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Vegetative Characteristics of Coastal Sage Scrub Sites Used by California Gnatcatchers: Implications for Management in a Fire-Prone Ecosystem

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Abstract. Coastal sage scrub is a fire-adapted, drought deciduous vegetation type, which is rapidly disappearing to urbanization in southern California. It is home to the threatened California gnatcatcher and several candidate vertebrate species. Planning efforts in southern California seek to identify and preserve key coastal sage scrub sites so that economic development activities may continue in other areas. Thorough knowledge of the habitat-requirements of the California gnatcatcher and associated species is critical to this effort. In 1993, fires in southern California burned more than 20,000 acres of prime sage scrub and in some cases spread to adjacent housing tracts, destroying many homes. Subsequent discussions about fire safety touted prescribed burning as a way to reduce fuel loads at the wildland-urban interface. However, concerns about impacts of burning on sensitive species' habitat make conducting bums difficult. We found that California gnatcatcher nesting territories typically have greater than 50% shrub cover, and average shrub height exceeds 1 m. Recently burned sage scrub is not used by California gnatcatchers until the physical structure of the vegetation resembles mature scrub, minimally 4 to 5 years after fire. If birds can move between burned and adjacent unburned vegetation colonization may occur sooner. This suggests that a prescribed fire program which creates a mosaic of burned and large unburned patches could conceivably be applied in California gnatcatcher habitat. Breaking up fuel continuity would benefit adjacent landowners and the reserve lands equally, making large, reserve-wide fires less likely to occur. Timing and intensity of fire also affect regeneration of coastal sage scrub plants and must be carefully considered in any prescribed fire program in this habitat.

Keywords: bird habitat; fire ecology; prescribed fire; vegetation development.

Introduction

Coastal sage scrub is a shrub-dominated, drought-deciduous vegetation type found in central and southern California and northern Baja California, Mexico. As the name implies, it is found primarily at low elevations near the coast and on foothill slopes in areas with some maritime influence. The term "coastal sage scrub" encompasses a number of vegetation associations that differ in species composition but share the characteristic that the predominant shrubs are aromatic, lose many of their leaves during the long summer dry season, and rarely exceed 2 m in height (Westman 1981, O'Leary 1990). Typical species include *Artemisia californica* (California coastal sagebrush), *Encelia californica* (California sunflower), *E. farinosa* (brittlebush), *Eriogonum fasciculatum* (flat-top buckwheat), and various species of *Salvia* including S. *apiana* (white sage), S. *leucophylla* (purple sage), and S. *mellifera* (black sage). On mesic sites, especially near the ocean, large-leafed evergreen shrubs such as *Malosma laurina* (laurel sumac), *Rhus integrifolia* (lemonadeberry), and *R. ovata* (sugarbush) may occur as emergents above the other vegetation (plant names follow Hickman 1993). Shrub cover is rarely 100%, and the spaces between shrubs are occupied by a variety of native and non-native grasses and forbs (O'Leary 1990). Sage scrub vegetation becomes quite dry and brittle by the end of the usually-rainless California summer, and fires are a common occurrence. The natural fire return interval for coastal sage scrub has been estimated to be about 20 years (Westman 1982).

Coastal sage scrub has been rapidly disappearing to agricultural and urban development. Less than 20% of the original extent of this vegetation may remain in southern California (Westman 1981, O'Leary 1990). Significant area reductions have occurred in Mexico as well (Bowler 1990). Remaining tracts of coastal sage scrub now occupy some of the most valuable real estate in California, and many areas are slated for some kind of development.

The California gnatcatcher (*Polioptila californica*) is a small gray songbird essentially restricted to coastal sage scrub, where it is a year-round resident (Woods 1921, 1928; Atwood 1993). Because of habitat loss, the northern subspecies of the California gnatcatcher, *Polioptila californica californica*, has been federally listed as "threatened" (US Fish and Wildlife Service 1993). Other

animal species found in coastal sage scrub that have been proposed for listing or are of special concern to biologists include die orange-throated whiptail *(Cnemidophorus hyperythrus),* San Diego horned lizard *(Phrynosoma coronatum blainvillei),* rufous-crowned sparrow *(Aimophila ruficeps canescens),* and coastal cactus wren *(Campylorhynchus brunnecapillus couesi).* Land development plans and the need to protect the estimated 2000 or fewer remaining pairs of California gnatcatchers (Atwood 1992) have, not surprisingly, come into conflict.

In 1992, the state of California began a pilot program designed to coordinate development planning and habitat preservation of the coastal sage scrub ecosystem within the range of the California gnatcatcher (for a summary, sec DeSimone and Silver 1995, Tippets et al. 1995). The Natural Communities Conservation Planning (NCCP) program relies on voluntary participation by counties, cities, land owners and the state and federal wildlife agencies to develop a plan for establishing habitat reserves sufficient to ensure survival of the California gnatcatcher and associated species. Remaining lands could then be developed without lengthy delays. Five counties are encompassed by the program: Riverside, San Bernardino, Los Angeles, Orange, and San Diego. This includes virtually all of the US range of the California gnatcatcher (Figure 1). A Scientific Review Panel drew up guidelines (Murphy et al. 1993) for collecting information on coastal sage scrub within the plan area, and an interim "take" of 5% of un-developed sage scrub land was recommended. Several sub-regional plans arc presently (1996) in draft form or nearing completion, and others arc well underway.

