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Chaparral in Southern and Central Coastal California in the Mid-1990s: Area, Ownership, Condition, and Change

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Cover Photos

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Abstract

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This report summarizes an inventory of chaparral-dominated lands in southern California conducted during the mid-1990s and provides a review of contemporary literature on the ecological dynamics of chaparral vegetation with emphases on stand development, species composition, and the role of fire. Detailed tables provide estimates of chaparral area by owner, type, size, and cover, and, for lands outside national forests, area by fire-hazard class and 10-year change in chaparral area.

Summary

In the mid-1990s, chaparral in California's south and central coast regions was estimated to occupy 4.6 million acres, 14 percent of total land area. About 2.1 million acres of the chaparral were privately owned, and 1.6 million acres were in national forests. The Bureau of Land Management, military reservations, and miscellaneous federal, state, and local agencies accounted for the rest. These estimates were among the results of a field-plot-based vegetation inventory with emphasis on woody species. Chaparral area decreased by 108,000 acres outside national forests between 1984 and 1994 owing to conversions to urban and agricultural use. At 42 percent of the total chaparral area, the chamise and red shank type was the most common type of chaparral, followed by mixed and montane (31 percent), scrub oak (12 percent) and coastal transition (15 percent). *Adenostoma fasciculatum* (chamise) was the most common shrub species, occurring on 71 percent of the area sampled, followed by *Quercus dumosa/john-tuckeri* (California scrub and Tucker oaks) at 39 percent, and *Heteromeles arbutifolia* (toyon) at 19 percent. Emergent trees, important to wildlife and scenery values, and thought by some to have been more prevalent in chaparral before Europeans settled here, were found on 11 percent of the area.

Outside national forests, 16 percent of the chaparral burned between 1984 and 1994; within national forests, 27 percent of the chaparral burned over that period. Remeasured plots that had burned between visits (all within 10 years) showed significantly less shrub and significantly more grass and forb cover. Notable was the loss of *Ceanothus* spp., obligate seeders that fix nitrogen in the soil. During this period, unburned chaparral outside national forests showed little evidence of degradation or loss of biodiversity. Shrub cover held steady or increased on 70 percent of the plots, and many shrub species increased in occurrence while very few decreased.

Outside national forests, application of a chaparral hazard class rating system based on ocular estimates of percentage of dead material in live shrubs and total shrub cover placed 38 percent of the chaparral area in the highest hazard class (greater than 25 percent cover of shrubs and greater than 25 percent dead material in more than half of those shrubs), and 42 percent in the moderate hazard class (greater than 25 percent cover of shrubs and some dead material in at least half of those shrubs). It appears that nearly all chaparral older than 10 years (i.e., since the last disturbance by fire) has moved out of the low-hazard category and would likely burn readily in a wildfire.

Keywords: Chaparral area, chaparral composition, fire hazard, ownership and change, southern California vegetation inventory.

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Introduction and Objectives

Presented here is an analysis of data collected on more than 500 chaparral inventory plots spanning all ownership categories in southern and central coastal California in the mid-1990s. Some of the plots had originally been established in the mid-1980s as part of a statewide chaparral assessment and were revisited to assess change over the 10-year interval. A reassessment of chaparral throughout the entire state—estimated in 1984 to cover 7.4 million acres—was recommended by several people, but limited funds restricted the project to a 14-county area extending from Marin County south to San Diego County (fig. 1). This area contains an estimated 4.6 million acres of chaparral—62 percent of the total in the state–much of which is intermingled and juxtaposed with populous areas undergoing rapid land use change.

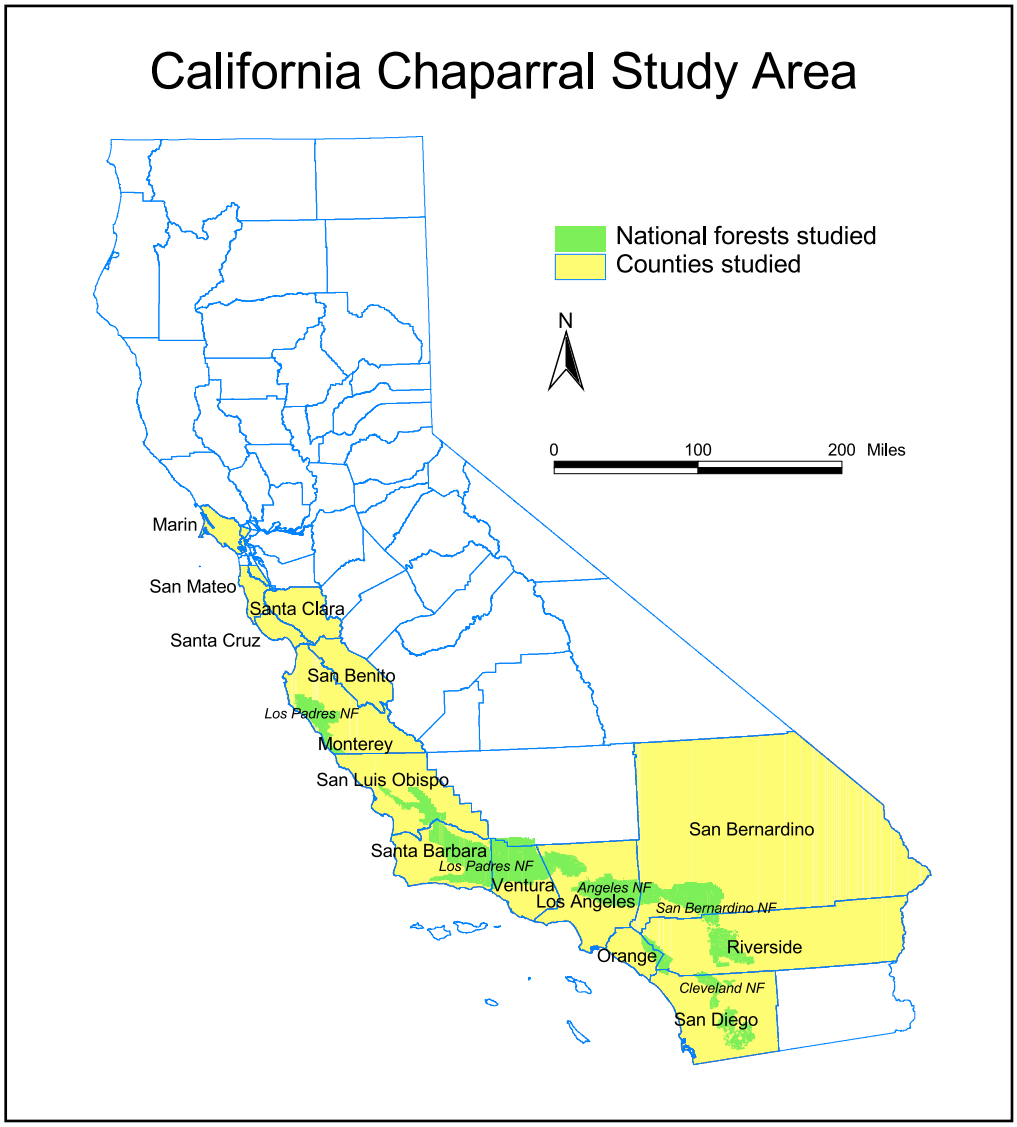

Figure 1—The central and southern coast forest survey units where chaparral was inventoried in the mid-1990s encompass 14 counties, 4 national forests, and considerable areas of reserved lands (e.g., state and federal parks).

Objectives of the inventory and of this study were to produce statistically reliable, replicable, and biologically sound estimates of the extent, ownership, condition, and dynamics of chaparral in the 14-county area, and to analyze this information as it relates to problems and opportunities that chaparral presents to land and resource managers, fire protection agencies, scientists, educators, and the general public. Special emphasis is given to flammability, loss of chaparral to development, characteristics of chaparral stands, and change in composition and density in burned and unburned stands. These objectives can be restated as questions as follows:

1. How much chaparral is there in southern and central coastal California? Who owns it? How much is in parks, preserves, and other kinds of public ownership where it is unlikely to be developed?
2. How much chaparral was lost to development between 1984 and 1994?
3. What are the major chaparral types and most abundant species?
4. How much chaparral burned between 1984 and 1994, and what fire-return interval is implied?
5. What is the postfire stocking condition of chaparral areas that burned since 1984?
6. How have chaparral stands in unburned areas changed? Are there signs of degradation or decline in species diversity?
7. What proportion of the chaparral seems to pose a medium-to-high fire hazard?
8. What proportion of the chaparral has emergent trees, and what tree species are present?

Three major sources of information were used in this study: (1) the rather voluminous and growing scientific literature on chaparral, (2) inventory data for national forest land gathered by the Pacific Southwest Region of the USDA Forest Service, Vallejo, California, and (3) inventory data for land outside national forests, gathered by the Pacific Northwest (PNW) Research Station of the USDA Forest Service, Portland, Oregon.

Data for national forest land were collected in 1993-96 by the Remote Sensing Lab of the Pacific Southwest Region, USDA Forest Service (the national forests in the 14-county study area are Angeles, Cleveland, Los Padres, and San Bernardino). Plots were distributed across these national forests on a systematic grid with an interval of 3.4 miles, and each plot nominally represented 7,400 acres. At each grid location in forest, woodland, or shrubland, a cluster of five, ¼-acre circular subplots was established over an area of about 2.5 acres. At each subplot, plants were recorded by life form (trees, shrubs, subshrubs, forbs, grasses, and grasslikes), species, height layer, and percentage of ground cover. Data quality was assured by specifications in the contract requiring check plots by registered professional foresters on the contractor staff as well as a check of 10 percent of the plots by Forest Service quality assurance staff. Plots in shrub types were not identified as chaparral by field crews; instead, computer models were used to screen the plant data for each plot in a shrub type to determine whether it was chaparral, and if it was, to identify its specific vegetation type (e.g., chamise, scrub oak) (table 1); then the results were scrutinized for reasonableness. A total of 340 national forest plots were classified by this process as chaparral (fig. 2).

Table 1—Area and percentage of total chaparral by type, for three chaparral classification systems, all ownerships

Classification system and type	Area	Percentage of chaparral
	Thousand acres	
PNW (1994):		
CH-Chamise and red shank	1,791.3	42
MIX-Mixed and montane	1,352.6	31
OAK-Scrub oak	500.9	12
CT-Coastal transition[a]	656.3	15
Total chaparral	4,301.1[b]	100
Nonchaparral[c]	55.9	NA
Total (513 plots)	4,357.0	NA
CALVEG:[d]		
BM—Curl-leaf mountain mahogany	7.2	0.2
BS—Basin sagebrush[e]	5.5	0.1
BX—High desert mixed chaparral	10.3	0.2
CA—Chamise	1,413.6	32.5
CC—Ceanothus chaparral	132.4	3.0
CD—Southern mixed chaparral	10.3	0.2
CG—Greenleaf manzanita	9.4	0.2
CQ—Lower montane mixed chaparral	1,479.5	34.0
CR—Red shank	131.4	3.0
CS—Scrub oak	328.1	7.5
CX—Montane-mixed chaparral	9.0	0.2
CZ—Semidesert mixed chaparral	82.7	1.9
DX—Mixed desert shrub[e]	10.8	0.3
JC—California juniper[e]	6.2	0.1
ML—Baccharis	15.7	0.4
NC—North coast chaparral	62.4	1.4
RS—Alluvial fan sage scrub[e]	57.0	1.3
SD—Manzanita chaparral	80.6	1.9
SH—Coastal bluff scrub	22.8	0.5
SM—Sumac	155.5	3.6
SQ—Mixed soft scrub chaparral[e]	25.0	0.6
SS—Coastal sage scrub[e]	240.8	5.5
WM—Birchleaf mountain mahogany	60.8	1.4
Total	4,357.0	100.0

continued next page

California Wildlife Habitat Relationships:		
CRC—Chamise-red shank	1,518.5	34.9
DSC—Desert scrub[e]	18.2	0.4
DSS—Desert succulent shrub[e]	1.7	T
JCW—Juniper[e]	13.2	0.3
MCH—Mixed chaparral	2,351.5	54.0
MCP—Montane chaparral	97.6	2.2
SCS—Coastal scrub[e]	343.6	7.9
SGB—Sagebrush[e]	12.7	0.3
Total	4,357.0	100.0

[a] Coastal transition includes hard chaparral that is geographically marginal to coastal scrub and early successional stages of hard chaparral in which coastal scrub species are temporarily abundant.
[b] 4,301.1 + 309.3 (untyped chaparral in reserved areas outside national forests) = 4,610.4 as shown in table 3.
[c] Classified as forest or as nonforest type other than chaparral by PNW's system.
[d] CALVEG = classification and assessment with Landsat of visible ecological groupings.
[e] Includes some nonchaparral by PNW.

