pink flowers do not seem to require specific pollinators (Bossard, Randall, and Hoshovsky 2000).

The distribution of ice plant varies from one plant community to another. For example, in coastal prairie, it needs rodents to disturb the vegetation and clear open areas for establishment (Bossard, Randall, and Hoshovsky 2000). Grasses usually out-compete the seedlings, but once it becomes established, ice plant can spread rapidly by vegetative reproduction (Bossard, Randall, and Hoshovsky 2000). Growth is also slowed by the lack of moisture and nutrients. Although ice plant can tolerate a wide range of impacts, it does not tolerate frost (Bossard, Randall, and Hoshovsky 2000).

Due to its high tolerance of impacts and its ability to reproduce vegetatively, ice plant is able to form large impenetrable mats that consume most of the resources in an area (Zedler and Scheid 1988; Bossard, Randall, and Hoshovsky 2000). Its impact on native plants is the worst during droughts. It is able to suppress the growth of native

plant seedlings and mature native shrubs. It can also lower the pH from 6 to 4 in loamy sand, impacting the availability of nitrogen (D'Antonio and Haubensak 1998) and causing changes in the root morphology of native shrubs (Bossard, Randall, and Hoshovsky 2000). An indirect effect is that in areas where large amounts of ice plant are killed by natural causes or by herbicides, it can increase the amount of organic matter in low-nutrient, sandy soils (Bossard, Randall, and Hoshovsky 2000). As a result, it promotes invasions by non-native plants that would not normally be able to survive in low-nutrient soils.

Blue gum eucalyptus (*Eucalyptus globulus*) (Figure 35) is a straight growing Australian tree, 150 to 180 feet (45 to 55 m) tall (Bossard, Randall, and Hoshovsky 2000). Eucalyptus has been planted extensively all over the world because it grows rapidly and adapts well to a wide range of environmental conditions. In California it is planted mostly in central coast areas but is found below 1000 feet (300 m) in elevation along the entire coast as well as in the Central Valley (Bossard, Randall, and Hoshovsky 2000). It grows in a wide range of soil types, but requires soil at least 2 feet (0.6 m) deep, with good drainage and low salinity (Bossard, Randall, and Hoshovsky 2000). Eucalyptus can survive with only 21 inches (533 mm) of annual rainfall in areas where fog provides the additional moisture needed (Bossard, Randall, and Hoshovsky 2000).

It reproduces from seed and by resprouting (Bossard, Randall, and Hoshovsky 2000). Insects and hummingbirds pollinate flowers, which bloom from November to April in California (Bossard, Randall, and Hoshovsky 2000). Fruit ripens from October to March. Seeds are not produced until trees are about 4 to 5 years old and good seed

crops occur every 3 to 5 years thereafter (Bossard, Randall, and Hoshovsky 2000). The small abundant seeds are dispersed by wind. Seedling establishment in groves is inhibited by tree litter, but can be significant after disturbances such as fires or clear cutting. Resprouting occurs from the main trunk, stumps, lignotubers, and roots. Lignotubers can live for many years in the soil and may account for sprouting that occurs away from the main stump. Eucalyptus grows in dense single species stands. It grows rapidly and 70% of the total height is reached in about 10 years (Bossard, Randall, and Hoshovsky 2000). Eucalyptus does not produce taproots and is not tolerant of shade, but it is tolerant of drought and frost (Bossard, Randall, and Hoshovsky 2000).

Eucalyptus aggressively invades plant communities if there is adequate moisture for seeds to establish (Bossard, Randall, and Hoshovsky 2000). For this reason, it is most invasive on sites with summer fog, such as along the coast, rather than in the Central Valley. Eucalyptus invades native plant communities and lowers the biodiversity. It inhibits understory plants from growing through the production of allelopathic chemicals and a thick litter layer of leaves, bark, and branches (Bossard, Randall, and Hoshovsky 2000). The degree of inhibition is dependent on the density of eucalyptus trees. The fuel load created by the litter is extremely flammable and windy conditions blow the burning stringy bark around and spread the fire. This makes eucalyptus groves the worst in the world for spreading fires (Bossard, Randall, and Hoshovsky 2000). The Oakland hills firestorm was exacerbated by the numerous stands of eucalyptus (Bossard, Randall, and Hoshovsky 2000). Trees growing near buildings or in public areas are also dangerous because of the damage falling branches can cause.

Non-native annual grasses can also inhibit the growth of native species (Figure 36). There have been many studies done on this subject. Factors that have been attributed to the survival of these grasses include out-competing natives for resources, rapid growth rates, loss of native seed banks, and low seed dispersal rates for natives (D'Antonio and Vitousek 1992). When there is little disturbance, shrubland can invade grassland. When there is frequent disturbance, such as grazing or fires, grassland replaces shrubland (Zink et al. 1995; Eliason and Allen 1997).

Low soil moisture is one of the main limiting factors to growth in shrublands such as southern California coastal sage scrub (Eliason and Allen 1997). The most common non-native annual grasses throughout California are from the genera *Avena* and *Bromus* (Figure 36) (Eliason and Allen 1997). These grasses have shallow root systems. They germinate soon after the first fall rains and have high transpiration rates, which allow them to deplete water from the root zone. They produce seeds and die once the rainy season ends, forming a thick thatch that produces grass seedlings with the next rainy season (Eliason and Allen 1997). California sagebrush (*Artemisia californica*) (Figure 13), the dominant shrub of southern California coastal sage scrub, also has a shallow root system that occupies the same soil region as the grasses (Eliason and Allen 1997). However, sagebrush seeds are not dispersed until January, long after non-native grass seedlings have become established. Sagebrush seed germination, first season growth, and seedling survival are all negatively related to the density of non-native annual grasses (Eliason and Allen 1997). The reduced seed germination rates are probably due to grass canopy and thatch reducing the amount of light at the soil surface (Eliason and Allen

1997). The reduction in growth and survival of seedlings is most likely due to the depletion of soil water by the grasses (Eliason and Allen 1997). However, by the second season of growth, grasses do not have a significant effect on sagebrush (Eliason and Allen 1997).

Another common non-native grass along the central coast of California, soft chess (*Bromus hordeaceus* L.), has also been found to inhibit the growth of a common native shrub coyote brush (*Baccharis pilularis* var. *consanguinea*) (Figure 14) (Da Silva and Bartolome 1984). The growth inhibiting effects of soft chess on coyote brush seedlings increase under dry conditions (Da Silva and Bartolome 1984). As with other species in the genus *Bromus*, soft chess seeds germinate after the first fall rains and become well established before coyote brush seeds are dispersed. However, late spring rains can increase the survival of coyote brush, by making more water available during the coyote brush's growing season. Soft chess has also been shown to suppress seedlings of the native perennial grass, purple needlegrass (*Nassella pulchra*) (Da Silva and Bartolome 1984).

As a result of the multiple impacts it can have upon chaparral burns, a current management strategy involving the aerial seeding of non-native ryegrass (*Lolium multiflorum*) into burned areas to reduce erosion is being discouraged by researchers. Ryegrass, as with other invasive non-native annual grasses, can inhibit the growth of chaparral shrub seedlings and native post-fire herbaceous species (California Native Plant Society 1987; Ainsworth and Doss 1995; O'Leary 1995; D'Antonio and Haubensak 1998; Bossard, Randall, and Hoshovsky 2000). Non-native grasses also have shallower

root systems than chaparral shrubs, so they are not able to stabilize wet soil as well (Keeler-Wolf 1995). Gophers are well adapted to grasslands and are likely to increase their numbers in areas converted from shrubland to grassland (Keeler-Wolf 1995). Their burrowing activities can increase erosion rates. Furthermore, dense stands of dry ryegrass can increase the fire frequency in chaparral (Ainsworth and Doss 1995), killing shrub seedlings and depleting seed banks. In southern California the fire frequency of chaparral stands seeded with ryegrass increased in fire frequency from once every 35 to 65 years, to once every 3 years (D'Antonio and Haubensak 1998).

However, there is controversy over whether emergency seeding, in general, is effective at reducing erosion and over the potential negative impacts it can have on post-fire vegetation development. Substituting native species for ryegrass in emergency seeding may not be a better alternative since the competitive interaction between the emergency seeded species and on-site species may be the same as with ryegrass (O'Leary 1995). Emergency seeding of any species, whether native or non-native, probably only serves as temporary solution but has the potential to alter ecosystem functions and change the plant community structure (O'Leary 1995). More research is needed to determine whether to continue emergency seeding for erosion control.

Since many invasive non-natives thrive in disturbed areas such as burned sites, fire may actually promote the invasion of non-native species if their seeds are present in the soil (Zedler and Scheid 1988; D'Antonio and Haubensak 1998; Bossard, Randall, and Hoshovsky 2000). Studies have determined that after a fire in chaparral, the amount of ice plant (*Carpobrotus edulis*) that invaded disturbed sites increased dramatically (Zedler

and Scheid 1988; D'Antonio and Haubensak 1998). Edge effects also influenced the establishment of ice plant. Human disturbance along the edges of the burned site allowed ice plant to establish and spread to the interior of the site (Zedler and Scheid 1988). These findings emphasize the importance of minimizing edge to area ratios of sites, to slow the spread of non-natives. They also suggest that longer intervals between fires should be used instead of shorter intervals when invasive non-natives that require open, disturbed sites are present (Zedler and Scheid 1988).

Invasive species may also increase the fuel load in an area, leading to more intense fires that kill off the native species and alter the community structure (Dunn 1986; Hobbs and Huenneke 1992). Pampas grass, other non-native grasses, and eucalyptus create excessive buildups of dead leaves and debris that are highly flammable. Some non-native species, such as eucalyptus, are more flammable than native species due to the presence of certain oils or chemicals in their vegetative parts. In combination with their prolific ability to reproduce, these invasive species alter the composition of the plant community, making it prone to more destructive fires. Thus, the possibility of non-natives invading burned sites needs to be considered when planning prescribed burns.

The hybridization of rare or threatened plant species with non-natives or other abundant species can eventually lead to the extinction of the rare species. This is a particular problem for manzanita species, which are notorious hybridizers (Figure 37) (Johnson 1997; Markos et al. 1998; Gankin 1999b). Hybrids of Pajaro manzanita and Hooker's manzanita are known to occur in Manzanita County Park, Prunedale, California (Gankin 1999a; Gankin 1999b). More hybrids form in disturbed habitats than in

undisturbed habitats (Gankin 1999a). Extinction occurs when a species disappears through demographic and genetic processes (Levin, Francisco-Ortega, and Jansen 1996). Hybridization encourages the extinction of a rare species by adversely affecting its reproductive ability, its competitive ability, and its interactions with pathogens and herbivores (Levin, Francisco-Ortega, and Jansen 1996). Its reproductive ability is affected as more viable hybrid offspring are produced at the expense of the parent stock.

Hybrid offspring may also be able to out-compete parent populations for space and resources, because hybrids normally have a broader range of tolerances and tend to do well in heterogeneous habitats created by disturbance (Hobbs and Huenneke 1992; Levin, Francisco-Ortega, and Jansen 1996). Conversely, for parent populations, the greater the amount of disturbance, the less suitable habitat available, and the smaller the effective population size. This leads to inbreeding, which further reduces the genetic diversity of parent populations. Lastly, hybridization may increase herbivore and pathogen pressure if the hybrid species are more susceptible to pests. Hybrids then form a vector of infection for parent species (Levin, Francisco-Ortega, and Jansen 1996).

In terms of disease, manzanitas are more susceptible to certain fungal infections in cultivated environments such as gardens and landscaping, but can succumb to them in natural habitats. *Botryosphaeria* and other fungi may cause spots on the leaves or kill entire branches (Smith 1985). These fungi flourish when leaves retain moisture and have poor ventilation because of crowded conditions. In this case, keeping branches thinned and avoiding crowding plants together will prevent fungal infections. Root rot can occur when shrubs are planted in heavy poorly drained soils, with frequent watering (Smith

1985; Smith 1988). Root-rotting fungi most commonly occur when these soil conditions are present during summer heat. Replanting the shrubs on slopes or mounds, or in soils with good drainage, will help alleviate this problem. Insects rarely cause significant problems. The most annoying insect pest is a small aphid that produces inflated, crescent-shaped galls on the edges of the leaves (Smith 1985; Smith 1988). Spraying insecticides in the late spring may help, but the best method is removing and destroying the affected leaves, and controlling ant populations (Smith 1985).

It has recently been discovered that Sudden Oak Death (SOD) syndrome may be a threat to CMC. Sudden Oak Death is caused by *Phytophthora ramorum* (Frankel 2001; Garbelotto et al. 2002), a recently identified microbe related to brown algae but commonly referred to as a fungus (Kan-Rice 2001). *Phytophthora ramorum* was originally discovered in 1993 in Europe as the cause of a new disease in ornamental rhododendrons (Kan-Rice 2001; Zandonella 2001; Garbelotto, Svihira, and Rizzo 2001; Garbelotto et al. 2002). Since it was discovered in California in 1995, it has killed tens of thousands of oaks and oak relatives and researchers have reported mortalities of 40% to 80% in infected groves (Zandonella 2001; Garbelotto, Svihira, and Rizzo 2001). Despite the name "Sudden Oak Death," given because the foliage of infected trees often turns brown in only a few weeks, it may take several months or years to actually kill a tree (Garbelotto et al. 2002). The hardest hit counties are Marin, Sonoma, and Santa Cruz, but SOD has also been found in Alameda, Mendocino, Monterey, Napa, San Mateo, Santa Clara, and Solano counties (Kan-Rice 2001; University of California at Berkeley 2001).

In California, *P. ramorum* was first found to affect two species of native oaks, black oak (*Quercus kelloggii*) and coast live oak (*Quercus agrifolia*), and a native oak relative, tanoak (*Lithocarpus densiflorus*) (Zandonella 2001; Kan-Rice 2001; Garbelotto, Svihra, and Rizzo 2001; Garbelotto et al. 2002). Coast live oaks (Figure 8) are a component of CMC communities and are also part of the transitional oak woodland communities that border CMC (Figure 28). Manzanita County Park in North Monterey County recently identified and removed an infected coast live oak within the park (Higgins 2002). The huge dieback of trees not only disrupts ecosystems, through the loss of habitat and food for wildlife, it also increases the amount of dead vegetation that may lead to destructive wildfires (Zandonella 2001).

Ongoing research is identifying more plants that are affected by SOD. At least 11 other unrelated plants species may act as hosts to *P. ramorum* (Frankel 2001; Garbelotto et al. 2002). The list of plants includes species that are associated with CMC communities, such as manzanita (*Arctostaphylos* spp.), toyon (*Heteromeles arbutifolia*) (Figure 17), and California coffeeberry (*Rhamnus californica*) (Figure 21) (Frankel 2001; Garbelotto et al. 2002). It is still not known how *P. ramorum* affects these CMC species. As with the oaks, symptoms include lesions and/or twig and branch dieback, however, it is not certain whether the fungus actually kills adult or juvenile plants of these three species outright (Garbelotto et al. 2002). It may be possible for hosts to be killed if they are small, shrubby, or weak and progressive dieback of branches can also eventually lead to the death of the plant (Garbelotto et al. 2002).

Many plants rely on insects, birds, or mammals to pollinate their flowers and disperse their seeds. The long-term survival of a plant population may depend on the presence and numbers of these animals. The more specific the relationship between the plant and animal, the greater the effect one has on the survival of the other (Huenneke 1988). Usually vertebrates are more susceptible to human disturbances than insects, so plants that depend on vertebrate mutualists may be more vulnerable too (Huenneke 1988). For example, hummingbird pollinated plants may be more impacted by human encroachment into their habitats than plants that are bee-pollinated or wind-pollinated.

Animals may also have detrimental effects on the survival of certain chaparral plant species. Since the palatability of plants and plant parts varies widely between species, herbivory can affect the relative abundance of species (Bullock 1991). In California, *Ceanothus* has been determined to be the most important genus of food plants for deer (Bullock 1991). One study found that herbivory, in this case by brush rabbits (*Sylvilagus bachmani*), was the main factor in limiting the growth of *Ceanothus greggii* seedlings at the study site (Bullock 1991). Rabbits ate the stems but not the leaves of the seedlings. The effect of herbivory at the seedling stage subsequently affected the later stages of plant growth. On average, grazed *C. greggii* plants were less dense, shorter, took longer to begin reproducing, and flowered less frequently than ungrazed plants. It was also determined that chamise (*Adenostoma fasciculatum*) served as a nurse plant, protecting *C. greggii* from herbivores (Bullock 1991). In grazed areas, *C. greggii* plants grew tallest in the heaviest cover. However, dense cover was also found to reduce lateral growth of *C. greggii* in areas protected from herbivores (Bullock 1991).

Another study of herbivory on seedlings after fires in southern California chaparral determined that insect herbivory had very little effect on the survival of 2 shrub seedlings, *C. greggii* and chamise, during their first year of survival (Force 1990). However, the study found that *C. greggii* was significantly impacted during the second and third year of growth when both insect and mammal herbivory were allowed (Force 1990). As a result, chamise had the competitive advantage over *C. greggii*. When only insect herbivory was allowed, *C. greggii* had a competitive advantage over chamise (Force 1990). These studies suggest that mammal herbivory can be a major factor affecting the relative abundances, sizes, and distributions of the dominant shrubs in chaparral and may play an important role in the survival of some species.

The species composition of chaparral may differ greatly between sites with similar physical conditions and initial flora, depending on the effects of fire on the cover of resprouting shrubs and seed banks, and the accessibility to herbivores, seed predators, and pollinators (Bullock 1991; Tyler 1996). A study found that the direct effect of fire was found to be the main factor in producing the abundance of shrub and subshrub seedlings after a fire, by enhancing germination and resprouting (Tyler 1996). The combination of indirect effects of fire, specifically the removal of shrubs and mammalian herbivores, was found to be the most important factor in improving the survival of annuals and may also be important in improving the survival of the perennial herbs (Tyler 1996). Both the direct and indirect effects of fire contributed to the postfire establishment of seedlings, but different factors were responsible for increases in different plant groups (Tyler 1996).

Thus, natural disturbance and human impacts are critical concepts in the management of CMC. As discussed above, CMC experiences many types of impacts, such as fire suppression, wild fires, prescribed burning, erosion, flooding, habitat fragmentation, invasions, hybridizations, and disease. Even conservation and restoration efforts can be considered impacts to a certain degree. However, it is critical that the type and frequency of disturbance that promotes the survival of this sensitive rare plant community is maintained (if not naturally, then through human management). Thus, managing disturbances and impacts can pose problems for resource managers. The continued existence of a species or community often requires some type of disturbance, so disturbance regimes need to be incorporated into management plans (Hobbs and Huenneke 1992). However, some disturbances may also lead to the degradation of a community by promoting invasions (Hobbs and Huenneke 1992). Managers must find a balance between the two.

Management Strategies

Several types of management strategies are used or recommended by federal, state, and local agencies and other organizations for managing rare plant communities. The choice of strategy is influenced by several factors, such as the biological and ecological requirements of the species, community history, local conditions, and potential impacts that vary with the location of the community.

Rare plant conservation efforts need to take into consideration a variety of factors if they are to be successful. General guidelines for managing specific target plants

include understanding the biological and ecological requirements of the target species, choosing the appropriate boundaries for the management area, choosing compatible on-site land uses that maintain proper environmental conditions for the survival of the plant population, and provide long-term protection (Huenneke 1988). Adaptive management is necessary to make improvements to the management program as new information and strategies are developed.

The most important factors in rare plant management are the biological and ecological requirements of the threatened species (Schemske et al. 1994). Without knowing what a species or community requires for its survival, it will be impossible to develop a successful management plan. This entails studying metapopulations of species as well as populations, thus taking an ecosystem approach to conservation (Schemske et al. 1994; Keeler-Wolf 2001). Although it is impossible to determine the exact requirements of every species in an ecosystem, it is possible to formulate a comprehensive management plan based on the requirements of a group of indicator or "focal species" (Lambeck 1997). Each focal species is chosen because it has the most demanding requirements for a particular resource or habitat condition necessary for the survival of its entire community. A focal species indicates the minimum acceptable level for that resource or condition, such as minimum area requirements, nutrient requirements, or fire intervals. In theory, since the species with the most restricted requirements are selected, a habitat managed to meet their needs will also meet the needs of all other species in that community (Lambeck 1997).

In managing land to encourage animal mutualists that assist in the pollination of flowers and dispersal of seeds, an ideal refuge should be designed so that it is large enough and has the proper habitat to support viable populations of the animals (Huenneke 1988). Management activities that alter the chaparral vegetation, through prescribed burning, mechanical means, herbicides, replanting with non-native plant species, or conversion to other plant communities affect the presence and abundance of animals (Quinn 1990). If the target plant is insect-pollinated, then extreme care should be taken when deciding the timing and type of insecticide to use near these plants. If birds are important in pollination or seed dispersal, then encouraging other native plant species that serve as alternate sources of pollen or fruit may help attract and maintain bird populations on site during critical periods (Huenneke 1988).

To manage populations of chaparral dependent birds and their habitat, California Partners in Flight (CPIF) recommends protecting large blocks of chaparral habitats, wildlife corridors that connect them, and buffer zones around them to reduce impacts from edge effects (2002). Patch size, configuration, and connectivity all affect the long-term viability of bird populations. Fire should be used to maintain chaparral in a mosaic of different-aged stand but the intervals between fires should be extended up to 30 years to promote late community stages. Fuel management zones that are narrower and more intensively managed should be used instead of graded fuel reduction zones over a wide area. Restoration and maintenance activities should be conducted outside of the breeding season, from March to mid-August, for California chaparral birds. Human disturbance and future development should be minimized in chaparral habitats. Non-native plant

species and animal species such as feral cats should be controlled and eradicated. Long-term monitoring and research should be conducted to determine what management strategies are necessary to prevent further declines of songbird populations (CPIF 2002).

To optimize the habitat for all members of the wildlife community, Quinn (1990) has made the following recommendations. First, chaparral should be maintained in various age classes, so that any stage of plant community development that is needed by any animal is available. Second, prescribed burning should be conducted on areas of 100 hectares (250 acres) or less at one time, rather than on thousands of hectares. The home ranges of most mammals are small enough for populations can survive in areas of this size. Third, all sources of surface water should be protected and improved, to provide water for animals especially during the dry months in summer and fall (Quinn 1990).

As a result of the increasing effects of human disturbance at the urban/wildland interface, government agencies have been handed the complex task of developing management strategies for sensitive ecosystems that protect not only the interests of the wildlife species, but also humans. For example, the California Department of Fish and Game Natural Community Conservation Planning (NCCP) program is designed to protect the diversity of natural wildlife in general while allowing compatible economic growth and development (Tippets et al. 1995). Although not specific to CMC management, the NCCP program Conservation Guidelines recommend 6 basic principles to be included in all regional and subregional plans (Tippets et al. 1995):

1. Species that are well distributed across their native range are less prone to extinction than species restricted to small areas of their range.

2. Large patches of habitat that have large populations of the target species are better than small patches of habitat that have small populations.
3. Patches of habitat that are close together are better than patches that are far apart.
4. Habitat patches that are less internally fragmented are better than patches that are more internally fragmented.
5. Interconnected patches of habitat are better for conservation purposes than isolated patches, and habitat corridors work better when the habitat within them is similar to the habitat that is preferred by target species.
6. Patches of habitat that do not have roads or are inaccessible to humans are better at conserving target species than patches that have roads and are accessible.

The National Environmental Policy Act of 1969 (NEPA) and the California Environmental Quality Act of 1970 (CEQA) require applicants of land development projects to identify and avoid or reduce significant impacts to rare or endangered species. The DFG and the California Native Plant Society (CNPS) recommend the use of botanical surveys for determining the effects of a proposed development on any rare, threatened, and endangered plants and plant communities, whether or not these species are state or federally listed (California Department of Fish and Game 1997; California Native Plant Society 2001). They have developed a set of guidelines for conducting these surveys. Among their recommendations are to use qualified botanical consultants to conduct thorough and systematic floristic field surveys, during the proper times of the

year when species are evident and identifiable. In addition to identifying all plant species present on the project site, these surveys should identify any potential impacts to rare, threatened, or endangered species, and ways to avoid or mitigate them. These well-documented reports, including detailed maps, should be included with environmental assessments, negative declarations, mitigated negative declarations, Environmental Impact Reports (EIRs), and Environmental Impact Statements (EISs) (California Department of Fish and Game 1997; California Native Plant Society 2001).

The CNPS has developed a set of guidelines for mitigating impacts to rare, threatened, and endangered plants, based on the CEQA Statutes and Guidelines (California Native Plant Society 1998). The 5 mitigations for environmental impacts that are listed in CEQA are: avoiding the impact completely by not allowing a particular activity; minimizing impacts by limiting the degree of the activity; correcting the impact by restoring the impacted habitat; reducing or eliminating the impact through preservation or maintenance activities over the length of the project; compensating for the impact by providing substitute resources or habitats (California Native Plant Society 1998).

Out of these 5 mitigations in CEQA, the CNPS supports those methods that prevent the net reduction of the size of a population or the viability of a species (California Native Plant Society 1998). In some cases, this requires that impacts be fully avoided through pre-project planning and design, redesigning an existing project, or adopting the no-project alternative. Measures to avoid impacts may include fencing around sensitive areas, conservation easements, and transfer of development rights

(California Native Plant Society 1998). The CNPS believes that methods other than avoidance, allow net losses of rare plant populations and their habitat, so they do not fully mitigate for significant impacts (California Native Plant Society 1998). These other methods, such as off-site introduction, transplantation, and restoration are usually unsuccessful because most rare plants have specialized, poorly understood, habitat requirements. Recreating the exact environmental conditions they require may difficult if not impossible to do. However, effective mitigations that can avoid or reduce significant impacts may be limited and the use of multiple alternative measures may be necessary depending on the type of project and the requirements of the species. Mitigation measures to avoid or reduce significant impacts to a less than significant level should be determined on a case-by-case basis in consultation with appropriate resource agencies (California Native Plant Society 1998).