California gnatcatchers appear to require mature coastal sage scrub vegetation during the nesting season (Atwood 1980). Most of our knowledge of their habitat requirements comes from studies done by consultants hired by developers during project planning. Atwood (1993) compiled data on California gnatcatcher home ranges from several of these hard-to-obtain reports. He noted that *Artemisia californica* (California sagebrush) was a major component of the plant community at all sites except one in Riverside County (Table 1). Average total shrub canopy cover in California gnatcatcher breeding territories ranged from 62% in San Diego County (ERCE 1990) to 66% in Orange County (Bontrager 1991), although Atwood (1993) cited individual observations where shrub cover was less. Anderson (1991) sampled 20 sites in San Diego County known to have California gnatcatchers and found that total shrub cover averaged 56%, with only two plots having less than 40% shrub cover.

In October and November 1993, large wind-driven wildfires burned extensive areas of southern California, including about 10,000 ha (24,000 acres) of coastal sage scrub. Possibly 330 pairs of California gnatcatchers were displaced or killed by the fires, approximately 15 % of the southern California population (Cone 1993). Most of

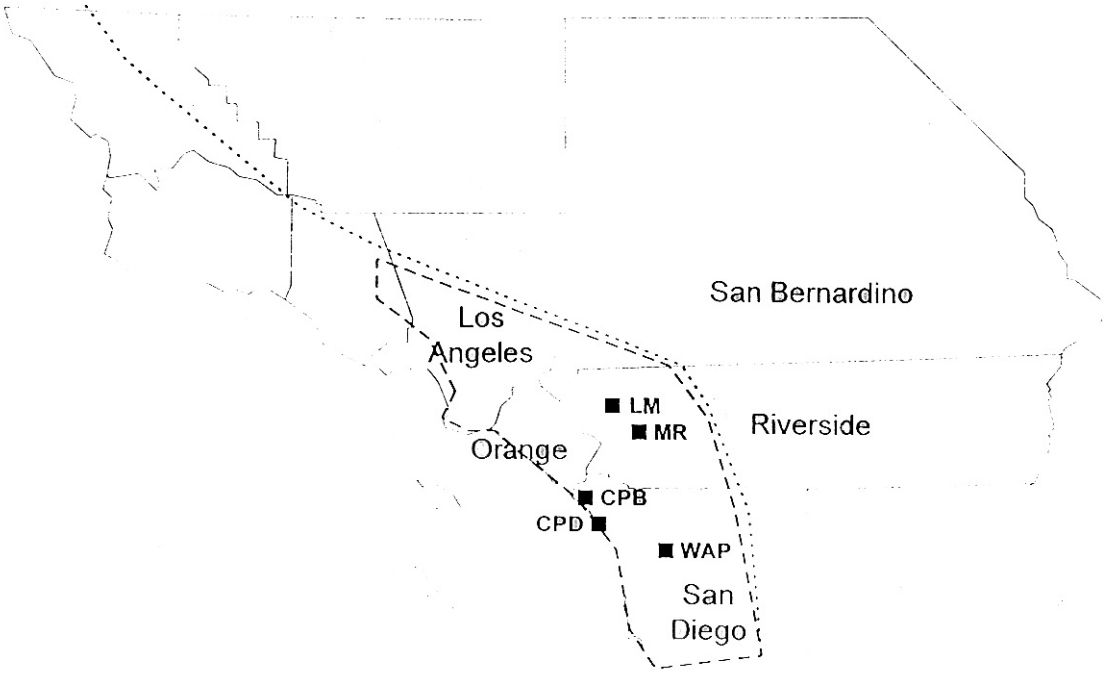

Figure 1. Map of the southern third of California, showing counties involved in the NCCP program and study sites sampled for this report. Dotted line is the approximate eastern limit of coastal sage scrub vegetation (confined to areas below about 1000 m elevation). Gray area within dashed lines is the approximate historical range of the California gnatcatcher (below 750 m elevation). Study sites (y): LM =Lake Mathews; MR = Motte Reserve; CPB = Camp Pendleton, Basilone/San Onofre sites; CPD = Camp Pendleton, Don/Agra sites; WAP = San Diego Wild Animal Park.

Table 1. Relative dominance of various shrub species and mean total percent shrub canopy cover in California gnatcatcher home ranges sampled by other researchers.

