VEGETATION ASSOCIATION: CHAPARRAL

MAPPED SUBASSOCIATIONS: Chaparral (undifferentiated), Chamise Chaparral, Red Shank Chaparral, and Semi-Desert Chaparral. Vegetation Chaparral

DATA CHARACTERIZATION

No objective measurement of the accuracy of the MSCHP vegetation map has been conducted, therefore no definitive statements can be made about the accuracy of chaparral vegetation on a polygon by polygon basis. Because mapping utilized several different sources and was spot-checked in the field, it is probable the general distribution of chaparral within the Plan Area has been accurately depicted. The boundaries between chaparral and most vegetation types (*e.g*., coastal sage scrub, grasslands, oak woodlands, and coniferous forest) are reasonably interpretable from the 1:24000 aerial photos. Inaccuracy at small scales (*e.g.*, variation in polygon boundaries or mis-classification) due to problems of interpretation are most likely to occur in areas that were recently burned when the photos were taken, areas where the vegetation types are fragmented, and in more arid regions where chaparral shrubs are sparse (*e.g*, the Badlands and Vail Lake areas). In these areas there is a higher probability for misinterpretation of chaparral and coastal sage scrub. Because much of the mapping was field checked specifically for coastal sage scrub these errors should be infrequent.

Because of the difficulty in interpreting different types of chaparral from the scale of the aerial photography the acreage of chamise, red shank chaparral, and semi-desert chaparral is likely understated. For the same reason other subassociations of chaparral (montane chaparral, ceanothus chaparral, and manzanita chaparral) known to occur within the Plan Area were not differentiated in the mapping.

Research concerning the physiology and ecology of chaparral species is extensive; however, important questions are unresolved concerning some of the ecosystem processes important to the development and maintenance of chaparral (*e.g.*, the appropriate fire regimes for long-term management of the vegetation type).

BIOGEOGRAPHY

Chaparral vegetation occurs regionally along the Pacific Coast to the mountain foothills (0–2,000 meters) from southern Oregon to the San Pedro Martir Mountains in Baja California (Detling 1961; Axelrod 1973). Most of chaparral's distribution lies within the state of California where it is one of the most widespread vegetation types, encompassing approximately 29,000 square-kilometers (km) or seven percent of the total land area of the state (Davis *et al.* 1994). Species composition is varied within California where as many as 50 different subassociations have been recognized (Sawyer and Keeler-Wolf 1995). Additional forms of chaparral are known from Arizona and northeastern Mexico, and the Rocky Mountain Region but these types are isolated by greater than 200 km of desert, and are adapted to summer rainfall and a different fire regime (Keeley 2000). Within the Plan Area many subassociations of this vegetation type occur at both regional and local scales based on variation in rainfall, temperature, elevation, fire regime, slope aspect, soils and disturbance regimes.

RANGE AND DISTRIBUTION WITHIN WESTERN RIVERSIDE COUNTY

Chaparral vegetation is the most abundant and widespread vegetation type in Western Riverside County, covering approximately 35% (435,000 acres) of the Plan Area. Large contiguous stands of chaparral occur along the Santa Ana Mountains in the western portion of the Plan Area, and along the San Bernardino, San Jacinto, and Agua Tibia Mountains in the eastern and southern portions. Although chaparral is less common than other vegetation types in the central lowlands of Riverside County three large chaparral-dominated areas occur on steeper lands near the Gavilan Hills-Gavilan Plateau-Meadowbrook Region, the Lakeview Mountains-Double Butte area, and the Sedco Hills-Hogbacks area.

Four types of chaparral have been mapped for the Plan Area based on variation in species composition: chamise chaparral, red shank chaparral, semi-desert chaparral, and chaparral (undifferentiated). The undifferentiated chaparral category is an artifact of the amalgamation of several different mapping sources and less detailed mapping effort of chaparral in portions of the Plan Area (PSBS 1995). The areas mapped as undifferentiated chaparral are composed of many different chaparral sub associations including southern mixed chaparral, montane chaparral, scrub oak chaparral, and several forms of manzanita or ceanothus chaparral. Because much of the variation of these vegetation types is continuous with nodes of dominance by one or a few species, these vegetation types will be described within the mixed chaparral category for this Habitat account. It is probable that a significant portion of undifferentiated chaparral includes chamise chaparral and smaller patches of red shank and semi-desert chaparral.