Measures to minimize impacts include: reducing the size of the project, locating the project in the least sensitive area, placing buffer zones or fencing around sensitive areas, salvaging the rare plants that will be lost, and establishing permanent conservation easements around portions of the site not included in the project (California Native Plant Society 1998). Monitoring plants and habitats during all phases of the project will help prevent construction and operation activities from impacting protected areas.

The CNPS and existing biological resource laws regard *in situ* or on-site approaches to conserving rare, threatened, and endangered plants as the best available approach for conserving biological diversity at the species level (CNPS Board of Directors 2001). On-site conservation protects and enhances threatened populations by

protecting appropriate habitat within the historic range of the species. *Ex situ* or off-site techniques include: permanent protection of an existing off-site native plant population; permanent protection of an off-site introduced population; a combination of the two techniques; or mitigation banking (California Native Plant Society 1998). Off-site protection does not fully compensate for the loss of habitat known to support a viable natural population since any loss brings the rare species and habitat closer to extinction. CNPS strongly opposes the use of off-site conservation techniques when used as mitigation for human-caused impacts to natural populations, when adequate ecological information does not exist for the natural populations of a target species, when reestablishment in the wild of plant material that was stored off-site could genetically contaminate existing wild populations, when off-site techniques are not based on scientific information, or when off-site techniques are not conducted by qualified biologists with the consent of relevant government agencies (CNPS Board of Directors 2001).

If off-site compensation is used, species preservation is greatly enhanced when several separate sites are protected. The size of site will depend on various factors such as the type, condition, extent, and rarity of the habitat and species, as well as the ability to acquire the parcel of land. To increase the survivability of the species and habitat, the ratio of acquisition to loss must exceed 1:1 for any species, and should be higher for rarer species, especially those that occur in irreplaceable habitats (California Native Plant Society 1998).

The CNPS also opposes the use of transplantation as mitigation for impacts to rare plants because rare plants rarely survive and flourish at new sites after transplantation (Hubbart et al. 2001). The DFG found that even under optimum conditions and sufficient time for planning, transplantation was successful in only 15% of the projects studied (Hubbart et al. 2001). Other researchers have encountered similar problems.

There are several reasons for the failure of transplantations (Hubbart et al. 2001). There is often very little information on the biology and intricate habitat requirements of rare species. Sites that are suitable for transplantation may not be available. Digging up, transporting, and replanting plants, or their reproductive parts is very stressful on the plants and can result in their death. Scientifically tested and reliable methods for propagation and transplantation are not available for many rare species. Sites where the rare species are already present are often at maximum capacity, and transplanting more plants into the existing population may actually decrease their survival. Hybridization of distant genetic populations with local populations may affect survival rates if the distant populations are not able to adapt to local environmental conditions. Transplantation activities cause disturbance to the site, which may encourage the establishment of invasive non-native species (Hubbart et al. 2001). Transplanted plants may also introduce disease into the new site, such as Sudden Oak Death Syndrome. The DFG now recommends the protection of intact habitat and the restoration of degraded habitat instead of the use of transplantation, for full mitigation of project impacts (Morey and Ikeda 2001).

If transplantation is attempted, an ecological study of the site and an inventory of the rare species present are necessary to determine if transplantation will be feasible (California Native Plant Society 1998). Genetic contamination and hybridization between transplanted stock and local populations must be avoided. Site acquisition or other permanent protection measures are needed to ensure adequate long-term protection and mitigation for the net loss of rare plants or habitat. A propagation plan should be developed for the salvage and transfer of the rare plants from the project site on a case-by-case basis (California Native Plant Society 1998). Each plan should provide adequate time to carry out the transfer at the correct time of year and to complete it before construction activities destroy plants or habitats. Maintenance and monitoring programs should be developed to ensure the transplanted population is self-sufficient and the mitigation is a success (California Native Plant Society 1998).

Ecological restoration involves restoring both the biological and physical integrity of the habitat. The CNPS stresses that restoration plans must be individually tailored to the requirements of the habitat and species present on the project site (California Native Plant Society 1998). The former Fort Ord's Habitat Management Plan (HMP) suggests that a site is successfully restored if it supports naturally reproducing CMC habitat that becomes a functioning part of the entire CMC ecosystem (Smith et al. 2002). The HMP recommends using local natural, functioning, undisturbed CMC sites as reference sites for measuring success. Given adequate time, the resulting restoration site should be indistinguishable from the surrounding ecosystem.

Qualitative criteria that can be used to define a successful restoration site may include: low mortality rates among transplanted vegetation; species composition that mimics adjacent, undisturbed reference sites or is likely to evolve to that point naturally; significant levels of sustainable regeneration or natural propagation, or soil surface textures that are capable of sustaining natural regeneration and propagation; well-drained soils; little or no erosion; and restoration that improves the stability of the ecosystem as a whole (Smith et al. 2002).

All of the qualitative criteria can be met if the following conditions are established: the site is physically enhanced to resemble the local equilibrium habitat; proper species and densities are planted to match reference sites; soil preparation creates conditions that match reference sites; landscape enhancement reduces or eliminates erosion potential; public access is limited; and extremely intense rainfall does not occur before the restoration site matures (Smith et al. 2002). It is important to match the soil chemistry and nutrient levels to pre-disturbance conditions, since higher levels of available nutrients, especially nitrogen, in normally nutrient-poor chaparral soils can favor the establishment of invasive non-native plant species (Zink et al. 1995). Poor restoration efforts can promote exotic invasion and further degradation of the habitat (Zink et al. 1995).

Proper soil conditions and surface flow management are crucial for successful restoration. A hard crust on the soil surface severely restricts plant survival, regeneration, volunteer recruitment, and creates excessive overland flow that can cause erosion (Smith et al. 2002). Site preparation techniques that create a loose, permeable layer of topsoil

that is about 8 inches (20 cm) deep and has a litter layer, enhances vegetative growth and reduces erosion (Smith et al. 2002). The goal of soil restoration is to create well-drained soil with mycorrhizae and a low number of invasive non-native species in the seed bank. Each ripped site should be treated with either topsoil from a nearby site or chipped chaparral.

The following site preparation and planting methods have been used in successful maritime chaparral restoration projects in California (Smith et al. 2002):

1. Choose a site with compacted, but not cemented soils
2. Collect seeds from the adjacent undisturbed maritime chaparral plant community
3. Do not rip the site, or limit ripping to one time, to reduce the amount of disturbance to mycorrhizae and the seed bank
4. Use a backhoe bucket to dig holes for plants if soil is too hard for hand tools
5. Add collected seeds to enrich the seed bank
6. Plant mainly coyote bush about eight feet apart or according to its spacing in adjacent mature maritime chaparral
7. Cover soil with mulch or chipped chaparral
8. Control weed growth
9. Allow chaparral to mature through a combination of seed bank sprouting, volunteer growth, and lateral growth of adjacent chaparral.

Mitigation methods and reporting procedures need to be clearly documented. The responsibilities of all parties involved (the landowner or applicant, contractors, and

agencies) and criteria that define successful mitigation should be included to avoid any confusion (California Native Plant Society 1998). If mitigation agreements are required as part of a development permit, the agreement must contain assurances of implementation, monitoring, and maintenance (California Native Plant Society 1998). One way to assure adherence to mitigation agreements is to require a negotiable performance security from the applicant (California Native Plant Society 1998). The amount of the security should be large enough to complete the mitigation and to purchase other rare plant habitat if the applicant fails to successfully complete the work according to the mitigation agreement. Clear definitions of success criteria that must be met should be included in the agreement to determine when the security should be refunded. The length of the monitoring period for the mitigations will vary based on the requirements of the species, but should be conducted for at least five years before the security is refunded (California Native Plant Society 1998).

Monitoring is a necessary management strategy used to evaluate the progress and effectiveness of management and mitigation efforts and to document compliance with mitigation agreements. Section 21081.6 of CEQA allows California agencies to require monitoring of mitigation measures that were defined for a project (California Native Plant Society 1998). The monitoring criteria must be outlined in a written monitoring plan, which must identify mitigation violations throughout the life of the project, not just for the construction phase. Agencies can enforce compliance with monitoring plans by assigning penalties for failure to meet monitoring requirements, through the use of fines or restraining orders, and by requiring a performance security from the project applicant

(California Native Plant Society 1998). The project applicant usually has the financial responsibility for the monitoring and maintenance of rare plant populations and habitats (California Native Plant Society 1998). In the case of conservation easements, the easement holder is responsible for monitoring the easement and for seeking compensation for easement violations (California Native Plant Society 1998). A qualified botanist should always be used to conduct the monitoring.

Monitoring criteria and maintenance responsibilities should be clearly defined in written agreements and both should be designed according to the ecological requirements of the species and habitat and the types of mitigations involved (California Native Plant Society 1998). For example, construction activities may require short-term, constant monitoring to determine if these activities are damaging rare plant habitat. While conservation easements may require long-term periodic monitoring to evaluate the health of the plants, to identify weed infestations, and to determine if violations have occurred. The Habitat Management Plan for the former Fort Ord requires 5 years of monitoring the recovery of the vegetation after a burn (Harding ESE, Inc. 2002a). The California Native Plant Society's Rare Plant Science Committee is working on developing a statewide, systematic monitoring program for rare plants species (Woodward 2001).

Currently the CNPS has developed the following general guidelines for conducting an initial inventory and for monitoring rare plant populations (Woodward 2001). Select the area that includes the plant populations to be inventoried to establish a baseline. Conduct the surveys at the appropriate times of the year when the rare plants are identifiable, usually during their flowering period, and present, usually after seed

germination. Map the locations of the rare plant populations and the individual patches at each location. Survey the site by walking the entire site, counting the number of plants, and evaluating their condition. For large populations, the site can be sampled using transects or quadrats and then using statistical analysis to arrive at an estimated population size. Accurate descriptions of the plants should be provided that include information on flowering, fruiting, pollinators, age classes, size of plants, whether the plants are reproducing, and the condition of the habitat. All threats, both direct and indirect, should be identified. Associated vegetation types and plant species occurring in the area should be identified using the CNPS Vegetation Rapid Assessment Protocol. Identify who conducted the survey, when it was done, and how to contact surveyor. Detailed descriptions of the monitoring methods should be included. Photographs of the general setting of the plant populations and various views of each sampling point should be taken to give a visual frame of reference for the site. Close-up pictures of the individual plants are also useful to confirm the identity and condition of the species. Findings should be reported to the California Natural Diversity Data Base using their standard report form (Woodward 2001).

In accordance with the requirements of the California Coastal Act of 1976, Monterey County has developed a Local Coastal Program (LCP), designed to carry out the goals and policies of the Act (Monterey County Planning Department 1981). The California Coastal Act emphasizes the importance of protecting environmentally sensitive habitats and mandates that future development within or adjacent to sensitive areas must be of appropriate use, design, and location so as not to degrade or jeopardize

these sensitive areas (Monterey County Planning Department 1981). According to the LCP definition, "Environmentally sensitive habitats are areas in which plant or animal life or their habitats are rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments" (Monterey County Planning Department 1981, 7). More specifically it states that "Inland portions of the North Monterey coastal area also support a diversity of sensitive habitats including: riparian corridors, freshwater marshes, and maritime chaparral. These have been threatened to varying degrees by agricultural and residential uses" (Monterey County Planning Department 1981, 7).

The key policy of the North Monterey County LCP for environmentally sensitive habitats is as follows: "The environmentally sensitive habitats of North County are unique, limited, and fragile resources of statewide significance, important to the enrichment of present and future generations of county residents and visitors; accordingly, they shall be protected, maintained, and, where possible, enhanced and restored" (Monterey County Planning Department 1981, 8).

Under Section 2.3 of the LCP the County describes general and specific policies related to "Environmentally Sensitive Habitats" such as CMC (Monterey County Planning Department 1981). General policies include prohibiting all development in environmentally sensitive habitat areas, requiring land uses and development adjacent to sensitive habitats to be compatible with long-term maintenance of the resource, maintaining where significant and possible, continuous areas of undisturbed land, restricting the removal of indigenous vegetation and land disturbance to the minimum

necessary for structural improvements in approved developments, and requiring the use of non-invasive plant species in proposed landscaping (Monterey County Planning Department 1981). The County also stipulates that if private development is proposed in sensitive habitats, field surveys by qualified individuals are required to determine precise locations and to recommend mitigation measures to protect any sensitive habitat (Monterey County Planning Department 1981).

Specific policies for maritime chaparral include restricting public access to areas of rare, endangered, and sensitive plants (Monterey County Planning Department 1981). Development in maritime chaparral is restricted by discouraging the further conversion of maritime chaparral to agricultural uses, and siting and designing new development in areas of chaparral that will protect the maximum amount of habitat (Monterey County Planning Department 1981). To prevent erosion, the County prohibits disturbance of all chaparral on land exceeding 25% slope (Monterey County Planning Department 1981).

The requirement of permanent conservation easements in development permits is another management strategy used by the Monterey County Planning and Building Inspection Department. The idea is to set aside land that will not be developed, in order to preserve habitat for the threatened species. The County requires permanent conservation easements for proposed developments, which will be a part of the deed restrictions so that new property owners will not be able to develop more habitat in the future (Monterey County Planning Department 1981). For properties that have already been developed, the County is strongly encouraging property owners to voluntarily place

the portions of their land containing maritime chaparral into permanent easements (Monterey County Planning Department 1981).

Despite these recommendations, the County does not state the specific requirements that must be included in the design of a conservation easement. The County only makes general statements such as maintain continuous areas of undisturbed land, and site and design new development in areas of chaparral that will protect the maximum amount of habitat (Monterey County Planning Department 1981). The county policies also states that where private development is proposed in sensitive habitats, field surveys by qualified individuals are required to determine precise locations and to recommend mitigation measures to protect any sensitive habitat (Monterey County Planning Department 1981). The qualified biological consultants who have submitted botanical surveys of proposed developments have also been general in their recommendations for conservation easements. They only state that the portions of the property, containing the majority of the maritime chaparral, not included in the proposed development, will be placed in scenic easement (Mercurio 1998; Vandevere and Associates 1994).

However, the parameters that define a conservation easement are important in determining the overall effectiveness of the easement. These parameters include width, area, habitat quality within the easement, matrix quality, spatial arrangement, and connectivity (Soulé et al. 1988; Loney and Hobbs 1991; Simberloff et al. 1992; Fahrig and Merriam 1993). The quality and quantities of these parameters are dependent on other factors such as the biological and ecological requirements of the species in need of

protection, the quality and quantity and location of the habitat patches, and federal, state, and local ordinances regarding development constraints. These factors will be different for each species, ecosystem, and geographical location under consideration.

The biological and ecological requirements of the focal species are the most important factors to take into consideration when designing an easement. Some species require large contiguous tracts of habitat to survive, while others can survive in smaller, high quality patches (Shafer 1995). Species that are poor dispersers may need habitat patches that are located close together or are connected by corridors.

Landscape spatial structure is one of the main concepts needed to determine the effects of fragmentation on the survival of populations. Landscape spatial structure is defined as the spatial relationships between habitat patches and the matrix that surrounds them (Fahrig and Merriam 1994). It is important to understand that not all habitat patches are equivalent in size and quality and not all patches are equally accessible by dispersers. The heterogeneous nature of the landscape spatial structure is due to both natural processes and human activities. As a result of disturbances and demographic variability, local extinctions of fragmented populations are common (Fahrig and Merriam 1994). Therefore, recolonization after local extinctions is critical for the survival of fragmented populations on a regional scale. The probability of colonization depends on differences in habitat patch size, shape, quality, and quantity, the spatial relationships between habitat patches and the matrix through which dispersers move, dispersal characteristics of the species, and changes in the landscape structure over time (Yahner 1988; Loney and Hobbs 1991; Fahrig and Merriam 1994). These factors are especially

important for rare species since they are usually limited in their dispersal range and habitat preferences.

The factors that influence colonization of patches affect population persistence in different ways. There is a positive relationship between patch size and population persistence (Fabrig and Merriam 1994; Shafer 1995). As patch size increases, so do population size and population survival ability. However, large tracts of land are often difficult to obtain. In some locations, small patches are the only options available for some plant communities. Despite this problem, the presence of multiple patches, that are close enough or connected by usable corridors, may actually increase gene flow, provide more habitat variation than a single large tract, or may guard against the effects of environmental catastrophes that can wipe out a single population (Shafer 1995).

Patch shape influences population survival through the edge-to-interior habitat ratio. An edge can be defined as the interface between two different landscape elements, such as a plant community, successional stage, or land use (Yahner 1988). This junction is either a well-defined boundary, such as between woodland and urban area, or an ecotone, a transition zone where wildlife communities from both sides mix together to form a new type of community, such as between grassland and woodland. Edge habitat favors species adapted to disturbances and may have greater wildlife diversity than either parent habitat, due to the presence of these disturbance-adapted species in addition to some species from each parent habitat (Yahner 1988; Loney and Hobbs 1991). Habitat patches that are long and narrow have a larger percentage of edge area than patches that have a large diameter. The edge effect may also be more pronounced on one side of the

interface of the two habitats than the other when vegetation composition differs drastically on each side (Yahner 1988). For example, at the interface of chaparral and a residential tract, the species diversity on the chaparral side may change but the diversity on the residential side, which is low to begin with, would probably not. Thus, patches with differing amounts of edge area and types of adjacent habitats will have different population dynamics. Continuous edge disturbance and the high edge to interior habitat ratio also favor the maintenance of early successional plant communities (Loney and Hobbs 1991). This may prevent the establishment of late successional communities.

Patch quality can also affect survival rates (Fahrig and Merriam 1994). Poor quality patches will support fewer species than good quality habitats. As a result, species living in poor quality patches will require more patches with larger areas to meet their biological needs than species living in good quality patches.

The spatial configuration of the landscape components can affect population survival. Landscape components include both habitat patches and the matrix habitat surrounding them. For population survival, the total number of dispersal routes in the matrix may be less important than their orientation to the habitat patches (Fahrig and Merriam 1994). For example, dispersal routes to good quality patches are more important than routes to poor quality patches. One study determined that when one patch was different from the others in terms of demography or dispersal, the spatial location of this patch affected the regional population dynamics. The more central the patch was, the more impact it had (Fahrig and Merriam 1994). Regional population persistence is also

affected by the spatial configuration of high and low quality patches and connections, and the positive effects of clumping of patches together (Fahrig and Merriam 1994).

The recolonization of local patch extinctions depends on the dispersal ability of the species (Fahrig and Merriam 1994). Populations that are poor dispersers will have greater rates of local extinctions. The components of dispersal that are important for recolonization are the dispersal probability, the dispersal distance, the temporal pattern of dispersal, and the dispersal behavior (Fahrig and Merriam 1994). The most important factor in determining regional population abundance was the ability of the dispersers to locate new patches (Fahrig and Merriam 1994).

Although most of the known factors and conditions regarding the use of corridors relate to animal populations, some of these can be applied to plant populations. The presence of dispersal routes throughout the landscape can aid in the dispersal success of populations (Simberloff et al. 1992). If the quality of the matrix is high, then specific dispersal routes may not be necessary. However, when the quality of the matrix is low, then dispersal corridors may be necessary. The quality of these corridors also affects the dispersal rates of populations. Poor quality corridors may impede the rate of dispersal or stop it all together if the corridors increase the mortality rates of the populations. The spatial arrangement of corridors relative to the habitat patches may also affect the probability of the populations finding them and using them (Simberloff et al. 1992).

Other potential disadvantages of corridors include the ability of catastrophes to spread through them. Fires, diseases, or introduced species can use corridors to accelerate their dispersal to other areas (Simberloff et al. 1992; Shafer 1995; Zink et al.

1995). Low-quality corridors may also serve as sinks or traps for dispersing populations, because once they arrive there, the lack of adequate resources for reproduction and survival causes the demise of the population (Simberloff et al. 1992).

A study on the effectiveness of biological corridors postulated that the use of biological corridors may actually promote the destruction of more habitat (Rosenberg, Noon, and Meslow 1997). Determining the habitat requirements of a species is difficult. If corridors are not designed properly and do not accomplish what they are supposed to do, then they may be useless or even harmful (Rosenberg, Noon, and Meslow 1997). Some species may actually need large intact tracts of habitat and may not be able to survive in small patches connected by narrow corridors. If it is assumed that corridors will adequately mitigate the loss of habitat within a patch, when they actually do not, then they provide planners with a false sense of security. As a result, planners may allow more fragmentation and habitat removal in large tracts to occur, which may ultimately lead to the local extinction of a species and a decrease in the biological diversity of an area. Thus, biological corridors, may actually increase the rate of decline of a population, rather than protect it. Since conservation easements set aside for maritime chaparral are essentially corridors, or fragments of natural areas in an urban landscape (Scott 1995), it is crucial to determine the characteristics, qualities, and effectiveness of these corridors in preserving ecological functioning.

According to the California Native Plant Society (1998), when designing conservation easements, the following factors need to be taken into consideration: the size of the easement must be large enough to support a naturally reproducing population

with an adequate buffer zone, indefinitely. The proposed land use surrounding the easement needs to be compatible with the long-term protection of the easement. The boundaries of the easement and management plan must be based on the ecological requirements of the species, using baseline studies (California Native Plant Society 1998).

A comprehensive stewardship program for conservation easements must include baseline data and a record-keeping system to assist in the protection of the easement (Diehl and Barrett 1988; Bay Area Open Space Council 1999). Baseline documentation is necessary for comparison for each monitoring trip and can be used in enforcement actions as proof that change has occurred, so it should include fairly detailed quantitative vegetation, wildlife, and environmental measurements, including maps and photographs (Diehl and Barrett 1988; Bay Area Open Space Council 1999). Monitoring is necessary not only to identify violations and potential problems, but also to evaluate and maintain the underlying conservation values of the easement (Bay Area Open Space Council 1999). As a result, monitoring activities for conservation easements over sensitive habitats should involve more than just looking for gross violations. It should be done on an annual basis and include measurements for vegetation, wildlife, erosion, etc (Diehl and Barrett 1988; Bay Area Open Space Council 1999). Enforcement is necessary to correct and prevent direct violations and to prevent potential problems from evolving into future violations (Bay Area Open Space Council 1999).

With open space or conservation easements, the landowner transfers the rights to develop the easement to a conservation organization or public agency. Easements

granted to an impartial third party, such as a conservation organization or resource agency, are the only secure types, because those granted to a public agency can be eliminated or modified by a majority vote (California Native Plant Society 1998).

Conservation easement contracts should include a legal description of the easement, the purpose of the easement, the specific resources protected within it, the rights of the grantee, the rights of the grantor, all restrictions, and should state that all conditions of the easement are binding to the grantor and all successors (California Native Plant Society 1998). More specifically, the contracts should include measures to protect the easement from land use changes, the introduction of non-native plant species, and public access. In addition, the contracts should state the grantee's right to enforce compliance with the terms of easement and to require the grantor to pay for restoration of any damage the grantor may cause to the easement (California Native Plant Society 1998). Maintenance and monitoring criteria and agreements should also be written into the easement contract (California Native Plant Society 1998).

The Elkhorn Slough Foundation's recommendations for managing CMC include permanently protecting large connected blocks of associated sensitive habitats, wildlife corridors, and associated buffer zones (Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001). Buffer zones should be maintained for 100 m (330 feet) from the edges of all sensitive habitats to capture sediment and chemicals in runoff from adjacent lands, to maintain groundwater aquifer levels, and to restore natural habitats and wildlife movement. Other recommendations include accepting donations of land and easements, or purchase fee easements, conservation

easements, or parcels covering the largest blocks of sensitive habitats and areas around sensitive habitats that can be used as a 100-meter buffer. Existing easements should be inventoried, monitored, and enforced. County policies to prevent development and further loss of sensitive habitats should be strengthened. Appropriate sensitive habitat areas should be restored. Landowners should be encouraged to control non-native species on their properties. Incentives should be provided to landowners to implement a Watershed Habitat Conservation Program or Natural Community Conservation Plan (Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001).

Fire is another factor that needs to be addressed in CMC management plans. Prescribed burns not only help maintain the vegetation structure of the fire-dependent CMC community, they help reduce high fuel loads that could lead to large destructive wildfires. Using prescribed burns to maintain chaparral in a shifting mosaic of age classes can drastically reduce the impact of large fires, maintain the native vegetation, and is more ecologically sound than any widespread replacement by grasses or other low biomass vegetation (Riggan, Franklin, and Brass 1986).

The California Department of Forestry and Fire Protection's (CDF) Vegetation Management Program is a cost sharing program between the CDF and private landowners that uses prescribed fire and mechanical methods to reduce fire-prone vegetation on State Responsibility Areas while protecting natural resources (California Department of Forestry and Fire Protection 2001). The long-term goal of the program is to maintain a mosaic of vegetation types and age classes to provide optimum fire protection and manage various plant and animal species while protecting the soil and

water from the effects of erosion and floods that often follow fires (California Department of Forestry 1981). A prescribed burn site can be used as a firebreak by firefighters to stop the spread of fire since fire tends to stop burning when it reaches the boundary of less flammable, younger vegetation (Stassforth 1997). The average cost of a prescribed burn is \$25 to \$30 per acre, but it can vary depending on the number of resources needed for the particular project. Through this cost-sharing program, the landowner pays about 25 to 30% of the total project cost (California Department of Forestry and Fire Protection 2001).