	Near Perris[1]	Palos Verdes Peninsula[1]	Mission Viejo[2]	El Cajon[3]	Rancho San Diego[4]
County	Riverside	Los Angeles	Orange	San Diego	San Diego
Distance from coast (km)	56	3	11	29	16
Re1ative Dominance:					
Artemisia californica	1	12	49	23	38
Baccharis sp.	--	--	--	3	1
Encelia farinosa	35	--	--	--	--
Encelia californica	--	50	--	--	--
Eriogonum fasciculatum	2	--	37	53	28
Malosma laurina	--	--	--	10	16
Salvia mellifera	11	--	--	--	--
Other shrub species	51	38	14	12	17
Total Shrub Cover (%)	(not stated)	(not stated)	66	62	66

[1] Data from Atwood (1993).
[2] Data from Bontrager (1991).
[3] Data from ERCE (1990).
[4] Data from Roach (1989).

those birds lived in central orange County and were affected by the Laguna Fire.

Numerous homes burned in the Laguna Fire as well (Froomkin 1993). Wood shake roofs and dense ornamental vegetation contributed to the spread of the fire through residential areas (Franklin 1995). In the aftermath of the blazes, officials discussed ways to avoid such disasters in the future. Some suggested that restrictions on prescribed burning in California gnatcatcher habitat could have contributed to the severity of the fires because fuel was not reduced (Bigelow and Silvern 1993). Regular burning of coastal sage scrub adjacent to housing tracts, to keep fuel volume low, was suggested as a preventive measure (California Board of Forestry meeting, February 1, 1994).

What is the impact of fire on California gnatcatcher habitat? Is regular prescribed burning within home ranges feasible or advisable? If coastal sage scrub habitat reserves are intermixed with suburban and commercial development, how can adjacent development be protected from fires that might bum through the reserves? Conversely, how can reserves be protected from fires starting near developments? For the NCCP planning process to work and the envisioned habitat reserves to be successful, these questions must be addressed by scientists and planners (Tippets et al. 1995). Most of our information on California gnatcatcher habitat, however, concerns only areas of mature coastal sage scrub.

In 1992, we began studying the impact of fires on the California gnatcatcher and associated bird species (Mayer and Wirtz 1995) and their habitats. We have continued that work with new sites created by the 1993 fires. A companion paper (Wirtz et al., this volume) will report the results of the bird censuses conducted in the study. Here we contrast vegetation composition and structure within California gnatcatcher territories with areas not used by gnatcatchers, and we discuss the implications of those results for fire management within coastal sage scrub reserves.

Methods

Previous studies have found differences in California gnatcatcher territory size and use between coastal and inland sites (Atwood 1993). Our study sites were chosen to represent the range of conditions where California gnatcatchers are found (Figure 1). Inland sites were located near Lake Mathews, a reservoir of the Metropolitan Water District of Southern California, and the University of California at Riverside's Motte Reserve, both in Riverside County. Coastal sites were located on the Camp Pendleton Marine Base in San Diego County. An intermediate site was located at the San Diego Wild Animal Park in Escondido, San Diego County, where 325 ha (800 ac) of undeveloped Park land burned in the October 1993 Guejito Fire. At each site, vegetation was sampled within known California gnatcatcher territories and in areas that did not have California gnatcatchers. In some cases the plots without gnatcatchers were located within recent burns, and in others they were located in unburned but unused sage scrub. Vegetation data were collected in the spring of 1993 (Motte, Mathews, Pendleton sites) and in 1995 (Wild Animal Park; burn plots at Mathews and Pendleton).

Plant species composition and cover were quantified via the line-point method in a plot layout similar to that

used by Westman (1981). After each plot was located, either within a known gnatcatcher home range or from points randomly plotted on a map, a 25 m baseline was laid out due west from a randomly-chosen starting point. Four 25 m transects were then laid out perpendicular to the baseline (due north) at randomly selected points. Along each 25 m transect, a pointer was dropped every 0.5 m and each species of plant touching the pointer was recorded. In addition, the height of each species was recorded by 0.5 m classes (e.g. 0-0.5; 0.5-1.0, etc.) at each point. A total of 200 points was thus sampled per plot, and these values were used to determine percent cover by species. Trace species were recorded within a 1.0 m wide belt extending the length of each transect. Species observed but not contacted along the point-transects or belts were recorded as "seen but not sampled" and were also treated as trace species for a plot.

Results

In this paper we report total shrub species cover and height information. At the Motte Reserve, all California gnatcatcher territories were located within vegetation that had last burned in 1979, making it 14 years old at the time of sampling. These plots had a north or northeast aspect (Table 2). Plots without California gnatcatchers were located in the 1979 burn on different aspects or in a 1981 burn (12 years old) (Table 3). At Lake Mathews, plots within California gnatcatcher territories also had a north or northeast aspect and were located in vegetation (hat had not burned in at least 20 years (Table 2). Plots without birds faced south or southwest, or else were located within an area that burned in 1990 (Table 3). Two areas were studied at Camp Pendleton. The "Don" site, unburned in at least 22 years, was located on a bluff above the Pacific ocean (Table 2) and was adjacent to an area that burned in 1990, designated "Agra". The second unburned site, "Basilone," was located slightly inland. It was less than 1 km from the "San Onofre" site, which also burned in 1990. At the San Diego Wild Animal Park, burned and unburned plots were located on separate ridges, one of which burned in a 1993 fire, and had similar aspects (Tables 2 and 3).