VEGETATION CHARACTERISTICS

Chaparral is a shrub-dominated Habitat that is composed largely of evergreen, sclerophyllous species that range from 1 to 4 meters in height (Keeley 2000). Other growth forms including soft-leaved subshrubs, perennial herbs, geophytes (bulbs and corms), and annual herbs are less abundant in mature chaparral but can be present in abundance in early and late successional stands of chaparral (Keeley and Keeley 1988). Sparse stands of trees can occur within chaparral, typically within transition areas with conifers at higher elevations and oaks on north-facing slopes or ravines (Hanes 1977; Keeley and Keeley 1988). Depending on the species composition and underlying topography and soil, the structure of chaparral can range from low, monotonous, smooth-textured vegetation to more heterogeneous stands approaching the vertical structure of woodlands (Keeley 2000).

From inland and high elevations to coastal locations, chaparral occurs in both large continuous stands or within a patchwork of Habitats including coastal sage scrub, grasslands, oak woodlands, coniferous Habitats and several wetland Habitats (Heady 1977; Hanes 1977; Callaway and Davis 1993). Chaparral near the coast tends to occur in disjunct patches occupying more mesic Habitats whereas coastal sage scrub is distributed more extensively in drier Habitats (Kirkpatrick and Hutchinson 1980; Malanson and O'Leary 1994). Mountain foothill and high elevation stands of chaparral are larger and more continuous, with coastal sage scrub occurring in smaller patches generally restricted to steep and south-facing exposures (Keeley 2000; PSBS 1995). Oak woodlands border chaparral in more mesic areas (*e.g.* ravines, north-facing slopes) that have developed deeper soils (Griffen 1977). Oak woodlands are thought to develop within late successional chaparral in areas with more developed soils (Cooper 1922; Wells 1962). The native grassland-chaparral interface is not well understood; however, research has shown cases of type conversion from chaparral to non-native annual grasslands with frequent fire or mechanical disturbance (Zedler *et al.* 1983).

Chaparral generally is thought to be a fire dependent system based on the many adaptations of its characteristic species, and its resilience in form and species composition to periodic burning (Keeley 1986; Keeley 1992). Most of the characteristic shrub species in chaparral can be organized generally into three adaptive strategies related to fire: (1) shrubs that have stems that regenerate following fire from below ground burls (resprouters); (2) shrubs that produce large amounts of dormant seed that persist for long periods of time and germinate by heat or chemical processes initiated by fire (obligate seeders); and (3) plants that apply both strategies (Keeley 1977). Within chaparral vegetation non-shrub plant growth forms may also employ these strategies or fire avoidance to persist within this fire prone system (*e.g.*, geophyte species whose bulbs or corms persist following fire, annual herb species with long seed dormancy and heavy annual seed production, annuals with the ability to disperse seeds over long distances) (Keeley 1986).

The species composition of a particular chaparral stand is largely influenced by fire. Chaparral generally returns to pre-fire structure and composition within a normal fire regime (Keeley 1986); however, considerable research has documented various effects of fire regime on species mortality (Keeley 2000). Frequency of fire has been shown to affect chaparral species composition, where short fire intervals may eliminate obligate seeding species in favor resprouters (Keeley 1986; 1992). Additional research has shown that fire temperature or intensity also has a strong influence on post-fire species composition (Davis *et al.* 1989; Rice 1993; Tyler 1995). Stand age following fire is thought to influence the reproduction of species based on reproductive strategies. Research has shown that seedling recruitment is more common for resprouting species in old (> 56 yr.) stands of chaparral whereas seedling recruitment for obligate seeding species was extremely uncommon (Keeley 1986; 1992). This research has led to the conclusion that short intervaled fires may adversely affect the presence of obligate resprouting species in favor of obligate seeders.