Data for land outside national forests (except parks and other reserved areas) were collected by the Forest Inventory and Analysis Program (FIA) of the Pacific Northwest Research Station (PNW) of the USDA Forest Service in two inventories. In 1981-84, 72 plots were established in chaparral on a 6.8-mile grid, and each plot represented an average of about 29,600 acres. In 1993-94, these 72 plots were revisited, and an additional 109 plots were established on a new 6.8-mile grid offset so that the intersections fell in the interstices of the original grid (fig. 2). When used together, the plots in the two combined grids each represented an average of about 14,800 acres. Crews classified each plot in the field as chaparral or not chaparral (in contrast to procedure followed on national forest land). At plots classified as chaparral, crews established a 55-foot-radius circular plot on which they tallied plants by life form, species, height layer, and density in about the same manner as done on national forests. In addition, crews made ocular estimates of the amount of dead material for each shrub species by height layer; for remeasured plots in chaparral that had burned since the 1984-86 inventory, they determined the year of the fire—usually by contacting residents, landowners, or local agencies. As with all inventory data collected by PNW-FIA, a quality assurance system consisting of management quality objectives and spot checks of field measurements by quality assurance staff was relied on to ensure consistently precise measurements. By using decision rules implemented in computer models, we determined the chaparral type of each plot in the same manner used for national forest plots (except we did not have to determine which plots were chaparral, as that had already been done in the field). For parks and reserved areas, we obtained chaparral area by contacting the park managers or their agencies. In most cases, chaparral in these reserved areas was not classified by types consistent with our other data.

From these data we developed the summaries and analysis presented in this report. The literature reviewed in "A Chaparral Primer" of this report emphasizes the work completed since 1984 in the report, *Shrubs of California's Chaparral, Timberland, and Woodland* (Bolsinger 1989), in order to provide a foundation for the analysis results that follow. Following sections present and discuss the results of our analysis

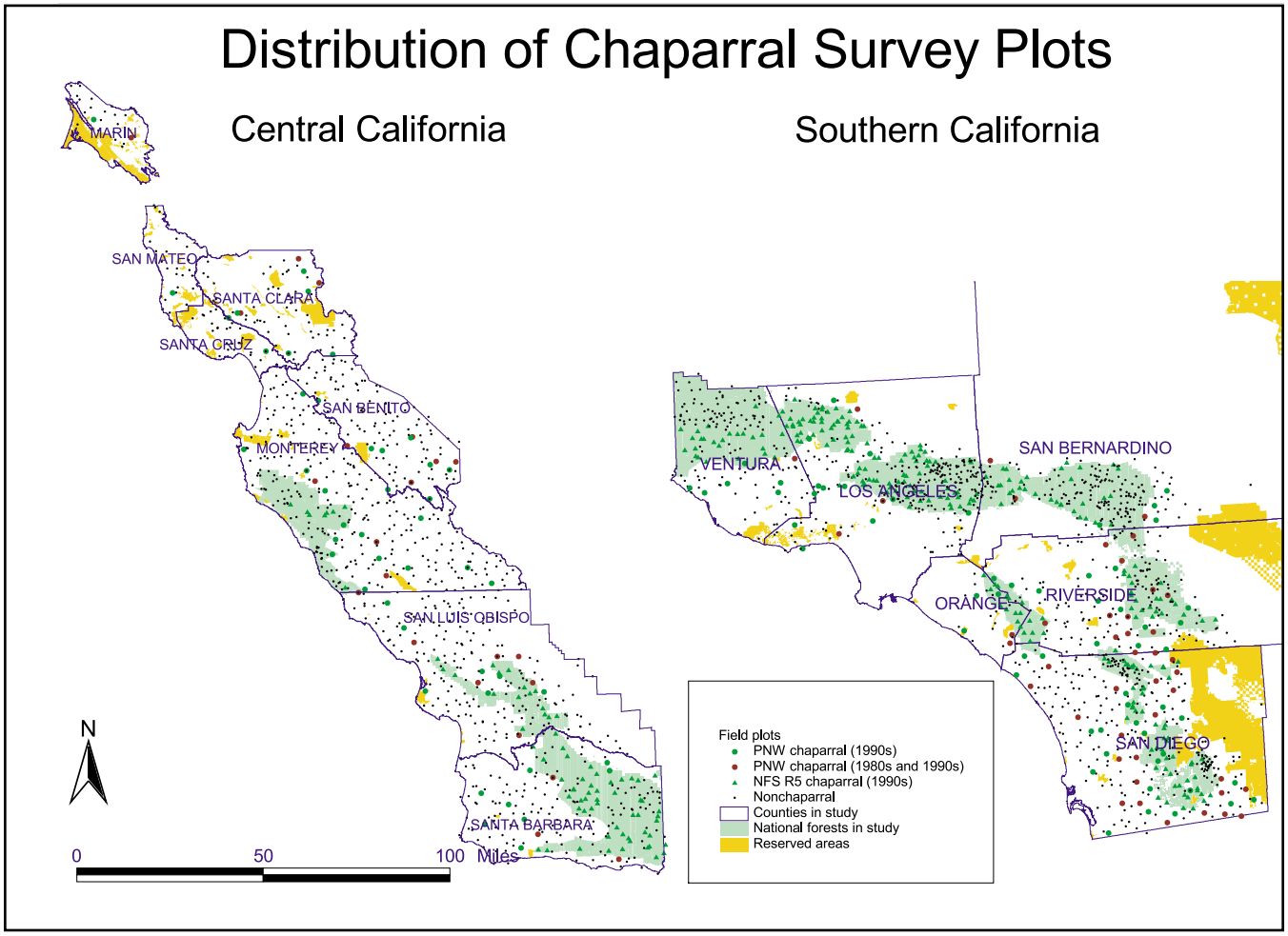

Figure 2— Forest Inventory and Analysis (FIA) field plots in the chaparral study area installed by PNW FIA and National Forest System (NFS) Region 5 as new or remeasured plots; nonchaparral plots also were visited in the field and classified as forest, oak woodland, or other (e.g., urban, agriculture) types. Plot locations are "fuzzed" by up to 8,200 feet (2500 meters) in X and Y dimensions to comply with federal statutes on plot confidentiality.

and relate them to information in the literature to enhance their context and meaning, and "The Next Steps" section outlines potential analytic extensions for which we believe these data may be suited along with plans for the next chaparral inventory.

A Chaparral Primer

Chaparral Defined

"Chaparral," derived from the Spanish "chaparra" for scrub oak (McMinn 1939), refers to a group of biotic communities or vegetation types comprising several genera of shrubs, some of which exhibit treelike growth forms under optimal conditions. Chaparral is often referred to simply as "brush," although in the past it was also called "elfin forest," a poetic term apparently no longer in use. In California, chaparral occurs within the Mediterranean-type climate zone, which is characterized by hot, dry summers and mild, moist winters. Most plant growth occurs in late winter and spring when moisture is available; many chaparral plants are virtually dormant during lengthy periods of summer drought. Similar chaparral also grows in a non-Mediterranean-type climate in

Arizona and northeastern Mexico, where summer rains extend the period of plant growth (Rundel and Vankat 1986). The Mediterranean-type climate zone in California also supports grasslands, coastal scrub, oak woodland, oak savanna, and coniferous forests. Chaparral vegetation at a given place reflects the combined influences of disturbance, macroclimatic factors, and microenvironmental effects that vary by elevation, aspect, and distance from the ocean (Boorse et al. 1998, Keeley 1986, Riggan et al. 1988). Soil type and parent material influence growth and composition of chaparral much less than does climate, except on serpentine and peridotite formations, which are often dominated by specialized plants that tolerate low levels of calcium and the presence of toxic elements (Carrington and Keeley 1999, Keeley 1986).

Dominant shrubs in chaparral are often deeply rooted and usually evergreen and sclerophyllous. In California, major families include the Anacardiaceae, Compositae, Ericaceae, Fagaceae, Lamiaceae, Rhamnaceae, and Rosaceae. Among the genera of woody plants commonly found in California chaparral are *Adenostoma, Arctostaphylos, Artemisia, Baccharis, Ceanothus, Cercocarpus, Garrya, Heteromeles, Malosma, Prunus, Quercus, Rhamnus, Rhus, Salvia,* and *Toxicodendron* (see “Scientific and Common Plant Names” section). At lower elevations on dry sites, chaparral grades into the coastal scrub vegetation type, which includes many drought-deciduous plants (Mooney 1986). In general, chaparral species dominate where summer droughts last no longer than 100 days, and coastal scrub species dominate where summer droughts exceed 100 days (Field and Davis 1986). Within the growing season, photosynthesis of chaparral species is relatively temperature insensitive and differs little with change in elevation. However, differences can occur on a given site among species with contrasting or complementary morphologies and physiological dissimilarities such as different hydraulic properties, rooting depths (as much as 36 percent of chaparral biomass is below ground), and phenologies. This niche segregation or resource partitioning explains the coexistence of species that have different environmental responses, thus accounting for the botanical richness characteristic of many chaparral stands (Oechel and Reid 1984, Redtfeldt and Davis 1996, Vogl 1982). Among the plants that typify the coastal scrub are species of *Salvia, Lotus, Eriogonum, Artemisia,* and *Lupinus.* Chaparral grades into conifer forest or hardwood woodland on moister sites at higher elevations, or on north-facing slopes, and in canyons. Tree species include *Quercus agrifolia, Q. chrysolepis, Q. kelloggii* (on the very moist sites—McDonald 1990b), *Pinus coulteri, P. jeffreyi, P. ponderosa, Pseudotsuga macrocarpa, P. menziesii,* and *Sequoia sempervirens* (Monterey County and north). *Quercus douglasii* occurs in enclaves above, below, and within extensive areas of chaparral, on certain soil types, north of northern Los Angeles County (McDonald 1990a). The boundaries between chaparral and coastal sage scrub types are rarely sharp (fig. 3), with both mixtures of types and abundant type transitions, which appear to follow slight changes in slope, aspect, physiography, soil moisture, and air drainage. Fire effects tend to blur the already indistinct boundaries between chaparral and coastal sage scrub at low elevations and on xeric sites, and between chaparral and forest (including hardwood woodland) at higher elevations and on mesic sites, especially during the first few years following fire. With some exceptions, such as where serotinous conebearers are present (Ne’eman et al. 1999), species from both neighboring types are often present during the early successional period (Vogl 1982). At lower elevations on xeric sites, the presence of a few woody chaparral species, even as sprouts or seedlings, lends weight to a classification of chaparral

rather than coastal scrub. At higher elevations and on mesic sites, snags, tree seedlings, and the presence of shrub species associated with the trees promote the conclusion that a forest preceded the fire, and that it will return given a sufficiently long period of fire exclusion. Among the shrubs found in forest and hardwood woodland more often than in chaparral on plots established by PNW in southern and coastal California in the 1980s (Bolsinger 1989) were *Arctostaphylos patula, A. pringlei* spp. *drupacea, Ceanothus integerrimus, C. cordulatus, C. thyrsiflorus* (often in canyons with *Quercus agrifolia, Q. chrysolepis, Pseudotsuga menziesii,* and *Sequoia sempervirens), C. sorediatus, Holodiscus discolor, Rhamnus californica, Rhus trilobata, Ribes* spp., *Rosa* spp., and *Symphoricarpos* spp. In several places in southern California, the chaparral zone is bounded in the east by desert shrub types, containing genera such as *Larrea, Prosopis, Baccharis, Ephedra, Encelia, Frasera, Atriplex, Coleogyne, Yucca,* and *Opuntia* (McMinn 1939).

Figure 3—California sagebrush, a common species in coastal sage scrub, also occurs in chaparral, as shown here in this association of scrub oak and other shrub species. (Photo by Br. Alfred Brousseau, St. Mary's College)

What We Think We Know About Chaparral

In the past four decades there has been a tremendous increase in the volume of scientific literature on chaparral. As in many fields, newer studies in chaparral have debunked earlier theories and cast doubt on what were thought to be immutable truths of chaparral ecology. There is no reason to believe that ongoing or future investigations will not result in further revisions of chaparral "knowledge," or that all scientists and resource managers will ever be in complete agreement. In fact, many scientists have cautioned users to apply their findings with discretion, and have often been blunt about what is not known. H.A. Mooney (1986): "Recent knowledge creates new puzzles…" Jon Keeley (1986): "…we are far from thoroughly understanding its [chaparral's] mysteries." Numerous authors emphasize "… the need for continued monitoring and research…" (Beyers et al. 1998) or that "…the effort presented here is meant to be a cautionary note…" (Fairbanks et al. 1999), or "The long-term ecological effect…is a critical unknown" (Fenn and Poth 1992). The

following points concerning chaparral's origins, adaptations, and relation to fire, which we accept as true until contradicted by compelling evidence, are contextual to this report. Our findings are not dependent on these points being true. The significance and relevance of our findings may, however, change as a result of new research.