Total shrub cover on plots located within California gnatcatcher home ranges averaged greater than 50% at all sites except Basilone (Table 2). Shrub species composition varied considerably among the sites. *Salvia mellifera* (black sage) was a major component of the vegetation only at Motte Reserve, and *Lotus scoparius* (deerweed) had the greatest cover of all species at Basilone. At the other sites, *Artemisia californica* (California sagebrush) was the most abundant shrub. Species composition was quite variable even within a site (note the relatively large standard errors in cover values). Slope angle varied among sites, although no site was particularly steep.

Table 2. Average percent shrub canopy cover (∂ S.B.). percent slope (∂ S.B.) and other characteristics of California gnatcatcher home ranges sampled in this study. Total cover may not equal sum of species because shrub canopies often overlapped.

	Lake Mathews	Motte Reserve	S.D. Wild Animal Park	Pendleton Don	Pendleton Basilone
County	Riverside	Riverside	San Diego	San Diego	San Diego
Distance from coast (km)	48	56	29	0.5	2
Aspect	N,NE	N,NE	W	W,SW	S,SW
Percent Slope	17.8 (5.2)	19.2 (7.1)	28.0 (2.0)	2.5 (1.0)	15.8 (3.9)
Percent Shrub Cover:					
Artemisia californica	30.5 (10.0)	4.2 (2.3)	29.8 (10.4)	78.4 (3.8)	11.5 (4.1)
Baccharis pilularis	--	--	--	3.3 (1.2)	--
Encelia californica	--	--	--	--	1.4 (1.4)
Encelia farinosa	28.1 (7.2)	7.9 (5.9)	--	--	--
Eriogonum fasciculalum	0.4 (0.2)	19.2 (9.4)	8.7 (4.7)	--	7.4 (7.4)
Lotus Scoparius	--	Tr.	5.5 (3.0)	--	22.4 (6.4)
Malosma laurina	--	--	12.8 (1.9)	--	0.4 (0.4)
Salvia apiana	--	0.2 (0.2)	12.5 (11.5)	--	--
Salvia mellifera	--	32.1 (10.1)	--	--	--
Other shrub species	0.6 (0.6)	--	9.6 (5.6)	Tr.	2.9 (0.9)
Total Shrub Cover	58.7 (5.3)	55.8 (10.3)	61.5 (16.6)	79.0 (3.5)	43.8 (6.5)
number of plots	4	4	3	4	4

Table 3. Average percent shrub canopy cover (∂ S.E.), percent slope (∂ S.E.) and other characteristics of coastal sage scrub plots without California gnatcatchers, sampled in this study. Total cover may not equal sum of species because shrub canopies often overlapped.

	Lake Mathews	Lake Mathews	Motte Reserve	Motte Reserve	S.D. Wild Animal Park	Pendleton San Onofre	Pendleton Agra
County	Riverside	Riverside	Riverside	Riverside	San Diego	San Diego	San Diego
Years Since Fire	>20	5	14	12	2	3	3
Aspect	S,SW	S,SW,N	various	SW,NW	W	NW	SW
Percent Slope	28.5 (2.6)	28.7 (3.0)	15.5 (2.2)	7.5 (1.5)	30.3 (3.7)	7.7 (0.7)	2.0 (0}
Percent Shrub Cover							
Artemisia californica	1.3 (0.9)	Tr.	6.4 (6.4)	0.1 (0.1)	0.7 (0.4)	11.8 (0.9)	0.8 (0.8)
Baccharis pilularis	--	--	--	--	--	0.3 (0.2)	Tr.
Encelia californica	--	--	--	--	--	--	--
Encelia farinosa	31.1 (7.3)	4.4 (2.2)	0.5 (0.5)	--	--	--	--
Eriogonum fasciculatum	1.7 (1.0)	Tr.	9.5 (4.7)	5.6 (1.7)	1.2 (0.7)	--	--
Lotus scoparius	--	0.3 (0.3)	0.1 (0.1)	0.1 (0.1)	0.7 (0.3)	4.3 (2.0)	--
Malosma laurina	--	--	--	--	8.7 (3.4)	3.5 (3.0)	--
Salvia apiana	--	--	--	--	10.0 (5.3)	--	--
Salvia mellifera	--	--	24.3 (6.2)	--	--	--	--
Other shrub species	0.3 (0.1)	1.5 (1.5)	--	--	Tr.	0.2 (0.2)	3.0 (3.0)
Total Shrub Cover	33.6 (7.4)	6.2 (0.9)	36.6 (6.5)	5.8 (1.7)	15.3 (3.3)	18.7 (4.2)	3.8 (2.2)
number of plots	4	3	4	4	3	3	2

Plots without California gnatcatchers averaged less than 40% shrub cover at all sites (Table 3), although a few individual plots exceeded that (Figures 2, 3). The unburned plots at Mathews had virtually no *Artemisia*, and the 12 year old unused plots at Motte lacked *Salvia mellifera.* The recently burned plots at Lake Mathews had little shrub cover at all.