SPECIES COMPOSITION

The floristic composition of chaparral varies depending on biogeography, local Habitat characteristics and fire history. Of the many growth forms present in chaparral, woody evergreen perennials are the dominant plants and, as such, exert the most influence on the Habitat. The most common and widespread species within chaparral is chamise *(Adenostoma fasciculatum)* (Hanes 1971). This species occurs in most stands of chaparral and is the dominant plant in drier Habitats (Keeley 2000). The ubiquity of this species is likely explained by its many adaptations to drought, fire and disturbance (Hanes 1977). Other common shrub species include representatives from manzanita (*Arctostaphylos* spp.), wild-lilac (*Ceanothus* spp.), silk-tassel bush (*Garrya* spp.), oak (*Quercus* spp.), redberry (*Rhamnus* spp.), Rhus spp., laurel sumac (*Malosma laurina*), mountain-mahogany (*Cercocarpus betuloides*), toyon *(Heteromeles arbutifolia*), holly-leaf cherry *(Prunus ilicifolia*), and mission manzanita (*Xylococcus bicolor*) (Holland 1986). Soft-leaved subshrubs are less common in chaparral than in coastal sage scrub but occur within canopy gaps of mature stands, and may be more prevalent following fire (Holland 1986; Keeley and Keeley 1988; Sawyer and Keeler-Wolf 1995). Common species include California buckwheat (*Eriogonum fasciculatum*), sages (*Salvia* spp.), California sagebrush (*Artemisia californica*), and monkeyflower (*Mimulus* spp.). Suffrutescent and perennial herbaceous species commonly include deerweed (*Lotus scoparius*), nightshade (*Solanum* spp.), Spanish bayonet (*Yucca whipplei*), rock-rose (*Helianthemum scoparium*), golden yarrow (*Eriophyllum confertiflorum*), Bloomeria spp., Brodiaea spp., onion (*Allium* spp.), sanicle (*Sanicula* spp.), Lomatium spp., soap plant (*Chlorogalum* spp.), and bunch grasses

(*Nassella* spp., and *Melica* spp.) (Holland 1986; Keeley and Keeley 1988; Sawyer and Keeler-Wolf 1995). Vines commonly present in chaparral include wild cucumber (*Marah* spp.), dodder (Cuscuta spp.), chaparral-pea (*Lathyrus* spp.), bedstraw (*Galium* spp.), poison-oak *(Toxicodendron diversilobum*), and honeysuckle (*Lonicera* spp.) (Keeley and Keeley 1988). Annual species persisting in mature chaparral or in the post-burn flora vary according to geographic location, but typically include lupine (*Lupinus* spp.), Lotus spp., California thread-stem (*Pterostegia drymarioides*), Claytonia spp., Gnaphalium spp., Phacelia spp., Gilia spp., whispering bells (*Emmenanthe pendulflora*), fiesta-flower (*Pholistoma* spp.), and many others (Holland 1986; Keeley and Keeley 1988; Sawyer and Keeler-Wolf 1995).

VARIATION IN SPECIES COMPOSITION, STRUCTURE AND DISTRIBUTION BY MAPPED HABITAT TYPE

Chamise Chaparral: Chamise chaparral occurs throughout much of the range of chaparral in California from approximately 10 to 1800 meters in elevation (Sawyer and Keeler-Wolf 1995). This vegetation is found on all slope-aspects on shallow soils (Gordon and White 1994; Sawyer and Keeler-Wolf 1995). Seven patches of chamise chaparral totaling 362 acres were delineated within the Plan Area. These patches were identified at Estelle Mountain, Steele Peak, Meadowbrook, southeast of Table Mountain, and in the Lakeview Mountains near the town just west of Hemet. The mapped acreage is an underestimate. Because of the difficulty in differentiating different subassociations of chaparral from aerial photography many stands of chamise chaparral likely were included within the undifferentiated chaparral category.