Origin of chaparral—Chaparral vegetation did not develop in a Mediterranean climate as defined today. It began in the form of an understory layer of plants in forest and woodland that thrived in a less mountainous landscape with a milder climate than now exists, and with moist summers, or at least some rainfall sometime during the warmer part of the year. As the climate became more xeric and mountains formed, a fire-prone ecosystem evolved. The combination of drought and fire all but eliminated overstory trees, and high-intensity—often human-caused—fires of current times could accelerate disappearance of these trees. What was originally an understory shrub layer in forests in a maritime/continental climate has become the dominant vegetation now called chaparral in the Mediterranean-like climate (Axelrod 1986, Graumlich 1993, Rundel and Vankat 1986).

Adaptation to drought—Chaparral plants have many survival traits and adaptations to the long summer drought. Among these are deep roots and some species with dual root systems; drought-deciduous root hairs; osmotic adjustability; specialized stomatal structure and placement; leaf angle, surface (pubescent or sclerophyllous), dimorphism, and drought-deciduous response of foliage (fig. 4); shape of canopy (dissipates radiation by convection); height of shrubs (keeps leaves away from hot soil surface); and adaptive wood anatomy (i.e., vasicentric tracheids, grouping of vessels, helical vessel shape) that maintains water column integrity during environmental extremes (Carlquist 1986, Davis 1986, Ehleringer and Comstock 1986, Field and Davis 1986, Hanes 1974, Kummerow and Ellis 1986, Oechel and Reid 1984).

Figure 4—*Aesculus californica* (California buckeye), a drought-deciduous shrub or small tree. (Photo by Br. Alfred Brousseau, St. Mary's College)

Relation to fire—Recurrent fire and persistent drought are the primary environmental factors that determine chaparral community structure. Opinions among chaparral scientists on the degree to which chaparral is dependent on fire differ: “Fire is an ecosystem property rather than an exogenous force…” (Riggan et al. 1988). “…fire may be necessary for ecosystem perpetuation…” (Wohlgemuth et al. 1998). “Increasing site stability allows chaparral to be replaced by oak or pine woodland, savanna, or grassland…” (Vogl 1982). Davis et al. (1998) and Keeley (1995) suggest that chaparral might be characterized as fire tolerant rather than fire dependent. Many chaparral plants have fire-adaptive traits, such as postfire crown sprouting, seeds that usually require high temperature or high concentrations of soil carbon before they will germinate, or ability (e.g., *Ceanothus* spp.) to restore soil nitrogen levels to preburn levels via biological fixation within 2 to 4 years after a fire (Ellis and Kummerow 1986). Chaparral plant communities exhibit successional patterns that begin and end with fire: rapid recovery and growth after fire followed by a brief fire-resistant period, a period of increasing buildup of flammable material, and completing the cycle, the recurrence of fire that removes all vegetation, preparing sites for the establishment of new stands. Despite the many fire adaptations of chaparral, the existence of “vigorous shrub populations, not obviously senile or senescent” (Keeley 1992), in chaparral stands where no burning has occurred for more than a century, indicates that in certain conditions chaparral can get along without fire for relatively long periods (Keeley et al. 1986, Lloret et al. 1999).

Frequency, size, and intensity of fires—Frequency and size of chaparral fires before arrival of European settlers cannot be definitively assessed; however, there are indications of fire-return intervals on the order of 50 to 100 years (Keeley et al. 1986). Although indigenous people set fires and probably increased fire frequency over the natural rate even before European settlers arrived, human populations were very small and vast areas were totally uninhabited. Burcham (1974) conjectures that, except in local areas, fires set by indigenous people would have had little effect on chaparral. Gannet (1900) reported that the grazing of cattle, sheep, and goats numbering in the tens of thousands, and fires set by herdsmen to open up grazing areas, removed vegetation over vast areas in southern Oregon and California between 1850 and 1899, the same period when miners were burning the slopes to expose rock outcrops. This doesn’t mean the indigenous people did not set fires, but the dense vegetation in unburned areas described by Gannet suggests fire had been absent for a long time in many areas. Gannet’s report suggests that European herdsmen, along with miners, might have had a hand in creating the “parklike” forests (stands lacking understory vegetation) photographed in the early 1900s and credited to lightning and indigenous people. In southern California, there is evidence that before the arrival of Europeans, fires in chaparral burned less frequently, but were larger and more intense when they did occur (Axelrod 1986, Byrne 1978). Lightning was probably the major cause of ignition, occurring mostly at higher elevations in areas now mostly within national forests.

Over the past several decades, a tremendous investment has been made in fire suppression and controlled burning in chaparral (fig. 5) aimed at decreasing the number, size, and intensity of catastrophic wildfires. The success of this effort is open to debate. Minnich (1983), in a study based on analysis of Landsat imagery, concluded: “Fire control in chaparral reduces the number of fires, not burned hectarage; **fires consequently increase in size, spread rate, and intensity and**

become uncontrollable in severe weather conditions" (emphasis added). A somewhat different view is offered by Keeley et al. (1999): "…analysis of the California Statewide Fire History Database shows that, since 1910, fire frequency and area burned have not declined, and **fire size has not increased**. Fire rotation intervals have declined and fire season has not changed, implying that the **fire intensity has not increased**" (emphasis added). Based on their findings (which used total county area in calculating return interval), Keeley et al. (1999) suggested that fire suppression does "…play a critical role in offsetting potential impacts of increased ignitions." Also, because "large fires were not dependent on old age classes of fuels…it is unlikely that age class manipulation can prevent large fires. Expansion of the urban-wildland interface is a key factor in wildland fire destruction."

Figure 5—Controlled burn in chaparral. (Photo by USDA Forest Service, Pacific Southwest Research Station)

Response to fire—Fires usually occur in chaparral in late summer or fall. The following spring, herbaceous vegetation appears. Almost immediately, preburn shrubby species emerge—sprouters such as *Adenostoma fasciculatum* (fig. 6) and many *Arctostaphylos* species, and obligate seeders such as certain species of *Ceanothus* (Carrington and Keeley 1999, Lloret et al. 1999, Sparks and Oechel 1993, Stohlgren et al. 1986). A very hot fire in chaparral on a harsh site, though, may cause "shock stagnation," resulting in a semipermanent coastal sage scrub community, or even a depauperate grassland. On some sites, "flash-fuel species," such as *Lotus scoparius* and *Eriogonum fasciculatum,* are among the first woody or semiwoody plants to appear after a fire (Vogl 1982). These species have finely dissected foliage, and like annual grasses, become easily ignitable and highly flammable in late summer, increasing the chance of reburning before stand recovery. Chaparral that burns a second time within a few years often undergoes a dramatic change in vegetation, with the loss of obligate seeders and weakening of some sprouters (Keeley 1995, Riggan et al. 1988). The practice of seeding burned areas to annual grasses, such as *Lolium perenne* ssp. *multiflorum* (Italian ryegrass), can lead to early reburning, as well as

Figure 6—Sprouting chamise after fire killed the aboveground growth. (Photo by USDA Forest Service, Pacific Southwest Research Station)

delayed or failed regeneration of woody plants owing to grass root competition (Vila and Sardans 1999, Wohlgemuth et al. 1998).

Importance of chaparral—Chaparral's inherent flammability generates a lot of attention from land managers who are indirectly charged with protecting the property and lives of millions of people placed at risk from uncontrolled fires. Ongoing encroachment of development into chaparral ecosystems is placing more people in jeopardy and increasing the costs and complexity of management. Human encroachment also threatens the health, function, and even the existence of chaparral in four ways: (1) outright replacement of natural communities by urban and commercial development, putting many species of plants and animals in peril (e.g., San Diego County "…is home to more endangered species than any other county in the Continental United States" [Nickens 2001]); (2) fragmentation of habitat into pieces too small or too narrow to be self-sustaining or useful to wildlife (Bolger et al. 1997); (3) increased frequency of human-caused wildfires, resulting in degradation of chaparral communities (Keeley 1995); and (4) damage and degradation of stands by various human activities. Chaparral managers also are faced with trying to control or minimize erosion and mass movement of steep slopes—which, like fire, can lead to property damage and loss of life–and maintaining air and water quality, viewsheds, and open space. Soils under chaparral have been found to have relatively high concentrations of organic carbon and nitrogen, an important consideration locally, but also important at the global scale because soils store about twice the amount of carbon stored in living biomass or the atmosphere (Quideau et al. 1998).

Chaparral is important habitat for many species of birds, reptiles, and mammals—year-round residents as well as seasonal transients. Some deep-habitat dwellers rely almost entirely on chaparral for food, shelter, and reproduction sites, whereas others occupy the ecotonal zones between chaparral and woodland or chaparral and grassland, and use chaparral and nonchaparral habitats to satisfy their various

needs (Bolger et al. 1997, Mayer and Laudenslayer 1988, Quinn 1990, Wirtz 1991). Chaparral management activities intended to protect or enhance one set of values may be at cross-purposes with other values and objectives. For example, prescribed fire is an important tool for maintaining healthy chaparral and minimizing the risk of catastrophic wildfire (Biswell 1989), but smoke emissions from controlled burns negatively affect air quality (Hardy et al. 1996), a critical factor in southern California where chaparral is juxtaposed and intermingled with built-up areas.

Chaparral Area, Ownership, and Classification

Chaparral Area

As defined in this study, chaparral covers about 4.6 million acres—approximately 7,200 square miles—in the southern and central coastal region of California. This is 14 percent of the total land in the 14-county study area (tables 2 and 3). Area of chaparral in central coastal and southern California by type and Bailey's ecosection (Bailey et al. 1994) is shown in tables 4, 5 and 6, and the distribution of chaparral plots by ecosection is shown in figure 7. Chaparral tends to be concentrated in counties that abut the ocean from Monterey south to San Diego. Excluded from the study are the Bay Area counties of Alameda, Contra Costa, and San Francisco, which are heavily urbanized, and contain relatively little chaparral; and Solano County, which consists mostly of agricultural and urban areas. Chaparral amounts to only 10.9 percent of the land area in Riverside County and 2.2 percent in San Bernardino, but these percentages are somewhat misleading (fig. 8). These counties collectively contain nearly 800,000 acres of chaparral. The percentages are small only because of the enormous size of the counties.

Table 2—Chaparral[a] area by county, owner class, and reserved status

County	Unreserved			Reserved			Total
	National forest	Other public[b]	Private	National forest	Other public[c]	Private[c]	
			Acres				
Los Angeles	300,582	21,420	175,730	18,406	36,981	670	553,789
Marin		21,462	9,124		6,580	400	37,566
Monterey	12,954	72,970	238,170	33,832	11,400	20	369,345
Orange	45,997		56,932		5,220	3,400	111,550
Riverside	79,357	78,708	231,185	79,202	30,208	500	499,160
San Benito		95,204	138,919		12,500		246,623
San Bernardino	163,681	10,782	91,117		10,430		276,010
San Diego	195,028	240,259	454,138	12,271	101,230	515	1,003,441
San Luis Obispo	72,508	85,846	209,269	30,635	19,460		417,718
San Mateo			18,249		17,843	60	36,152
Santa Barbara	167,420	38,631	117,431	115,263	1,900		440,645
Santa Clara			170,307		18,120		188,427
Santa Cruz			25,913		6,415		32,328
Ventura	79,315	21,462	114,420	85,825	25,425		326,447
Total	1,116,842	686,743	2,050,906	375,434	303,712	5,565	4,539,201

[a] PNW chaparral determined in field. National forest chaparral determined by <10 percent cover, and CALVEG type considered to be hard chaparral.
[b] Includes federal, state, county, and municipal agencies.
[c] Reserved other public and reserved private data are from reports by those owners, i.e., not sampled.

Table 3—Chaparral area, by county

County	Total land area	Chaparral area[a]	Percentage of county in chaparral	Study area chaparral in county
	---------- *Acres* ----------		---------- *Percent* ----------	
Los Angeles	2,514,560	588,896	23.4	12.8
Marin	332,800	37,566	11.3	.8
Monterey	2,126,080	369,345	17.3	8.0
Orange	505,600	111,550	22.1	2.4
Riverside	4,613,120	502,725	10.9	10.9
San Benito	888,960	246,623	27.7	5.3
San Bernardino	12,839,040	279,574	2.2	6.1
San Diego	2,691,200	1,003,441	37.3	21.8
San Luis Obispo	2,114,560	417,718	19.7	9.1
San Mateo	287,360	36,152	12.6	.8
Santa Barbara	1,628,800	462,344	28.4	10.0
Santa Clara	826,240	188,427	22.8	4.1
Santa Cruz	285,440	32,328	11.3	.7
Ventura	1,181,440	333,680	28.2	7.2
All	32,835,200	4,610,368	14.0	100.0

[a] County acreages differ from those in table 2 because National Forest System classifications of chaparral used in some counties differ from PNW classifications.