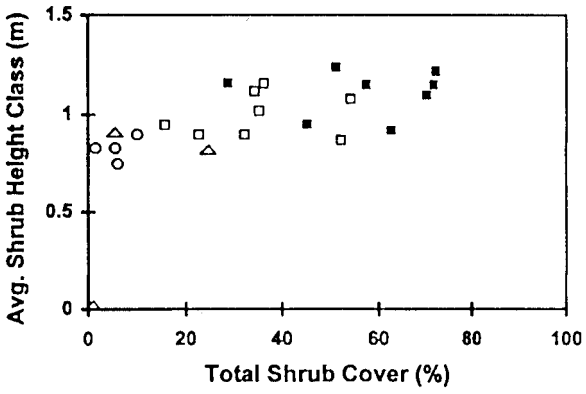

Figure 2. Total shrub canopy cover and average maximum shrub height of individual vegetation plots located in western Riverside County. y = plots within California gnatcatcher home ranges at Lake Mathews and Motte Reserve; Ĭ = plots without gnatcatchers at Motte in 1979 burn and in unburned vegetation at Lake Mathews; O = plots without gnatcatchers within 1981 burn at Motte; ÷ = plots without gnatcatchers in 1990 bum at Mathews.

Average shrub height class exceeded 1 m on most plots located within gnatcatcher home ranges (Figures 2, 3). Because shrub height was recorded only by 0.5 m class, these values represent the average maximum height, not actual height, of the vegetation. Some unoccupied plots had relatively tall vegetation as well, especially the unburned plots at Motte and Lake Mathews. There was no significant difference in average height class (all shrub species considered together) between the occupied and unoccupied plots of the same age since fire at Mathews or at Motte ($p>0.05$, tested using a bootstrap randomization procedure [Manly 1991]). Recently burned plots had shorter vegetation than occupied plots, as did the 12 year old plots at Motte.

Four burned plots at Pendleton that were resampled in 1995 are also plotted on Figure 3. Two of those plots had shrub cover and height values similar to the unburned plots, and in fact California gnatcatchers were observed within these plots in 1995. No gnatcatchers were seen at the other two plots, which still had low total shrub cover even though average shrub height was similar to that of unburned plots. The increase in cover on the two occupied plots was apparently by growth of existing shrubs and recruitment of their seedlings, because shrub species composition did not change.

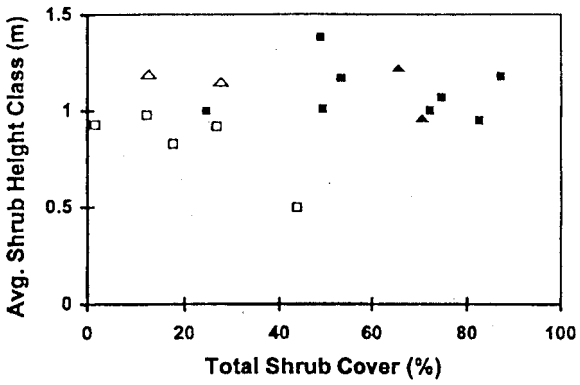

Figure 3. Total shrub canopy cover and average shrub height of individual vegetation plots located at Camp Pendleton, San Diego County. y = plots within California gnatcatcher home ranges at Don and Basilone sites; Ĭ =plots within 1990 bum sites, measured in 1993, without gnatcatchers; z = plots within 1990 burn sites, remeasured in 1995, without gnatcatchers; 1 =plots within 1990 bum sites, remeasured in 1995, now included in California gnatcatcher home ranges.

Discussion

Total shrub cover appears to be more important than shrub height in determining habitat suitability for California gnatcatchers. Species composition was quite variable, although, like Bontmger (1991), we did not find high percentage cover of broad-leafed evergreen shrubs, such as *Malosma laurina,* in our plots. Shrub canopy cover in our occupied plots was similar to measurements reported by Anderson (1991) and Atwood (1993), generally greater than 50%. Several studies have reported that gnatcatchers forage preferentially in shrubs, especially *Artemisia californica* and *Eriogonum fasciculatum* (Woods 1921, Roach 1989, Mock and Bolger 1992, Ezovski et al. 1995). Gaps between shrubs were occupied by herbaceous vegetation, often non-native annual grasses and forbs, especially in the recently-burned and non-occupied plots. We hypothesize that these annual plants do not support a sufficient insect fauna, especially after they dry out in late spring, to support the strictly insectivorous California gnatcatcher. There are probably differences in insect availability among shrub species as well, which could explain apparent shrub species preferences by gnatcatchers. Studies addressing the insect community in coastal sage scrub stands and the diet requirements of California gnatcatchers are obviously needed.

Areas burned in 1990 were not used as part of California gnatcatcher home ranges until shrub cover exceeded 50%. This had occurred by 5 years after fire on two of the burned plots sampled.