Managers conducting a prescribed burn should be trained and certified and should work closely with the local office of the CDF to ensure safe and effective burns (Bossard, Randall, and Hoshovsky 2000). Safe and effective prescribed burns require, among other things, a burn plan, site preparation, follow-up procedures to ensure the fire is fully contained, proper permits from agencies such as the regional air quality board, and compliance with state and federal rules and regulations including the CEQA, and California and Federal Clean Air and Endangered Species Acts (Green 1981; Bossard, Randall, and Hoshovsky 2000; California Department of Forestry and Fire Protection 2001; Harding ESE, Inc. 2002a).

A burn plan should include: the objectives of the burn; the size of burn area; and the range of environmental conditions needed to conduct the burn such as topography, time of burn, temperature, humidity, wind speed and direction, fuel load, level of fuel moisture, and chemical content of fuels (Green 1981; Harding ESE, Inc. 2002a). The burn plan should also describe the manpower, equipment, and communication procedures

required to properly conduct the burn. Site preparation activities should include establishing and managing primary, secondary, and tertiary containment lines, staging areas, and escape routes (Green 1981; Harding ESE, Inc. 2002a).

The ratio of dead to live fuel in chaparral is important. Chaparral with less than 20% dead fuel rarely burns during prescribed burn conditions and chaparral less than 25 years old usually has less than 20% dead fuel (Green 1981). Chaparral 35 to 50 years old with 30 to 45% dead fuel is best for prescribed burning (Green 1981). Chaparral that is 45 to 100% dead will create intense fires unless there is adequate moisture content to reduce the intensity (Green 1981). Mature chaparral over 8 feet (2 m) tall will produce flames over 50 feet (15 m) high and has the potential to burn out of control, by creating its own windstorms and hurling burning debris past firebreaks (Franklin 1993; Barbour et al. 1993). A pound of chaparral fuel contains about 8,500 BTUs, which is equal to a cup of gasoline (Franklin 1993). On a hot day with high winds, fire can cause chaparral to explode like gasoline.

In contrast, high moisture content in chaparral vegetation can result in low intensity fires, which can reduce germination rates of chaparral plants (Franklin 1993; Smith et al. 2002). Wet chaparral or chaparral on north or east slopes will barely ignite without strong winds (Franklin 1993). A burn site preparation method that can be used to optimize burn conditions by reducing the moisture content in vegetation before a burn is pre-crushing (mechanical crushing) (Harding ESE, Inc. 2002a). This method reduces the moisture content by causing the vegetation to die or wilt. This results in a hotter burning fire that creates less smoke while increasing the height of the smoke convection column

to aid in smoke dispersal, and creates a difference in the moisture levels between the burn site and the surrounding vegetation to reduce the likelihood of fire escaping into moister vegetation (Harding ESE, Inc. 2002a). Burns conducted under cool, moist conditions with high fuel moisture will create more smoke, which will stay close to the ground (Harding ESE, Inc. 2002b).

Los Angeles County developed the pre-crushing technique to address the problems of high live fuel moisture and tall shrub canopy in prescribed burns. They crush the chaparral using a bulldozer with the blade up (Franklin 1993; Shelly et al. 1998). Eight-foot (2 m) tall chaparral is crushed into a layer about a foot (0.3 m) deep. Four to eight weeks later the crushed vegetation is burned. Crushed chaparral produces flames only about 2 feet (0.6 m) high because crushing compacts the finely divided leaves of the tall shrub canopy on the ground (Franklin 1993). Although the flame height of crushed chaparral is much shorter and easier to control than standing chaparral, soil surface temperatures in crushed chaparral are similar to that of standing chaparral, around 1,650° F (850° C), which is hot enough to stimulate germination (Franklin 1993).

Crushing and burning chaparral has other advantages as well. The crushed vegetation can be burned at a time when the moisture level in the surrounding vegetation is too high to cause a fire (Stassforth 1997). Crushed chaparral buffers the soil and greatly reduces impacts such as erosion and hydrophobic effects associated with intense fires (Franklin 1993). A study found that the germination of chaparral shrubs, such as ceanothus species (*Ceanothus oliganthus* and *Ceanothus megacarpus*), was 5 times greater in crushed and burned chaparral compared to other techniques used (Franklin

1993). Other techniques in the study consisted of burning standing chaparral, burning cut chaparral that was piled into stacks 5 feet (1.5 m) deep and a quarter mile (0.4 km) long, and multicut chaparral, which is chaparral that has been cut into pieces less than 6 inches (14 cm) long and less than an inch (2.5 cm) in diameter, then left to form a mulch.

Burning piled chaparral caused the most impacts to the soil and seedling growth (Franklin 1993). Another study found there was a higher diversity of herb species on crushed and burned sites than on burns in standing chaparral, shrub seedling mortality was less than or equal to that in standing chaparral, and all herb species bloomed and set seed before the start of the summer heat (Stassforth 1997). The crush and burn technique also produces significantly less smoke than standing chaparral or piled chaparral (Franklin 1993). In addition, a crushing vehicle called the gravity roller can be used on steep, rocky slopes without causing much impact to the soil (Franklin 1993). The gravity roller is easier to maneuver than a bulldozer, costs less to operate, can flatten branches larger than 4 inches (10 cm) in diameter, and is controlled by cables that allow it to create natural mosaics in the ground cover to benefit wildlife (Franklin 1993).

However, there are a few drawbacks to the crush and burn technique. Factors that can affect the success rate are the types of species present, the age of the stand, and the timing of the burn (Stassforth 1997). Species with large heavy trunks, such as greenbark ceanothus (*Ceanothus spinosus*) and laurel sumac (*Malosma laurina*), have high mortality rates as a result of their burls being uprooted by the bulldozers. Crushing also stimulates resprouting before the vegetation is burned and some species are not able to resprout a second time after the fire. For example in one study, 20% of chamise

(*Adenostoma fasciculatum*) and scrub oak (*Quercus berberidifolia*) shrubs did not resprout a second time (Stassforth 1997). In terms of the age of the stand, younger stands have fewer uprooted burls because younger stems are more flexible, but younger vegetation has a lower fuel load, which results in lower intensity fires and lower germination rates. Conducting burns in the late spring may result in lower seedling survival rates since there is not adequate time for the seedlings to grow before the summer dry season (Stassforth 1997).

Prescribed burning in Los Angeles using various techniques has been successful, both economically and environmentally, as a way to create younger stands of chaparral with low amounts of dead vegetation and high leaf moisture. The newest and most cost-effective technique used in Los Angeles in chaparral adjacent to buildings, in riparian zones, or other sensitive habitats is multicutting, which is also called strategic recycling or chipped biomass (Franklin 1993; Shelly et al. 1998). This technique, as mentioned before, involves hand-cutting chaparral into small pieces then spreading it on site 4 to 8 inches (10 to 20 cm) deep. This mulch, similar to wood chips, compresses to a layer 2 to 3 inches (5 to 8 cm) deep (Franklin 1993). It acts as a ground cover that prevents erosion (Franklin 1993, Smith et al. 2002) and blocks sunlight from reaching the soil, inhibiting the establishment of invasive non-native plants that thrive in open, disturbed areas (Franklin 1993). The mulch reduces the amount of moisture that evaporates from the soil, which is beneficial to natives growing in dry areas (Franklin 1993, Smith et al. 2002). In addition, the mulch aids burrowing insects that break up the soil, creating an organic litter layer that can aid volunteer seed propagation (Smith et al. 2002). Since the

mulch is left on site, there are no transportation and landfill costs. The mulch will burn in extreme conditions, but the flames are less than 1 foot (0.3 m) high (Franklin 1993). In contrast, non-natives such as oats produce flames 8 to 10 feet (2 to 3 m) high and black mustard produces flames over 20 feet (6 m) high (Franklin 1993).

However, cutting alone is not recommended by the U.S. Army Corps of Engineers or the U.S. Fish and Wildlife Service for use in place of prescribed burns for the regeneration of chaparral plant species (Harding ESE, Inc. 2002a). Many obligate seeder chaparral species require the stimulus from fire for reproduction and cutting cannot duplicate this process. As a result many of these fire dependent species would be substantially reduced or eliminated from sites that are cut. In a study conducted on the former Fort Ord in Monterey County, California, shrub regeneration density was over 3,000 seedlings per acre (0.4 hectares) after burning compared to 29 seedlings per acre after cutting (Harding ESE, Inc. 2002a). Species diversity is usually lower and fewer native herbaceous species are present on cut sites. Cutting can also disturb the soil surface and cause erosion as a result of the equipment scraping the surface and tire tracks creating ruts.

According to the Habitat Management Plan (HMP) for the former Fort Ord, prescribed burning is the primary vegetation clearance method required for extensive use in designated HMP CMC habitats (Harding ESE, Inc. 2002a). The HMP states "methods of vegetation clearance in maritime chaparral that do not involve burning are not consistent with the habitat and species preservation and protection goals of the HMP" (Harding ESE, Inc. 2002a, 41). "If cutting were used to clear Central Maritime Chaparral

(CMC) vegetation, natural re-vegetation of the area would likely be less diverse and abundant and contain fewer threatened, endangered, and native plant species than present in vegetation communities prior to cutting. Cutting may result in converting existing high quality CMC habitat to a more common and lower quality habitat type" (Harding ESE, Inc. 2002a, A4).

The same statements apply to the use of goat grazing and herbicides to clear CMC vegetation (Harding ESE, Inc. 2002a). Since goats prefer to graze on herbaceous plants rather than woody vegetation, they may impact sensitive CMC herbaceous species. The woody plant material is also left behind, so the dead fuel load still remains high (Harding ESE, Inc. 2002b). In the case of browning, or the use of herbicides, some herbicides can kill standing CMC vegetation while also reducing the viability of seeds in the soil (Harding ESE, Inc. 2002a). Burl-forming shrubs normally resprout quickly after a fire or other disturbance and provide ground cover. However, they do not reproduce from seeds as frequently as obligate seeding species. If all shrubs are killed and the viability of the seed stock is reduced, the recovery of the community is slowed because now all shrubs have to germinate from the remaining seeds. This extended recovery period increases the vulnerability of the community to invasions by non-native species or by coast live oak. HMP requirements on the former Fort Ord limit the use of vegetation clearance methods that do not involve burning to areas less than fifty acres in size (Harding ESE, Inc. 2002a). These methods would also cost more and take longer to implement than prescribed burning (Harding ESE, Inc. 2002a).

According to the HMP, fire-generated disturbance is necessary for maintaining a mosaic of various age stands in maritime chaparral (Smith et al. 2002). The HMP suggests the habitat quality of chaparral, and thus species diversity, can be optimized by sequentially burning areas approximately 500 acres (200 hectares) in size, at a frequency of about 15 years. However, the frequency of burns is still being debated. The average fire interval for human-caused fires in chaparral communities at Fort Ord is 29 years (Harding ESE, Inc. 2002b). Lighting is the most common natural-cause of wildfires that occur throughout the western United States each year (Ainsworth and Doss 1995), but it is not known what the natural fire frequency from lightning strikes would be at Fort Ord. According to some researchers, a fire interval of 30 to 60 years appears to be best for the maintenance of most types of chaparral (Florence 1986), while other researchers have found chaparral communities 100 years or older to be quite productive without burning (Keeley and Keeley 1986). More research is needed to determine a proper burn frequency, which optimizes habitat diversity while minimizing erosion (Smith et al. 2002).

The California Department of Forestry and Fire Protection (CDF) and the U.S. Forest Service (USFS) have developed fire protection guidelines for developments in wildland areas such as chaparral (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). Since it is unlikely that all development will be prohibited in fire-adapted wildland areas such as CMC, these guidelines provide homeowners, lawmakers, and planners with ways to deal with wildfires in the urban/wildland interface. California Government Code, Section 65302(i) requires all

counties to include fire safety standards in the safety section of their general plan (California Department of Forestry and Fire Protection 2000). These standards should include evacuation routes, peak load water supplies, minimum road widths, and clearances around structures. Local government is granted the authority to provide fire protection and to approve local construction and development. According to the CDF, "When growth is allowed to continue in rural areas, local government must ensure that growth is responsible, limiting risks to an acceptable level" (California Department of Forestry and Fire Protection 2000, 10).

Land use designations, policies, and zoning ordinances should be compatible with wildland protection. The CDF and the USFS recommend the use of Fire Hazard Severity Zones to identify areas where development can occur and under what conditions (Moore 1981; California Department of Forestry and Fire Protection 2000). Residential, open space, and preserve land uses should be designated to include fuel breaks, fuel reduction zones, and greenbelts/buffer zones, such as golf courses and parks, between developments and wildlands (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). Developers should be required to put up assurance bonds of performance to ensure that they provide fire safe measures (California Department of Forestry and Fire Protection 2000). Developers should also be required to hire a licensed urban forester to assist with planning the location of fire protection measures related to vegetation such as the location of parks, golf courses, utility corridors, road, streets, and landscaping (California Department of Forestry and Fire Protection 2000).

The foundation for the Board of Forestry's fire-safe regulations and CDF's wildland fire prevention planning program is the concept of defensible space (California Department of Forestry and Fire Protection 2000). Defensible space is defined as "the area within the perimeter of a parcel, development, neighborhood or community where basic wildland fire prevention practices and measures are implemented, providing the key point of defense from approaching wildfire, an encroaching wildfire or an escaping structure fire" (California Department of Forestry and Fire Protection 2000, 8).

Defensible space provides built-in fire prevention and is one step in mitigating wildland fire losses. Fire fighting equipment and personnel are very expensive and many counties are not able to increase their budget for fire fighting resources to keep pace with wildland development needs. However, no amount of fire engines and firefighters can protect every home threatened during a wildfire. As a result, the responsibility for fire protection ultimately lies with the homeowner, developer, and contractor who create the environment. The CDF and USFS stress that each home built in the wildlands must provide some basic level of self-protection and each resident and developer must accept part of the responsibility for including basic perimeter fire prevention measures into the design and construction of structures and developments in wildlands (Moore 1981; California Department of Forestry and Fire Protection 2000).

The CDF and the USFS make the following recommendations for fire prevention measures (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). Buildings must be set back at least 30 feet (9 m) from the property line on parcels 1 acre (0.4 hectares) and larger. The CDF recommended building densities

are: on 15 to 30% slope, a maximum of three buildings per acre; on 31 to 50% slope, a maximum of one building per 3 to 5 acres (1 to 2 hectares); where slopes and fuels are considered very high fuel hazards, development should be prohibited or more stringent standards should be used; and in all cases, development on ridgelines or canyons should be limited or mitigated with greater levels of built-in fire protection (California Department of Forestry and Fire Protection 2000). The USFS states that clustering developments can have some advantages. Clustering allows land outside the development envelope to be reserved for open space, it is aesthetically pleasing, and it can improve fire safety in wildland areas as long as minimum spacing standards are followed and the native vegetation is modified to fuel break standards between clusters (Moore 1981).

Fire resistant building materials should be used for all exterior structures such as in roofs, siding, windows, balconies, fences, street signs, house numbers, etc. (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). All chimney and exhaust vents should have a spark arrester and air vents should have corrosion resistant, wire mesh, screen covers. Roofs and gutters should be kept clean of debris. Fire resistant vegetation should be used in landscaping and flammable vegetation clearance of at least 30 feet should be maintained around structures. The fire marshal or the Director of Forestry may recommend a minimum vegetation clearance of 100 feet (30 m) in areas of high fire danger. The USFS may even recommend minimum clearances of 200 to 400 feet (60 to 120 m) where feasible in some areas of high fire danger (Moore 1981; Radtke 1992). Firewood piles and fuel tanks should be located a minimum of 30

feet from any structure and should have a minimum vegetation clearance of 10 feet (3 m) in all directions (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000).

Other recommendations include constructing roadways for subdivisions with multiple exit and access routes, to provide adequate escape routes for residents and entrances for emergency vehicles. Roadways, turnarounds, turnouts, driveways, gate entrances, and bridges should be wide enough to accommodate fire fighting equipment and emergency vehicles. Roadside vegetation clearance should be 10 feet wide on each side of the road. Roadside fuel modification areas, where vegetation is thinned, should be 100 to 300 feet (30 to 90 m) wide, depending on management needs and local conditions. Adequate water supplies for fire fighting purposes, in addition to domestic needs, should be included in design plans. Residences with swimming pools should be required to provide access areas to allow fire engines within 12 feet (4 m) of the pool, and have a gasoline powered water pump to assist in fire fighting (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000).

On the issue of invasive non-native plants, cutting or mowing can be used as a method of weed control by preventing seed formation on tall weeds, but repeated mowing can favor low-growing weeds and damage native plants (Bossard, Randall, and Hoshovsky 2000). The most effective and efficient method of weed control is to prevent invasions by new species and early detection of invasions that do occur so that weeds can be controlled before they spread (Bossard, Randall, and Hoshovsky 2000). Since all of the non-native plants that are invading CMC have escaped from landscaped or cultivated

areas, the best way to keep them from spreading into natural habitats is to restrict or prohibit their use. There are many native plants that can be used instead that are drought-tolerant, fire-resistant, able to stabilize steep slopes, and aesthetically pleasing (Franklin 1993). Local native plant nurseries can be consulted for the proper species to plant.

Precautions that can be taken to stop or slow the establishment of invasive non-natives, during normal management activities, include: removing plants with seeds from dispersal routes such as trails, roads, and waterways; close unnecessary roads and trails; minimize soil disturbance and replant native vegetation quickly in disturbed areas; limit the use of construction materials that may contain weed seeds or propagules such as gravel, mulch, and straw; wash vehicles and equipment that may be contaminated with weed seeds and other propagules before they are used elsewhere; monitor work sites to detect new invasions; and educate the public on the importance of preventing the spread of invasive non-native plants (Bossard, Randall, and Hoshovsky 2000).

Control methods for invasive non-native plant species that have become established vary depending on the species. These control methods fall into three categories: physical control, biological control, and chemical control (Bossard, Randall, and Hoshovsky 2000). Physical control involves methods such as hand pulling, prescribed burning, flooding and draining, mulching, and soil solarization. Biological control involves the use of organisms that are natural enemies of the target weed, the use of native plant species to outcompete non-natives, and grazing. Chemical control involves the use of herbicides that selectively kill the target weed species. Environmental problems caused by herbicides include drift, volatilization, persistence in the

environment, groundwater contamination, and harm to non-target species (Bossard, Randall, and Hoshovsky 2000). California's programs to regulate agricultural pesticides and pesticide applicators are the most stringent in the nation and are regulated by the California Department of Food and Agriculture and enforced by the county agricultural commissioner's office (Bossard, Randall, and Hoshovsky 2000).

Methods to control pampas grass are limited because pampas grass is usually located in sensitive coastal habitats such as CMC and coastal dunes. Infestations of pampas grass may sometimes be stopped, by seeding disturbed sites with native vegetation to prevent pampas grass seedlings from establishing (Bossard, Randall, and Hoshovsky 2000). Hand pulling pampas grass seedlings or using a shovel to remove larger clumps are very effective methods (Bossard, Randall, and Hoshovsky 2000). To prevent resprouting, it is necessary to remove the entire crown and top section of the roots. Plant parts left lying on the ground may sprout roots if the soil is moist. Removing or burning the flowers, especially before seed maturation, is important to prevent seed dispersal. No fungi or insects have been identified for biological control (Bossard, Randall, and Hoshovsky 2000). Grazing in New Zealand has been successful but it is not known if it has been successful in the United States (Bossard, Randall, and Hoshovsky 2000). The use of the chemical glyphosate in spot treatments has been reported to control over 90% of an infestation during the first season, but continued spot treatments were necessary to prevent rapid reestablishment (Bossard, Randall, and Hoshovsky 2000). Fall applications work better than summer applications because photosynthetic compounds

are moving down toward the roots more quickly in the fall (Bossard, Randall, and Hoshovsky 2000).

Methods used to control ice plant include hand pulling, the use of tractors, and the application of herbicides. Hand pulling is effective, but all live plant segments must be removed from the site to prevent resprouting at the nodes (Bossard, Randall, and Hoshovsky 2000). If removal is not possible, mulching will kill most of the plants, but at least one follow up is necessary to remove resprouts (Bossard, Randall, and Hoshovsky 2000). Large infestations may be removed with a brush rake attached to the scoop of a tractor, if plants are not located in sensitive habitats or on highly erodible sites (Bossard, Randall, and Hoshovsky 2000). The use of glyphosate has been effective, but re-treatment is necessary because it takes several weeks for the plants to die and resprouting can occur in the meantime (Bossard, Randall, and Hoshovsky 2000). To reduce the impacts to native plants, spraying should be done in early or mid-winter when most native plants are dormant.

Other control methods for ice plant are not used for various reasons. No insects or fungi have been found to be effective biological controls (Bossard, Randall, and Hoshovsky 2000). Grazing does not work because of the salty and astringent quality of the leaves and woody quality of the stems (Bossard, Randall, and Hoshovsky 2000). Solarization and freezing do not eradicate ice plant (Bossard, Randall, and Hoshovsky 2000). Finally, prescribed burning is not effective because of the high moisture content of the leaves (Bossard, Randall, and Hoshovsky 2000).

Control methods for eucalyptus such as tree removal and stump grinding are difficult, expensive, and impractical for large numbers of trees on rough terrain (Bossard, Randall, and Hoshovsky 2000). Prescribed burning can reduce fuel load in eucalyptus stands and kill seedlings, but will also clear away vegetation and open up areas for seedlings of invasive species to establish later (Bossard, Randall, and Hoshovsky 2000). Since eucalyptus is valued as an ornamental tree in California, biological controls cannot be considered as a practical option (Bossard, Randall, and Hoshovsky 2000). The most effective method to control sprouting is through the immediate application of chemicals such as triclopyr or glyphosate to the stump's freshly cut surface (Bossard, Randall, and Hoshovsky 2000). Triclopyr works best and the best time of year to cut trees is in the fall. Any resprouts from the stump, should have their leaves retreated with the chemical when they are 3 to 5 feet (1 to 2 m) tall (Bossard, Randall, and Hoshovsky 2000).

Prescribed burns have been used successfully in coastal areas to decrease some non-natives, such as *Avena* spp., *Bromus diandrus*, and *Brassica* spp. (Zedler and Scheid 1988). Timing of the burns was an important factor in controlling these invasive species. The burns were conducted when they would kill most of the non-native seeds without harming the native seeds (Zedler and Scheid 1988) or before annual grasses went to seed (Smith et al. 2002).

Another very successful method of weed control in shrubland, developed in Australia, is the Bradley method (Fuller and Barbe 1985; Bossard, Randall, and Hoshovsky 2000). It basically involves hand-pulling weeds from small areas of native vegetation without replanting, in a way to allow the weeded areas to be quickly re-

inhabited and stabilized by the growth of native plants. Conventional methods of weeding, involving clearing or burning large areas and removing debris, do not work well because large disturbed areas with exposed soil will promote the reinvasion of weeds. The Bradley method encourages the re-establishment of native vegetation, with minimal maintenance.

The theory behind the Bradley method is that a well-trained person working alone will do more good than many people trampling through a treatment area (Fuller and Barbe 1985). The strategy is to tip the ecological balance away from the weeds and towards the native plants. If weeds are cleared out of the most heavily infested areas first, then the weeds will return because they have been provided with the ideal conditions of bare, disturbed soil, exposed to direct sunlight. By working little by little, from the dense native vegetation towards the weeds, the native vegetation's regenerative ability is favored over the weeds. In addition, the soil in native vegetation is covered with a litter layer that inhibits weed seedlings from growing, so it is important to replace this natural litter layer when weeding is completed, since weeding disturbs and exposes the soil. Even the weeds themselves can be added to the litter layer, without their seeds, bulbs, rhizomes, or other resprouting parts (Fuller and Barbe 1985). As a final step, it is important to keep written records and maps of the treatment areas, as well as monitoring and retreating the infestations to ensure they don't reestablish (Fuller and Barbe 1985).

The use of native plants to outcompete weeds is a potentially powerful restoration tool (Bossard, Randall, and Hoshovsky 2000). In some cases, the native seedlings must be planted and cared for until they are well established, such as in an area with a thick

cover of non-native grasses. Reseeding with native species may also work in some grasslands. In other instances, the native plants may reestablish by themselves once the disturbance is removed. However, supplemental weeding may be necessary to promote the establishment of the natives. The native seeds or propagules used in restoration should be collected on site or from adjacent sites within the same watershed (Bossard, Randall, and Hoshovsky 2000). Seeds and propagules collected from distant sites can cause problems if the distant genotypes are not able to survive the conditions on the restoration site. Distant genotypes may also introduce diseases into the restoration site and may outcompete or hybridize with the locally adapted genotype (Bossard, Randall, and Hoshovsky 2000).

Disturbance not only promotes invasions by non-native plants, it also increases the possibility for hybridization between native species, such as manzanitas. Hybrid offspring may be able to out-compete parent plants because hybrids have a broader range of tolerances and tend to do well in disturbed habitats (Hobbs and Huenneke 1992; Levin, Francisco-Ortega, and Jansen 1996). Strategies designed to limit disturbance in CMC will help reduce the rate of hybridization.

Sudden Oak Death (SOD) syndrome is a fairly new management concern for CMC. Since SOD affects rhododendrons, which are used as ornamental plants in landscaping, SOD has the potential of spreading to more areas throughout California, as well as to other states and other countries. Currently there are no measures that will control the disease. Fungicides often don't kill the fungus on rhododendrons, and may actually mask the symptoms making infected plants difficult to identify (Kan-Rice 2001;

Garbelotto, Svihra, and Rizzo 2001). As a result, researchers make the following recommendations: inspect rhododendrons, oaks, and other potential host species for symptoms of SOD; don't transport host species, wood products such as mulch, bark, or firewood, and/or soil out of SOD areas; after visiting SOD areas clean the soil from exposed clothing and equipment; and if a plant is suspected of having SOD, report it to the local county agricultural commissioner (Zandonella 2001).