Table 4—Area by Bailey's ecosection, owner group, and PNW chaparral classification system

Bailey's ecosection	Owner group	Chamise	Coastal transition	Mixed chaparral	Scrub oak	Non-chaparral	Total
		----------	----------	*Acres*	----------	----------	----------
Bay area/delta	NF,[a] unreserved						0
	NF, reserved						0
	Other public	21,462					21,462
	Private	114,055	50,184	22,811	10,630		197,681
Colorado Desert	NF, unreserved	4,133					4,133
	NF, reserved				10,233		10,233
	Other public	32,346		17,970	6,829		57,145
	Private	58,912		47,129	15,710		121,751
Mojave	NF, unreserved						0
	NF, reserved						0
	Other public		10,782				10,782
	Private	15,710		15,710	40,845		72,265
San Joaquin Valley	NF, unreserved						0
	NF, reserved						0
	Other public			21,462			21,462
	Private				22,811		22,811
South-central coast	NF, unreserved	52,727	28,932	211,584	35,606	42,858	371,707
	NF, reserved	70,066	36,165	155,960	25,063		287,253
	Other public	107,308	30,046	103,016	30,819		271,189
	Private	440,755	53,743	105,273	107,121		706,892
South coast	NF, unreserved	259,546	85,313	395,609	92,862	13,061	846,390
	NF, reserved	30,367	10,233	50,510	8,536		99,646
	Other public	122,196	140,063	42,445			304,704
	Private	461,679	210,858	163,119	93,850		929,506
Total		1,791,263	656,319	1,352,596	500,914	55,919	4,357,011

Note: Other public includes federal, state, county, and municipal agencies.
[a] NF = national forest.

Table 5—Area by Bailey's ecosection, owner group, and CALVEG classification system

Bailey's ecosection	Owner group	Curl-leaf mountain mahogany	Basin sagebrush	High desert mixed chaparral	Chamise	Ceanothus chaparral	Southern mixed chaparral	Greenleaf manzanita	Lower montane mixed chaparral
		Acres							
Bay area/delta	NF, unreserved								
	NF, reserved								
	Other public								21,462
	Private				68,433				68,433
Colorado Desert	NF, unreserved				4,133				
	NF, reserved								10,233
	Other public				32,346				17,970
	Private				31,294	15,710			15,710
Mojave	NF, unreserved								
	NF, reserved								
	Other public								
	Private				15,710				15,710
San Joaquin Valley	NF, unreserved								
	NF, reserved								
	Other public								21,462
	Private								
South-central coast	NF, unreserved				42,384				255,283
	NF, reserved				58,245				182,805
	Other public				85,846	17,169		9,357	42,923
	Private				395,133				91,586
South coast	NF, unreserved	7,208	5,517	10,264	210,795	27,617	10,347		371,397
	NF, reserved				10,279				41,604
	Other public				104,226				63,907
	Private				354,821	71,857			258,974
Total		7,208	5,517	10,264	1,413,646	132,353	10,347	9,357	1,479,458

Note: Other public includes federal, state, county, and municipal agencies.

Table 5—Area by Bailey's ecosection, owner group, and CALVEG classification system (continued)

Bailey's ecosection	Owner group	Red shank	Scrub oak	Baccharis	Montane-mixed chaparral	Semidesert mixed chaparral	Mixed desert shrub	California juniper	North coast chaparral
		Acres							
Bay area/delta	NF, unreserved								
	NF, reserved								
	Other public								
	Private		10,630						27,373
Colorado Desert	NF, unreserved								
	NF, reserved								
	Other public		6,829						
	Private	27,618							
Mojave	NF, unreserved								
	NF, reserved								
	Other public						10,782		
	Private		40,845						
San Joaquin Valley	NF, unreserved								
	NF, reserved								
	Other public								
	Private		22,811						
South-central coast	NF, unreserved		6,675			13,389		6,156	
	NF, reserved		10,597			7,233			
	Other public		21,462			21,462			
	Private		84,310			22,811			25,913
South coast	NF, unreserved	19,860	53,759			17,817			
	NF, reserved	28,948	4,652		9,024				
	Other public	17,970							
	Private	36,981	65,573	15,710					9,124
Total		131,377	328,141	15,710	9,024	82,711	10,782	6,156	62,411

Note: Other public includes federal, state, county, and municipal agencies.

Table 5—Area by Bailey's ecosection, owner group, and CALVEG classification system (continued)

Bailey's ecosection	Owner group	Alluvial fan sage scrub	Manzanita chaparral	Coastal bluff scrub	Sumac	Mixed soft shrub chaparral	Coastal sage scrub	Birchleaf mountain mahogany	Total
		----------	----------	----------	*Acres*	----------	----------	----------	----------
Bay area/delta	NF, unreserved								0
	NF, reserved								0
	Other public								21,642
	Private						22,811		197,681
Colorado Desert	NF, unreserved								4,133
	NF, reserved								10,233
	Other public								57,145
	Private				31,420				121,751
Mojave	NF, unreserved								0
	NF, reserved								0
	Other public								10,782
	Private								72,265
San Joaquin Valley	NF, unreserved								0
	NF, reserved								0
	Other public								21,462
	Private								22,811
South-central coast	NF, unreserved	32,493					11,441	3,885	371,707
	NF, reserved	7,233					14,466	6,675	287,253
	Other public		42,923			21,462	8,585		271,189
	Private		13,687	22,811			50,641		706,892
South coast	NF, unreserved	17,253	18,847		10,933	3,564	28,963	32,249	846,390
	NF, reserved		5,140						99,646
	Other public				50,316		50,316	17,970	304,704
	Private				62,839		53,628		929,506
Total		56,979	80,596	22,811	155,508	25,026	240,850	60,779	4,357,011

Note: Other public includes federal, state, county, and municipal agencies.

Table 6—Area by Bailey's ecosection, owner group, and California Wildlife Habitat Relationships classification system

Bailey's ecosection	Owner group	Chamise-red shank	Mixed chaparral	Montane chaparral	Coastal scrub	Juniper	Desert succulent	Desert scrub	Sagebrush	Total
		Acres								
Bay area/delta	NF, unreserved									0
	NF, reserved									0
	Other public		21,462							21,462
	Private	68,433	79,063		50,184					197,681
Colorado Desert	NF, unreserved	4,133								4,133
	NF, reserved		10,233							10,233
	Other public	32,346	24,799							57,145
	Private	43,202	78,549							121,751
Mojave	NF, unreserved									0
	NF, reserved									0
	Other public									0
	Private	15,710	56,555					10,782		83,047
San Joaquin Valley	NF, unreserved									0
	NF, reserved									0
	Other public		21,462							21,462
	Private		22,811							22,811
South-central coast	NF, unreserved	42,384	294,693	10,041	11,441	13,147				371,707
	NF, reserved	58,245	200,635	13,908	14,466					287,253
	Other public	85,846	145,939	9,357	30,046					271,189
	Private	395,133	212,394		99,365					706,892
South coast	NF, unreserved	230,048	528,153	41,224	25,078		1,713	7,449	12,725	846,390
	NF, reserved	28,994	65,513	5,140						99,646
	Other public	122,196	114,223	17,970	50,316					304,704
	Private	391,802	474,952		62,752					929,506
Total		1,518,473	2,351,434	97,639	343,649	13,147	1,713	18,231	12,725	4,357,011

Note: Other public includes federal, state, county, and municipal agencies.

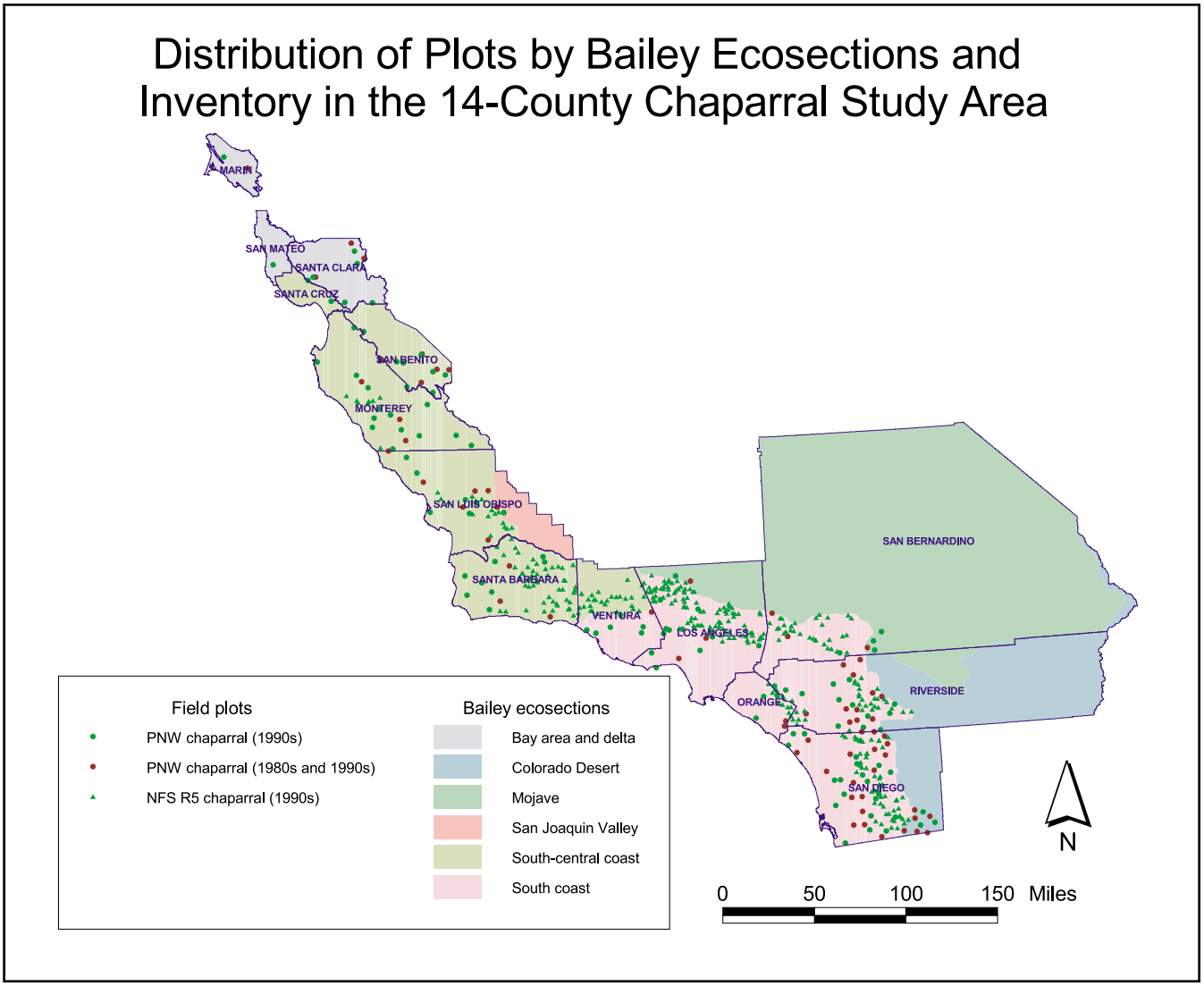

Figure 7—Distribution of chaparral plots by Bailey's ecosection.