Four to five years seems to be a minimum length of time for postfire vegetation recovery at these coastal sage scrub sites, and other burned sites did not attain enough shrub cover to be attractive to California gnatcatchers even 12 years after fire (Motte Reserve results). Our inland (Riverside County) sites with gnatcatchers were located on north or northeast-facing slopes, suggesting that only those aspects were mesic enough to support the necessary shrub density and cover. Plots located on other aspects may never attain enough shrub cover, no matter how long they are protected from fire, to support California gnatcatchers. Western Riverside County receives less rainfall, on average, than Camp Pendleton or the Wild Animal Park, and average summer temperatures are higher as well (NOAH 1994). Both factors may limit shrub growth.

Although California gnatcatchers do not routinely use recently-burned areas, there are accounts of gnatcatchers successfully nesting on first-year postburn sites (Beyers et al. 1995, Bontrager et al. 1995). We found that birds forage in rapidly-regrowing riparian vegetation within a burn site before venturing into the surrounding low vegetation (Wirtz et al., this volume). One pair reported by Beyers et al. (1995) nested in postfire herbaceous vegetation at the San Diego Wild Animal Park. The birds presumably survived the fire by taking refuge in an adjacent avocado grove or within the developed portion of the Park itself, which did not burn. These areas may have continued to provide foraging habitat during and after the breeding season. No California gnatcatchers were found nesting in herbaceous vegetation at the same site during the next breeding season. However, birds noted a short distance away in vigorously-regrowing shrubs may have been the same pair (personal observation, J. Beyers). Pairs reported by Bontrager et al. (1995) occupied largely-unburned islands of sage scrub, which retained considerable shrub cover, near the perimeter of one of the large 1993 fires.

Fire Management Implications

California gnatcatchers appear to require coastal sage scrub with a shrub canopy cover of 50% or more and average shrub height of 1 m or greater. Such vegetation has a fairly high fuel load, perhaps unacceptably high from a fire safety perspective. Because of development pressures in southern California, it is certain that any open space reserves set aside for California gnatcatchers and associated species will be bounded at least in part by subdivisions or industrial parks. Maintaining "good" California gnatcatcher habitat adjacent to housing or other development thus poses a management challenge. If high shrub cover is maintained in reserves, fire burning through a reserve may threaten homes. In addition, fires started carelessly or by arson near developments obviously threaten adjacent wildlife habitat (many of the fall 1993 fires in southern California were deliberately set). Yet if fuel load is reduced by prescribed burning or mechanical means, California gnatcatchers

may be eliminated from the area until the vegetation regrows. Repeated prescribed fires, to keep fuel low, arc obviously incompatible with maintaining California gnatcatchers. What else could be done?

A common practice in newer southern California subdivisions built at the edge of open space preserves is to irrigate a belt of vegetation immediately adjacent to homes, in order to provide high fuel moisture to stop a fire. Native sage scrub plant species are often used, but the habitat value of these typically-small plantings is unknown and maintenance is expensive. Planting naturally fire-resistant but drought-tolerant plants, such as *Opuntia* species, in a belt nearest to vulnerable structures could also provide fire protection while providing habitat for some sage scrub animal species in smaller reserves.

The willingness of gnatcatchers to use islands of unburned vegetation within burns suggests that creating a mosaic of burned and unburned patches could be used to break up fuel continuity within large reserves while still providing adequate gnatcatcher habitat. Broken fuel continuity would make fires easier to control and large, reserve-wide fires less likely to occur. Although fewer total pairs might be supported in a reserve composed of a mosaic of different-aged patches, in the long run California gnatcatchers and other species should benefit if the entire reserve is never burned at once. The technical aspects of creating a mosaic may be more complex than doing a uniform burn, however, especially during the dry season, and the difficulties encountered in carrying out any prescribed burn in southern California cannot be understated. Air quality management, viewshed concerns, and seasonal constraints on burning all reduce the available burning windows (Biswell 1989, Bigelow and Silvers 1993).

Timing and intensity of afire may influence postfire recovery in coastal sage scrub after both prescribed fire and wildfire. Any planned prescribed fire program must keep these influences in mind. However, most of the published information on fire effects in coastal sage scrub comes from studies conducted after wildfires in the Santa Monica mountains, outside the range of the California gnatcatcher. *Artemisia californica* and *Eriogonum fasciculatum*, shrub species associated with the California gnatcatcher, appear to be less vigorous sprouters than the *Salvia* species or *Malosma laurina*. There may be geographic differences within a given species of sage scrub shrub in the ability to resprout after fire, with coastal plants showing more vigorous sprouting than those in western Riverside County (Myers and Ellstrand 1986, Westman and O'Leary 1986). Much of the postfire shrub seedling recruitment is believed to come from seeds produced by resprouting shrubs, rather than from a surviving seedbank (Westman et al. 1981, Malanson and O'Leary 1982, Keeley and Keeley 1984). Modeling efforts have predicted that even in coastal locations, repeated fires at 10 year intervals may virtually eliminate weak sprouters such as *Artemisia californica* (Malanson 1985). However, in another study Malanson (1984) found substantial cover of *Artemisia* (from 9 to 28%) on some sites that had burned as many as. four times in the previous 50 years (average 11 years between fires), making it clear that our understanding of the fire response of key coastal sage shrub species is incomplete. Season of burn may be as important as fire frequency for some species, though this factor has not been well-studied. There are indications that sage scrub and chaparral shrubs sprout less vigorously after late spring burns than summer bums (White et al. 1995). Fire intensity may also affect vegetation recovery in coastal sage scrub, but comparative studies have been difficult to interpret (e.g. see Westman et al. 1981). Data collected after the 1993 southern California wildfires, some of which burned with considerable intensity, should help illuminate the role of this factor. Additional research into the response of coastal sage scrub plants to prescribed fire, however, is obviously needed.