In North Monterey County, the main strategy for managing CMC is the use of conservation easements to preserve habitat while allowing development. Since there is currently no monitoring program for the conservation easements, this thesis will investigate how well these easements are protecting this sensitive habitat. Field data was collected on the percent cover of non-native plants, to be used as an indicator of the health of the easements. In addition, various resource management agencies and organizations were interviewed to determine what their current strategies and recommendations are for managing CMC.

CHAPTER 3

METHODS

Study Area

The location of the study area is in North Monterey County, California (Figure 38). The primary focus is on the coastal zone, which is governed by the California Coastal Act and is under the jurisdiction of the California Coastal Commission (CCC). Communities in the study area include Watsonville, Castroville, and Prunedale. This is the area in and around the Elkhorn Slough Watershed. Some of the study sites in the Prunedale area are not within the coastal zone boundary and, therefore, not under the jurisdiction of the CCC. However, these sites were used to compare Monterey County's management strategies of CMC outside of the coastal zone with strategies for management of habitat within the coastal zone.

Although CMC is found in other parts of Monterey County, such as the former Fort Ord Military Base, the study area (Figure 38) was selected because the Prunedale Hills have the largest amount of CMC on private land. As a result, the CMC community of the Prunedale Hills is under the most threat of decline due to habitat loss and fragmentation from development pressures. Most of the CMC at the former Fort Ord is protected from development because it is located on Bureau of Land Management land. The portion of CMC located on U.C. Santa Cruz's Native Plant Reserve at Fort Ord is also protected from development. Thus, management strategies that balance natural

resource conservation with natural resource use are urgently needed in the Prunedale Hills.

In this part of the county, the sandy soils are developed from the underlying Aromas red sands, which are well-drained and nutrient poor (Griffin 1978; Mercurio 1998). The general topography of this area is characterized by rolling hills. The northern and eastern slopes tend to be more heavily forested due to greater moisture levels (Figure 5), while the southern and western slopes have more brush, with a few patches of grasslands (Figure 6). The flatter areas are dominated by grasslands, or grasslands with scattered coast live oaks (Figure 6) (Mercurio 1998). The ridgelines are predominately CMC and some of this extends along the southern slopes (Figure 7) (Mercurio 1998; Scharffenberger et al. 1999). The distribution of CMC in these locations is a result of thin soils [10-20 inches (25 to 50 cm) of the Arnold-Santa Ynez complex], which creates a shallow root penetration zone (Mercurio 1998). Central maritime chaparral thrives only in shallow, well-drained, sandy soils within the cool summer fog zone. The elevation ranges from 160 to 490 feet (50 to 150 meters) (Van Dyke and Holl 2000). On lower elevations, the deeper sandy soils (Arnold loamy sand) are preferred by coast live oak, which eventually develops as the mature community (Mercurio 1998). Species of CMC are also present in the successional stage preceding coast live oaks on lower elevations (Mercurio 1998).

The common occurrence of fog during the summer dry season reduces the amount of evaporation and increases the amount of moisture present (Griffin 1978; Mercurio 1998). The average yearly rainfall for North Monterey County is about 15 inches (380

mm) per year (Mercurio 1998). No large wildfires have occurred in this region in approximately 80 years due to fire suppression (Van Dyke and Holl 2000).

For proposed developments, permanent conservation easements are required by Monterey County's Local Coastal Program (LCP) for the portions of the property that contain the majority of the maritime chaparral not included in the development envelope.

Data Collection

The methodology is divided into two sections: vegetation surveys on conservation easements and agency interviews.

I. Vegetation Surveys

Vegetation surveys of CMC conservation and scenic easements on residential parcels in North Monterey County were conducted from June 2001 to September 2001. The objective of the vegetation surveys was to determine if there was a correlation between the dimensions and spatial arrangements of easements and the percent cover of non-native species. This research tested the following null hypothesis:

- H_0 : There is no significant correlation between the size, shape, and spatial arrangements of conservation easements and the percent cover of non-native plant species present.

Through the assistance of the Monterey County Planning and Building Inspection Department in Salinas, 40 residential parcels in North Monterey County, on which botanical surveys of CMC were conducted in the past, were identified. These surveys

were required by the County for proposed developments in environmentally sensitive habitats and conducted by various biological, ecological, and environmental consultants from 1987 to January 1999. From these 40 surveys, 33 parcels with conservation/scenic easements designated on them were identified. Landowners of these 33 parcels were sent a letter describing the thesis study, along with a consent form to gain permission to go onto their property to conduct vegetation surveys. Ten of the 33 landowners gave permission, 3 declined to participate, 2 letters were not delivered because the owners had moved, and 18 landowners did not respond. The pool of ten parcels contained a combined total of 13 easements. These easements were identified by the following numbers: 1a (Figures 39 and 40), 12a (Figures 41 and 42), 12b (Figures 41 and 43), 17 (Figure 44 and 45), 21a (Figures 46 and 47), 21b (Figures 46 and 48), 21c (Figures 46 and 49), 21d (Figures 46 and 50), 21e (Figures 46 and 51), 23 (Figures 52 and 53), 26a (Figures 54 and 55), 26b (Figures 54 and 56), and 28 (Figures 57 and 58). These numbers corresponded to the identification numbers assigned to the initial 40 botanical surveys.

The decision of whether to use transects, quadrats, or both to conduct vegetation surveys depends on the purpose of the surveys and the type of vegetation present. Although transects and quadrats can be used to estimate percent cover of plant species (Mueller-Dombois and Ellenberg 1974; Bonham 1989; Reid and Thompson 1996), both methods have advantages and disadvantages. The advantages of transects or the line-intercept method are that they were developed for use in dense, shrub-dominated vegetation such as CMC and are as accurate as the use of quadrats but are less time-

consuming (Barbour et al. 1999). Transects are more useful for measuring cover over a larger area, such as for woody plants, shrubs and trees (Mueller-Dombois and Ellenberg 1974). Transects are also used for measuring changes in vegetation composition along a continuum or environmental gradient (Reid and Thompson 1996), or as in this study, the disturbance gradient in CMC easements. The disadvantages of transects are that they can only be used for plants with almost 100% crown cover or relatively large basal areas (Mueller-Dombois and Ellenberg 1974) and cannot be used for density and frequency measures because no area is involved (Barbour et al. 1999). For sparse understories of herbaceous vegetation as found in CMC vegetation, quadrats are more useful. For density and frequency measurements, quadrats can be combined with transects by placing the quadrats along the length of the transect (Barbour et al. 1999). For this study, both transects and quadrats were used: transects for measuring the disturbance gradient and quadrats for measuring density and frequency.

The length of the transects and size of the quadrats depend upon the type of vegetation. In general, cover in shrub and tree communities can be measured with transects that are 50 m or greater (Bonham 1989). For short, herbaceous vegetation, 1 m² quadrats are normally used (Reid and Thompson 1996).

For this study, each easement was surveyed using randomly placed transects selected using a random numbers table (Zar 1999). The number and length of each transect used per easement varied according to the size of each easement. Three to ten transects, ranging from 7 to 50 meters in length, were used per easement. An average of seven, 50-meter long transects were used for easements that were large enough to

accommodate this length. Smaller easements had more transects that were shorter in length. Each transect was placed with one end at the edge of the easement and the other end toward the center (Figure 59), to measure vegetation composition along the disturbance gradient. Along each transect, 1 m² quadrats were placed at 5-meter intervals (Figure 60). For each quadrat, the name and percent cover of each species was recorded. The percent cover of each species was estimated by visually dividing each quadrat into four equal quadrants and visually estimating the percentage of space the species occupied in each quadrant. Then the percentages from all 4 quadrants were added together to get the total percent cover of that species for that quadrat.

For each transect, the percent cover of each plant species encountered was measured using the line-intercept method (Mueller-Dombois and Ellenberg 1974; Bonham 1989; Barbour et al. 1999). When a plant intercepted the transect, the name of the species and the length of the interception was recorded. For each transect, the individual interception lengths of a species were added together and the total interception length was divide by the length of the transect to get the percent cover of that species.

For each quadrat and transect, three vegetation layers were measured: tree layer, shrub layer, and herb layer. The percent cover a species in all three layers was added together to get the total percent cover of that species for that quadrat or transect. If a species was present in more than one layer, the total percent cover of a species could be more than 100% percent per quadrat or transect. For example, if eucalyptus seedlings, saplings, and trees were all present in a quadrat, their percent cover may add up to more than 100% for that quadrat.

A list of all plant species encountered in the vegetation surveys was compiled (Table 2). Nomenclature follows *The Jepson Manual* (Hickman 1993). For each easement, the area, perimeter, edge to area ratio, and distance to the nearest source of non-natives and CMC (Table 3) were measured. Aerial photos and assessor's parcel maps were used to help determine the shape and spatial arrangement of the easements (Figures 39, 41, 44, 46, 52, 54, and 57). From the data collected, the density and average percent cover of non-native and native plant species were calculated for each easement; one calculation was developed for transects and one calculation for quadrats (Tables 4 and 5). The average percent cover of live and dead rare species (transects and quadrats) and frequencies of live and dead rare species (quadrats) were also calculated for each easement (Table 6).

II. Agency Interviews

The second methodology involved interviewing federal, state, and local agencies, as well as other organizations involved with managing CMC, to collect information on their policies, strategies, and recommendations. A list of nine agencies and organizations was compiled from a list of groups that participated in an Elkhorn Slough Foundation workshop on the Elkhorn Slough Watershed. Agency personnel knowledgeable on the management of CMC were contacted by telephone or email. Participants were asked to sign a San Jose State Human Subjects Review Board interview consent form. When one person was not completely knowledgeable about the subject matter, two people from the agency or organization were interviewed together.

The interviews were conducted from February 2002 to September 2002, either in person or over the telephone, according to the interviewee's preference. Each interviewee was asked a standard set of questions. During the course of the interview process, the interview questions were revised to elicit more specific answers from participants. After the initial interviews were conducted the agencies/organizations that were interviewed before the questions were revised were contacted again to get their responses to the new questions.

Data Analysis

The information obtained from the literature review and the agency interviews was compiled to determine what is known about the biological and ecological requirements of CMC and where there was a lack of information. Information from these two sources was also compared to determine which strategies and policies are currently being used and which are recommended for the conservation of CMC.

For the field data obtained on the conservation easements, a Product Moment Correlation statistical test (Fowler, Cohen, and Jarvis 1998) was done to determine whether there was a significant relationship between the average percent cover of non-native species in an easement and the easement size, shape, and distance to the nearest source of non-natives and CMC. Statistical analysis was also done to determine if there was a significant correlation between the average percent cover of native species in an easement and the easement size, shape, and distance to the nearest source of non-natives and CMC.

CHAPTER 4

RESULTS

Vegetation Surveys

Table 3 lists the dimensions of the easements as well as the distances from the easements to the nearest sources of non-natives and CMC. The sizes of the easements ranged from 15228.6 m² to 245.7 m². The edge to area ratios ranged from 0.05 to 0.31. As expected, the largest easements generally had the smallest edge to area ratios and the smallest easements had the largest ratios (Figure 61). However, some larger easements had higher edge to area ratios than smaller easements. The area of easement 17 (Figure 37) was 3437.3 m², which is 10% larger than the area of easement 12b (Figure 36) at 3118.6 m², but the edge to area ratio of easement 17 was 0.21, which is more than twice the value of easement 12b at 0.10. Similar results were obtained for easement 26a (Figure 40) and easement 21d (Figure 38), where 26a was larger than 21d, but had a smaller edge to area ratio. In these two examples, the larger easements had larger edge to area ratios because the shapes of these easements were more elongated than the smaller easements.

Eleven of the 13 easements studied were adjacent to sources of non-natives (Table 3). Ten of the easements were located adjacent to roadways, paths, building envelopes, and other disturbed areas where non-natives tend to thrive: easement 1a (Figure 35), 12a and 12b (Figure 36), 17 (Figure 37), 21a-e (Figure 38), and 23 (Figure 39). Easements

26a and 26b were located furthest from disturbed areas and therefore non-natives (Figure 40).

Most of the easements (10 of 13) were also located adjacent to sources of CMC. For ten easements, one or more of the boundaries went through CMC habitat. This occurred when the easement was not drawn around all the CMC on the parcel, as on easements 12a and 12b (Figure 36), 17 (Figure 37), and 26a and 26b (Figure 40). In other cases, the easement boundaries coincided with parcel boundaries, dividing the maritime chaparral habitat between two or more parcels: easements 1a (Figure 35), 12a and 12b (Figure 36), 17 (Figure 37), 21d and 21e (Figure 38), 23 (Figure 39), 26a and 26b (Figure 40), and 28 (Figure 41). Only easements 21a, 21b, and 21c (Figure 38) were not adjacent to maritime chaparral habitat.

The results of the vegetation surveys using transects and quadrats are listed in Tables 4, 5, 6, 7, and 8. The density of non-native species for the transect surveys ranged from 0 to 550 species per hectare and the percent cover of non-natives ranged from 0 to 89 % per easement (Table 4). For the quadrat surveys, the density of non-native species ranged from 0 to 450 species per hectare and the percent cover ranged from 0 to 70% per easement (Table 4). Results from the transect and quadrat surveys showed the percent cover of non-natives did not always increase as the density of non-natives species increased.

The density of native species measured with transect surveys ranged from 7 to 450 species per hectare and the percent cover of natives ranged from 36 to 221% per easement (Table 5). For the quadrat surveys, the density of native species ranged from 7

to 550 species per hectare and the percent cover of natives ranged from 29 to 173% per easement (Table 5). Similar to the results of the non-native surveys, the percent cover of natives did not always increase as the density of native species increased.

Table 1 lists the sensitive plant species found in CMC of North Monterey County. Of these rare species only Pajaro manzanita (*Arctostaphylos pajaroensis*), Hooker's manzanita (*Arctostaphylos hookeri* ssp. *hookeri*), and Monterey ceanothus (*Ceanothus cuneatus* var. *rigidus*) were encountered in the vegetation surveys for this study. Table 6 lists the percent cover and frequency of live and dead species per easement for these three rare species. All the easements had live rare species and all the easements except for 12a had dead rare species. For the transects, the percent cover of live rare species ranged from 0 to 42% and the percent cover of dead rare species ranged from 0 to 13%. For the quadrats, the frequency or percent of quadrats with live rare species ranged from 4 to 67% and the percentage with dead rare species ranged from 0 to 35%.

The Product moment correlation analysis at α -level of 0.05 (Table 7) showed no significant correlation or only a weak correlation ($r < 0.553$) between the percent cover of non-natives and the area of the easement (quadrats and transects) (Figures 62 and 63), the distance to the nearest source of non-natives (quadrats and transects), or the distance to the nearest source of maritime chaparral (quadrats and transects). There was a significant correlation ($r \geq 0.553$, $\alpha = 0.05$) between the percent cover of non-natives and the edge to area ratio of the easements for both transects ($r = 0.73$) (Figure 64) and quadrats ($r = 0.60$) (Figure 65).

Similar results were obtained for the correlation analysis for native species. The Product moment correlation analysis at α -level of 0.05 (Table 8) showed no significant correlation or only a weak correlation ($r < 0.553$) between the percent cover of natives and the area of the easement (quadrats and transects) (Figures 66 and 67), the distance to the nearest source of non-natives (quadrats and transects), or the distance to the nearest source of maritime chaparral (quadrats and transects). There was a significant negative correlation ($r \geq 0.553$, $\alpha = 0.05$) between the percent cover of natives and the edge to area ratio of the easements for both transects ($r = -0.74$) (Figure 68) and quadrats ($r = -0.77$) (Figure 69).

Agency Interviews

Tables 9 and 10 provide a summary of the responses from the nine interviews with federal, state, and local agencies and organizations, and Table 11 provides the complete responses. For simplicity, all entities interviewed will be henceforth referred to as an "agency." Fifty five percent of the agencies list loss of habitat or habitat fragmentation as the management concern that has the highest priority for CMC (Table 9). Thirty three percent list fire suppression and another 33% list invasive non-native plant species as having the highest priority (Table 9).

In terms of the types of management plans or policies for CMC: 56% involved conservation easements, 100% involved impact restrictions, 78% involved mitigations, 44% involved prescribed burning, 0% involved mowing, 89% involved control of invasive plants, 78% involved restoration, 78% involved monitoring, and 78% involved

enforcement (Table 10). Only 44% of the agencies had specific policies for CMC (Table 10). The other 56% of the agencies just applied general rare plant or resource conservation plans or policies to their management of CMC. For other types of management strategies, 44% involved voluntary compliance by landowners, 11% involved incentives for landowner participation, and 67% involved public education (Table 11).

The agencies were also asked if they recommended additional or alternative tools or policies to protect CMC species and habitats (Table 11). The most common recommendation was for conserving more habitat through appropriate land use zoning that set aside land that could not be developed, as in conservation banks, easements, the clustering of building envelopes, and the prohibition of ridgeline development (78%). The second most common recommendation was to conduct prescribed burns (44%). Other recommendations include updating the General Plan policies on CMC (44%), prioritizing sites for protection (33%), and improving monitoring (22%).

CHAPTER 5

DISCUSSION

Vegetation Surveys

According to the literature, the parameters that define a conservation easement are important in determining the overall ecological effectiveness of the easement. These parameters include width, area, habitat quality within the easement, matrix quality, spatial arrangement, and connectivity (Soulé et al. 1988; Loney and Hobbs 1991; Simberloff et al. 1992; Fahrig and Merriam 1993). There is a positive relationship between patch size and population persistence (Fahrig and Merriam 1994; Shafer 1995). As patch size increases, so do population size and population survival ability. Patch shape influences population survival through the edge-to-interior habitat ratio. Edge habitat favors species adapted to disturbances (Yahner 1988; Loney and Hobbs 1991). Invasive non-native plant species thrive in areas with bare, disturbed soil, exposed to direct sunlight (Fuller and Barbe 1985), such as in areas disturbed by fire or construction activities (Zedler and Scheid 1988; Hobbs and Huenneke 1992; Zink et al. 1995). Habitat patches that are long and narrow have a larger percentage of edge area than patches that have a large diameter. The more edge habitat, the more sites for invasive non-natives to establish and spread. Continuous edge disturbance and the high edge to interior habitat ratio also favor the maintenance of early successional plant communities (Loney and Hobbs 1991). This may prevent the establishment of late successional communities.

As a result, it would be expected that the percent cover of non-native species would increase as the area of the easement decreased and the percent cover of native species would increase as the area of the easement increased. However, the analysis of the easement vegetation surveys for this study suggest there is no significant correlation between the percent cover of non-natives and the area of the easement (Table 7) and the percent cover of natives and the area of the easement (Table 8) for either the transect surveys or the quadrats. The reasons for these findings may be due to the fact that non-natives tend to thrive in disturbed, open areas in the shrub canopy and few intact CMC easements had disturbed open areas in the interior portions, unless there was a trail present. In addition, the percent cover of non-natives and natives was dependent on the designation of easement boundaries. For example, some easements were designated only around intact CMC habitat while others encompassed a combination of CMC and eucalyptus groves.

This study did show that edge to area ratio is a significant correlate with percent cover by non-native species (Table 7) (Figures 64 and 65) and with percent cover of native species (Table 8) (Figures 68 and 69). In general, as the edge to area ratio increased, the percent cover of non-natives increased and the percent cover of natives decreased. These findings may be a result of the fact that non-natives were mainly found along edges of the easement that were along disturbed areas such as roadways, development envelopes, or trails. For example, easements 12b (Figure 36 and 44), 26a and 26b (Figures 40, 52, and 53), and 28 (Figure 41), invasive non-natives were present in easements and/or adjacent to them only along boundaries next to roadways, building

envelopes, or other disturbed areas. Easements 1a, 12a, 17, 21b, and 23 (Figures 35 to 39) contained paths or trails through the easements that created additional sites where seedlings of invasive non-native species were beginning to spread into interior areas. Research has shown that such disturbance corridors can provide a direct route for non-natives to invade native communities (Simberloff et al. 1992; Shafer 1995; Zink et al. 1995). Thus, the shape of the easement is an extremely important factor to consider when designating easement boundaries as well as limiting or restricting disturbance corridors. The larger the intact interior areas are the better the protection for CMC species.

Invasive non-natives, such as iceplant and English ivy (*Hedera helix*) that escaped from landscaped areas within adjacent building envelopes, presented another point of invasion into easements 1a, 12a, 12b, and 17 (Figures 35 to 37). In one easement, *Myoporum* sp., a ground cover used in the adjacent landscaping was starting to invade the easement. This species could become a problem invasive if left unchecked. Therefore, restricting the use of invasive non-native plants in landscaping is another important management consideration.

In other cases, past land uses, rather than adjacent land uses, determined which non-natives were present in the easements. For example, easements 21a, 21c, 21d, 21 e, and 23 (Figures 38 and 39), mature stands of eucalyptus were present. Easement 21c had also formerly been a tree farm and had a mature stands of trees that included, in addition to eucalyptus, black locust (*Robinia pseudoacacia*), black walnut (*Juglans californica* var. *hindsii*), and *Prunus* sp. These past land uses may skew the results of the vegetation

surveys to indicate there are more non-natives present in this sample size than are actually present in the overall CMC population. However, the presence of invasive non-natives such as eucalyptus, as a result of past land uses, is an important consideration in the survival of adjacent CMC habitat since these non-natives provide a source for future invasions. Past land uses can affect the survival of CMC. Rare plant management needs to address any impacts that may cause the further decline of the rare plant community.

According to the literature, survival of a population is affected by the spatial configuration of high and low quality patches and connections, and the positive effects of clumping of patches together (Fahrig and Merriam 1994). However, results from this study indicated there was no significant correlation between the percent cover of non-natives and the distance to the nearest sources of non-natives and CMC for either the transect or quadrat surveys (Table 7). There was also no significant correlation between the percent cover of natives and the distance to the nearest sources of non-natives and CMC for either the transect or quadrat surveys (Table 8). The lack of correlation with the distance to non-natives and CMC may be due to the fact that most of the easements were adjacent to both sources of non-natives and CMC.

In addition, the CMC community is mature due to fire suppression in this area for the past 80 years (Van Dyke and Holl 2000). It is possible for CMC to live for a hundred years or more (Keeley and Keeley 1986), but without new plants to take their place, existing CMC species will eventually die off. As expected, no manzanita or ceanothus seedlings were found in the interior areas of the easements, since these obligate seeding species require the effects of fire to stimulate germination (Keeley and Keeley 1987,

Barbour et al. 1993; Holland and Keil 1995; Hanes 1995; Keeley and Fotheringham 1998). This finding is similar to that of Van Dyke and Holl (2000). However, a few Pajaro and Hooker's manzanita seedlings were present in recently graded areas within building envelopes adjacent to some easements. These seeds may have been stimulated to germinate from being scraped by grading activities (Keeley and Keeley 1987; Harding ESE, Inc. 2002a) or by high soil temperatures in open, disturbed areas (Keeley and Keeley 1987). For some obligate seeder species, artificially scarring the seed coat stimulates germination in the same way that heat from fire melts or cracks the cuticle (Keeley and Keeley 1987). High soil temperatures may also produce the same effect as heat shock, so germination may be stimulated in gaps in shrub canopy and on disturbed sites (Keeley and Keeley 1987).

At this stage, since the CMC is not reproducing, the effect of the distance to CMC seed sources may not be evident. When fire is reintroduced into the ecosystem, then the distance to sources of non-natives and CMC may have a more profound effect on the composition of post-fire communities. This is especially true if enough time passes to cause the present seed bank in the easements to become inviable (Went 1969; Westman 1979; Van Dyke and Holl 2000).

Density is defined as "the number of plants rooted within each quadrat" (Barbour et al. 1999, 223). "Density may not be proportional to cover" (Barbour et al. 1999, 223). In this study, the average percent cover of non-natives did not always increase or decrease as the density of non-natives increased or decreased. Rather, the percent cover was affected by both the density and size of the species present. For example, 5 mature

eucalyptus trees may have a lower density but higher percent cover than 10 eucalyptus seedlings. The same results were obtained for the percent cover of native species verses the density and size of natives per easement: 2 mature coast live oak trees may have a lower density but a higher percent cover than 5 coast live oak seedlings.

The frequencies of live rare species and dead rare species may have been affected by the percent cover of trees present in the easement. On easements 1a, 12b, 21b, 21c, 21d, 21e, 23, 26a, 26b, and 28, dead manzanitas were found in shady areas under dense tree canopies of coast live oak, eucalyptus, and Monterey pine. This finding is supported by other studies, which have suggested that shorter shrub species have become overtopped and shaded out by taller tree species (Davis 1972; Callaway and D'Antonio 1991; Van Dyke and Holl 2000). Manzanitas usually require at least half a day of direct sunlight to survive (Johnson 1997). In the absence of fire, community succession from CMC to live oak woodland is possible (Davis 1972; Griffin 1978; Van Dyke and Holl 2000).

Agency Interviews

The majority of the agencies interviewed list loss of habitat or habitat fragmentation as the management concern that has the highest priority for CMC (Table 9). This view is supported by the literature. In North Monterey County, habitat loss and fragmentation due to residential development and agricultural conversion along the ridgelines and southern slopes appears to be the biggest threat to CMC (Griffin 1978;

Mercurio 1998; Scharffenberger et al. 1999; Van Dyke and Holl 2000; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001).

Agencies listed two other management concerns for CMC as having the highest priority: fire suppression and invasive non-native plant species. These findings are also supported by the literature. Central maritime chaparral is a fire-adapted plant community. There is strong evidence that seeds of some species require a stimulus from fire for germination such as heat shock (Keeley and Keeley 1987; Barbour et al. 1993; Holland and Keil 1995; Hanes 1995), charred wood (Keeley and Keeley 1987; Barbour et al. 1993), and smoke (Keeley and Fotheringham 1998). Fire suppression can create a variety of management problems such as negatively impacting the germination rates of fire-adapted species like manzanitas and ceanothus (Keeley and Keeley 1987; Keeley and Fotheringham 1998; Van Dyke and Holl 2000), reducing species diversity (Rundel 1986; Hanes 1995; Holland and Keil 1995; Dallman 1998; Van Dyke and Holl 2000), and increasing community succession to oak woodland (Scott 1995; Scharffenberger et al. 1999; Van Dyke and Holl 2000; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001). In addition, fire suppression can create high fuel loads that result in infrequent intense fires that burn hotter and longer, consuming everything (Green 1981; Moore 1981; California Department of Forestry and Fire Protection 1981, 1993; Radtke 1992; Barbour et al. 1993) and increasing erosion rates (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000).