Vegetation structure is open to dense between 1 to 4 meters in height, with little litter and few understory species in mature stands (Hanes 1971; Holland 1986; Boyd and Banks 1995). Recent studies describe this association as having greater than 60% cover chamise (Gordon and White 1994; Sawyer Keeler-Wolf 1995). Where another species occurs at greater than 30% cover but chamise remains the dominant cover the stands have been described as a mixed series (e.g., chamise-bigberry, chamise-black sage, chamise-cupleaf ceanothus, chamise-Eastwood's manzanita, chamise-hoaryleaf ceanothus, chamise-mission manzanita-woollyleaf ceanothus series, chamise-wedgeleaf ceanothus, and chamise-white sage) (Sawyer and Keeler-Wolf 1995). These series all are likely included within the undifferentiated chaparral category in the MSHCP database. Evergreen species that commonly occur at less than 30 % cover within chamise chaparral in the MSHCP Plan Area include bigberry manzanita (*Arctostaphylos glauca*), Eastwood's manzanita (*Arctostaphylos glandulosa*), mission manzanita (*Xylococcus bicolor*), scrub oak (*Quercus berberidifolia*), interior live oak (*Q. wislizneii*), hoary-leaved ceanothus (*Ceanothus crassifolius*), Spanish bayonet *(Yucca whipplei*), laurel sumac (*Malosma laurina*), sugar-bush (*Rhus ovata*), toyon (*Heteromeles arbutifolia*), yerba santa (*Eriodictyon crassifolium* and *E. trichocalyx*), redberry (*Rhamnus crocea*), and chaparral beard-tongue (*Keckiella antirrhinoides*). Chamise chaparral often supports low cover of subshrubs characteristic of sage scrub (*e.g*., black sage [Salvia mellifera]), California buckwheat [*Eriogonum fasciculatum*], California sagebrush [Artemisia californica]), and saw-toothed goldenbush *[Hazardia squarrosa*]). Perennial herbaceous species are few in mature stands of chamise chaparral but cudweed (*Gnaphalium* spp.), Sanicula spp., southern taushia *(Tauschia arguta*), California melic (*Melica imperfecta*), lilac mariposa (*Calochortus splendens*), Bigelow's spike-moss (*Selaginella bigelovii*), and other post-burn or gap specialist annuals (*e.g., Phacelia* spp., whispering bells [*Emmenanthe pendulaflora*], *Cryptantha* spp., *Plagiobothrys* spp., spineflower [*Chorizanthe* spp.], *Camissonia* spp., and *Pterostegia drymarioides*) may be present.

Undifferentiated Chaparral/Mixed Chaparral: The majority of the chaparral vegetation in the Plan Area is mapped as undifferentiated chaparral. This vegetation covers approximately 363,000 acres, encompassing 29 % of the Plan Area. Several different subassociations may be included within this vegetation type based on variation in slope aspect, elevation and distance from the coast.

In the western portion of the Plan Area (*e.g.,* the Santa Ana Mountains, Agua Tibia Mountains) undifferentiated chaparral is dominated by chamise in drier Habitats and by a more diverse mixture of species in more mesic areas (analogous to southern mixed chaparral sensu, Holland 1986). Species composition ranges from that described for chamise chaparral (see above) to more diverse shrub associations supporting hoary-leaved ceanothus (*Ceanothus crassifolius*), birchleaf mountain-mahogany *(Cercocarpus betuloides*), toyon (*Heteromeles arbutifolia*), sugar bush (*Rhus ovata*), holly-leaf redberry (*Rhamnus ilicifolia*), heart-leaf penstemon (*Keckiella cordifolia*), southern honeysuckle (*Lonicera subspicata*), scrub oak (*Quercus berberidifolia*), black sage (*Salvia mellifera*), and other species.

The central portion of the Plan Area (*e.g.*, the Gavilan Hills, Sedco Hills, and Black Hills) is lower in elevation and supports a drier expression of chaparral with abundant stands of chamise along with more arid climate chaparral species [*e.g.,* jojoba (*Simmondsia chinensis*), chaparral beard-tongue (*Keckiella antirrhinoides*), and desert thorn (*Lycium andersonii*)] and Riversidian sage scrub [*e.g.,* brittlebush *(Encelia farinosa*), California buckwheat (*Eriogonum fasciculatum* var. *polifolium)* and white sage (*Salvia apiana*)].

Mesic areas (*e.g.*, north-facing slopes, narrow ravines) in this region support southern mixed chaparral, or red shank chaparral.