Influences other than the fire itself may affect sage scrub recovery. There is concern that in Riverside County non-native grasses are replacing sage scrub shrubs over large areas (Minnich 1995). Annual grasses may inhibit shrub seedling establishment by outcompeting them for water (Elaison and Allen 1994). Such competition might explain the low shrub cover found on the Motte Reserve plots that burned in 1981. Where naturally-occurring, nonnative grasses established vigorously in some of our burned plots at Camp Pendleton, shrub re-establishment has been low. Successful grass establishment can also increase the chances of an early reburn (Zedler et al. 1983), and repeated fires can cause type conversion of shrubland to a more grass-dominated vegetation type (D'Antonio and Vitousek 1992). Though grass fires pose less risk to adjacent structures than do shrubland fires, type conversion would be detrimental to the maintenance of California gnatcatcher populations.

Conclusions

California gnatcatcher home ranges typically have greater than 50% shrub canopy cover. Recently- burned coastal sage scrub vegetation is not used by California gnatcatchers for breeding unless it is adjacent to unburned patches. Regrowing sage scrub will be recolonized once total shrub cover approaches 50%, which takes a minimum of 4 or 5 years. Management activities in coastal sage scrub reserves should strive to maintain high shrub cover in at least part of the area while still protecting the reserve and adjacent human developments from fire. Additional research needs include investigating the relationship between sage scrub shrubs, associated insect species, and the diet needs of the California gnatcatcher; and evaluating the response of coastal sage scrub vegetation to prescribed fire.

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References

Anderson, E. R. 1991. Habitat preferences of the California gnatcatcher in San Diego County. Master's thesis, San Diego State University. 132 p.

Atwood, J. L. 1980. The United States distribution of the California black-tailed gnatcatcher. WesternBirds11:65-78.

Atwood, J. L. 1992. A maximum estimate of the California gnatcatcher's population size in the United States. Western Birds 23:1-9.

Atwood, J. L. 1993. California gnatcatchers and coastal sage scrub: the biological basis for endangered species listing. Pages 149-169 in Keeley, J. E. (ed.), Interface between ecology and land development in California. Southern California Academy of Sciences, Los Angeles.

Beyers, J. L., T. A. Stewart and C. Sharp. 1995. A postfire seeding experiment at the San Diego Wild Animal Park. Pages 199-202 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

Bigelow, B. V. and D. Silvem. 1993. Firefighters fume at red tape: it's tough getting OK on preventive burning. The San Diego Union-Tribune, November 4, 1993:A1, A8.

Biswell, H. H. 1989. Prescribed homing in California wildlands vegetation management. University of California Press, Berkeley. 255 p.

Bontrager, D. R. 1991. Habitat requirements, home range and breeding biology of the California gnatcatcher (*Polioptila californica*) in south Orange County, California. Unpublished report prepared for Santa Margarita Company, Rancho Santa Margarita, California.

Bontrager, D. R., R. A. Erickson and R. A. Hamilton. 1995. Impacts of the October 1993 Laguna Canyon foe on California gnatcatchers and cactus wrens. Pages 69-76 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

Bowler, P. A. 1990. Coastal sage scrub restoration - I: the challenge of mitigation. Restoration and Management Notes 8:78-82.

Cone, M. 1993. Many rare birds perished in blazes, biologists report. The Los Angeles Times, November 3, 1993:A25.

D'Antonio, C. M. and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

DeSimone, P. and D. Silver. 1995. The Natural Community Conservation Plan: can it protect coastal sage scrub? Fremontia 23(4):32-36.

Elaison, S. A. and E. B. Allen. 1994. Competition for soil water between Mediterranean annual grasses and Artemisia californica in southern California coastal sage scrub. Supplement to Bulletin of the Ecological Society of America 75:61.

ERCE. 1990. Phase I report, Amber Ridge California gnatcatcher study. Unpublished report prepared for Weingarten, Siegel, Fletcher Group, Inc., San Diego, CA.

Ezovski, J., T. Stecher and E. J. Woehler. 1995. Vegetation use by California gnatcatchers. Unpublished report distributed at CalGnat '95: Symposium on the biology of the California Gnatcatcher, September 15-16, 1995, University of California, Riverside.