Invasive non-native species are considered the second biggest threat to biological diversity around the world, right behind direct habitat loss and fragmentation (Bossard,

Randall, and Hoshovsky 2000). The invasive non-native species may alter ecosystem functions such as nutrient cycles, hydrology, and wildfire frequency, and the natural community structure through direct competition for resources and space, the exclusion of some species through allelopathic affects, and the hybridization of rare, threatened, or endangered species (Radtke 1992; Hobbs and Huenneke 1992; Levin, Francisco-Ortega, and Jansen 1996; Bossard, Randall, and Hoshovsky 2000). According to the agencies, the non-natives that are the biggest threats to CMC, in order of importance, are pampas grass, eucalyptus and ice plant, French broom (*Genista monspessulana*), non-native grasses, and Acacia (*Acacia* sp.). The California Exotic Pest Plant Council (CalEPPC) has included pampas grass, eucalyptus, ice plant, and French broom on their A-1 list of Exotic Invasive Plants of Greatest Ecological Concern in California (Bossard, Randall, and Hoshovsky 2000).

In comparison, results from the vegetation surveys determined the invasive non-natives with the highest to lowest percent cover for all the easements combined were eucalyptus, non-native grasses, pampas grass, ice plant, black locust, French broom, and English ivy respectively. English ivy is also on the CalEPPC A-1 list of Exotic Invasive Plants of Greatest Ecological Concern in California and black locust is on list B, which includes less invasive species that degrade habitats (Bossard, Randall, and Hoshovsky 2000). Although the agencies list pampas grass as the biggest threat, the vegetation surveys list eucalyptus as having the highest percent cover. The higher percent cover of eucalyptus may be due to past land uses that involved the intentional planting of eucalyptus and the inclusion of eucalyptus groves in conservation/scenic easement

designations. However, pampas grass was more widespread than eucalyptus. Pampas grass was present on 8 easements compared to eucalyptus, which was present on 6 easements. This may indicate that pampas grass is spreading faster than eucalyptus. The presence of ice plant on 4 easements was due to plants that escaped from adjacent landscaping and non-native grasses were present on 11 easements along roadsides and trails. Black locust, French broom, and English ivy were present on one easement each. Thus, although the percent cover of non-natives did not correspond exactly to the order of importance as listed by the agencies, 4 of the 5 species with the highest percent cover were included in the top 5 species listed by the agencies and should be considered top management priorities.

In addition to habitat loss/fragmentation, fire suppression, and invasive non-native plant species, CMC management strategies need to address specific impacts to these communities related to fire, hybridization, and disease. Only 44% of the agencies had specific management policies for CMC while the others applied general rare plant policies to their management efforts (Table 10). As a result, most agencies interviewed had impact restrictions to address the general rare plant issues of habitat loss/fragmentation and invasive species such as preventing the removal of plants, no building of structures, no trails, no building on steep slopes, and preventing the spread of weeds (Table 11). However, only 4 of the agencies had policies related to a specific CMC impact: fire suppression. These agencies recommended the use of prescribed burns, but none of them were actively conducting them. Fire can also produce impacts related to fire frequency (Haidinger and Keeley 1993; Scott 1995), fire intensity

(Borchert and Odion 1995; Smith et al. 2002), and the use of non-native rye grass for erosion control (California Native Plant Society 1987; Ainsworth and Doss 1995; O'Leary 1995; D'Antonio and Haubensak 1998; Bossard, Randall, and Hoshovsky 2000). Only one agency mentioned a policy that avoided the use of rye grass for erosion control. None of the agencies mentioned any policies to deal with hybridization although manzanitas are notorious hybridizers (Johnson 1997; Markos et al. 1998; Gankin 1999b). Only one agency addressed the recent management issue of Sudden Oak Death (SOD) syndrome, which has been found to affect some of the constituent plant species in CMC such as manzanita and toyon (Frankel 2001; Garbelotto et al. 2002). For those agencies that did not mention impacts related to prescribed burns, hybridization, and SOD, it was not clear whether these agencies had policies to deal with these impacts since they were not asked about them directly. However, it is important for agencies to have management plans or policies that address specific impacts to CMC since general rare plant policies may not cover these types of impacts.

Seventy eight percent of the agencies had policies for mitigations. Types of mitigations ranged from the general statements referring to those mitigations that are recommended by the biologist that did survey and to be determined on a case-by-case basis to the more specific mitigations of weed control, erosion control, replacement of native plants that are removed on a one to one ratio, and transplantation (Table 11).

These mitigations are generally supported in the literature with a few exceptions.

According to the California Native Plant Society (1998), to increase the survivability of the species and habitat, the ratio of acquisition to loss must exceed 1:1 for any species,

and should be higher for rarer species, especially those that occur in irreplaceable habitats. The CNPS also opposes the use of transplantation as mitigation for impacts to rare plants because rare plants rarely survive and flourish at new sites after transplantation (Hubbart et al. 2001). The DFG found that even under optimum conditions and sufficient time for planning, transplantation was successful in only 15% of the projects studied (Hubbart et al. 2001).

Other types of mitigations in current use for fire protection may actually undermine conservation efforts. The California Department of Forestry and Fire Protection (CDF) and the U.S. Forest Service (USFS) have developed fire protection guidelines for developments in wildland areas such as chaparral (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). These guidelines were developed as mitigations for development in fire prone areas. However, many of these mitigations require the removal of vegetation to clear fuel breaks around structures and roadways. These vegetation clearance zones can range anywhere from 10 to 400 feet in width (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000). This conflict of interest, in addition to the devastation caused by wildfires to homes and people living in fire prone areas such as in the Oakland Hills firestorm of 1991 and the Southern California fires of 2003, brings into serious question the decision to allow development to continue in fire prone areas. As is the case with other wildland areas, it is not a matter of if the CMC will burn, it is a matter of when.

Three agencies recommended off-site habitat protection on large intact areas in the form of conservation or mitigation banks since on-site habitats were not manageable

due to fragmentation and human encroachment. The use of mitigation or conservation banks that protect large tracts of land may be an alternative to small easements on individual parcels. Stewardship of a conservation bank by one entity will allow more effective, efficient, and uniform management than trying to coordinate management on several small easements involving multiple landowners. Prescribed burning will more likely be possible and feasible on a large tract of undeveloped land. Post-fire management concerns, such as erosion and invasive non-natives, will also be able to be more effectively addressed on large tracts of undeveloped land. However, land reserved for conservation banks must be carefully selected to encompass natural, historic areas of CMC habitat (CNPS Board of Directors 2001). Offsite re-creation of natural ecosystems is extremely difficult and often unsuccessful (California Native Plant Society 1998; Hubbart et al. 2001). Care must also be taken to ensure that genetic contamination (CNPS Board of Directors 2001) and hybridization of local populations of sensitive species does not occur (California Native Plant Society 1998; Hubbart et al. 2001).

The majority of the agencies had policies for restoration. According to the literature, restoration can range from simply removing the disturbance and letting nature take its course (Bossard, Randall, and Hoshovsky 2000), to trying to physically recreate a similar environment through soil preparation and plantings (Smith et al. 2002). If restoration is attempted, restoration plans must be individually tailored to the requirements of the habitat and species present on the project site (California Native Plant Society 1998). Local natural, functioning, undisturbed CMC sites should be used as a reference (Smith et al. 2002) and all plant materials, cuttings, seeds, bulbs, etc used in the

plantings should be collected on site or from adjacent sites within the same watershed (Bossard, Randall, and Hoshovsky 2000). Monitoring and maintenance is necessary until the restoration has been completed (Bossard, Randall, and Hoshovsky 2000). Fort Ord's Habitat Management Plan (HMP) suggests that a site is successfully restored if it supports naturally reproducing CMC habitat that becomes a functioning part of the entire CMC ecosystem and should be indistinguishable from the surrounding ecosystem. (Smith et al. 2002).

However, from an ecological standpoint, it is easier and more cost effective to preserve existing native habitat than to try to restore it or create it somewhere else. We do not understand the complex biological requirements and interactions of many species (California Native Plant Society 1998; Hubbart et al. 2001). Trying to physically recreate all the necessary elements and interactions in an ecosystem is very difficult, expensive, and time consuming (California Native Plant Society 1998). Many restoration efforts fail as a result of the lack of information and resources needed to implement and maintain a man made ecosystem (Hubbart et al. 2001).

Cooperative conservation planning for plant species, animal species, and vegetation communities, through an ecosystem or landscape approach, is regarded by many as the most ecologically sound and effective method (Schemske et al. 1994; Keeler-Wolf 2001; Morey and Ikeda 2001). The CNPS and existing biological resource laws regard *in situ* approaches to conserving rare, threatened, and endangered plants as the best available approach for conserving biological diversity at the species level (CNPS Board of Directors 2001). Conserving species in their natural habitats is key to their

long-term survival (Morey and Ikeda 2001). DFG “protects, maintains, and enhances plant and animal populations and natural communities through direct acquisition of habitat, conservation easements on private property, and management agreements with public and private agencies and organizations” (Morey and Ikeda 2001, 13). Land acquisition by BLM of 7,200 acres on Fort Ord will protect some of the last undisturbed maritime chaparral habitat in California, as well as several rare plant and animal species, by keeping it in public ownership (Willoughby 2001).

The majority of the agencies had policies for monitoring and enforcement, but several agencies only used these management tools on a limited basis. For example, monitoring was done only for listed species or if restoration was required (Table 11). For regulatory agencies, enforcement was used only for listed species or for blatant violations (Table 11). The frequency of monitoring also varied from several times a month to once every 15 years depending on the agency and the purpose of the monitoring (Table 11). The most common frequency was once a year. As a result, CMC habitats were often not monitored on a regular basis, making it difficult for the agencies to detect existing or potential violations and impacts and to make the necessary corrections in a timely manner.

Monitoring is important not only to identify violations of regulations and mitigation agreements, but also to evaluate the effectiveness of management efforts and to track changes in the plant community. Monitoring criteria and maintenance responsibilities should be clearly defined in written agreements and both should be designed according to the ecological requirements of the species and habitat and the types

of mitigations involved (California Native Plant Society 1998). A qualified botanist should always be used to conduct the monitoring (California Native Plant Society 1998). The CNPS has developed general guidelines for conducting an initial inventory to collect baseline data and for monitoring rare plant populations (Woodward 2001). Monitoring for easements should be done on an annual basis and include measurements for vegetation, wildlife, erosion, etc. (Diehl and Barrett 1988; Bay Area Open Space Council 1999).

Enforcement is necessary to correct and prevent direct violations and to prevent potential problems from evolving into future violations (Bay Area Open Space Council 1999). Agencies can enforce compliance with monitoring plans by assigning penalties for failure to meet monitoring requirements, through the use of fines or restraining orders, and by requiring a performance security from the project applicant (California Native Plant Society 1998).

Forty four percent of the agencies had policies that involved voluntary compliance by landowners, 11% involved incentives for landowner participation, and 67% involved public education (Table 11). Since much of the CMC in North Monterey County is on private property, it is important to gain the cooperation of landowners in management efforts. Without their cooperation, management becomes extremely difficult if not impossible. Providing landowner education may be one way to gain cooperation by increasing the awareness and understanding of the importance of CMC conservation efforts. Another option may be to offer incentives for voluntary participation through cost sharing programs such as the California Department of

Forestry and Fire Protection's (CDF) Vegetation Management Program (California Department of Forestry and Fire Protection 2001) and the USDA Natural Resources Conservation Service's Conservation Reserve Program (Table 11).

Agencies were asked if they had any other recommendations for protecting CMC. Related to the top management issues, the most common recommendation was for conserving more habitat through appropriate land use zoning that set aside land that could not be developed such as easements and conservation banks. Monterey County's current requirement of the use of conservation and scenic easements for proposed developments is only a partial and temporary solution to the problem of protecting sensitive species and habitats. The use of conservation easements in proposed developments is inconsistent. Some parcels have easements around all sensitive habitat not included in the development envelope, while other easements only protect a fraction of the sensitive habitat. There are even some parcels that, according to biological reports, have CMC on them, but no easement has been required. Without maintenance, monitoring, and enforcement, conservation easements are ineffective at protecting resources. For, although direct impacts to the easement, such as outright removal of sensitive species, may not occur, indirect impacts, such as invasion by non-natives, will eventually undermine the protective value of the easement.

The County has two types of Conservation and Scenic Easement Deeds: one for the coastal zone and one for the non-coastal zone (Appendix B). The two types of deeds are similar in their restrictions and requirements except that the coastal deed has four main provisions that are not included in the non-coastal deed. These provisions include

the Right of Entry, Enforcement, Maintenance, and Liability and Indemnification (Monterey County Planning and Building Inspection Department. n.d. a, n.d. b). The first three provisions are not always enforced for coastal conservation easements. Access to the easements was difficult due to the fact that although the coastal conservation deed included a Right of Entry provision, the County does not enforce it. According to a county planner, the only way to gain access to the easement was to get permission from the landowner. If the landowner did not give permission, the County would not go onto the easement. Another problem is that the Right of Entry provision only states the Grantee or its agent may enter "to ascertain whether the use restrictions set forth are being observed" (Monterey County Planning and Building Inspection Department. n.d. b, 5). It does not provide for entry to monitor the health of the vegetation or wildlife community, to maintain it, to restore it, or for research to improve ways to manage it. Currently the County does not have a monitoring or restoration program for conservation/scenic easements (Main 2002). Even though blatant violations may not be occurring, that does not ensure that the sensitive species present will not further decline. Passive management may be as harmful as direct impacts if doing nothing to the easement allows potential problems to eventually threaten the health of the easement. For example, if non-native invasive species are not controlled, they may spread out of control and impact sensitive native species. Likewise, without periodic burning, fire adapted species will decline, possibly to the point of extinction in some areas.

Even when violations occur, such as the building of structures in the easement, the County does not always enforce its right to require the Grantor to terminate the

violation and restore the damage done. The Maintenance provision, which allows the County to require the Grantor to pay for "all costs and expenses for such maintenance, improvement use, or possession," (Monterey County Planning and Building Inspection Department. n.d. b, 5) is also not always enforced.

Another significant problem encountered in the easement surveys was that the easement boundaries were not marked on the ground, making them very difficult to locate in the field. Some parcel maps were not drawn to scale, which made locating boundaries even more difficult and extremely time consuming. If one does not know where the easement is, how can it be protected? Even the most well-intentioned landowner can violate the easement restrictions, by building structures or removing vegetation in the easement, if they do not know where the easement boundaries are located. Easement boundaries need to be marked on the ground to make it easy for landowners and monitoring personnel to identify. Obvious markers may act as a deterrent to prevent easement violations from occurring by providing a constant reminder of the easement. However, in some cases, the markers may also result in some landowners building right up to the easement boundary, introducing impacts into the easement through edge effects (Van Dyke 2003). These impacts may be reduced or avoided by requiring a buffer zone of native vegetation between the easement and the development envelope (Van Dyke 2003). A poison oak buffer may provide a great deterrent to keep people away from the easement while also providing compatible native vegetation to CMC (Van Dyke 2003). GPS coordinates may also be a way to document the boundaries of the easement and should be included in the easement deed (Van Dyke

2003). Aerial photos with parcel boundaries overlaid can also provide documentation that should be included with easement deeds and monitoring data (Van Dyke 2003).

The use of buffer zones around sensitive habitats such as CMC has been recommended as a management strategy (Moore 1981; Radtke 1992; California Native Plant Society 1998; California Department of Forestry and Fire Protection 2000; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001; CPIF 2002; Delgado 2002). Several conservation organizations recommend protecting large blocks of chaparral habitats, wildlife corridors that connect them, and buffer zones around them to reduce impacts from edge effects (California Native Plant Society 1998; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001; CPIF 2002). Larger buffer zones, such as golf courses or parks in between developments and fuel reduction zones adjacent to CMC preserves, may be also useful in providing added protection to prevent fires from escaping from wildlands into developments and vice versa (Moore 1981; Radtke 1992; California Department of Forestry and Fire Protection 2000; Delgado 2002). These buffer zones should be incorporated into land use plans and developments.

Conservation areas, whether they are offsite conservation banks or onsite conservation easements, should be interconnected with larger habitat (Tippets et al. 1995; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design 2001; CPIF 2002). Various animal species are responsible for the dispersal of CMC plant species (Quinn 1990). Plant and animal species can suffer from inbreeding and succumb

to diseases and stochastic events in small, isolated populations, which may eventually lead to extinction (Fahrig and Merriam 1994; Shafer 1995).

The second most common recommendation was to conduct prescribed burns. Fire is not only important for the reproduction of fire-adapted CMC plant species but also to maintain the CMC habitats that provide food, shelter, and breeding grounds for insects and mammals. Periodic fires also reduce the fuel load in an area which in turn reduces the risk of catastrophic wildfires that may kill everything in their path (Green 1981; Moore 1981; California Department of Forestry and Fire Protection 1981, 1993; Radtke 1992; Barbour et al. 1993): entire plants and their reproductive parts such as seed banks, roots, burls; insects; animals; and even humans, when people build their homes in the chaparral. Using prescribed burning as a way to create a mosaic of different age burns can be an effective strategy for reducing fuel loads while protecting resources, encouraging the regeneration of chaparral species, and optimizing habitat for wildlife (California Department of Forestry 1981; Riggan, Franklin, and Brass 1986; Quinn 1990; CPIF 2002; Smith et al. 2002).

There is still debate over the proper burn frequency. Agency responses varied. Some said the frequency depended on various factors such as habitat, species, size of the site, risks to people, exposure, slope, topography, and natural fire return interval (Table 11). The DFG estimates the natural fire interval is about 80-120 years (Table 11). A couple agencies pointed out that the Fort Ord Habitat Management Plan suggests an interval of approximately 12-15 years (Table 11). However, 3 agencies stated that the 15-year interval was too short and the interval should be closer to 30 or 35 years (Table

11). The literature supports this view and suggests that burning at intervals of 35 to 50 years (Green 1981) or 30 to 60 years (Florence 1986) may be effective for most types of chaparral. Other researchers have found chaparral communities 100 years or older to be quite productive without burning (Keeley and Keeley 1986). Burning more frequently than 35 years may result in the conversion of shrubland to grassland (Haidinger and Keeley 1993; CPIF 2002), the loss of CMC plant and animal species (Force 1990; Quinn 1990; Haidinger and Keeley 1993), increased erosion rates, and decreased groundwater recharge (Radtke 1992). More research is needed to determine a proper burn frequency, which optimizes habitat diversity while minimizing erosion (Smith et al. 2002).

None of the agencies interviewed recommended mowing as a management strategy for CMC. This view is supported by the literature. Mowing without burning is not recommended for the regeneration of CMC because many obligate seeder chaparral species require the stimulus from fire for reproduction and mowing cannot duplicate this process (Harding ESE, Inc. 2002a). In a study conducted on the former Fort Ord army base, the density of shrubs was over 3,000 seedlings per acre (0.4 hectares) after burning compared to 29 seedlings per acre after mowing (Harding ESE, Inc. 2002a). Mowing can also disturb the soil surface and cause erosion as a result of the equipment scraping the surface and tire tracks creating ruts (Harding ESE, Inc. 2002a). However, mowing or clearing vegetation can stimulate a few chaparral species to germinate in small amounts (Harding ESE, Inc. 2002a). During field visits for this study, it was observed that in some areas where the vegetation had been cleared to bare ground along trails and around development envelopes, Pajaro manzanita and Hooker's manzanita seedlings were found.

Other recommendations include updating the General Plan policies on CMC, prioritizing sites for protection, and improving monitoring. Ensuring long-term protection for CMC will most likely be accomplished only through policy change. By using adaptive management to periodically update the General Plan and the LCP to include new information and improvements in management strategies, CMC, as well as other sensitive species and habitats, will have the best chance for survival.

CHAPTER 6

RECOMMENDATIONS

The following recommendations are general in nature. They highlight the most important issues facing resource managers when dealing with CMC plant communities. These strategies are meant to be a starting point, a foundation that can be built upon and tailored to meet a specific management program's needs. Detailed descriptions or step-by-step instructions on how to carry out a particular strategy require more research and are beyond the scope of this thesis. The most important overall recommendation is that resource managers use adaptive management to find better ways to manage this sensitive plant community. There is still not enough known about managing this community and data collection is essential to improving our knowledge.

1. Large tracts of interconnected natural habitat should be protected before development occurs. It is by far easier and less expensive to protect intact, functioning ecosystems than to try to create or restore fragmented, damaged ones.
2. Mitigation banks or conservation banks should be established to preserve large tracts of land that will not be developed.
3. Easements should be consistently designated across all sensitive habitats such that the edge to area ratio is minimized.

4. Monitoring programs should be established for scenic and conservation easements and deed restrictions to track the condition of the vegetation, identify impacts, evaluate the effectiveness of management strategies, document violations, etc. Monitoring efforts should use a combination of aerial or infrared photos with the easement and parcel boundaries overlaid and field visits. Monitoring intervals should be determined on a case-by-case basis according to factors such as the requirements of the species present, potential for impacts, maintenance or restoration efforts, etc., but should generally be done on an annual basis.
5. Monitoring, maintenance, restoration personnel, and researchers should be granted the authority for on-site access to easements and parcels as a condition of the Conservation and Scenic Easement Deed and deed restrictions. This "Right of Entry" provision should be enforced.
6. Easement boundaries must be clearly marked so that they can be easily identified in the field by landowners and monitoring personnel. A combination of several methods should be used to ensure accuracy and ease of identification. Permanent markers should be placed on the ground to physically mark boundaries. GPS coordinates should be recorded for the boundaries of each easement, and identified in the Conservation and Scenic Easement Deed and on parcel maps. Aerial photos with the easement and parcel boundaries overlaid should be provided to landowners and included with the Conservation and Scenic Easement Deed.

7. Violations of development restrictions for scenic and conservation easements and deed restrictions should be strictly enforced. Monetary fines may act as both a way to discourage landowners from violating restrictions while providing funding for monitoring efforts.
8. Incentive programs should be established, such as property tax breaks for landowners who establish conservation easements on their properties.
9. Buffer zones such as open space areas, parks, golf courses, agricultural lands, etc., should be included in subdivision design plans for use between large areas of CMC habitat or preserves and developments, to protect these sensitive habitats from human impacts. Buffer zones, adjacent to a 50 to 100 foot (15 to 30 m) firebreak, can also provide an added measure of fire safety, by protecting wildlands from fires that escape from developments and protecting developments from wildfires or prescribed burns that escape from wildlands: development | buffer | fuel break | CMC. Smaller buffer zones of native vegetation, such as poison oak, should be used on individual parcels between conservation easements and development envelopes.
10. Before a development permit is issued, a biological survey of the property should be conducted by a qualified biologist/botanist familiar with CMC habitats and species. Thorough and systematic floristic field surveys should be done during the proper times of the year when species are evident and identifiable. In addition to identifying all plant species present on the project site, these surveys should include detailed vegetation maps that show the

locations of all plant communities on the site as well as the locations and approximate numbers or percent cover of all sensitive species. These well-documented baseline reports should also identify any potential impacts to rare, threatened, or endangered species, and ways to avoid or mitigate them.

11. On parcels that will be developed, development envelopes should be clustered to preserve as much continuous open space as possible and reduce edge effects. Development clusters should be located as far away as possible from CMC habitat.
12. A program to monitor construction activities and mitigate impacts should be implemented for all proposed developments. Mitigation agreements should be required as part of a development permit and the agreement should contain assurances of implementation, monitoring, and maintenance.
13. Prescribed burning should be implemented on preserves at established intervals to create a mosaic of various vegetation age classes to promote the regeneration of CMC plant species, to manage various animals species, to prevent conversion to oak woodland, and to reduce the fuel load to prevent catastrophic fires. The interval of the prescribed burns should be determined on a case by case basis, depending on various factors such as the requirements of species present, air quality concerns, proximity to developments, safety concerns, etc. Intervals should not be less than every 25 years.
14. Mowing/cutting without burning is not recommended as a way to promote CMC regeneration.

15. A program to control and monitor invasive non-native plant species should be implemented on undeveloped and developed parcels to prevent spread from one area to another. The weed control program will vary according to the ecological requirements of the target species, but non-chemical control methods, such as the Bradley method (Fuller and Barbe 1985; Bossard, Randall, and Hoshovsky 2000), should be employed whenever feasible. Chemical methods of control can impact non-target species as well as the environment, and therefore should only be used as a last resort and only with the proper training and permits. Invasive non-native plant species that should be controlled are pampas grass (*Cortaderia jubata*), iceplant (*Carpobrotus edulis*), eucalyptus (*Eucalyptus globulus*), French broom (*Genista monspessulana*), and non-native grasses. Other invasive non-native species should be monitored to determine if they might become a threat to CMC in the future. New invaders should be eradicated or controlled as quickly as possible to prevent them from becoming established and spreading.
16. Landowners should be restricted from planting invasive non-native plants in their landscaping. Native, fire resistant plants should be used whenever possible. Local native plant nurseries can be consulted as to which species should be used. In cases where native, fire-resistant species are not locally available or available species have ecological requirements that are not compatible with CMC species, such as higher water or nutrient requirements, then some non-native species may be used as long as they are not invasive, are

fire-resistant, and are compatible with the native vegetation on site. The University of California Forest Products Laboratory has a list of fire resistant vegetation on the internet at <http://www.ucfpl.ucop.edu>, however this list includes some species that are considered invasive, such as iceplant, and those species should be avoided.