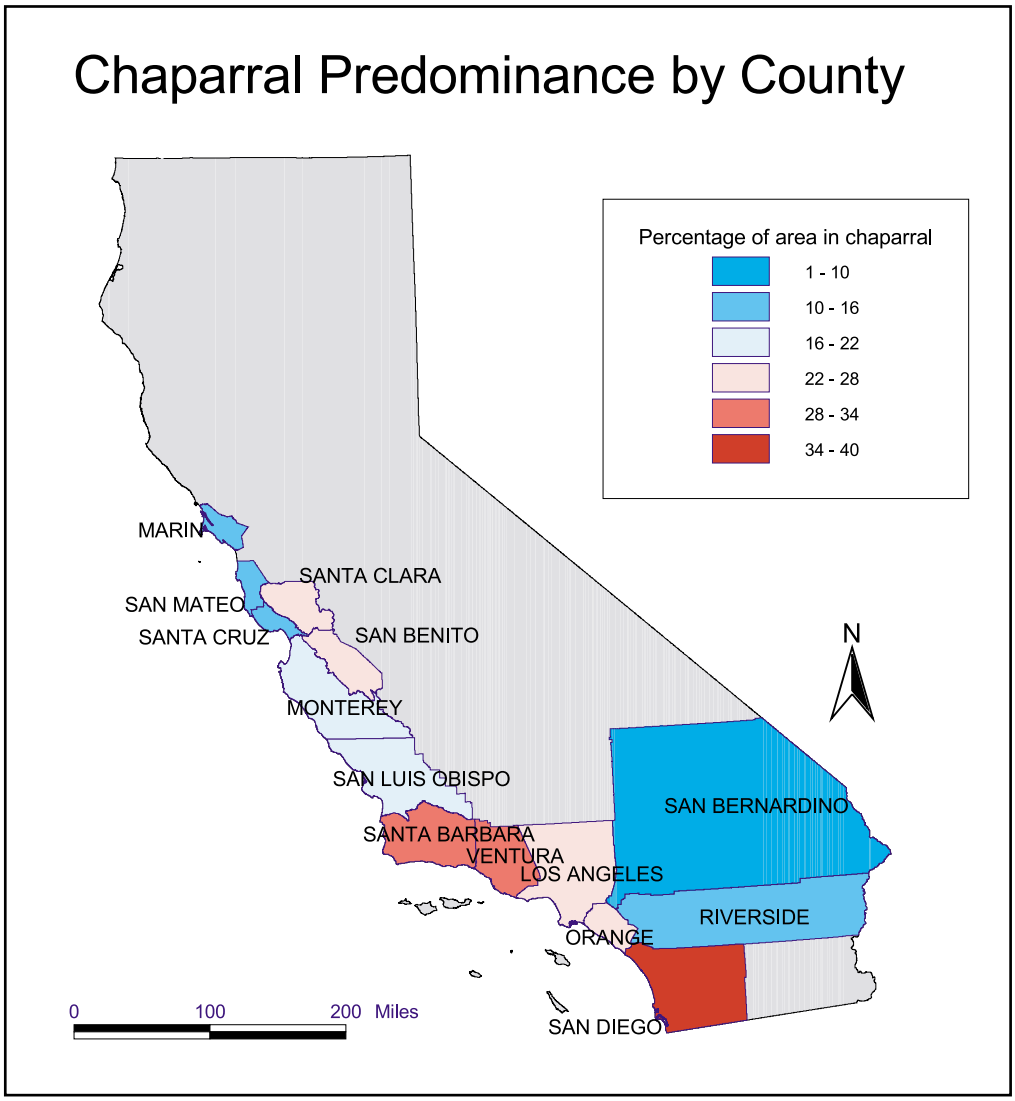

Figure 8—Chaparral predominance by county.

Ownership

A little more than 2 million acres (45 percent of chaparral area) of chaparral in southern and central coastal California is in private ownership, including 132,000 acres of tribal lands. About 1.2 million acres (34 percent) of chaparral are administered by the USDA Forest Service in the Angeles, Cleveland, Los Padres, and San Bernardino National Forests. The USDI Bureau of Land Management administers 392,000 acres (9 percent). The balance is fairly evenly divided among other federal, state, and county/municipal agencies, with roughly 200,000 acres (4 percent) in each ownership. About 15 percent of the chaparral is in parks, wilderness, and other reserved areas, as shown in table 7.

Table 7—Chaparral area by owner group

Ownership	Unreserved	Reserved	Total area	
	---------- *Acres* ----------			*Percent*
Private	2,050,905	5,565	2,056,470	44.6
National forest	1,166,311	397,132	1,563,443	33.9
Bureau of Land Management	392,095	41,030	433,125	9.4
Other federal[a]	177,195	22,910	200,105	4.4
State	0	171,506	171,506	3.7
County/municipal	117,453	68,266	185,719	4.0
Total	3,903,959	706,409	4,610,368	100.0

[a] Includes Department of Defense.

Change in Chaparral Area

Estimates of change in area of chaparral for land outside national forests are based on the classification of plots at two points in time. For example, the area represented by a plot classified as chaparral in the previous inventory (nominally 1984) and classified as nonforest urban in the next inventory (nominally 1994), would be counted as a decrease in chaparral area. Comparable change estimates cannot be made for national forests because plots have been visited only once. The primary causes of change in area of chaparral are urban, industrial, and agricultural developments, which are rare to nonexistent on national forest land. It is possible that land exchanges could have resulted in the development of land formerly under national forest control, but these areas would then be sampled by PNW plots, and theoretically accounted for in the resulting figures. Any change in area of chaparral in national forests caused by construction or removal of, for example, roads, reservoirs, and powerlines, cannot be accounted for by this analysis. The chaparral plots in national forests used in this study have been monumented for relocation, and will, if revisited in the future, provide a basis for monitoring change.

Based on the sample plots, the net decrease in chaparral outside national forests over the nominal 10-year period 1984-94 was 179,400 acres. This change comprises 108,400 acres in conversions to urban and agricultural/range uses; 84,000 acres dedicated to parks and other reserves (which are still chaparral, physically, but fell out of the inventory as defined in 1994); and, 13,000 acres of rangeland that became chaparral (fig. 9). This 13,000-acre conversion from rangeland to chaparral is a real change according to the definitions, but the land could possibly have been chaparral at some time prior to the 1984 inventory. All plots that changed land class were scrutinized closely to ensure that change was genuine and not simply the result of differences in the interpretation of definitions. For example, a plot classified as chaparral in the 1984 inventory was classified as oak woodland in 1994. On closer inspection the crews decided the plot really had been oak woodland all along, despite the abundance of chaparral species. That plot is not included in these change estimates. The net physical loss of chaparral is 95,400 acres—108,400 acres lost to development offset by 13,000 acres gained from grassland—and amounts to about 3.3 percent of the

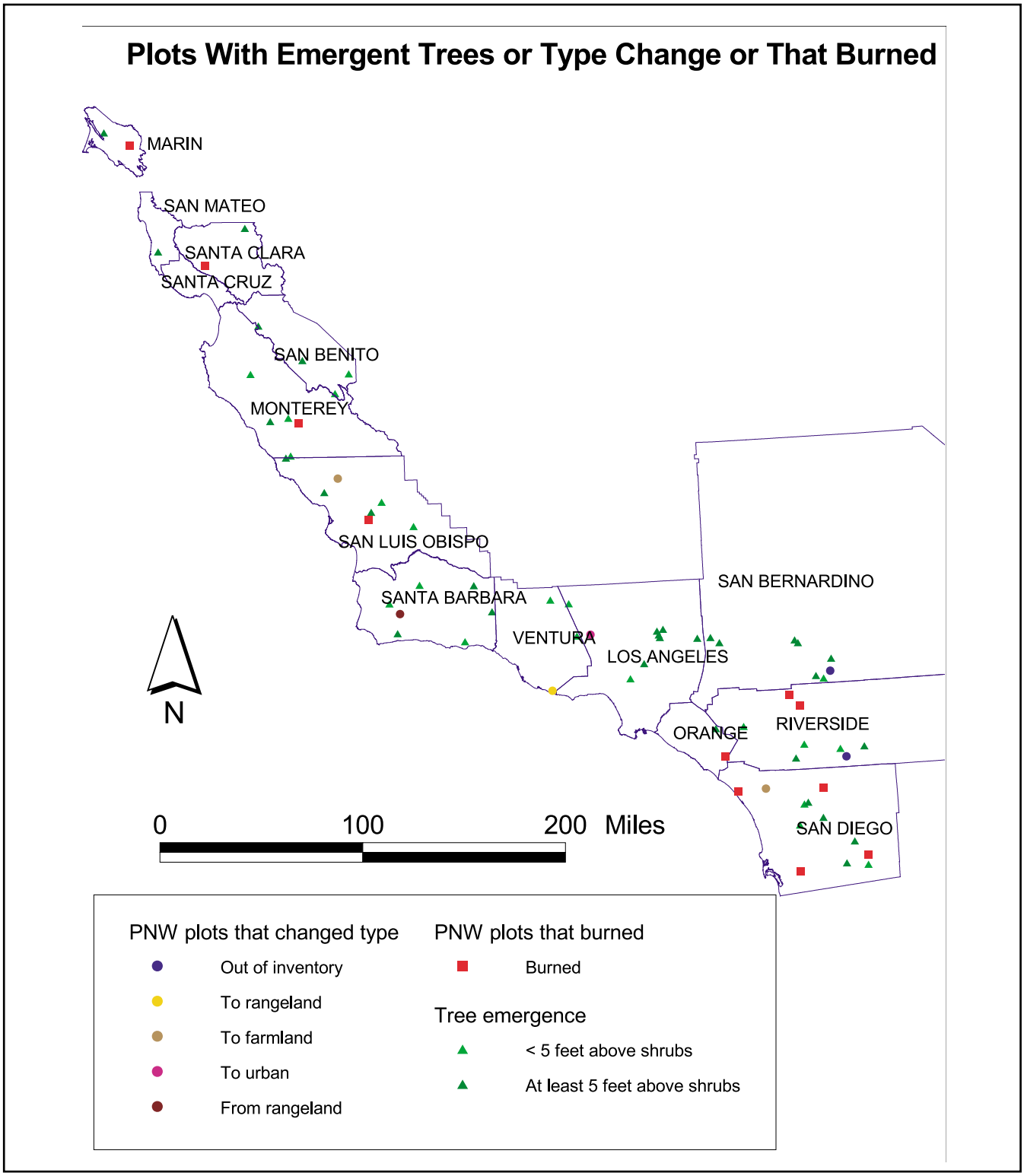

Figure 9—Plots outside national forest with type change or fire incidence between measurements and all plots with emergent or pre-emergent trees in the 1990s.

Table 8—Area by PNW chaparral type

PNW chaparral type	Area	Percentage of chaparral
	Thousand acres	
Chamise and red shank	3,822	51
Mixed and montane	1,520	20
Scrub oak	952	13
Mountain mahogany	309	4
Coastal transition	578	8
Untyped (in parks)[a]	267	4
Total	7,448	100

[a] Primarily where no systematic inventory has been undertaken and areas are estimated by park managers.

area of chaparral in 1984. This comes out to 9,540 acres—about 15 square miles per year. In the statewide chaparral inventory conducted in the 1980s (Bolsinger 1989), five broad types were recognized (table 8). The PNW chaparral types were classified by using the following protocol:

Chaparral Types in the 1980s

Chamise and red shank—Crown cover of *Adenostoma fasciculatum* or *A. sparsifolium* or both is 40 percent or more and exceeds that of all *Quercus* spp. combined, or *Cercocarpus* spp. combined, or other individual species; or, *Adenostoma* spp. have simple plurality if no species has 40 percent crown cover (fig. 10). In this report, plots that would have been classified as red shank in 1984 are usually lumped with the chamise type because red shank is so lightly represented in the study area covered by this report (five plots outside national forests and eight plots on national forests); however, results for red shank are listed separately from chamise in the burned area analysis and constancy tables because of possible differences between these two types.

Scrub oak—Crown cover of shrubby *Quercus* spp. is 40 percent or more and exceeds that of *Adenostoma* spp. combined, or *Cercocarpus* spp. combined, or other individual species; or, *Quercus* spp. have simple plurality if no species or type group has 40 percent crown cover.

Mountain mahogany—Crown cover of *Cercocarpus* spp. is 40 percent or more and exceeds that of *Adenostoma* spp. combined, or *Quercus* spp. combined, or other individual species; or, *Cercocarpus* spp. have simple plurality if no species or type group has 40 percent crown cover.

Coastal transition—Soft (pliable-stemmed) chaparral species (Paysen et al. 1980) make up 25 percent or more of the shrub cover, but hard (woody-stemmed) chaparral species are dominant, or when present but not dominant in immature stands are expected to dominate at maturity. Major hard chaparral species in this type are

Figure 10—Chamise stand with emergent trees in background. (Photo by Charles Webber, California Academy of Sciences)

Baccharis pilularis, Heteromeles arbutifolia, Rhus integrifolia, R. ovata, and *Malosma laurina,* but many others often occur. Common soft chaparral species are *Salvia* spp. (fig. 11), *Artemisia californica, Eriogonum* spp., *Lotus scoparius, Encelia* spp., and *Croton* spp. Stands classified as coastal transition were either in a zone of gradation from the more mesic hard chaparral to xeric scrub at lower elevation (geographic transition), or had been disturbed in the recent past and were temporarily (as judged by field crews) dominated by coastal scrub species (successional transition), although hard chaparral species were present.

Mixed and montane—Hard chaparral species dominate, and none of the above categories apply. In this broad type are species of *Adenostoma, Arctostaphylos, Ceanothus, Prunus, Rhus, Quercus, Garrya, Cercocarpus,* and many others (fig. 12).