Franklin, S. E. 1995. Fuel management, fire behavior and prescribed burning. Pages 29-33 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

Froomkin, D. 1993. Blaze sears O.C.: Santa Ana winds fan flames and give rise to the worst fire disaster in the county's history. Orange County Register, October 28, 1993:News 3, News 4.

Hickman, J. C. (ed.). 1993. The Jepson manual: higher plants of California. University of California Press, Berkeley. 1400 p.

Keeley, J. E. and S. C. Keeley. 1984. Postfire recovery of California coastal sage scrub. American Midland Naturalist 111:105-117.

Malanson, G. P. 1984. Fire history and patterns of Venturan subassociations of Californian coastal sage scrub. Vegetatio 57:121-128.

Malanson, G. P. 1985. Fire management in coastal sage-scrub, southern California, USA. Environmental Conservation 12:141-146.

Malanson, G. P. and J. F. O'Leary. 1982. Post-fire regeneration strategies of California coastal sage shrubs. Oecologia (Berl) 53:355-358.

Manly, B. J. F. 1991. Randomization and Monte Carlo methods in biology. Chapman and Hall, London. 281 p.

Mayer, A. L. and W. O. Wirtz, B. 1995. Effects of foe on the ecology of the Califomia gnatcatcher (*Polioptila californica*), and associated bird species, in the coastal sage scrub community of southern California. Pages 77-79 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

Minnich, R. A. 1995. Historical decline of coastal sage scrub in the Riverside-Penis Plain, California. Unpublished abstract of talk presented at CalGnat '95: Symposium on the biology of the California Gnatcatcher, September 15-16, 1995, University of California, Riverside.

Mock, P. J. and D. Bolger. 1992. Ecology of the California gnatcatcher at Rancho San Diego. Unpublished report prepared for Home Capital Development Corporation by Ogden Environmental and Energy Services Co., Inc., San Diego, CA.

Murphy, D. D., R. F. Noss, P. F. Brussard, J. F. O'Leary and M. S. Gilpin. 1993. Southern California coastal sage scrub Natural Communities Conservation Plan scientific review panel conservation guidelines and documentation. California Department of Fish and Game, Sacramento.

Myers, M. A. and N. C. Ellstrand. 1986. Post-fire succession at an inland (Riversidean) site of coastal sage scrub: variation in community response. Pages 129-132 in DeVries, J. J. (ed.), Proceedings of the chaparral ecosystems research conference, May 16-17, 1985, Santa Barbara, California. California Water Resources Center, Davis, CA.

NOAH. 1994. Climatological Data Annual Summary: California. Volume 98, Number 13. National Oceanic and Atmospheric Administration, National Climate Data Center, Asheville, NC.

O'Leary, J. F. 1990. Californian coastal sage scrub: general characteristics and considerations for biological conservation. Pages 24-41 in Schoenherr, A. A, (ed.), Endangered plant communities of southern California. Southern California Botanists Special Publication No. 3.

Roach, J. D. 1989. The influence of vegetation structure and arthropod abundance on the reproductive success of California black-tailed gnatcatchers *Polioptila melanura californica*. Master's thesis, San Diego State University. 63 p.

Tippets, W. E., L. H. Davis, T. A. Stewart and S. A. Cochrane. 1995. Fire and the Natural Communities Conservation Planning (NCCP) program, pages 35-40 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

US Fish and Wildlife Service. 1993. Federal Register 58(59):16742.

Westman, W. E. 1981. Diversity relations and succession in Californian coastal sage scrub. Ecology 62:170-184.

Westman, W, E, 1982. Coastal sage scrub succession. Pages 9198 in Conrad, C. E. and W. C. Oechel (eds.), proceedings of the symposium on environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report PSW-58. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Westman, W. E. and J. F. O'Leary. 1986. Measures of resilience: the response of coastal sage scrub to fire. Vegetatio 65:179189.

Westman, W. E., J. F. O'Leary and G. P. Malanson 1981. The effects of fire intensity, aspect and substrate on post-fire growth of Californian coastal sage scrub. Pages 151-179 in Margaris, N. S. and H. A. Mooney (eds.), Components of productivity of mediterranean-climate regions - basic and applied aspects. Dr W. Junk Publishers, The Hague.

White, T. C., J. Stephenson and F. Sproul. 1995. Postburn monitoring of the Eagle Fire: fast year recovery on sites seeded with buckwheat and coastal sage, pages 185-187 in Keeley, J. E. and T. Scott (eds.), Brushfires in California: ecology and resource management. International Association of Wildland Fire, Fairfield, WA.

Wirtz, W. O. II, A. L. Mayer and J. L. Beyers. 1997. Effects of fire on the ecology of the California gnatcatcher, Polioptila californica in California sage scrub communities. Pages 91-96 in J. Greenlee (editor), Fire effects on rare and endangered species and habitats. International Association of Wildland Fire, Fairfield, WA.

Woods, R. S. 1921. Home life of the black-tailed gnatcatcher. Condor 23:173-178.

Woods, R. S. 1928. Nesting of the black-tailed gnatcatcher. Condor 30:139-143.

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