The eastern portion of the Plan Area including the San Bernardino, San Jacinto, and Agua Tibia Mountains and foothill areas supports the largest continuous stands of undifferentiated chaparral. This area has a large elevational gradient supporting chaparral from about 400 to 2000 meters. This gradient allows for high variation in chaparral species composition and many different species associations. At lower elevations chaparral is composed of chamise, chaparral beard-tongue, toyon, scrub oak, California buckwheat and other species common to coastal southern California. With increasing elevation chamise remains abundant but with Eastwood's manzanita (*Arctostaphylos glandulosa*), bigberry manzanita (*Arctostaphylos glauca*), birch-leaf mountain-mahogany, chaparral whitethorn (*Ceanothus leucodermis*) and interior live oak (*Q. wislizenii*) becoming more abundant. At higher elevations where chaparral transitions to coniferous forest, chaparral is largely composed of Eastwood's manzanita, bigberry manzanita, pink-bract manzanita (*A. pringlei*), chaparral whitethorn *(Ceanothus leucodermis*), deer bush (*C. integerrimus*), and Veatch's silk-tassel (*Garrya veatchii*). At higher elevations chaparral also may support sparse stands of coniferous and oak species including Jeffrey pine (*Pinus jeffreyi*), ponderosa pine (*P. ponderosa*), Coulter pine (*P. coulteri*), black oak (*Quercus kelloggii*), canyon live oak (*Q. chrysolepis*), and interior live oak (*Q. wislizenii*). Understories are varied along the elevation gradient with species typical of chamise chaparral understories occurring at lower elevations, and species such as Bigelow's spike-moss (*Selaginella bigelovii*), bedstraw (*Galium* spp.), bird's-beak (*Cordylanthus* sp.), wallflower (*Erysimum capitatum*), yarrow *(Achillea millefolium*), rock cress (*Arabis perennans*), whiskerbrush (*Linanthus ciliatus*), claytonia *(Claytonia parviflora*), and Indian paintbrush *(Castilleja* spp.) occurring within canopy gaps at higher elevations. Presence of fire-following annual species in higher elevation chaparral is not as evident as at lower elevations (Sweeney 1968). Most of the species present after fire are present in open areas prior to burning (Hanes 1977).

Red Shank Chaparral: Red shank chaparral has a more restricted distribution than other chaparral associations within California with the greatest areal extent occurring within Riverside and northern San Diego counties in the interior valleys and the San Jacinto and Santa Rosa Mountains (Hanes 1977). The only other areas supporting significant stands of red shank chaparral are the Laguna and Palomar Mountains in San Diego County, inland northern Baja California, the Santa Monica Mountains in Los Angeles County, and the Cuyama Valley in Santa Barbara and San Luis Obispo counties (Hanes 1977). This vegetation generally occurs between 300 and 2000 meters and is usually found in areas with colder winters and greater precipitation than chamise chaparral

(Holland 1986). Redshank chaparral is the predominate vegetation type in the southeastern portion of the Plan Area. This area supports large blocks of redshank chaparral from the San Diego County border to the Table Mountain area. This vegetation covers approximately 1 percent of the Plan Area totaling 72,000 acres. North of Anza, redshank chaparral occurs in smaller patches interspersed with chamise chaparral, Jeffery pine forest, and oak woodland. Redshank chaparral is structurally taller (2 to 5 meters) than chamise chaparral and is more commonly found on granitic, more mesic and fertile soils, and deep alluvial soils (Beatty 1984; Holland 1986; Sawyer and Keeler-Wolf 1995). Typically red shank chaparral is dominated by red shank (*Adenostoma sparsifolium*), although many other shrub species may be present including chamise, toyon, holly-leaved cherry, bigberry manzanita, birch-leaf mountain-mahogany, Eastwood manzanita, cupleaf ceanothus (*Ceanothus greggii*), hoary-leaved ceanothus (*Ceanothus crassifolius*), scrub oak (*Quercus berberidafolia*), hollyleaf redberry (*Rhamnus ilicifolia*), and Veatch silktassel. Because of the more open architecture of *Adenostoma sparsifolia,* red shank chaparral typically has greater abundances of herbaceous species within the understories of mature stands than chamise chaparral (Hanes 1977; Boyd and Banks 1995). Typical herbaceous species may include southern tauschia (*Taushia arguta*), mesa saxifrage (*Jepsonia parryi*), coast figwort *(Scrophularia californica*), blue dicks (*Dichelostemma capitata*), miner's lettuce (*Claytonia perfoliata*), baby blue-eyes (*Nemophilia menziesii*), dwarf stonecrop (*Crassula connata*), and other common chaparral understory species (Boyd and Banks 1995).