Chaparral Types in the Current Study

In this study, the same broad types and definitions used in the 1980s chaparral inventory by PNW were used to develop basic statistics for comparative purposes with this exception: all species of *Cercocarpus* (mountain mahogany) were combined with mixed and montane chaparral because two-thirds of the area in mountain mahogany types is outside the central coast and southern California study area. Also, many of the stands with *Cercocarpus* species present were borderline, such that a difference in cover of 1 or 2 percent by any number of species could change the classification.[1] All plots in this study were classified according to the PNW

[1] The two most prevalent species of *Cercocarpus* in California—*C. ledifolius* and *C. betuloides*—occur in somewhat different environments and properly belong in different types, as they have been placed in the CALVEG and CWHR systems (see following section). There was only one plot with *C. ledifolius* in the current study area, so the matter is rather academic.

Figure 11—*Salvia mellifera* (black sage), a common species in coastal sage scrub, is seasonally dimorphic, with large, broad leaves during moist seasons, and small, narrow leaves during drought. (Photo by Todd Keeler-Wolf, California Department of Fish and Game)

chaparral types described above, and two other systems:[2] (1) Classification and assessment with Landsat of visible ecological groupings–CALVEG (USDA FS, 1981, 2000a, 2000b) and California wildlife habitat relationships (CWHR) (California Department of Fish and Game 1999, Mayer and Laudenslayer 1988). The CALVEG system is a constantly evolving mapping and hierarchical classification system that combines life form estimates derived from remotely sensed data with quite specific field observations of cover type, species, size, and other attributes of vegetation for broad-scale planning and analysis. The CWHR system, also hierarchical and evolving, incorporates information on vegetation life form, stand structure, and cultural and

[2] A system of vegetation classification developed by a group of distinguished scientists and published by the California Native Plant Society (CNPS) (Sawyer and Keeler-Wolf 1995) has much to offer, and we expect to test its use for future assessments. We didn't use it in this assessment for these reasons: (1) timing; (2) the large number of shrub series in the CNPS system would stretch the limitations of our plot sample; (3) the CNPS system uses qualitative (vs. quantitative) criteria, which we feel (perhaps unjustifiably) would make it difficult to get consistent results in repeat measurements by field crews with various levels of experience.

aquatic elements, at scales needed for wildlife habitat management and planning. Applying these three classification systems to the 513 chaparral plots resulted in three distributions of area by type and some differences in total chaparral area (because a plot could fit a chaparral type in one classification system, but not in another). Included in table 1 are areas for plant associations that qualify as chaparral by at least one classification system, even though they may not qualify by all systems. A complete summary of acres by type and owner can be found in tables 4, 5, and 6. Maps of plot locations symbolized by chaparral type under each classification system strongly suggest spatial clustering (figs. 13-15).

Figure 12—Mixed chaparral consisting primarily of *Arctostaphylos glandulosa,* (Eastwood's manzanita) with minor amounts of *Ceanothus* spp., *Prunus* spp., and *Quercus* spp. (Photo courtesy of Todd Keeler-Wolf, California Department of Fish and Game)

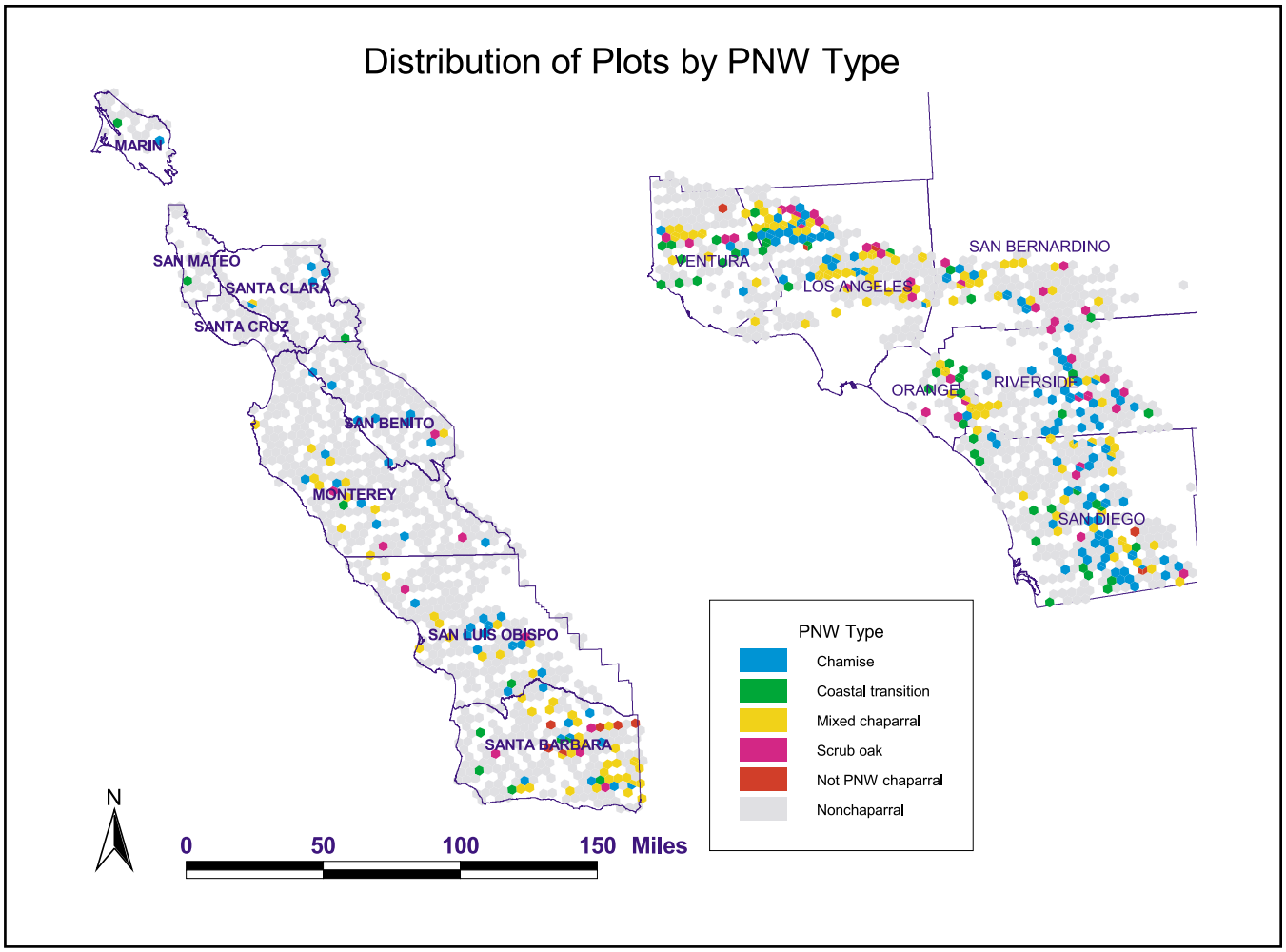

Figure 13—Distribution of chaparral plots by PNW type; to comply with federal statutes on plot confidentiality, 6,000-acre hexagons are attributed according to the plot or plots contained therein; where there are multiple plots in a hex with different attribute values, hexes are arbitrarily subdivided to ensure that all types are displayed.

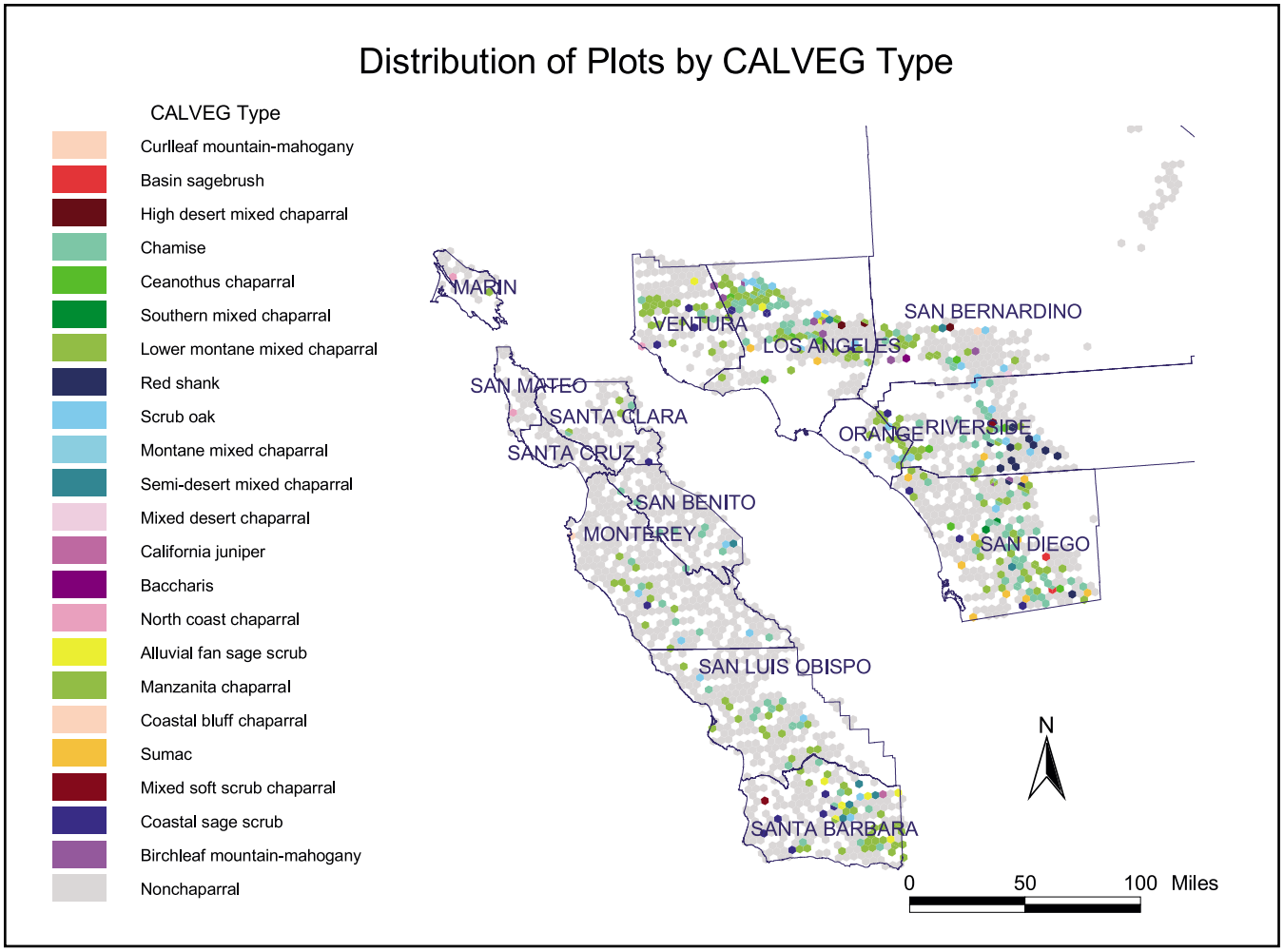

Figure 14—Distribution of plot locations coded by CALVEG type; to comply with federal statutes on plot confidentiality, 6,000-acre hexagons are attributed according to the plot or plots contained therein; where there are multiple plots in a hex with different attribute values, hexes are arbitrarily subdivided to ensure that all types are displayed. CALVEG = classification and assessment with Landsat of visible ecological groupings.