17. The removal of CMC species and the construction of paths or trails through CMC should be restricted. Public access should be also restricted or limited. If allowed, these areas should be carefully monitored and controlled for weed establishment, erosion, and other impacts.
18. Mitigation for the removal of sensitive plant species should require impacted species to be replaced on site at a minimum of a 2:1 ratio. The ratio should be higher for species that are more rare.
19. When creating a restoration program, environmental professionals with specific experience in the restoration of CMC communities should be consulted. Restoration activities should include soil preparation, weed control, and erosion control. All plant materials used for restoration and mitigation efforts such as seeds, seedlings, cuttings, etc., should be gathered from the same watershed where mitigation/restoration is occurring, to preserve local plant genetic stock and prevent hybridization of different species.
20. After prescribed burns, any surface erosion control on steep slopes involving reseeding should use deep-rooted native perennial grasses (e.g. needle grass)

and not the non-native ryegrass (*Lolium multiflorum*). Deep-rooted, dense, woody, chaparral vegetation should also be restored for permanent slope stability.

21. Sudden Oak Death Syndrome should be carefully monitored and controlled for in CMC to prevent spread to sensitive species such as coast live oak (*Quercus agrifolia*), manzanitas (*Arctostaphylos* spp.), California coffeeberry (*Rhamnus californica*), and toyon (*Heteromeles arbutifolia*).
22. All native wildlife populations should be protected. However, predators and prey that become pests should be live trapped and relocated by the Monterey SPCA when possible (Mercurio 1998). Poisons should be prohibited since they can kill animals other than the target species. Feral cats should be controlled since they can greatly impact small animal populations such as birds, rodents, amphibians, reptiles, etc. Any fencing should allow wildlife to cross. Wire fencing should have the lowest wire at least 18 inches (46 cm) above the ground and wood fencing should have at least 2 boards on a side spaced 15 inches (38 cm) apart (Mercurio 1998). Curbs should be at a low angle of 50° or less to allow invertebrates, amphibians, reptiles, and other small animals to cross over easily (Mercurio 1998). All sources of surface water should be protected and enhanced.
23. Public education programs should be implemented to increase awareness of the importance of CMC conservation and encourage community involvement and cooperation in management efforts.

CHAPTER 7

CONCLUSIONS

The biggest threat to central maritime chaparral in North Monterey County, California is habitat loss. Fire suppression is second and invasive non-native plant species are third. Consequently, the top management strategy recommended in the literature and by resource conservation agencies and organizations is that more habitat needs to be protected. However, there is still much debate over how this should be done: from the continued use of conservation easements, to the implementation of conservation banks, to the general restriction or limitation of development in central maritime chaparral.

In terms of the continued use of conservation easements, there is room for improvement in the current strategies used in North Monterey County. The current policies for conservation easements are inadequate for the protection of central maritime chaparral because of inconsistencies in designation of easement boundaries, and the lack of maintenance, restoration, monitoring, and enforcement. These issues must be addressed before easements will reach their full potential as an effective management strategy that will prevent, or at least significantly slow, the decline of this sensitive plant community.

However, easements are only one strategy that is needed to manage this habitat. Central maritime chaparral is a fire-adapted plant community and prescribed burning is necessary for its continued existence. No organism can live forever. Without fire to

stimulate the regeneration of its constituent plant species, no amount of habitat protection will save this plant community. "Community" is the key concept here. For although some central maritime chaparral species may reproduce without fire, the entire community will not. Fire suppression favors certain species over others, changing the vegetation community from one type to another.

As such, management strategies need to address the needs of this ecosystem as a whole, taking an ecosystem approach to conservation. That includes the needs of animals and insects as well. Everything is interconnected. The loss of a key species can have ramifications throughout the entire ecosystem. Concentrating management efforts on only certain needs while ignoring others may be detrimental to the survival of central maritime chaparral in the long run. Further research on the needs of this ecosystem and adaptive management will help to improve future management efforts.

Finally, public education and community involvement in central maritime chaparral management are important since the majority of the chaparral is located on private land in this part of the county. Community cooperation is essential to the success of management efforts.

ILLUSTRATIONS

Figure 1. Chamise chaparral at Sierra Azul Open Space Preserve, Santa Clara County, California.

Figure 2. Close-up of chamise chaparral. Pictured species include chamise (*Adenostoma fasciculata*), coyote brush (*Baccharis pilularis* var. *consanguinea*), coast sagebrush (*Artemisia californica*), buck brush (*Ceanothus cuneatus*), and golden yarrow (*Eriophyllum confertiflorum*).

Figure 3. Central maritime chaparral, North Monterey County, California.

Figure 4. Close-up of CMC. Pictured species include Pajaro manzanita (*Arctostaphylos pajaroensis*), coyote brush (*Baccharis pilularis*), and sticky monkey flower (*Mimulus aurantiacus*). Foreground, author surrounded by pampas grass (*Cortaderia jubata*) in disturbed areas.

Figure 5. Heavily forested northern slope of hill in North Monterey County.

Figure 6. Distributions of plant communities in North Monterey County. *Foreground*, southern slope of hill covered with CMC shrubs. *Top*, flat area at bottom of hill with grassland and scattered oaks around developments.

Figure 7. Ridgeline covered with CMC in North Monterey County.

A.

B.

Figure 8. *A* and *B*, coast live oak (*Quercus agrifolia*). Photos by Gary A. Klee.

A.

B.

Figure 9. A and B, chamise (*Adenostoma fasciculata*).

A.

B.

C.

Figure 10. *A*, *B*, and *C*, Hooker's manzanita (*Arctostaphylos hookeri* ssp. *hookeri*). Photos *A* and *B* by Gary A. Klee.

A.

B.

Figure 11. *A* and *B*, Pajaro manzanita (*Arctostaphylos pajaroensis*). Photo *A* by Gary A. Klee.

A.

B.

C.

Figure 12. A, B, and C, brittle-leaf manzanita (*Arctostaphylos tomentosa* ssp. *crustacea*). Photo A by Gary A. Klee.

A.

B.

Figure 13. *A* and *B*, coast sagebrush (*Artemisia californica*).

Figure 14. Coyote brush (*Baccharis pilularis* var. *consanguinea*). Photo by Gary A. Klee.

Figure 15. Golden yarrow (*Eriophyllum confertiflorum*).

A.

B.

Figure 16. *A* and *B*, rush-rose (*Helianthemum scoparium*).

A.

B.

Figure 17. *A* and *B*, toyon (*Heteromeles arbutifolia*).
Photos *A* and *B* by Gary A. Klee.

A.

B.

Figure 18. *A* and *B*, deerweed (*Lotus scoparius*).

A.

B.

Figure 19. *A* and *B*, sticky monkey flower (*Mimulus aurantiacus*).

Figure 20. Western bracken fern (*Pteridium aquilinum*).

A.

B.

Figure 21. *A* and *B*, California coffeeberry (*Rhamnus californica*).

A.

B.

Figure 22. *A* and *B*, black sage (*Salvia mellifera*).

Figure 23. Poison oak (*Toxicodendron diversilobum*).

A.

B.

Figure 24. *A* and *B*, Monterey ceanothus (*Ceanothus cuneatus* var. *rigidus*).

Figure 25. Habitat loss and fragmentation due to residential development.

Figure 26. Habitat loss from conversion to agricultural uses.

A.

B.

Figure 27. A and B, pampas grass (*Cortaderia jubata*) in disturbed areas along trails and roads.

A.

B.

Figure 28. *A*, CMC succeeding to oak woodland. *B*, dead manzanita under an oak tree.

A.

B.

Figure 29. Non-natives invading CMC. *A* and *B*, invasion of pampas grass (*Cortaderia jubata*) and non-native grasses in disturbed areas. *Foreground of B*, an invasion of ice plant (*Carpobrotus edulis*).

A.

B.

Figure 30. Ice plant (*Carpobrotus edulis*) invading CMC. A, ice plant choking out coyote brush (*Baccharis pilularis*). B, a mat of ice plant creeping toward CMC.

A.

B.

Figure 31. Blue gum eucalyptus (*Eucalyptus globulus*) invading CMC. *A*, low diversity of plant species in a grove of eucalyptus. *B*, only poison oak seedlings are present in this area of eucalyptus leaf litter.

A.

B.

Figure 32. *A* and *B*, mature manzanitas with high accumulation of dead wood in lower branches, due to years of fire suppression.

A.

B.

C.

Figure 33. A, B, and C, pampas grass (*Cortaderia jubata*). Photos B and C by Gary A. Klee.

A.

B.

Figure 34. *A* and *B*, Hottentot fig, ice plant (*Carpobrotus edulis*).

Figure 35. Blue gum eucalyptus (*Eucalyptus globulus*).

Figure 36. Non-native grasses. Pictured species include ripgut grass (*Bromus diandrus*) and Italian ryegrass (*Lolium multiflorum*).

A.

B.

Figure 37. *A* and *B*, *Arctostaphylos* hybrid.

Figure 38. Map of study area.

Figure 39. Parcel map overlaid on aerial photo of Study Site 1. Parcel boundaries in blue. Easement boundaries in red. In easements, lighter colored vegetation is CMC and darker vegetation woodland. *Lower easement*, Easement 1a surveyed. *Upper easement*, Easement 1b easement not surveyed. Photo by Eric Van Dyke.

A.

B.

Figure 40. *A*, Easement 1a. *B*, water towers on ridgeline trail between the two easements. Pampas grass growing in disturbed areas along trail and at base of water towers.

Figure 41. Easements 12a and 12b. *Lower easement*, Easement 12a. *Upper easement*, Easement 12b. Both easements surrounded by oak woodland. Photo by Eric Van Dyke.

A.

B.

Figure 42. *A* and *B*, Easement 12a. Pampas grass and other non-native species growing in disturbed areas throughout easement.

A.

B.

Figure 43. *A* and *B*, Easement 12b. *A*, pampas grass in adjacent easement to the right. *B*, *foreground*, nonnative grasses and ice plant growing around easement.

Figure 44. Easement 17. Pure stand of CMC over the majority of the easement. Photo by Eric Van Dyke.

A.

B.

Figure 45. *A* and *B*, Easement 17. Contains Pajaro manzanita hybrid. Non-native grasses and pampas grass present in and around easement in disturbed areas.

Figure 46. Easements 21a to 21e. *Left side, top to bottom:* Easement 21c, Easement 21a, and Easement 21e. *Right side, top to bottom:* Easement 21d and Easement 21b. Majority of easements contain woodland. *Center right,* pure stand of CMC on adjacent parcel. Photo by Eric Van Dyke.

Figure 47. Easement 21a. *Center*, narrow easement along hillside containing eucalyptus seedlings and non-native grasses. *Lower left*, rooftop of house below easement. Pajaro manzanita seedlings present in graded areas around drainage ditch between easement and house.

Figure 48. Easement 21b. *Center*, pampas grass seedlings and non-native grasses growing in disturbed areas along roadway. *Background*, eucalyptus grove adjacent to easement.

Figure 49. Easement 21c. Easement is mostly woodland containing non-native trees such as eucalyptus and black lotus. Manzanitas, present during initial botanical survey for development permit, are dead or dying under closing tree canopy.

Figure 50. Easement 21d. *Right*, CMC on ridgeline, along right side of road. Oak woodland down right side of hill. Pampas grass seedlings and non-native grasses growing along roadway. *Background*, eucalyptus grove adjacent to easement.

Figure 51. Easement 21e. *Center*, eucalyptus grove, non-native grasses, and French broom. *Background*, CMC. Ice plant adjacent to easement on the right.

Figure 52. Easement 23. Majority of CMC around house and along left side of the upper half of easement. Majority of easement is woodland composed of oak, pine, and eucalyptus. *Upper right*, pure stand of CMC on adjacent parcel. Photo by Eric Van Dyke.

Figure 53. Easement 23. *Center*, CMC on ridgeline around house. *Left*, successive habitats grading from eucalyptus to oak woodland to grassland, as move down hillside. Dead manzanitas under dense tree canopy in woodland.

Figure 54. Easements 26a and 26b. *Top*, Easement 26a. *Bottom*, Easement 26b. Pure stands of CMC located along left side and top of parcel and surrounded by oak woodland. Photo by Eric Van Dyke.

Figure 55. Easement 26a. *Upper center*, CMC along ridgeline. *Center*, oak woodland. *Left foreground*, landscaping with native species in building envelope around house.

Figure 56. Easement 26b. *Upper right*, CMC along ridgeline. *Center and left*, oak woodland. *Foreground*, landscaping with native plants in building envelope.

Figure 57. Easement 28. Central maritime chaparral and oak woodland in easement and in parcels above and below easement. Pure stand of CMC across the street to the left. Photo by Eric Van Dyke.

Figure 58. Easement 28. *Upper right*, easement with CMC next to house. *Right foreground*, eucalyptus grove on adjacent parcel.

Figure 59. Vegetation survey of an easement using a randomly placed transect along the disturbance gradient. Photo by Alfred Nakahara.

Figure 60. Vegetation survey of an easement using a 1 m² quadrat placed at 5-meter intervals along each transect. Photo by Alfred Nakahara.

Figure 61. Area of easement vs. perimeter of easement.

Figure 62. Relationship between percent cover of non-natives in transects and area of easement.

Figure 63. Relationship between percent cover of non-natives in quadrat and area of easement.

Figure 64. Relationship between percent cover of non-natives in transects and edge to area ratio of easement.

Figure 65. Relationship between percent cover of non-natives in quadrats and edge to area ratio of easement.

Figure 66. Relationship between percent cover of natives in transects and area of easement.

Figure 67. Relationship between percent cover of natives in quadrats and area of easement.

Figure 68. Relationship between percent cover of natives in transects and edge to area ratio of easement.

Figure 69. Relationship between percent cover of natives in quadrats and edge to area ratio of easement.

TABLES

Table 1. Sensitive species in central maritime chaparral of North Monterey County, California.

Plant species	Status*
<i>Arctostaphylos hookeri</i> ssp. <i>hookeri</i> (Hooker's manzanita)	CNPS List 1B / RED 2-2-3
<i>Arctostaphylos pajaroensis</i> (Pajaro manzanita)	Federal Species of Concern**; CNPS List 1B / RED 2-3-3
<i>Ceanothus cuneatus</i> var. <i>rigidus</i> (Monterey ceanothus)	Federal Species of Concern; CNPS List 4 / RED 1-2-3
<i>Chorizanthe pungens</i> var. <i>pungens</i> (Monterey spineflower)	Federally listed as Threatened; CNPS List 1B / RED 2-2-3
<i>Ericameria fasciculata</i> (Eastwood's goldenbush)	Federal Species of Concern**; CNPS List 1B / RED 3-3-3
<i>Lomatium parvifolium</i> (Small-leaved lomatium)	CNPS List 4 / RED 1-2-3
<i>Perideridia gairdneri</i> spp. <i>gairdneri</i> (Gairdner's yampah)	Federal Species of Concern; CNPS List 4 / RED 1-2-3
<i>Piperia michaelii</i> (Michael's rein orchid)	CNPS List 4 / RED 1-2-3
<i>Piperia yadonii</i> (Yadon's rein orchid)	Federally listed as Endangered; CNPS List 1B / RED 3-3-3
Animal species	Status
<i>Ambystoma macrodactylum croceum</i> (Santa Cruz long-toed salamander)	Federally listed as Endangered; State-listed as Endangered
<i>Anniella pulchra nigra</i> (Black legless lizard)	California Special Concern Species
<i>Neotoma fuscipes luciana</i> (Monterey dusky-footed woodrat)	California Special Concern Species
<i>Rana aurora draytonii</i> (California red-legged frog)	Federally listed as Threatened; California Special Concern Species

Sources: California Department of Fish and Game, Natural Diversity Database, *Special Animals List* [database on-line] (Sacramento, CA: The Resources Agency, January 2003, accessed 7 April 2003); available from <http://www.dfg.ca.gov/whdab/spanimals.pdf>; Internet; California Department of Fish and Game, Natural Diversity Database, *Special vascular plants, bryophytes, and lichens list* [database on-line] (Sacramento, CA: The Resources Agency, January 2003, accessed 7 April 2003); available from <http://www.dfg.ca.gov/whdab/SPPlants.pdf>; Internet; David P. Tibor, ed., *California Native Plant Society's inventory of rare and endangered plants of California*, Sixth ed.

(Sacramento, CA: California Native Plant Society, 2001), 76, 79, 116, 124, 152, 206, 243, 251; Elkhorn Slough Foundation and Tom Scharffenberger Land Planning and Design, *Elkhorn Slough at the crossroads* (Moss Landing, CA: Elkhorn Slough Foundation, 2001), 23-29.

Notes: * CNPS "LIST 1B: PLANTS RARE, THREATENED, OR ENDANGERED IN CALIFORNIA AND ELSEWHERE" (David P. Tibor, ed., *California Native Plant Society's inventory of rare and endangered plants of California*, Sixth ed. [Sacramento, CA: California Native Plant Society, 2001], 54). CNPS "LIST 4 = PLANTS OF LIMITED DISTRIBUTION - A WATCH LIST" (David P. Tibor, ed., *California Native Plant Society's inventory of rare and endangered plants of California*, Sixth ed. [Sacramento, CA: California Native Plant Society, 2001], 55).

CNPS R-E-D Code definitions:

- R-RARITY

1. Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time
2. Distributed in a limited number of occurrences, occasionally more if each occurrence is small
3. Distributed in one to several highly restricted occurrences, or present in such small numbers that it is seldom reported

- E-ENDANGERMENT

1. Not endangered
2. Endangered in a portion of its range
3. Endangered throughout its range

- D-DISTRIBUTION

1. More or less widespread outside California
2. Rare outside California
3. Endemic to California (David P. Tibor, ed., *California Native Plant Society's inventory of rare and endangered plants of California*, Sixth ed. [Sacramento, CA: California Native Plant Society, 2001], 55-56)

** listed as a Federal Species of Concern in Elkhorn Slough Foundation source citation but not in California Department of Fish and Game source citation.

Table 2. List of species encountered in easement vegetation surveys.

SCIENTIFIC NAME	COMMON NAME	FAMILY
<i>Achillea millefolium</i>	Common yarrow	ASTERACEAE
<i>Adenostoma fasciculatum</i>	Chamise	ROSACEAE
<i>Aira caryophylla</i>	Silvery hair-grass	POACEAE
<i>Anagallis arvensis</i>	Scarlet pimpernel	PRIMULACEAE
<i>Arctostaphylos hookeri</i> ssp. <i>hookeri</i>	Hooker's manzanita	ERICACEAE
<i>Arctostaphylos pajaroensis</i>	Pajaro manzanita	ERICACEAE
<i>Arctostaphylos pajaroensis</i> hybrid		ERICACEAE
<i>Arctostaphylos tomentosa</i> ssp. <i>crustacea</i>	Brittle-leaf manzanita	ERICACEAE
<i>Artemisia douglasiana</i>	California mugwort	ASTERACEAE
<i>Artemisia californica</i>	California sagebrush	ASTERACEAE
<i>Avena barbata</i>	Slender wild oat	POACEAE
<i>Avena fatua</i>	Wild oat	POACEAE
<i>Baccharis pilularis</i> var. <i>consanguinea</i>	Coyote brush	ASTERACEAE
<i>Bromus diandrus</i>	Ripgut grass	POACEAE
<i>Bromus hordeaceus</i>	Soft chess	POACEAE
<i>Calamagrostis koelerioides</i>	Tufted pine grass	POACEAE
<i>Carduus pycnocephalus</i>	Italian thistle	ASTERACEAE
<i>Carpobrotus edulis</i>	Hottentot fig, Iceplant	AIZOACEAE
<i>Castilleja foliolosa</i>	Woolly Indian paintbrush	SCROPHULARIACEAE
<i>Ceanothus cuneatus</i> var. <i>rigidus</i>	Monterey ceanothus	RHAMNACEAE
<i>Ceanothus thyrsiflorus</i>	Blue blossom	RHAMNACEAE
<i>Chlorogalum pomeridianum</i>	Soap plant, amole	LILIACEAE
<i>Conyza bonariensis</i>	South American conyza	ASTERACEAE
<i>Conyza canadensis</i>	Horseweed	ASTERACEAE
<i>Cortaderia jubata</i>	Pampas grass	POACEAE
<i>Cotoneaster</i> sp.	Cotoneaster	ROSACEAE
<i>Dactylis glomerata</i>	Orchard grass, Barnyard grass	POACEAE
<i>Dryopteris arguta</i>	Wood fern	DRYOPTERIDACEAE
<i>Dudleya cymosa</i>	Dudleya, Rock lettuce	CRASSULACEAE
<i>Epilobium brachycarpum</i>	Panicled willow herb	ONAGRACEAE

Table 2 - *Continued.*

SCIENTIFIC NAME	COMMON NAME	FAMILY
Eriophyllum confertiflorum	Golden yarrow	ASTERACEAE
<i>Eucalyptus globulus</i>	Blue gum, Eucalyptus	MYRTACEAE
<i>Euphorbia peplus</i>	Petty spurge	EUPHORBIACEAE
<i>Filago gallica</i>	Narrow-leaved filago	ASTERACEAE
Galium californicum	California bedstraw	RUBIACEAE
Garrya elliptica	Coast silk-tassel	GARRYACEAE
<i>Genista monspessulana</i>	French broom	FABACEAE
Gnaphalium californicum	California everlasting	ASTERACEAE
Gnaphalium canescens ssp. beneolens	Fragrant everlasting	ASTERACEAE
<i>Gnaphalium luteo-album</i>	Weedy cudweed	ASTERACEAE
Gnaphalium purpureum	Purple cudweed	ASTERACEAE
<i>Hedera helix</i>	English ivy	ARALIACEAE
Helianthemum scoparium	Rush-rose	CISTACEAE
Heteromeles arbutifolia	Toyon	ROSACEAE
Heterotheca grandiflora	Telegraph weed	ASTERACEAE
<i>Holcus lanatus</i>	Velvet grass	POACEAE
Hordeum vulgare	Common barley	POACEAE
<i>Hypochaeris glabra</i>	Smooth cat's ear	ASTERACEAE
<i>Hypochaeris radicata</i>	Hairy cat's ear	ASTERACEAE
Juncus occidentalis	Western rush	JUNCACEAE
Juncus sp.	Rush	JUNCACEAE
Juniperus californica	California juniper	CUPRESSACEAE
Lepechinia calycina	Pitcher sage	LAMIACEAE
<i>Lolium multiflorum</i>	Italian ryegrass	POACEAE
Lotus scoparius	Deerweed	FABACEAE
Marah fabaceus	Wild cucumber	CUCURBITACEAE
<i>Medicago polymorpha</i>	Bur-clover	FABACEAE
<i>Mentha spicata</i>	Spearmint	LAMIACEAE
Mimulus aurantiacus	Sticky monkey flower	SCROPHULARIACEAE
<i>Myoporum sp.</i>		MYOPORACEAE
Opuntia sp.	Cactus	CACTACEAE
Oxalis albicans ssp. pilosa	Hairy wood-sorrel	OXALIDACEAE
Pinus radiata	Monterey pine	PINACEAE
Plantago erecta	California plantain	PLANTAGINACEAE
<i>Plantago lanceolata</i>	English plantain, Ribgrass	PLANTAGINACEAE

Table 2 - *Continued.*

SCIENTIFIC NAME	COMMON NAME	FAMILY
<i>Polygonum arenastrum</i>	Common knotweed	POLYGONACEAE
<i>Polypogon monspeliensis</i>	Rabbitfoot grass	POACEAE
<i>Prunus</i> sp.		ROSACEAE
<i>Pteridium aquilinum</i> var. pubescens	Western bracken fern	DENNSTAEDTIACEAE
<i>Quercus agrifolia</i>	Coast live oak	FAGACEAE
<i>Rhamnus californica</i>	California coffeeberry	RHAMNACEAE
<i>Robinia pseudoacacia</i>	Black locust	FABACEAE
<i>Rosa californica</i>	California wild rose	ROSACEAE
<i>Rosa gymnocarpa</i>	Wood rose	ROSACEAE
<i>Rubus parviflorus</i>	Thimbleberry	ROSACEAE
<i>Rubus ursinus</i>	California blackberry	ROSACEAE
<i>Rumex acetosella</i>	Sheep sorrel	POLYGONACEAE
<i>Salvia mellifera</i>	Black sage	LAMIACEAE
<i>Silene gallica</i>	Catchfly, Windmill pink	CARYOPHYLLACEAE
<i>Sonchus oleraceus</i>	Common sow thistle	ASTERACEAE
<i>Stachys bullata</i>	Wood mint, Calif. hedge-nettle	LAMIACEAE
<i>Symphoricarpos mollis</i>	Creeping snowberry	CAPRIFOLIACEAE
<i>Taraxacum officinale</i>	Common dandelion	ASTERACEAE
<i>Toxicodendron diversilobum</i>	Poison oak	ANACARDIACEAE
<i>Trifolium hirtum</i>	Rose clover	FABACEAE
<i>Trifolium pratense</i>	Red clover	FABACEAE
<i>Vitis</i> sp.	Grape	VITACEAE
<i>Vulpia myuros</i> var. <i>hirsuta</i>	Foxtail fescue	POACEAE
<i>Zigadenus fremontii</i> var. fremontii	Fremont's star lily	LILIACEAE

Notes: nomenclature follows James C. Hickman, ed., *The Jepson Manual: Higher plants of California* (Berkeley, CA: University of Californian Press, 1993), 89-1312. Native species are in bold print.

Table 3. Dimensions of easements and distances to sources of non-natives and chaparral.