Semi-Desert Chaparral: Semi-desert chaparral is a transitional chaparral association that occurs primarily on the interior of the transverse and peninsular ranges on the border of the Mojave and Colorado deserts between 610-1500 meters in elevation (Holland 1986). Semi-desert chaparral was mapped in four separate polygons (19 acres) within a mile of the community of Anza. Because semi-desert chaparral may not appear distinctly from aerial photo interpretation additional acreage of this vegetation type is probably included within undifferentiated chaparral in the desert transition areas. Shrub cover for this vegetation is lower than most other chaparral associations owing to its occurrence within drier regions (Gordon and White 1994). Species composition usually includes chamise and cup-leaved ceanothus as co-dominates with lower cover of sugarbush, scrub oak (*Quercus berberidifolia*), California buckwheat, Spanish bayonet (*Yucca whipplei*), birch-leaved mountain mahogany, and desert-apricot *(Prunus fremontii*) (Gordon and White 1994; Sawyer and Keeler-Wolf 1995).

PHYSICAL ENVIRONMENT

Chaparral generally is limited to the Mediterranean-type climate region of California from sea level to approximately 2000 meters in elevation (Keeley 2000). This region receives from 200 to 1000 mm of precipitation, most of which falls from November to April (Miller and Hajek 1981). Because this region has concentrated rainfall in the winter months and prolonged summer drought much of the current flora has adaptations that allow for rapid growth during the winter and spring and water Conservation during the summer and fall (Harrison *et al.*, 1971; Poole and Miller 1981). Because many of these adaptations have facilitated periodic fires, most chaparral species have evolved mechanisms to succeed within a fire-prone ecosystem as described below.

Although physical environmental factors typically exert a strong influence over the distribution of vegetation at the landscape-scale, the influence of fire upon chaparral makes these relationships more complex. Few strong relationships have been established between specific physical site factors and the distribution of chaparral on the landscape (Wells 1962; Bradbury 1978; Keeley 2000). Chaparral is known to occur on many different types of soils and geologic substrates (Minnich and Howard 1984). The literature relating physical environmental factors to chaparral species composition showed few strong or repeatable relationships over regions, however, the literature revealed that localized patterns may exist based on topographic position and soils (Gauss 1964; Gordon and White 1994; Keeley 2000). In coastal areas where coastal sage is more widely distributed, chaparral is more likely to occur within more mesic topographic positions (*e.g.* north-facing slopes, and areas with low slope angles) (Kirkpatrick and Hutchinson 1980). Within more inland and high elevation sites chaparral is more broadly distributed occurring on most slope-aspects and slope angles (Hanes 1971; Gordon and White 1994). Generally chaparral is thought to occur upon thin, porous, and rocky soils that are relatively low in nitrogen, potassium and phosphorous (Vlamis *et. al.* 1954; Crawford 1962; cited in Hanes 1977). One study has provided evidence that while chaparral and other Mediterranean-type vegetation changes over time depending on fire and disturbance regimes, chaparral is likely to be the edaphic climax vegetation on well drained rocky soils with or without the influence of fire (Callaway and Davis 1993). Most research has asserted that physical environmental factors and fire interact to control the landscape-scale distribution of chaparral versus other vegetation types (*e.g.*, coastal sage scrub, oak woodlands, and grasslands) (Westman 1983; Callaway and Davis 1993; Zedler *et. al.* 1983).

ECOSYSTEM PROCESSES

The dominant driving force in chaparral is fire. The majority of chaparral species are either adapted to occasional fire or are able to persist in fire prone ecological regimes (Hanes 1977; Zedler and Zammit 1989). Chaparral has been described as "autosuccessional," undergoing a rapid succession from largely herbaceous flora immediately after fire to relatively dense woody vegetation in a short time period with minimal loss of species (Hanes 1971; Zedler and Zammit 1989). Early research suggested that without fire, chaparral would develop into oak woodlands or grasslands (Sampson 1944; Wells 1962). Chaparral succession to oak woodlands may occur in mesic situations adjacent to current stands of oak woodlands (e.g., Callaway and D'Antonio 1991) but most research has provided examples of greater than 100 year-old chaparral stands without evidence of physiognomic succession (Zedler 1981; Keeley 1992). This research has shown that in addition to remaining stable and reproductively viable following long periods without fire, some chaparral species (most resprouting species) sexually reproduce largely within older aged stands (Zedler 1981; Keeley 1992). Additional research has shown that high frequency burning of chaparral in the presence of non-native grasses can cause type-conversion from shrublands to non-native grasslands (Wells 1962; Zedler *et al.* 1983; Keeley 1990). So that while chaparral appears to be fire-adapted, it can remain healthy for long periods without fire and too-frequent fire may cause conversion to grassland.