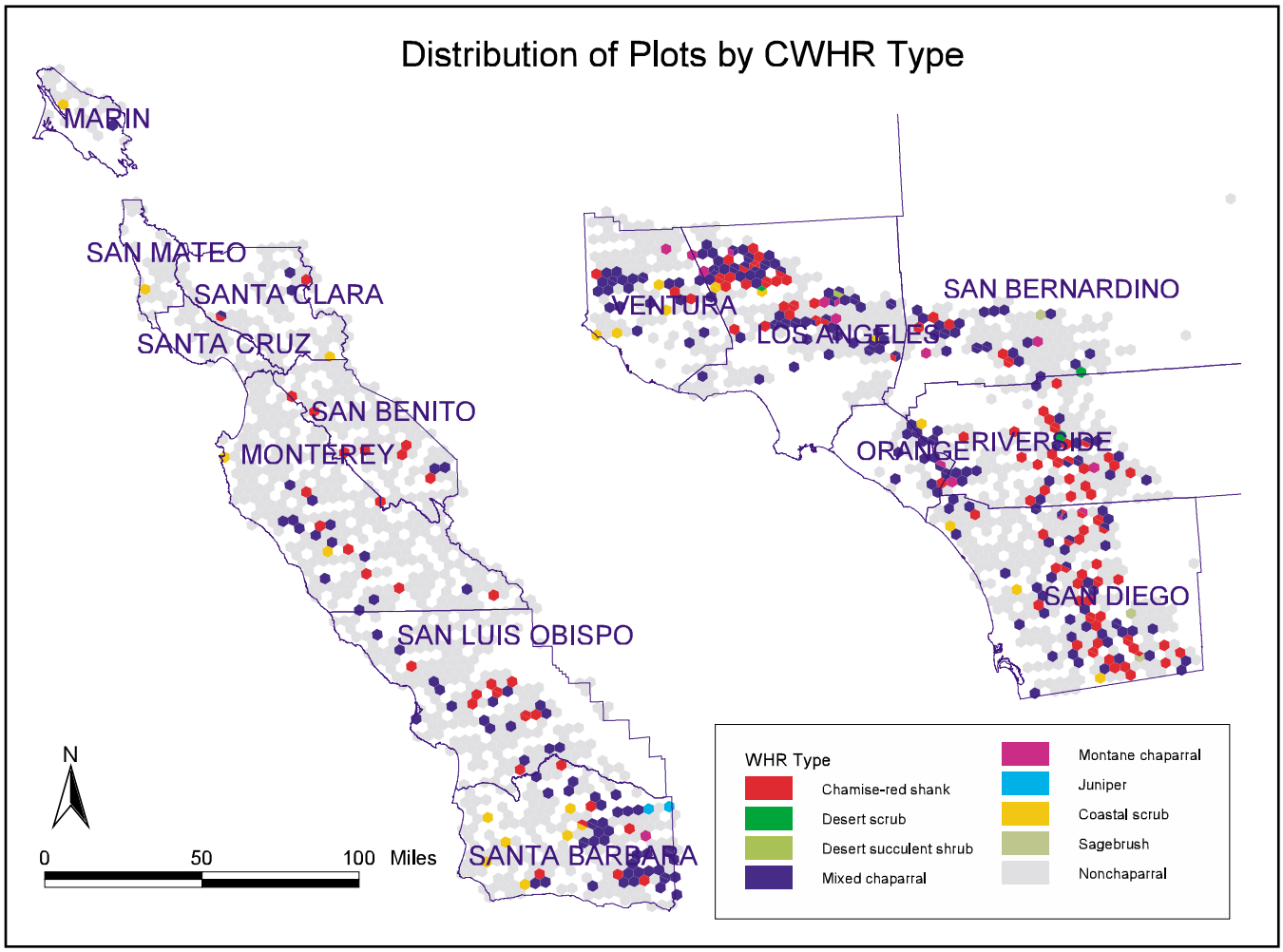

Figure 15—Distribution of plot locations coded by CWHR type; to comply with federal statutes on plot confidentiality, 6,000-acre hexagons are attributed according to the plot or plots contained therein; where there are multiple plots in a hex with different attribute values, hexes are arbitrarily subdivided to ensure that all types are displayed. CWHR = California wildlife habitat relationships.

Major Chaparral Types

Chamise (includes red shank)—This type occupies 1.5 or 1.8 million acres, depending on the classification system, or 32 to 42 percent of the chaparral in the study area. This type, dominated by *Adenostoma fasciculatum* or *A. sparsifolium* (fig. 16) or both, is more prevalent outside national forests (generally at lower elevation), where it makes up 52 percent of the chaparral area (PNW system). It accounts for 26 percent of the chaparral in national forests.

Figure 16—Chamise and red shank. (Photo by USDA Forest Service, Pacific Southwest Research Station)

Mixed and montane chaparral—This type, as a single type (PNW), or a group (CALVEG and CWHR), is the second most extensive type by PNW's system (fig. 17), and the most extensive type by the CALVEG and CWHR systems. This type, actually a collection of many different plant associations (see "Characteristics of Chaparral Stands" section), occupies 1.4 million acres by PNW's system, 1.5 million acres by CALVEG (lower montane plus montane mixed), and 2.4 million acres by CWHR (mixed plus montane). More common at high elevations, it accounts for 50 percent of national forest chaparral, but only 19 percent of other ownerships.

Scrub oak—This type occupies about 500,000 acres by PNW's system, 328,000 acres by CALVEG, and is included in mixed chaparral in CWHR. Like mixed and montane, scrub oak type is made up of several plant associations, the common factor being that a species of shrub-size *Quercus* is dominant. Among the oaks in this type are *Q. dumosa* (some of which has recently been renamed *Q. berberifolia*), *Q. john-tuckeri* (called *Q. dumosa* in the 1980s), *Q. palmeri, Q. wislizeni* var. *frutescens, Q. agrifolia, Q. engelmannii, Q. chrysolepis,* and *Q. durata,* which typically grow on serpentine-peridotite soils (fig. 18). Scrub oak type makes up 11 percent of the chaparral both inside and outside national forests, although the predominant oak species in these two broad ownerships differ (see "Characteristics of Chaparral Stands" section).

Figure 17—Mixed chaparral. (Photo by USDA Forest Service, Pacific Southwest Research Station)

Figure 18—*Quercus durata* (leather oak) on a serpentine ridge. (Photo courtesy of Todd Keeler-Wolf, California Department of Fish and Game)

Coastal transition—This type occupies about 656,000 acres and is more prevalent at lower elevations, amounting to 18 percent of the chaparral outside national forests, and 10 percent within national forests. Common hard chaparral species in this type are *Baccharis* spp., *Ceanothus greggii* var. *perplexans, Heteromeles arbutifolia, Rhus ovata* (fig. 19), and *Malosma laurina.* Many soft chaparral species are also present, among them *Artemisia californica, Lotus scoparius, Eriogonum* spp., *Croton* spp., and *Salvia* spp. (figs. 3 and 11).

Figure 19—*Rhus ovata* (sugar sumac) in bloom. (Photo by USDA Forest Service, Pacific Southwest Researech Station)

Coastal transition type is a PNW classification with no exact counterpart in CALVEG or CWHR. The PNW plots were classified in the field, and the types were assigned based on the plants present as well as other indicators on and in the general vicinity of the plot. The CALVEG and CWHR types were classified in the office and are based strictly on vegetation information collected by the field crews. A rough equivalent to coastal transition type in the CALVEG system would be a combination of coastal sage, scrub, mixed soft scrub chaparral, coastal bluff scrub, and sumac (totaling 444,000 acres); and in the CWHR system, coastal scrub (344,000 acres). We believe the PNW system provides a reasonable estimate of the total **potential** area of chaparral in undeveloped areas, whereas CALVEG and CWHR provide reasonable estimates of the area of plant communities as they **currently exist.** In this resource bulletin, any reference to chaparral type refers to PNW type, unless otherwise stated.

Characteristics of Chaparral Stands

Factors Affecting Composition and Structure

Chaparral ranges from nearly pure stands of chamise, manzanita, or scrub oak of uniform height and density, to ragged-looking stands of mixed chaparral in which every shrub seems to be of a different species, height, and form. The makeup of the overstory is greatly influenced by water availability. On drier chaparral sites, hard chaparral species—mainly *Adenostoma fasciculatum*—intermingle with soft chaparral or coastal sage-scrub species such as *Artemisia californica, Salvia apiana* (fig. 20), and *Eriogonum fasciculatum.* Moving along a gradient of increasing moisture, soft chaparral species give way to increasingly moisture-dependent associations of hard chaparral species. In a given geographic area the change is somewhat predictable, as shown in a conceptual chart of three-species associations (fig. 21), for the Forest Service Laguna Morena Demonstration Area (White 1981).

The assemblages of species that occur along the moisture gradient differ from one area to another, those on mesic sites more than those on xeric. The greatest departure occurs on serpentine sites, which support several species that occur

Figure 20—*Salvia apiana* (white sage), a soft chaparral or coastal sage species. (Photo by Todd Keeler-Wolf, California Department of Fish and Game)

Association											
ARCA	ERFA	ADFA	ADFA	ADFA	AFDA	CEGR	CEGR	QUDU	QUDU	CEBE	QUKE
SAAP	ADFA	ERFA	ERFA	CEGR	CEGR	ADFA	ADFA	ADFA	CEBE	QUDU	CEPA
ERFA	SAAP	SAAP	CEGR	YU	ARGL	ARGL	QUDU	CEGR	ADFA	ADFA	GR
Increasing moisture →											

Code	Species, genus, or life form
ARCA	*Artemisia californica*
ADFA	*Adenostoma fasciculatum*
ARGL	*Arctostaphylos glandulosa*
CEBE	*Cercocarpus betuloides*
CEGR	*Ceanothus greggii* var. *perplexans*
CEPA	*Ceanothus palmeri*
ERFA	*Eriogonum fasciculatum*
GR	Grass
QUDU	*Quercus dumosa*
QUKE	*Quercus kelloggii*
SAAP	*Salvia apiana*
YU	*Yucca* spp.

Figure 21—Progression of species composition along a moisture gradient. Within each of the 12 associations, relative abundance of the species decreases moving down the column.

rarely or not at all on nonserpentine sites. Among these are *Quercus durata, Arctostaphylos bakeri, A. hispidula, A. hookeri* spp. *montana* (fig. 22), *A. viscida* ssp. *pulchella, Ceanothus ferrisiae, Ceanothus jepsonii,* and *Rhamnus californica* spp. *occidentalis.*

Composition of chaparral stands changes rapidly during the first 1 to 3 years of recovery after a fire (fig. 23). Annual forbs and grasses in great abundance and variety become established the first spring after a fire, and this lush growth attracts plant-eating animals and insects that, in turn, attract predators (Force 1982, Quinn 1982, Wirtz 1982). The herbaceous growth by the second or third year is usually replaced by shrubs, both sprouters and seeders. Dense stands often undergo self-thinning within a few years, then enter a period of apparent stability in terms of structure, density, and composition, although biomass continues to accumulate. In unusually long fire-free periods, chaparral stands will undergo changes in composition and structure.

Chaparral has been called a paradoxical vegetation type: it seems that its long-term existence depends on periodic disturbance, usually fire; otherwise it will give way to forest, oak savanna, or grass. However, extreme disturbance, especially one that soon follows a previous disturbance, will sometimes cause "shock stagnation"—a semipermanent degradation of the vegetation, often to exotic grasses such as *Avena fatua* (Vogl 1982). Just how long chaparral can exist without disturbance is not known. It would seem likely that it depends on type, site, and many other factors, as indicated by the existence of both healthy stands past the century mark and much younger stands that appear senescent (Keeley 1992, Stohlgren et al. 1986, Vila and Sardans 1999, Zedler and Zammit 1986). Although in many cases the primary determinants of stand composition are the species that occurred in the previous stand and elapsed time since fire, many other variables can come into play, including:

1. Mix of species with respect to their behavior after fire or in the long-term absence of fire. Chaparral species have been classified according to their postfire reproduction mode into obligate resprouters, facultative resprouters, and obligate seeders. Among the obligate resprouters are most species of *Quercus, Heteromeles arbutifolia, Rhamnus crocea, Prunus ilicifolia,* and *Cercocarpus betuloides.* Facultative resprouters (sprouters that also can regenerate from seed after a fire) include *Adenostoma* spp., *Arctostaphylos glandulosa, Ceanothus spinosus, Rhus ovata* (fig. 24), and *Salvia mellifera.* Obligate seeders include *Arctostaphylos glauca, A. viscida, A. manzanita* spp. *elegans, Ceanothus crassifolius* (fig. 25), *C. cuneatus, C. megacarpus,* and many others (Keeley 1986, Moreno and Oechel 1993). Chaparral species also have been classified into “fire recruiters” and “fire persisters,” according to their behavior in the long-term absence of fire, and their adaptation to different site conditions. In mesic, closed communities where fire has been absent for long periods, fire persisters such as species of *Quercus, Rhamnus, Prunus, Cercocarpus,* and *Heteromeles* often dominate, and in certain conditions may reproduce by seed. On arid, open sites, fire recruiters such as *Adenostoma, Arctostaphylos,* and *Ceanothus* generally prevail. On some sites, both categories of shrubs may coexist for periods of time, as different species capture moisture and nutrients from different environmental niches. This “niche segregation” or “resource partitioning” in chaparral is thought to occur at the initial regeneration phase after a fire (Davis et al. 1998). Certain species of obligate resprouters can regenerate from seed when stands have escaped fire for prolonged

Figure 22—*Arctostaphylos hookeri* (Hooker's manzanita) on serpentine outcrop. (Photo by David Graber, Sequoia and Kings Canyon National Park)

Figure 23—Annual forbs (Brassicaceae family) appear with shrub sprouts the first spring following a fire in chaparral. (Photo by USDA Forest Service, Pacific Southwest Research Station)

Figure 24—*Rhus ovata* (sugar sumac), a facultative resprouter, resprouting following fire. (Photo by USDA Forest Service, Pacific Southwest Research Station)

Figure 25—*Ceanothus crassifolius* (hoaryleaf ceanothus), an obligate seeder, in bloom. (Photo by USDA Forest Service, Pacific Southwest Research Station)

periods and litter has built up under shady canopies. These species may also produce sprouts of different ages from roots as well as burls, creating mixed-age stands, in contrast to obligate seeders, which always date back to the last fire (Keeley 1986, Zedler 1982, Zedler and Zammit 1986).

