RODENT DIVERSITY, VEGETATION COMPLEXITY, AND PATCH SIZE IN REMNANT COASTAL SAGE SCRUB HABITAT OF SOUTHERN CALIFORNIA

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Abstract: In 1996, I trapped rodents at seven sites of remnant coastal sage scrub habitat of southern California. I caught eight murid and two heteromyid species of rodents. Including two other sites where contemporary rodent trapping took place by others, rodent diversity at these nine sites ranged from 1.55 to 5.23. The composition of species was similar to nearby sites trapped almost three decades earlier, although *Dipodomys agilis* was not found. I measured vegetation characteristics at four of these sites and at the two additional sites. Neither cover values of component vegetation, a linear combination of these values, a physiognomic complexity index of vegetation, nor patch size significantly explained rodent diversity or relative abundance. However, rodent diversity was significantly related to shrub diversity at these sites.

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Key words: Rodents, diversity, coastal sage scrub, vegetation complexity, southern California

Forces generally thought to be responsible for structuring local community composition are competition, predation, and habitat size and structure (MacArthur and MacArthur 1961, Paine 1966, 1974, MacArthur and Wilson 1967, Ricklefs 1990). Communities of rodents have often been studied attempting to determine the causes of species diversity. Evidence has been found for a variety of contributors to rodent diversity, including competition leading to differential use of mirco-sites (Price 1978, Brown 1989), predation by owls reinforcing habitat selection differences (Longland and Price 1991), differences in plant productivity (Brown 1975, Whitford 1976, Owen 1988), and aspects of habitat structure (Rosenzweig and Winakur 1969, Hafner 1977, Dueser and Brown 1980, Germano and Lawhead 1986).

Understanding mechanisms regulating community composition can be important to conserving diminishing ecosystems. In southern California, burgeoning human populations have led to the loss of large tracts of habitat and marked fragmentation of that which remains (Bolger et al. 1997). This is particularly true of coastal sage scrub habitat from Los Angeles to San Diego. Rodent communities in these remaining fragments may be jeopardized if these areas do not provide fundamental habitat structure necessary for most species. I surveyed rodent communities at seven sites coastal sites in Orange and San Diego counties and characterized the vegetation structure at four of these sites. In addition, I characterized the vegetation at two other sites where contemporary rodent trapping had occurred. I asked the questions: (1) Can small, remnant habitats still support the diversity of rodents found in the past, and (2) Does the structure of the habitat contribute to the diversity of the rodent community?

STUDY AREAS

I trapped at seven sites of remnant coastal sage scrub within 4 km of the coast of California from Newport Beach in Orange County to the Mexican border in San Diego County (Fig. 1). The most northern sites were the coastal section of Crystal Cove State Park and four small disjunct habitats in the Pelican Hill area in Orange County. The coastal strip of Crystal Cove State Park (between Highway 1 and the ocean) was habitat that was severely degraded in the past, but which had been revegetated. After revegetation, it supported coastal sage scrub habitat mixed with exotic plants. Pelican Hill is about 1 km due north of Crystal Cove State Park and is adjacent to Spyglass Hill, an historic site of rodent studies in the late 1960s (M'Closkey 1972, Meserve 1976). There were several small areas of coastal scrub / chaparral habitat there among new housing developments and golf courses, although these sites joined a much larger area of native vegetation.

Farther to the southeast, I trapped at three small sites on the southwest part of Camp Pendleton Marine Corps Base in San Diego County (Fig. 1). I designated these sites, all of which were on bluffs overlooking the Santa Margarita River, as Wire Mountain, River Mouth North, and Lemon Grove. The Wire Mountain site was an area of intact coastal sage scrub and was adjacent to the Wire Mountain elementary school. The two other sites were southwest of the Wire Mountain site (closer to the ocean) and were on either side of the river. River Mouth North was coastal scrub but with a thick covering of exotic grasses, especially in areas less densely covered by shrubs. Lemon Grove was partly an old citrus grove that was being reinvaded by coastal scrub plants and partly an area of grassy scrub habitat.