Easement	Area* (m ²)	Perimeter* (m)	Edge to area ratio**	Distance to nearest source of non-natives*** (m)	Distance to nearest source of maritime chaparral*** (m)
1a	2134.3	197.7	0.09	0	0
12a	473.5	117.8	0.25	0	0
12b	3118.6	325.8	0.10	0	0
17	3437.3	721.5	0.21	0	0
21a	245.7	75.4	0.31	0	20
21b	722.7	126.8	0.18	0	10
21c	4563.6	359.1	0.08	0	35
21d	10745.4	557.0	0.05	0	0
21e	643.8	166.6	0.26	0	0
23	10303.3	648.5	0.06	0	0
26a	15228.6	838.3	0.06	20	0
26b	5269.1	409.4	0.08	130	0
28	1777.2	226.1	0.13	5	0

Source: Eric Van Dyke, GIS coordinator, correspondence with author, 2 September 2002, email, Elkhorn Slough Foundation, Watsonville, CA.

Notes: * data obtained from source citation. ** Edge to area ratio values calculated by dividing Area by Perimeter. *** Distance measurements made using parcels maps superimposed on aerial photos obtained from source citation.

Table 4. Density and percent cover of non-native species per easement.

Easement	Area (hectares)	Transect measurements		Quadrat measurements	
		Density (# of non- native species per hectare)	Average percent cover of live and dead non-native species (%)	Density (# of non- native species per hectare)	Average percent cover of live and dead non-native species (%)
1a	0.21	48	16	48	15
12a	0.05	160	74	160	48
12b	0.31	26	19	23	19
17	0.34	41	20	29	16
21a	0.02	550	68	450	33
21b	0.07	29	0	0	0
21c	0.46	26	24	15	13
21d	1.07	3	28	2	28
21e	0.06	100	89	117	70
23	1.03	13	26	8	23
26a	1.52	1	0	1	0
26b	0.53	0	0	2	1
28	0.18	22	2	33	2

Table 5. Density and percent cover of native species per easement.

Easement	Area (hectares)	Transect measurements		Quadrat measurements	
		Density (# of native species per hectare)	Average percent cover of live and dead native species (%)	Density (# of native species per hectare)	Average percent cover of live and dead native species (%)
1a	0.21	71	123	62	106
12a	0.05	200	69	200	59
12b	0.31	35	100	35	85
17	0.34	59	90	59	83
21a	0.02	450	49	550	29
21b	0.07	129	95	86	90
21c	0.46	28	221	24	173
21d	1.07	17	144	14	106
21e	0.06	150	36	133	36
23	1.03	20	141	21	116
26a	1.52	7	88	7	84
26b	0.53	21	168	25	157
28	0.18	78	85	72	79

Table 6. Percent cover and frequency of live and dead rare species per easement.

Easement	Transect measurements		Quadrat measurements		Quadrat measurements	
	Average percent cover of live rare species (%)	Average percent cover of dead rare species (%)	Average percent cover of live rare species (%)	Average percent cover of dead rare species (%)	Frequency of live rare species (% of quadrats)	Frequency of dead rare species (% of quadrats)
1a	37	1	36	0	50	0
12a	19	0	15	0	38	0
12b	9	0	8	0	14	0
17	42	7	37	5	67	14
21a	0	0	1	0	40	20
21b	21	11	15	15	27	35
21c	2	8	1	6	4	8
21d	8	13	8	14	10	22
21e	1	1	0	4	4	4
23	8	4	7	3	8	10
26a	36	10	28	13	32	22
26b	8	3	2	11	7	25
28	37	1	34	5	47	8

Table 7. Product moment correlation analysis of non-native cover.

x	y	Value of correlation coefficient r (with 11 degrees of freedom)	Meaning*	Level of significance (r = 0.553 at $\alpha = 0.05$)
% cover of non-natives for transects	Area	-0.41	A modest correlation	Not significant
% cover of non-natives for quadrats	Area	-0.33	A weak correlation	Not significant
% cover of non-natives for transects	Edge to area ratio	0.73	A strong correlation	Significant
% cover of non-natives for quadrats	Edge to area ratio	0.60	A modest correlation	Significant
% cover of non-natives for transects	Distance to nearest source of non-natives	-0.34	A weak correlation	Not significant
% cover of non-natives for quadrats	Distance to nearest source of non-natives	-0.35	A weak correlation	Not significant
% cover of non-natives for transects	Distance to nearest source of chaparral	0.09	A very weak correlation	Not significant
% cover of non-natives for quadrats	Distance to nearest source of chaparral	-0.08	A very weak correlation	Not significant

Notes: * meaning of the correlation coefficient taken directly from descriptive interpretations presented in Table 14.1 in Jim Fowler, Lou Cohen, and Phil Jarvis, *Practical statistics for field biology*, Second ed. (New York: John Wiley & Sons Ltd., 1998), 132.

Table 8. Product moment correlation analysis of native cover.

x	y	Value of correlation coefficient r (with 11 degrees of freedom)	Meaning*	Level of significance (r = 0.553 at $\alpha = 0.05$)
% cover of natives for transects	Area	0.37	A weak correlation	Not significant
% cover of natives for quadrats	Area	0.36	A weak correlation	Not significant
% cover of natives for transects	Edge to area ratio	-0.74	A strong negative correlation	Significant
% cover of natives for quadrats	Edge to area ratio	-0.77	A strong negative correlation	Significant
% cover of natives for transects	Distance to nearest source of non-natives	0.33	A weak correlation	Not significant
% cover of natives for quadrats	Distance to nearest source of non-natives	0.46	A modest correlation	Not significant
% cover of natives for transects	Distance to nearest source of chaparral	0.40	A modest correlation	Not significant
% cover of natives for quadrats	Distance to nearest source of chaparral	0.29	A weak correlation	Not significant

Notes: * meaning of the correlation coefficient taken directly from descriptive interpretations presented in Table 14.1 in Jim Fowler, Lou Cohen, and Phil Jarvis, *Practical statistics for field biology*, Second ed. (New York: John Wiley & Sons Ltd., 1998), 132.

Table 9. Habitat management concerns for CMC with the highest priority.

	Which management concern for CMC has the highest priority?			
	Loss of habitat.	Habitat fragmentation.	Fire suppression.	Invasive non-native plant species.
California Coastal Commission	Yes.			
US Bureau of Land Management Fort Ord			Yes.	
US Fish and Wildlife Service	Yes.			
USDA Natural Resources Conservation Service				Yes.
California Department of Fish and Game		Yes – On regulated lands.	Yes – On DFG lands.	
County of Monterey Planning and Building Inspection		Yes.		Yes.
Monterey County Parks				Yes.
California Native Plant Society, Monterey Bay Chapter			Yes.	
Elkhorn Slough Foundation		Yes.		
Percentage with “yes” responses.	22%	33%	33%	33%

Table 10. Summary of interviews with agencies and organizations.

	Do your principal management plans or policies for CMC involve any of the following tools?:				
	Conservation Easements?	Impact restrictions?	Mitigations?	Prescribed burning?	Mowing?
California Coastal Commission	Yes.	Yes.	Yes.	No.	No.
US Bureau of Land Management Fort Ord	No.	Yes.	Yes.	Yes.	No.
US Fish and Wildlife Service	Yes.	Yes.	Yes.	Yes.	No.
USDA Natural Resources Conservation Service	No.	Yes.	Yes.	Yes.	No.
California Department of Fish and Game	Yes.	Yes.	Yes.	No.	No.
County of Monterey Planning and Building Inspection	Yes.	Yes.	Yes.	No.	No.
Monterey County Parks	No.	Yes.	No.	No.	No.
California Native Plant Society, Monterey Bay Chapter	Yes.	Yes.	Yes.	Yes.	No.
Elkhorn Slough Foundation	No.	Yes.	No.	No.	No.
Percentage with "yes" responses.	56%	100%	78%	44%	0%

Table 10 - *Continued.*

	Do your principal management plans or policies for CMC involve any of the following tools?:				
	Control of invasives?	Restoration?	Monitoring?	Enforcement?	Specific policies for CMC?
California Coastal Commission	No.	Yes.	Yes.	Yes.	Yes.
US Bureau of Land Management Fort Ord	Yes.	Yes.	Yes.	Yes.	Yes.
US Fish and Wildlife Service	Yes.	Yes.	Yes.	Yes.	No.
USDA Natural Resources Conservation Service	Yes.	Yes.	Yes.	Yes.	No.
California Department of Fish and Game	Yes.	Yes.	Yes.	Yes.	No.
County of Monterey Planning and Building Inspection	Yes.	No.	No.	Yes.	Yes.
Monterey County Parks	Yes.	No.	No.	No.	No.
California Native Plant Society, Monterey Bay Chapter	Yes.	Yes.	Yes.	Yes.	No.
Elkhorn Slough Foundation	Yes.	Yes.	Yes.	No.	Yes.
Percentage with "yes" responses.	89%	78%	78%	78%	44%

Table 11. Interviews with agencies and organizations.

	What types of lands do you work with?
California Coastal Commission	All types.
US Bureau of Land Management Fort Ord	Public lands.
US Fish and Wildlife Service	All types that contain listed, proposed, or candidate species under the ESA and narrowly endemic species that may need listing in the future.
USDA Natural Resources Conservation Service	Agricultural, State, and Federal lands.
California Department of Fish and Game	All types of public and private lands that require review under CEQA.
County of Monterey Planning and Building Inspection	All types.
Monterey County Parks	Monterey County Parks.
California Native Plant Society, Monterey Bay Chapter	All types, except agricultural lands which are exempt from CEQA.
Elkhorn Slough Foundation	All lands within Elkhorn Slough Watershed, except government lands.

Table 11 - *Continued.*

	What are your organization's habitat management concerns for CMC?	Which concern has the highest priority?
California Coastal Commission	Loss of habitat: habitat fragmentation, invasive non-native plant species, and fire suppression.	Loss of habitat.
US Bureau of Land Management Fort Ord	Fire suppression, invasive non-native plant species, erosion, overuse from recreation, and residential development.	Fire suppression. If prescribed burning is done, everything else is doable.
US Fish and Wildlife Service	Invasive non-native plant species, loss of habitat, and fire suppression.	Loss of habitat.
USDA Natural Resources Conservation Service	Invasive non-native plant species, loss of habitat, and fire suppression.	Invasive non-native plant species.
California Department of Fish and Game	Fragmentation, invasive non-native plant species, and fire suppression.	Fire suppression on DFG lands; fragmentation on regulated lands.
County of Monterey Planning and Building Inspection	Fire suppression, invasive non-native plant species, and fragmentation.	Invasive non-native plant species and fragmentation.
Monterey County Parks	Invasive non-native plant species, Sudden Oak Death Syndrome, and fire suppression.	Invasive non-native plant species.
California Native Plant Society, Monterey Bay Chapter	Fire suppression, fragmentation, transplantation, seed collection, and invasive non-native plant species.	Fire suppression.
Elkhorn Slough Foundation	Habitat fragmentation, fire suppression, protected species, and invasive non-native plant species.	Habitat fragmentation.

Table 11 - *Continued.*

	Do your principal management plans or policies for CMC involve any of the following tools?: Easements?	Do you require easements?
California Coastal Commission	Yes.	No. The Monterey County Local Coastal Program does.
US Bureau of Land Management Fort Ord	No conservation easements. At Fort Ord, there are utility easements, right of way easements, and access easements.	No.
US Fish and Wildlife Service	Yes.	Require easements for listed species. Recommend easements for unlisted species.
USDA Natural Resources Conservation Service	No.	N/A
California Department of Fish and Game	Yes.	Yes. Sometimes DFG requires them. Sometimes recommends other local lead agencies to require them.
County of Monterey Planning and Building Inspection	Yes.	Yes, for proposed developments.
Monterey County Parks	No.	N/A
California Native Plant Society, Monterey Bay Chapter	Yes. Encourage other agencies to take easements, but our CNPS chapter has never accepted one.	N/A
Elkhorn Slough Foundation	No. Maybe in the future. Currently have fee acquisitions: purchase land for conservation.	N/A

Table 11 - *Continued.*

	How is it determined where to place the easement on a parcel?
California Coastal Commission	It should be determined by the extent of the environmentally sensitive habitat area (ESHA). A biologist surveys the site and plots areas of chaparral on a map and the map is used to record the offer to dedicate.
US Bureau of Land Management Fort Ord	N/A
US Fish and Wildlife Service	(No information provided.)
USDA Natural Resources Conservation Service	N/A
California Department of Fish and Game	When DFG requires where to put an easement, it is related to a listed species. When DFG recommends or requires a local lead agency to use an easement, identify project area and put easement over everything else.
County of Monterey Planning and Building Inspection	Based on recommendations from biologist in biological report.
Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	N/A
Elkhorn Slough Foundation	N/A

Table 11 - *Continued.*

	How successful has this tool been in protecting CMC, on a scale from 0-4, with 0 being unsuccessful and 4 being successful?
California Coastal Commission	Don't know. It is one step in protecting the habitat type. The other step is managing it...which means burning.
US Bureau of Land Management Fort Ord	N/A
US Fish and Wildlife Service	Listed plant species have limited protection on private lands. Listed plants don't have same protection as listed animals.
USDA Natural Resources Conservation Service	N/A
California Department of Fish and Game	1, on private property. Habitat area is much larger than what is owned by a single landowner and to reinitiate a fire regime in an area interspersed with houses is not possible. Difficult to enforce easements on private property. Easements don't resolve conservation problem, which is a fire issue.
County of Monterey Planning and Building Inspection	3. Pretty effective. Over time it is even more effective. Slowly raising awareness. Requiring more conditions. Neighbors or long time residents know that a subdivision was approved with conservation easements. If they see a violation, they will report it.
Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	Not very successful because of lack of monitoring.
Elkhorn Slough Foundation	N/A

Table 11 - *Continued.*

	Impact restrictions?	What kinds of restrictions?
California Coastal Commission	Yes.	Refer to the LCP. No removal of plants; no building structures in chaparral; no trails; no grading; no building on slopes exceeding 25%, etc.
US Bureau of Land Management Fort Ord	Yes.	2% development restriction: out of 7200 acres, can only develop 140 acres. Restrict public access and use.
US Fish and Wildlife Service	Yes.	Depends on level of protection. Prohibit further decline of species. Make recommendations on restrictions for unlisted species; do not require them.
USDA Natural Resources Conservation Service	Yes.	Avoid endangered and threatened species; prevent erosion by keeping livestock from degrading habitat; and discourage farming on slopes exceeding 15%.
California Department of Fish and Game	Yes.	Restrict any activity that would damage the resources for which the easement is established.
County of Monterey Planning and Building Inspection	Yes.	Impact restrictions are mainly for coastal zone. Can't convert CMC to agricultural uses. Try to avoid pristine CMC 100%; may require land to be re-subdivided to cluster development. Non-coastal zone is not well protected; can still do grubbing.
Monterey County Parks	Yes.	All open space is preserved as open space. Only actively manage trail system for public safety and do weed control. Don't cut, burn, or spray CMC. Leave CMC in its existing condition for nature to take care of.
California Native Plant Society, Monterey Bay Chapter	Yes.	No mowing in areas of habitat preservation; minimize any disturbance to habitat, such as clearing for firebreaks; and do not seed with rye grass for erosion control after burns.
Elkhorn Slough Foundation	Yes.	No bikes, motorcycles, or equestrian uses. Hiking allowed; dogs must be on a leash. Sustainable agriculture allowed in accordance with lease. Try to take steep slopes out of agricultural production through fee acquisition.

Table 11 - *Continued.*

	How successful has this tool been?	Mitigations for impacts?
California Coastal Commission	Probably 1. Better than nothing.	Yes.
US Bureau of Land Management Fort Ord	3. Still have impacts from horses spreading weeds through manure and erosion from trail use and maintenance.	Yes.
US Fish and Wildlife Service	2 on Fort Ord because has large contiguous blocks of habitat that can be managed with fire and can reduce edge effects. Outside of Fort Ord, fragmentation does not make it adequately successful.	Yes.
USDA Natural Resources Conservation Service	2. Future restrictions are needed to protect ridgelines from over-development.	Yes.
California Department of Fish and Game	1 or 2. Lack of enforcement has been the big issue.	Yes.
County of Monterey Planning and Building Inspection	Best thing is a conservation easement for protection.	Yes.
Monterey County Parks	4. In terms of the second-generation growth, it has been successful.	No.
California Native Plant Society, Monterey Bay Chapter	3 to 4 on BLM lands. 0 to 1 on private lands.	Yes.
Elkhorn Slough Foundation	85% successful.	No.

Table 11 - *Continued.*

	What kinds of mitigations?
California Coastal Commission	Depends on the impacts. This could be done if recommended by the biologist who has surveyed the site.
US Bureau of Land Management Fort Ord	Mitigations determined on a case-by-case basis. Choose best time of year to do projects. Repair activities after projects. For example, a mountain bike race damaged trails. Got money from event planner to pay for repairs. Require equestrian groups to pick up manure at staging area.
US Fish and Wildlife Service	Require mitigations for listed species. Recommend mitigations for unlisted species. Habitat protection provides best chance of long-term viability. Off-site preservation has more conservation value. On-site preservation is not manageable due to housing and human encroachment. Use conservation banks to protect larger areas of relatively intact habitat instead of protecting small bits on site.
USDA Natural Resources Conservation Service	1:1 ratio for replacement of native plant species that are removed; control invasive exotic plant species where possible if the landowner agrees; and control excessive erosion by vegetative methods or structural practices as needed.
California Department of Fish and Game	Need to work on a larger scale, at biggest possible acreage. Concentrate on policy at the County General Plan level rather than on a 5-acre parcel with a single-family dwelling. The smaller the parcel the harder it is to preserve habitat. For appropriate mitigation, it is easier to identify a conservation bank area rather than try to implement conservation on every little parcel.
County of Monterey Planning and Building Inspection	Mitigate in terms of replacement of CMC that is removed. If historical grading on site and only place to put house is in degraded CMC, sometimes allow removal and transplantation of CMC to a better location.

Table 11 - *Continued.*

Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	Weed control and erosion control after fire, mowing, and detonation of unexploded ordnance on Fort Ord lands; and avoid use of transplanting due to inadequacies.
Elkhorn Slough Foundation	May work with other agencies or organizations in the future to purchase land for mitigation (mitigation banks).

Table 11 - *Continued.*

	How successful has this tool been?	Prescribed burning?
California Coastal Commission	Don't know. No one to follow up on permits.	We would probably not recommend this.
US Bureau of Land Management Fort Ord	4	Yes.
US Fish and Wildlife Service	1	Yes, recommend it for Fort Ord in HMP. Prescribed burn plan is not developed yet.
USDA Natural Resources Conservation Service	3	Yes.
California Department of Fish and Game	1 or 2. Hard to conserve chaparral on 5-acre parcels.	No.
County of Monterey Planning and Building Inspection	(No information provided.)	No, except on Fort Ord by the Army.
Monterey County Parks	N/A	No.
California Native Plant Society, Monterey Bay Chapter	3 to 4 on BLM lands. 1 to 2 on private lands because of rough mowing.	Yes. Burn and let burn where public health and esthetic values can be protected; burn instead of mow whenever possible; time burns to mimic natural regime as close as possible; minimize disturbance as much as possible during burns; and weed control after a fire.
Elkhorn Slough Foundation	N/A	No, but it remains an option.

Table 11 - *Continued.*

	Which agency is responsible for conducting the burn?	How often is it done?
California Coastal Commission	N/A	The answer to this question would depend on the site...how big is the site, what are the risks to neighbors, what is the exposure, slope, topography, species assemblage...
US Bureau of Land Management Fort Ord	In the past: US Army, Navy, and North Tree Fire.	HMP suggests 12-15 year rotation. Most people think that's too frequent. Burn plan actual frequency maybe closer to 100 years due to logistical difficulties. The closer to 35 years, the better. Maritime chaparral needs to burn less frequently than inland chaparral.
US Fish and Wildlife Service	N/A	15-year interval is too short. Should be closer to 30 years.
USDA Natural Resources Conservation Service	California Department of Forestry and Fire Protection on rangeland and open spaces.	Not widely used in the Elkhorn Watershed.
California Department of Fish and Game	N/A	Natural fire return interval is approximately 80-120 years. Prescribed burning interval depends on location and other management considerations such as patch size and fire return interval.
County of Monterey Planning and Building Inspection	N/A	N/A
Monterey County Parks	N/A	N/A
California Native Plant Society, Monterey Bay Chapter	U.S. Army has conducted burns on Fort Ord lands.	Every 10-15 years by Army at Fort Ord. Natural interval is about every 30 years.
Elkhorn Slough Foundation	CDF, County, DFG, and FWS.	Frequency depends on habitat and species.

Table 11 - *Continued.*

	How successful has this tool been?	Mowing?	How often is it done?
California Coastal Commission	Don't know.	We would not recommend this.	N/A
US Bureau of Land Management Fort Ord	Don't know.	No. Mowing results in young stands that are homogeneous and lack fire dependent natives.	Army has mowed several hundreds of acres in past years.
US Fish and Wildlife Service	N/A	No. Don't recommend it, although Army does it. Rare species in chaparral are not burl sprouters; require regeneration by seed.	N/A
USDA Natural Resources Conservation Service	N/A	No.	N/A
California Department of Fish and Game	N/A	No. Sometimes done in preserves but not in chaparral.	N/A
County of Monterey Planning and Building Inspection	N/A	No.	N/A
Monterey County Parks	N/A	No.	N/A
California Native Plant Society, Monterey Bay Chapter	Don't know.	No.	N/A
Elkhorn Slough Foundation	N/A	No.	N/A

Table 11 - *Continued.*

	How successful has this tool been?	Control of invasive non-native plant species?
California Coastal Commission	Don't know.	This is usually a condition of approval imposed by the County.
US Bureau of Land Management Fort Ord	1. Maybe better than nothing in areas where prescribed burning is not possible.	Yes. Treat small outlying infestations first; working towards larger core infestations.
US Fish and Wildlife Service	N/A	Yes, recommend it.
USDA Natural Resources Conservation Service	N/A	Yes. NRCS does not do pest control, the Resource Conservation District does.
California Department of Fish and Game	N/A	Yes.
County of Monterey Planning and Building Inspection	N/A	Yes.
Monterey County Parks	N/A	Yes.
California Native Plant Society, Monterey Bay Chapter	N/A	Yes.
Elkhorn Slough Foundation	N/A	Yes.

Table 11 - *Continued.*

	Which invasive plant species are the biggest threats to CMC?	How successful has this tool been?
California Coastal Commission	Call CNPS to discuss this issue.	Don't know. No follow up - no way to know for sure.
US Bureau of Land Management Fort Ord	Ice plant, pampas grass, and French broom.	3
US Fish and Wildlife Service	Pampas grass, non-native annual grasses, broom, and ice plant.	3, on Fort Ord.
USDA Natural Resources Conservation Service	Pampas grass, eucalyptus, and ice plant.	2
California Department of Fish and Game	Pampas grass and eucalyptus.	3 if low level infestation; harder to control for well-established infestations.
County of Monterey Planning and Building Inspection	Pampas grass and eucalyptus.	Not really working. Pampas grass is hard to get rid of. Need to figure out a simple, easy, effective method of control.
Monterey County Parks	Pampas grass, French broom, ice plant, and eucalyptus.	4. By reducing competition of aggressive non-native plants, the established chaparral is able to mature as it did prior to the introduction of the non-natives.
California Native Plant Society, Monterey Bay Chapter	Pampas grass.	3 to 4 on BLM lands.
Elkhorn Slough Foundation	Velt grass, Acacia, and pampas grass.	3

Table 11 - *Continued.*

	Restoration?	How successful has this tool been?
California Coastal Commission	We would recommend restoration if development occurred without a permit.	Don't know. Not a tool to protect - used after habitat has been damaged.
US Bureau of Land Management Fort Ord	Yes.	3 for the restoration of plants. 4 for getting people involved, partnerships formed, and environmental education.
US Fish and Wildlife Service	Yes, recommend it. Need on the ground land managers.	2
USDA Natural Resources Conservation Service	Yes. Use a Resource Management System approach to conservation planning. Requires building a trusting relationship with landowner. Ultimately landowner makes decision with NRCS technical assistance.	3
California Department of Fish and Game	Yes.	2
County of Monterey Planning and Building Inspection	No. Current policy is to deal with existing chaparral. Need to develop a restoration program as the next step.	N/A
Monterey County Parks	No	N/A
California Native Plant Society, Monterey Bay Chapter	Yes.	1, but techniques are improving.
Elkhorn Slough Foundation	Yes, in former agricultural fields adjacent to chaparral to stop gully erosion. Provide opportunity for chaparral to move into these areas through succession.	4 in agricultural fields.

Table 11 - *Continued.*

	Monitoring?	Who does the monitoring?
California Coastal Commission	Yes.	This is the problem. Usually the applicant or biologist on contract to the applicant, but usually only if restoration is required.
US Bureau of Land Management Fort Ord	Yes.	BLM on BLM lands. Harding and Associates on Army land.
US Fish and Wildlife Service	Yes for listed species.	Not FWS.
USDA Natural Resources Conservation Service	Yes. Limited staff and time. Do not regularly monitor maritime chaparral. Policy of avoiding threatened and endangered species. Put up temporary fence or 20 foot buffer to prevent damaging plants.	NRCS.
California Department of Fish and Game	Yes, but not much.	DFG does a little bit of rare plant mapping.
County of Monterey Planning and Building Inspection	No. Starting to work on it.	N/A
Monterey County Parks	No.	N/A
California Native Plant Society, Monterey Bay Chapter	Yes. Develop baseline data before prescribed burns and monitor for 5 years afterward to identify and quantify annual fire followers.	BLM staff and volunteers on BLM lands.
Elkhorn Slough Foundation	Yes.	ESF Land manager and assistant land steward.