2. Age of previous stand. Older sprouters generally have larger lignotubers (burls), which promote copious sprouting after a fire. In the case of chamise, the primary function of burls may be to protect the latent buds from fire, rather than storage of carbohydrates, as has been generally assumed in the past (Sparks and

Oechel 1993). If stands burn at a very young age, obligate seeders, such as certain species of *Arctostaphylos* and *Ceanothus,* are killed before they can bear seed, and are thus eliminated from the site (Keeley 1986).

3. Age of present stand. Obligate seeders–many species of *Ceanothus* for example–are relatively short-lived, although their seeds may stay viable in the soil for a long time. In older stands, these short-lived species start dropping out, allowing existing, longer lived shrubs to expand their dominance, or for the recruitment of new species or both. The seeds of short-lived species may be present in the soil, but they generally won't germinate until there is a fire. Although it might appear that obligate seeders are somewhat at risk, some believe they actually have a genetic advantage over sprouters. After each fire cycle, a new genetic pool is produced, creating an ever-changing mix of genotypes of which some, theoretically, will be more adapted to changing environmental conditions. And as it turns out, most obligate seeders are more tolerant of environmental extremes than co-occurring sprouters (Davis et al. 1998, Zedler and Zammit 1986).

4. Amount of dead material in previous stand. Although older stands are often assumed to have more dead material than younger stands, factors other than age, such as disease, insects, herbivory, frost, drought, and atmospheric pollutants can also result in dead material (Paysen and Cohen 1990). Fire burning through large amounts of dead materials may generate intense hot spots in which lignotubers are damaged or killed. This results in few postfire sprouts and clumpy regeneration, which could lead to a change in species composition and even chaparral type. For example, seedlings of certain species of *Arctostaphylos* and *Ceanothus* are more likely to survive and thrive if nearby *Adenostoma* burls fail to sprout (Odion and Davis 2000).

5. Season and weather conditions when the last fire burned. These relate to maximum soil temperature and duration of high temperatures, and whether bud primordia were present at the time of the fire (Keeley 1986).

6. Presence of herbivores in the previous and present stand. Herbivory that targets certain species can alter the composition of stands. Although often negative, herbivory can have a positive effect: at certain times of the year rabbit browsing promotes the formation of bud primordia on certain shrub species. Harvester ants also can play a positive role by collecting seeds of *Ceanothus* and other shrub species and caching them in the soil below the lethal-heating zone (Ne'eman et al. 1999, Odion and Davis 2000). Mammals and birds as well as insects also may bring seeds of herbaceous plants from nearby coastal sage scrub into chaparral areas, either before a chaparral fire or immediately afterward. The herbaceous layer is generally very short-lived in chaparral, with many species disappearing within 2 to 3 years. In coastal sage scrub, however, many of these same herbaceous species exist in the understory for several years to decades. The flush of herbaceous vegetation the first spring following a fire is extremely important to erosion reduction, recovery of the chaparral, and animals that feed on the herbs, or animals that feed on those animals. To some extent, chaparral is dependent on, or at least benefits from, juxtaposition with coastal sage scrub as a source of seeds of herbaceous plants essential during the postfire recovery

period and on fauna that move between these two vegetation types as vectors (Westman 1979).

7. Site variations. Specifically, the focus is on site variations caused by interrelated factors such as elevation, distance from the ocean, slope, aspect, precipitation, physiography, and in some cases parent material and soil type (in general, climate overrides the influence of soils, with the exception of serpentine sites and extremely harsh sites on rocky ridgetops) (Carrington and Keeley 1999). In the case of sumacs, frost seems to be a critical factor. *Rhus ovata* is more cold hardy than *Malosma laurina* (previously *Rhus laurina),* tolerating temperatures as low as –4 degrees Fahrenheit. Pioneer citrus growers in southern California used *M. laurina* as an indicator of sites suitable for planting orchards (Boorse et al. 1998).

8. Human factors. Much attention has been given to the results of fire-prevention and fire-management efforts over the past several decades in terms of area burned, frequency of fires, nature of the resulting vegetation types, and patterns of vegetation across the landscape (Agee 1993, Biswell 1989, Conrad and Oechel 1982, Minnich 1983, Minnich and Chou 1997). With growing human presence in chaparral areas, ignition probability has increased, posing the threat of a drastically altered fire cycle (Keeley 1995), which, there is reason to believe, could produce wholesale changes in species composition and chaparral structure. Vegetation types that are inferior in the qualities people value might take the place of chaparral (Vogl 1982). Urbanization in some places has carved up the chaparral in sizes and configurations that put native plants and animals in jeopardy (Bolger et al. 1997). Various activities of humans in these areas—such as dumping trash, letting pets roam, riding motorbikes through the chaparral, planting invasive exotic plants, and plinking—have made things worse. The effect of smog, especially the phytotoxicity of ozone, has long been recognized, but more recently a different but related problem has been getting attention—nitrogen deposition in excess of what plants can use (referred to as “N saturation,” or “chronic N inputs,” or “elevated N deposition”). How serious this is in California has not yet been determined, but in other areas of the world nitrogen saturation has been associated with nutrient deficiencies, soil acidification, decreased mychorrhizal symbiosis, and increased susceptibility of plants to environmental stresses (Bytnerowicz and Fenn 1996, Fenn and Poth 1992, Riggan et al. 1985).

Shrub Species Tallied in the Inventory

In the statewide chaparral inventory conducted in the mid-1980s (Bolsinger 1989), about 60 species and varieties of shrubs were identified in the southern and coastal regions on land outside national forests. In the study reported here, about 70 species and varieties of shrubs were identified in the southern and coastal areas outside national forests. The greater number of species tallied in the more recent inventory is thought to be a function of the larger number of plots (about twice as many), the recent division of some species into two or more taxa, natural change, and possibly better plant identification.

In the mid-1980s inventory, plant species information was not available for national forests. In the current study, though, plants were identified on field plots in national forests. Because of the greater range of environmental conditions within national forests, as well as the greater number of plots, more shrub species were found in national forests than outside, 100 vs. 70. Table 9 lists shrub and subshrub species

Table 9—Constancy by PNW chaparral classification system, life form, and species in national forests (NF) and outside national forest (ONF) lands

	Chamise		Red shank		Scrub oak		Mixed chaparral		Coastal transition	
Life form	**NF**	**ONF**	**NF**	**ONF**	**NF**	**ONF**	**NF**	**ONF**	**NF**	**ONF**
	Constancy value[a] (percentage of plots on which species occurred)									
Shrubs:										
Adenostoma fasciculatum	100	96	63	40	48	24	73	71	75	16
Adenostoma sparsifolium	4	4	88	100			3	9	3	3
Arctostaphylos canescens	11	9			9	0	19	17	19	0
Arctostaphylos glandulosa	10	4	0	20	7	14	6	9	6	0
Arctostaphylos hookeri							0	3		
Arctostaphylos patula					2	10				
Arctostaphylos pringlei ssp. *drupacea*							1	3		
Arctostaphylos pungens	5	3			0	5	1	3		
Arctostaphylos spp.	53	1	38	0	48	5	43	3	22	0
Artemisia californica			13	0	2	5	12	3	28	50
Artemisia tridentata			25	20	2	10	3	3	3	0
Baccharis pilularis							3	0	6	0
Baccharis salicifolia									0	6
Baccharis spp.	1	3							0	29
Ceanothus cordulatus					5	0			3	0
Ceanothus crassifolius	8	5			2	5	17	11	16	0
Ceanothus cuneatus					2	10	4	17		
Ceanothus greggii var. *perplexans*	51	9	75	40	16	10	31	14	28	0
Ceanothus griseus									6	0
Ceanothus integerrimus					7	0	3	0	3	0
Ceanothus leucodermis	26	1			30	5	29	9	3	3
Ceanothus megacarpus	3	0					6	3	6	0
Ceanothus oliganthus							4	3	0	3
Ceanothus papillosus							6	3		
Ceanothus spinosus							1	11	6	0
Ceanothus thyrsiflorus							3	0	3	3
Ceanothus spp.					24	5	17	6	6	3
Cercocarpus betuloides	22	3	50	20	52	10	62	29	44	0
Cercocarpus ledifolius					2	5				
Chrysothamnus spp.	4	1	13	0	11	0	8	0	13	0
Cneoridium dumosum							1	3		
Comarostaphylis diversifolia							0	6		
Dendromecon rigida	5	0			5	0	11	0	6	0
Diplacus aurantiacus							0	3	0	3
Encelia farinosa									9	0
Encelia spp.									0	3
Ephedra viridis									3	0
Ephedra spp.							5	0	0	3

Ericameria ericoides							0	3		
Ericameria spp.							4	0	3	3
Eriodictyon californicum					0	5				
Eriodictyon capitatum									3	0
Eriodictyon crassifolium	26	0	13	0	5	0	15	3	22	0
Eriodictyon tomentosum	0	4								
Eriodictyon traskiae	7	0	13	0	5	0	19	0	16	0
Eriodictyon spp.							1	6		
Escobaria vivipara			13	0						
Fraxinus dipetala					0	5				
Fremontodendron californicum					5	0	6	0	3	0
Garrya fremontii					16	0	7	0	30	0
Garrya veatchii			13	0	18	0	13	0	3	0
Garrya spp.	4	1								
Hazardia squarrosa	7	3								
Heteromeles arbutifolia	7	10			30	14	42	23	31	16
Isomeris arborea									6	0
Juniperus californica	3	3			7	10	2	3	0	3
Keckiella antirrhinoides							0	3		
Keckiella ternata					9	0	11	0		
Keckiella spp.									6	0
Leptodactylon californicum					0	5				
Lonicera interrupta									3	0
Lonicera spp.					13	0	13	3	19	5
Lupinus spp.									3	0
Malacothamnus spp.							2	3	3	5
Malosma laurina	5	6			2	5	6	17	25	45
Philadelphus microphyllus					0	5				
Penstemon spp.							4	0		
Prunus ilicifolia	10	7	13	0	11	0	38	3	50	3
Prunus spp.							0	3		
Purshia glandulosa							5	0	6	0
Purshia tridentata var. *glandulosa*					5	0				
Quercus agrifolia var. *oxyadenia*							0	3		
Quercus chrysolepis					27	5	10	3		
Quercus dumosa/john-tuckeri	41	20	88	20	87	76	56	51	37	5
Quercus durata					0	10	0	3		
Quercus engelmannii					0	5				
Quercus wislizeni					23	0	18	0	3	0
Quercus spp.	9	0	0	20	2	5			0	3
Rhamnus californica							11	0	3	5
Rhamnus crocea	14	0	38	0			37	3	41	3
Rhamnus crocea var. *licifolia*					27	10	3	9	0	8
Ribes spp.			13	0	7	5	12	0	3	3
Rhus integrifolia									0	5

Rhus ovata	14	5	63	0	5	5	21	23	31	11
Rhus trilobata					7	0	6	0		
Rosa spp.							3	0		
Rubus ursinus					0	5			0	8
Rubus spp.							4	0		
Salix spp.							6	0	9	0
Salvia clevelandii	5	0								
Salvia leucophylla	3	0							9	0
Salvia mellifera	25	15			7	5	30	14	72	26
Salvia spp.			13	20			5	0	3	0
Sambucus spp.					2	5				
Symphoricarpos spp.	4	0	13	0	32	5			13	0
Toxicodendron diversilobum	7	0	13	0	36	10	27	11	16	24
Umbellularia californica							6	0		
Xylococcus bicolor	4	0	13	0						
Yucca schidigera									3	0
Yucca whipplei			63	0			58	0	75	0
Yucca spp.	67	4			38	5				
Subshrubs:										
Eriogonum fasciculatum	49	28	75	20	32	19	59	27	84	21
Eriogonum spp.									0	8
Gutierrezia sarothrae									0	3
Lotus scoparius	32	14	25	20	16	5	25	3	56	24
Lotus spp.									6	3
Opuntia acanthocarpa							0	3		
Opuntia basilaris									9	0
Opuntia occidentalis									0	3
Opuntia spp.			25	0	5	0			3	3
Salvia apiana	11	5	0	20			14	0	41	5
Salvia spp.					7	5	0	3	0	16
Solanum xanti			13	0					3	0
Sphaeralcea ambigua			13	0						

[a] Constancy values for national forests and other ownerships are not combined because of the different intensities and methodologies of the two inventories.

Continued (Part b)