The distribution and species composition of chaparral, at the landscape-scale, is largely influenced by varying interactions between fire regime (frequency, seasonal timing, size, and intensity) and physical environment (Zedler 1981; Zedler *et al.* 1983; Davis *et al.* 1988; Moreno and Oechel 1991a; Minnich 1995; Keeley 2000). The primary source of wildfires prior to human alteration of the "natural" fire regime was lightning (Keeley 1982). Although lightning-caused fires remain, fire regimes have changed due to increased anthropogenic ignitions and fire suppression (Keeley 1982; Timbrook et al. 1982; Minnich 1995). Although much research has been conducted concerning the relationship between chaparral and fire, there are varying opinions on the frequency and patterns of the anthropogenic fire regimes. Two basic models have been described for the "natural" fire regime in chaparral: (1) the fuel dynamics model where fire regime is determined primarily by the amount of combustible plant material (fuel dynamics) and where ignition frequency and source are unimportant (Minnich 1989; 1995); and (2) the ignition/allogenic model where fire is dependent on stochastic combinations of events (weather, ignition source, topography, and vegetation flammability) and where fire history and patch structure are not important (Keeley *et al.* 1989; Minnich 1995). The fuel dynamics model suggests a shorter frequency of fires that preferentially burn where there are suitable fuel loads and avoid recently burned areas (Minnich 1989; 1995). According to the ignition/allogenic model the rates of fire return are presumed to be long-term with large and extensive fires (Keeley *et al.* 1989). Because questions remain about the fire regimes present prior to human alteration, the implications of the altered fire regimes on the functioning of ecosystems in the long-term is not clearly known (Keeley *et al.* 1989; Keeley 2000). Nonetheless, both models suggest that equilibrium in species composition of chaparral is likely produced by variable burning regimes.

Most research has suggested returning to "natural" fire regimes similar to those existing before European settlement in order to improve chaparral Habitat quality (Minnich 1993; Keeley 2000). Because of the high risk involved in allowing fuel loads to develop in urban areas, such fire regimes must be managed in isolated preserves (Tippets *et al.* 1993). Preserve selection and management strategies that recognize the value of "natural" fire regimes are necessary to maintain Habitat capable of supporting the majority of the existing native plants and animals for long periods of time, and allowing for the evolution of new species.

Larger preserve areas with less urban edges and more spatially heterogeneous topography and vegetation would be more likely to maintain "natural" fire regimes. Within larger and more topographically diverse areas there are more opportunities for different plant associations, age stands, and potential for unburned patches to occur. Larger areas with smaller urban edges also reduces the public safety risk from fire. Because of the existing pattern of urban development in southern California and the rarity of some Habitats and species near urban areas, smaller Habitat preserves are inevitable. In smaller preserve areas it may be necessary to actively maintain and manage more diverse patch structure to insure both public safety and functioning ecosystems. Because of the presence of annual grasses and higher frequencies of human fire ignitions in urban areas, active management likely will be required to maintain healthy populations of chaparral species. Because of increased fire frequency and the potential for type conversion of chaparral to non-native grasslands in reserves near urban development, management effort should be focused on maintaining a balance of both old (50 to 100+ years) and younger aged stands. Adaptive management programs will need to be tailored to the composition of chaparral, size of the reserve area, and biological goals of the reserve.

THREATS

Because chaparral and many of its component species are widely distributed there is no direct threat to chaparral as a vegetation type. Certain stands of chaparral that support sensitive species (*e.g.*, Rainbow manzanita [*Arctostaphylos rainbowensis*]) or unique species composition may be threatened by urban development or type conversion at local scales. Precise locations of chaparral endemic sensitive species or unique chaparral associations are required to address potential threats. Large-scale changes in climate or pollution may affect the distribution of chaparral species but research on the effects of potential changes is not well developed. Fire suppression has been described as a threat to chaparral but this has not been demonstrated over large areas. Fire suppression that subsequently allows catastrophic fire likely is a threat to chaparral Habitat quality within isolated reserves because widespread catastrophic fire within a single age-class may eliminate species that do not reproduce well following fire.

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