Table 11 - *Continued.*

	How often is the monitoring done?
California Coastal Commission	There are several types of monitoring: compliance and effectiveness monitoring. First you need to determine what you are monitoring for then you can ask the question how long it would be appropriate. Usually once a year for 5 years.
US Bureau of Land Management Fort Ord	Ongoing. Official monitoring is on an annual basis.
US Fish and Wildlife Service	N/A
USDA Natural Resources Conservation Service	1 to 15 years depending on the program.
California Department of Fish and Game	Try to do on a yearly basis. Usually average once every 2-3 years.
County of Monterey Planning and Building Inspection	N/A
Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	It varies: every 1-2 years, 5 years, 10 years, etc.
Elkhorn Slough Foundation	Monitoring for health of habitat all year round; multiple times a month. No set schedule.

Table 11 - *Continued.*

	How successful has this tool been?
California Coastal Commission	Don't consider monitoring a tool that protects habitat. No follow up and usually done after habitat has been damaged.
US Bureau of Land Management Fort Ord	2
US Fish and Wildlife Service	N/A
USDA Natural Resources Conservation Service	2
California Department of Fish and Game	3
County of Monterey Planning and Building Inspection	N/A
Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	Think it will be successful once the program is restarted.
Elkhorn Slough Foundation	Good for now. Needs to be increased in the future.

Table 11 - *Continued.*

	Policy enforcement?
California Coastal Commission	Yes. If it is not damaged to begin with the policy would require an easement, which should be protective.
US Bureau of Land Management Fort Ord	Yes.
US Fish and Wildlife Service	Yes for listed species.
USDA Natural Resources Conservation Service	Yes. Not a regulatory agency, so cannot fine. Landowners are reimbursed for cost-share program (EQIP) when installation of a conservation practice is completed. Doesn't affect maritime chaparral very much.
California Department of Fish and Game	Yes, try to do. In general do not concentrate on enforcement. Only pursue in blatant cases.
County of Monterey Planning and Building Inspection	Yes, if there is a code violation.
Monterey County Parks	No.
California Native Plant Society, Monterey Bay Chapter	Yes. File lawsuits against regulatory agencies for non-compliance, as a last resort (done rarely); appeal agency management plans; and comment on agency plans.
Elkhorn Slough Foundation	No, not a regulatory agency. Will contact sheriff or neighbors. Trespassing is a main concern.

Table 11 - *Continued.*

	How successful has this tool been?	Voluntary compliance for landowners?
California Coastal Commission	Don't know. No follow up.	All of these are more or less voluntary.
US Bureau of Land Management Fort Ord	3	N/A
US Fish and Wildlife Service	1, on private lands. Depends if federally listed or not, and whether plant vs. animal.	Yes for listed species. Safe Harbors Program: encourage private landowners to restore and create protected habitat for protected species. If species is not on their land now, it protects landowner from future restrictions.
USDA Natural Resources Conservation Service	1	Yes. All compliance is voluntary because this is a non-regulatory agency.
California Department of Fish and Game	3 or 4	Yes. Try to encourage landowners to take care of chaparral not owned by DFG. Developed educational materials on best ways to maintain and live with chaparral.
County of Monterey Planning and Building Inspection	Works pretty well. Neighbors or long time residents know that a subdivision was approved with conservation easements. If they see a violation, they will report it.	(No information provided.)
Monterey County Parks	N/A	N/A
California Native Plant Society, Monterey Bay Chapter	Rarely use this tool.	N/A
Elkhorn Slough Foundation	N/A	No.

Table 11 - *Continued.*

	How successful has this tool been?	Landowner incentives?	What types of incentives?
California Coastal Commission	1-2. No one follows up.	Don't know. This would be a good idea.	Don't know.
US Bureau of Land Management Fort Ord	N/A	N/A	N/A
US Fish and Wildlife Service	1	Don't know.	Don't know.
USDA Natural Resources Conservation Service	2	Yes.	Cost sharing through Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), Resource Conservation and Development program (RC&D), Wildlife Habitat Incentives Program (WHIP), and grants.
California Department of Fish and Game	Unclear. No follow-up.	No.	There was a state income tax credit available for putting a conservation easement over private property, through Wildlife Conservation Board, for about 2-3 years.
County of Monterey Planning and Building Inspection	(No information provided.)	No.	N/A
Monterey County Parks	N/A	N/A	N/A
California Native Plant Society, Monterey Bay Chapter	N/A	N/A	N/A
Elkhorn Slough Foundation	N/A	No.	N/A

Table 11 - *Continued.*

	How successful has this tool been?	Landowner education?
California Coastal Commission	Don't know.	If there is - the County would do this (because they actually issue the permit and deal with landowner) and it would probably help as a long-term solution.
US Bureau of Land Management Fort Ord	N/A	Yes.
US Fish and Wildlife Service	Don't know.	No.
USDA Natural Resources Conservation Service	3. Programs have been cumbersome in past because of shortage of funds, awkward application procedures, and oversight.	Yes. Key to protecting maritime chaparral. Promote Coordinated Resource Management and Planning (CRMP).
California Department of Fish and Game	Don't know if anyone in central coast took advantage of it.	Yes. Workshops, literature, public outreach, and talks to organizations such as CNPS and Elkhorn Slough Foundation.
County of Monterey Planning and Building Inspection	N/A	Not through County. CSUMB Watershed Institute does public outreach.
Monterey County Parks	N/A	Yes.
California Native Plant Society, Monterey Bay Chapter	N/A	Yes. Plant sales; wildflower shows; testimony at public hearings; writing letters to the editor; CNPS meetings with guest speakers; and fieldtrips.
Elkhorn Slough Foundation	N/A	Yes.

Table 11 - Continued.

	How successful has this tool been?	Do you have written plans, goals, procedures, or policies specifically for managing CMC lands that include the tools that we just discussed?
California Coastal Commission	Don't know.	Yes.
US Bureau of Land Management Fort Ord	4	Yes.
US Fish and Wildlife Service	N/A	Not aware of any.
USDA Natural Resources Conservation Service	4	No. Follow broad guidelines and local guidelines.
California Department of Fish and Game	(No information provided.)	No.
County of Monterey Planning and Building Inspection	N/A	Yes.
Monterey County Parks	3. Most visitors understand the need to preserve areas of native plants and cooperate with the established rules and regulations.	No. Don't have a management plan or rare plant policy in effect. Rely on the recommendation and guidance of the Ag. Department and UC Extension.
California Native Plant Society, Monterey Bay Chapter	1 to 2	No.
Elkhorn Slough Foundation	4	Yes.

Table 11 - *Continued.*

	What documents are they found in?
California Coastal Commission	North Monterey County LCP. Land Use Plan. Environmentally Sensitive Habitat Area (ESHA) policies in Coastal Act Section 302.40. Coastal zone boundary policies in Coastal Act.
US Bureau of Land Management Fort Ord	Policies found in Habitat Management Plan. Methods in environmental assessment documents. Monitoring in BLM files, student reports, and internal and external contracted reports.
US Fish and Wildlife Service	N/A
USDA Natural Resources Conservation Service	Federal, state, and local laws, regulations, and policies such as ESA, County General Plan, County LCP, and NRCS Wisconsin Field Office Technical Guide.
California Department of Fish and Game	Have general guidelines for rare plants: "Guidelines for Assessing the Effects of Proposed Developments on Rare, Threatened, and Endangered Plants and Plant Communities."
County of Monterey Planning and Building Inspection	Policies in North Monterey County LCP.
Monterey County Parks	N/A
California Native Plant Society, Monterey Bay Chapter	N/A
Elkhorn Slough Foundation	Elkhorn Slough Watershed Conservation Plan and Elkhorn Slough at the Crossroads.

Table 11 - *Continued.*

	Would you recommend additional/alternative tools or policies to protect CMC species and habitats?
California Coastal Commission	Need long-term management plan/conservation strategy for CMC. Identify areas of high priority for conservation. Need distribution data for habitats and species. Need to develop a burning regime. Need to zone land use appropriately. Need funding for conservation efforts. Recommendations should be turned into LCP amendments or policies. County should contract with specialists.
US Bureau of Land Management Fort Ord	Conservation banks: Require developer to create; pick largest areas of known habitat; set aside areas that can be managed properly; zone it as land that cannot be developed; manage with money from developer. Best idea is to draft General Plan to limit development on every parcel. Require wide enough fuel breaks between chaparral and developments: 50-100 feet. Require land use between homes and BLM fuel break to be zoned for parks or other open space areas to widen fuel break/buffer zone: home/park/ fuel break/BLM.
US Fish and Wildlife Service	A strategy that evaluates numerous factors and provides ranking for any given parcel (on which mitigation ratios and options may be based) may offer advantages over one that focuses on absolutes (absolutes, for example, being off-site vs. on-site mitigation for all parcels over a certain size; or a set mitigation ratio for all maritime chaparral parcels). Factors include: parcel size and shape; surrounding land uses; number of rare species and importance of their populations; linkages with other conserved parcels; options for enhancement; etc.
USDA Natural Resources Conservation Service	Avoid impacts, conserve habitat, and conduct prescribed burning.

Table 11 - *Continued.*

California Department of Fish and Game	Most successful strategy is to purchase big blocks of land and put in conservation ownership like Fort Ord; conservation hard to do on small parcels. Have not had conservation banks for CMC, but looking into it for Santa Cruz and San Luis Obispo counties. Maybe a good strategy because on-site conservation is usually not practical given management needs.
County of Monterey Planning and Building Inspection	Continue using conservation and scenic easements. Increase awareness of CMC. Make protection policies stronger, especially in the non-coastal areas. Through the General Plan, need to look at the big picture. Figure out which areas are most degraded and prioritize protection. Off-site mitigation is not very helpful because it allows people to remove vegetation on-site. Need to develop a restoration program.
Monterey County Parks	One tool that is needed for the effective life cycle of chaparral is burning. Burning not only reduces the amount of available fuel for potential wildfires, but promotes the active re-growth of healthy plants.
California Native Plant Society, Monterey Bay Chapter	Leave larger portions of CMC habitat intact. Cluster building envelopes. Preserve habitat before development, not after. Need more baseline studies during the blooming period of rare, threatened, & endangered species. Use prescribed burning instead of mowing whenever possible. Time burns to closely mimic natural regime. Weed control and erosion control after burns. Careful use of a Prescribed Burn Plan to reduce impacts on public health. Don't seed with rye grass after burns. Need better monitoring and policy enforcement by regulatory agencies.
Elkhorn Slough Foundation	Influence General Plan update: parcel distribution, fragmentation trends, prohibit subdivisions, prohibit ridgeline development, easement policies. Network more in the future with BLM, Monterey County CNPS, and UCNRS. Independent monitoring for County.

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APPENDIX A

LIST OF ABBREVIATIONS

CCA	California Coastal Act
CCC	California Coastal Commission
CDF	California Department of Forestry and Fire Protection
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CMC	Central Maritime Chaparral
CNPS	California Native Plant Society
DFG	California Department of Fish and Game
FESA	Federal Endangered Species Act
HMP	Habitat Management Plan
LCP	Local Coastal Program
NCCP	California Department of Fish and Game Natural Community Conservation Planning
NDDB	California Department of Fish and Game Natural Diversity Data Base
NEPA	National Environmental Policy Act
SJSU	San José State University
SOD	Sudden Oak Death
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

APPENDIX B

When recorded return to:

MONTEREY COUNTY PLANNING AND
BUILDING INSPECTION DEPARTMENT
240 CHURCH STREET, ROOM 116
P. O. BOX 1208
SALINAS, CA 93901
(831) 755-5025

Space above for Recorder's Use

Permit No.: _____

Applicant Name: _____

Project Planner: _____

CONSERVATION AND SCENIC EASEMENT DEED (COASTAL)

THIS DEED made this ____ day of _____, _____, by and between

_____ as Grantor, and the
COUNTY OF MONTEREY, a political subdivision of the State of California, as Grantee,

WITNESSETH:

WHEREAS, said Grantor is the owner in fee of the real property more particularly described in Exhibit "A" attached hereto and made a part hereof, situated in Monterey County, California (hereinafter "*the property*"); and

WHEREAS, the said land of said Grantor has certain natural scenic beauty and existing openness; and

WHEREAS, the Grantor and the Grantee desire to preserve and conserve for the public benefit the great natural scenic beauty and existing openness, natural condition and present state of use of said property of the Grantor; and

WHEREAS, the California Coastal Act of 1976, (hereinafter referred to as the "Act") requires that any coastal development permit approved by the County must be consistent with the provisions of the certified Local Coastal Program (LCP); and

WHEREAS, pursuant to the Act, and the LCP, Grantor applied to the County for a permit to undertake development as defined in the LCP; and

WHEREAS, a coastal development permit (Permit No. _____) was granted on _____, _____, by the County in accordance with the provisions of the Staff Recommendation and Findings, attached hereto as Exhibit "B" and hereby incorporated by reference, subject to the following condition(s): _____

WHEREAS, the County, acting on behalf of the People of the State of California and pursuant to the Act, and in accordance with the findings contained in Resolution No. _____ attached hereto as Exhibit "C" and hereby incorporated by reference, granted the permit to the Grantor upon condition (hereinafter the "**Condition**") requiring inter alia, that the Grantor record a conservation and scenic easement over the property as shown in Exhibit "D" attached hereto and hereby incorporated by reference, and agree to restrict development on and use of the property so as to preserve the open space, scenic, and/or natural resource values present on the property and so as to prevent the adverse direct and cumulative effects on coastal resources and public access to the coast which could occur if the property were not restricted in accordance with this easement; and

WHEREAS, the County has placed the Condition on the permit because a finding must be made under the law that the proposed development is in conformity with the provisions of the certified Local Coastal Program and that in the absence of the protections provided by the Condition said finding could not be made; and

WHEREAS, Grantor has elected to comply with the Condition and execute this easement so as to enable Grantor to undertake the development authorized by the Permit; and

WHEREAS, it is intended that this easement is irrevocable and shall constitute enforceable restrictions within the meaning of Article XIII, Section 8, of the California Constitution and that said easement shall thereby qualify as an enforceable restriction under the provision of the California Revenue and Taxation Code, Section 402.1; and

WHEREAS, the said Grantor is willing to grant to the County of Monterey the scenic use as herein expressed of the said land, and thereby protect the present scenic beauty and existing openness by the restricted use and enjoyment of said property by the Grantor through the imposition of the conditions hereinafter expressed;

NOW, THEREFORE, for and in consideration of the premises the Grantor does hereby grant and convey unto the County of Monterey an estate, interest, and conversation and scenic easement in said real property of Grantor of the nature and character and to the extent hereinafter expressed, which estate, interest, and easement will result from the restrictions hereby imposed upon the use of said property by said Grantor, and to that end and for the purposes of accomplishing the intent of the parties hereto, said Grantor covenants on behalf of itself, its heirs, successors, and assigns, with the said Grantee, its successors and assigns, to do and refrain from doing severally and collectively upon the Grantor's said property the various acts hereinafter mentioned.

A. **LAND SUBJECT TO EASEMENT.** The land of the Grantor hereinabove referred to and to which the provisions of this instrument apply is situated in the County of Monterey, State of California, and is particularly described in Exhibit "D", attached hereto, and made a part hereof.

B. **RESTRICTIONS.** The restrictions hereby imposed upon the use of said property by the Grantor and the acts which said Grantor shall refrain from doing upon the said property in connection herewith are, and shall be, as follows:

1. That no structures will be placed or erected upon said described premises except _____

2. That no advertising of any kind or nature shall be located on or within said property except _____

3. That the Grantor shall not plant nor permit to be planted any vegetation upon said premises, except _____

4. That, except for the construction, alteration, relocation and maintenance of public roads, public and private pedestrian trails, _____ the general topography of the landscape shall be maintained in its present condition and no excavation or topographic changes shall be made.

5. That no use of said described property which will or does materially alter the landscape or other attractive scenic features of said land other than those specified above shall be done or suffered.

C. EXCEPTIONS AND RESERVATIONS. The following are excepted and reserved to the Grantor:

1. The right to maintain all existing private roads, bridges, trails and structures upon said land, and the right to _____

2. The use and occupancy of said land not inconsistent with the conditions and restrictions herein imposed.

D. SUBJECT TO ORDINANCES. Land uses permitted or reserved to the Grantor by this instrument shall be subject to the ordinances of Grantee regulating the use of land.

E. BENEFIT AND BURDEN. This grant of conservation and scenic easement shall run with and burden the property, and all obligations, terms, conditions, and restrictions hereby imposed shall be deemed to be covenants and restrictions running with the land and shall be effective limitations on the use of the property from the date of recordation of this document and shall bind the Grantor and all of its successors and assigns. This grant shall benefit the County of Monterey and its successors and assigns forever.

F. RIGHT OF ENTRY. The Grantee or its agent may enter onto the property to ascertain whether the use restrictions set forth above are being observed at times reasonably acceptable to the Grantor. The public may enter onto the property for scientific research purposes at times reasonable acceptable to the Grantor.

G. ENFORCEMENT. Any act or any conveyance, contract, or authorization whether written or oral by the Grantor which uses or would cause to be used or would permit use of the property contrary to the terms of this offer will be deemed a breach hereof. The Grantee may bring any action in court necessary to enforce this grant of easement, including, but not limited to, injunction to terminate a breaching activity and to force the restoration of all damage done by such activity, or an action to enforce the terms and provisions hereof by specific performance. It is understood and agreed that the Grantee may pursue any appropriate legal and equitable remedies. The Grantee shall have sole discretion to determine under the what circumstances an action to enforce the terms and conditions of this grant of easement shall be brought in law or in equity. Any forbearance on the part of the Grantee to enforce the terms and provisions hereof in the event of a breach shall not be deemed a waiver of Grantee's rights regarding any subsequent breach.

H. MAINTENANCE. The Grantee shall not be obligated to maintain, improve, or otherwise expend any funds in connection with the property or any interest or easement created by this grant of easement. All costs and expenses for such maintenance, improvement use, or possession shall be borne by the Grantor, except for costs incurred by Grantee for monitoring compliance with the terms of this easement.

I. LIABILITY AND INDEMNIFICATION. This conveyance is made and accepted upon the express condition that the Grantee, its agencies, departments, officers, agents, and employees are to be free from all liability and claim for damage by reason of any injury to any person or persons, including Grantor, or property of any kind whatsoever and to whomsoever belonging, including Grantor, from any cause or causes whatsoever, except matters arising out of the sole negligence of the Grantee, while in, upon, or in any way connected with the property, Grantor hereby covenanting and agreeing to indemnify and hold harmless the Grantee, its agencies, departments,

officers, agents, and employees from all liability, loss, cost, and obligations on account of or arising out of such injuries or losses however occurring. The Grantee shall have no right of control over, nor duties and responsibilities with respect to the property which would be subject the Grantee to any liability occurring upon the land by virtue of the fact that the right of the Grantee to enter the land is strictly limited to preventing uses inconsistent with the interest granted, the property is not "property of a public entity" or "public property," and Grantee's rights here in do not include the right to enter the land for the purposes of correcting any "dangerous condition" as those terms are defined by California Government Code Section 830.

J. SUCCESSORS AND ASSIGNS. The terms, covenants, conditions, exceptions, obligations, and reservations contained in this conveyance shall be binding upon and inure to the benefit of the successors and assigns of both the Grantor and the Grantee, whether voluntary or involuntary.

K. CONSTRUCTION OF VALIDITY. If any provision of this conservation and scenic easement is held to be invalid or for any reason becomes unenforceable, no other provision shall be thereby affected or impaired.

Executed this ____ day of _____, ____, at _____, California.

Signed: _____

Type or print name of above - **GRANTOR**

Signed: _____

Type or print name of above - **GRANTOR**

STATE OF CALIFORNIA)
) SS.
 COUNTY OF MONTEREY)

On _____, before me, _____, Notary Public, personally appeared _____, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

WITNESS my hand and official seal.

Signature _____

(Seal)

This is to certify that the Conservation and Scenic Easement Deed set forth above is hereby acknowledged by the Board Chair on behalf of the Monterey County Board of Supervisors pursuant to the action of the _____ when it granted Coastal Development Permit No. _____ on _____ and the Monterey County Board of Supervisors consents to recordation thereof by its duly authorized officer.

DATED: _____

 Chair, Monterey County Board of Supervisors

ATTEST:

DATED: _____

 Clerk of Said Board

Document Form/Content Acceptable:

 County Counsel

 Planning and Building Inspection Department

EXHIBITS TO BE ATTACHED TO:**CONSERVATION AND SCENIC EASEMENT DEED**

1. **EXHIBIT "A":** Full legal description of the entire property for which a Coastal Development Permit was granted. The legal description may be obtained from a grant deed or title report for the property. A parcel number will not be accepted as a legal description.
2. **EXHIBIT "B":** A copy of the Planning and Building Inspection Department's staff report containing recommended findings and conditions for the grant of Coastal Development Permit.
3. **EXHIBIT "C":** A copy of Planning Commission Resolution # _____ granting the Coastal Development Permit.
4. **EXHIBIT "D":** An official surveyor's map, parcel map or plot plan, accompanied by a metes and bounds description, prepared by a licensed surveyor, showing the exact location of the easement on the property.

When recorded return to:

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MONTEREY COUNTY PLANNING
AND BUILDING INSPECTION
DEPARTMENT
240 CHURCH STREET, ROOM 116
P.O. BOX 1208
SALINAS, CA 93901
(408) 755-5025

Space above for Recorder's Use

CONSERVATION AND SCENIC EASEMENT DEED

THIS DEED made this _____ day of _____, 19____, by and between _____, as Grantor, and the *COUNTY OF MONTEREY*, a political subdivision of the State of California, as *Grantee*;

WITNESSETH:

WHEREAS, the said Grantor is the owner if fee of the real property hereinafter described, situate in Monterey County, California; and

WHEREAS, the said land of said Grantee desire to preserve and conserve for the public benefit the great natural scenic beauty and existing openness, natural condition and present state of use of said property of the Grantor; and

WHEREAS, the said Grantor is willing to grant to the County of Monterey the scenic use as hereinafter expressed of the said land, and thereby protect the present scenic beauty and existing openness by the restricted use and enjoyment of said property by the Grantor through the imposition of the conditions hereinafter expressed;

NOW, THEREFORE, for and in consideration of the premises, the Grantor does hereby grant and convey unto the County of Monterey an estate, interest, and conservation and scenic easement in said real property of Grantor of the nature and character and to the extent hereinafter expressed, which estate, interest, and

easement will result from the restrictions hereby imposed upon the use of said property by said Grantor, and to that end and for the purpose of accomplishing the interest of the parties hereto, said Grantor covenants on behalf of itself, its heirs, successors, and assigns with the said Grantee, its successors and assigns to do and refrain from doing severally and collectively upon the Grantor's said property the various acts hereinafter mentioned.

The restrictions hereby imposed upon the use of said property of the Grantor and the acts which said Grantor shall refrain from doing upon their said property in connection herewith area, and shall be as follows:

1. That no structures will be placed or erected upon said described premises except _____.

2. That no advertising of any kind of nature shall be located on or within said property except _____.

3. That the Grantor shall not plant nor permit to be planted any vegetation upon said premises, except _____.

4. That, except for the construction, alteration, relocation and maintenance of public roads, public and private pedestrian trails, _____.

the general topography of the landscape shall be maintained in its present condition and no excavation or topographic changes shall be made.

5. That no use of said described property which will or does materially alter the landscape or other attractive scenic features of said land other than those specified above shall be done or suffered.

The land of the Grantor hereinabove referred to and to which the provisions of this instrument apply is situated in the County of Monterey, State of California, and is particularly described in Exhibit A, attached hereto, and made a part hereof.

Excepting and reserving to the Grantor:

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(1) The right to maintain all existing private roads, bridges, trails and structures upon said land, and the right to _____

(2) The use and occupancy of said land not inconsistent with the conditions and restrictions herein imposed.

Land uses permitted, or reserved to the Grantor by this instrument shall be subject to the ordinances of Grantee regulating the use of land.

To have and to hold unto the said County of Monterey, its successors and assigns forever. This grant shall be binding upon the heirs and assigns of the said Grantor.

COUNTY OF MONTEREY

By

Chair, Board of Supervisors
GRANTEE

GRANTORS:

That certain real property situate in the County of Monterey, State of California, described as follows:

That areas designated as "scenic easement" as shown on that certain map filed this _____ day of _____, 19____ in Volume _____ of Parcel Maps at Page _____, Monterey County Records.

San José State
UNIVERSITY

**Office of the Academic
Vice President**

**Associate Vice President
Graduate Studies and Research**

One Washington Square
San José, CA 95192-0025
Voice: 408-283-7500
Fax: 408-924-2477
E-mail: gstudies@whoo.sjsu.edu
<http://www.sjsu.edu>

APPENDIX C

To: Tami Nakahara
3635 Bercaw Lane
San José, California 95124-2831

From: Nabil Ibrahim,
AVP, Graduate Studies & Research

Date: July 27, 2001

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"Management Strategies for Central Maritime Chaparral."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year, and data collection beyond July 26, 2002 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

San José State
UNIVERSITY

**Office of the Academic
Vice President**

**Associate Vice President
Graduate Studies and Research**

One Washington Square
San José, CA 95192-0025
Voice: 408-283-7500
Fax: 408-924-2477
E-mail: gstudies@wahoo.sjsu.edu
<http://www.sjsu.edu>

To: Tami Nakahara
3635 Bercaw Lane
San José, CA 95124-2831

From: Nabil Ibrahim
AVP, Graduate Studies & Research

Date: July 17, 2002

This letter acknowledges that the Human Subjects-Institutional Review Board has received the request for extension of time for the study entitled:

"Management Strategies for the Maritime Chaparral."

Since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one-year extension effective from the date of this letter. Data collection beyond July 17, 2003 requires an extension request.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.