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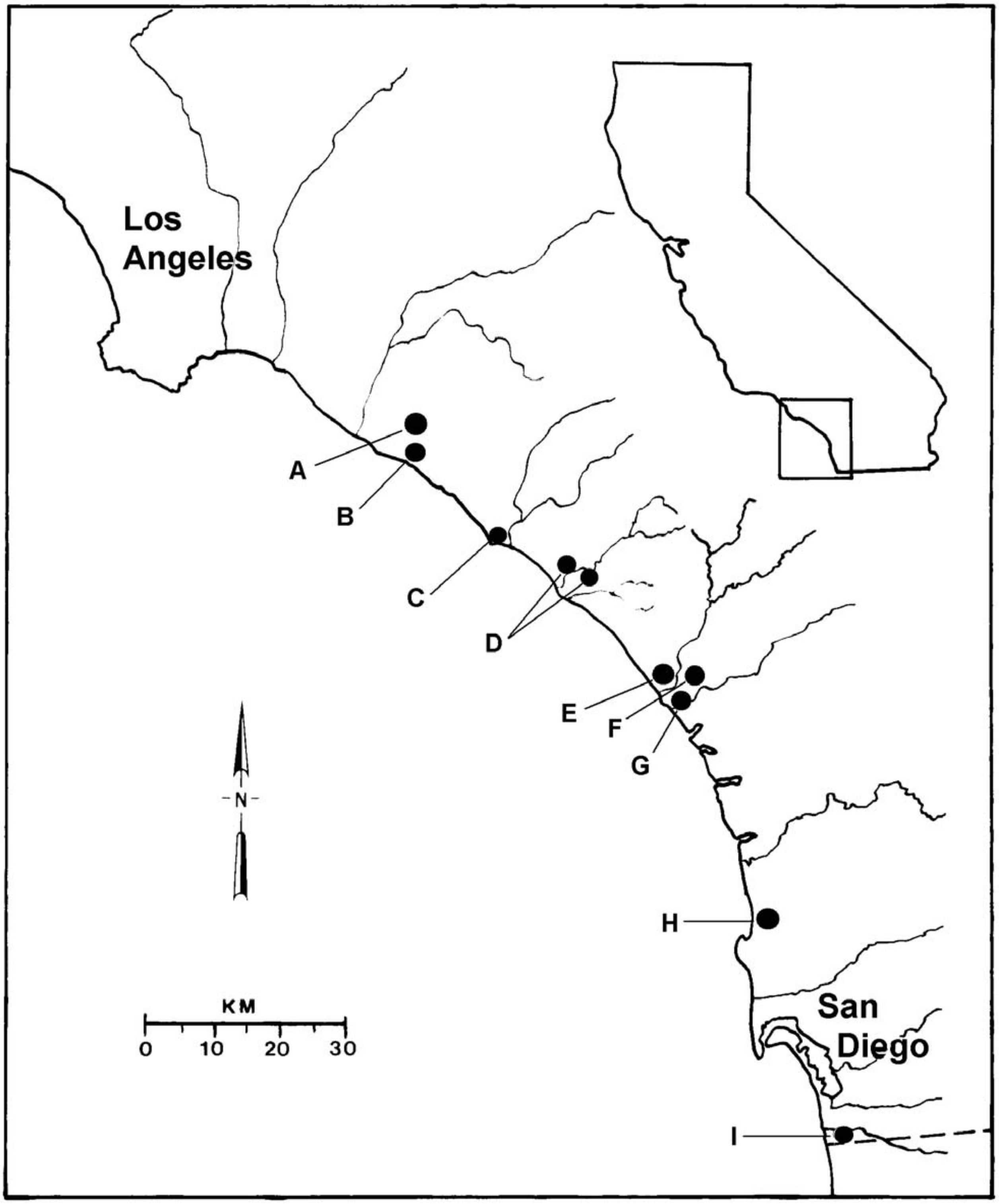

Figure 1. Location of sites in coastal Southern California where rodent trapping and vegetation analysis occurred in 1996 (A = Pelican Hills, B = Crystal Cove State Park, C = Dana Point, D = San Mateo sites, E = River Mouth North, F = Wire Mountain, G = Lemon Grove, H = Torrey Pines State Reserve, and I = Tijuana River Estuary).

Farthest southeast were sites in three locations within the Torrey Pines State Reserve and in Borderfield State Park at the Tijuana Estuary in San Diego County (Fig. 1). Torrey Pines State Reserve had several pockets of coastal scrub and an overstory of pine forest. Two trapping sites were within 100 m of the beach on a bluff. The third location was adjacent to Highway 1 in an area called East Grove. These areas were believed by Park personnel to be the best coastal sage habitats in the reserve. At the Tijuana River estuary site, I set traps on two small bluffs along the U.S./Mexico border. One bluff closest to the ocean (less than 100 m from high tide) was topped by a parking lot, lawn, and sidewalks, but had a small strip (ca. 100 x 75 m) of coastal scrub habitat on the downslope side of the bluff. The other bluff, further from the beach and also along the border, had no man-made structures or habitats, but was sparse scrub densely covered with exotic grasses. Both sites were contiguous with a much larger expanse of native vegetation surrounding the river estuary.

METHODS

Rodent Trapping

I used Sherman live-traps in transect lines of variable length and number of traps based on the size of the habitat to be sampled. I spaced traps about 10 m apart and usually placed them at the edge of shrubs. Traps were baited with birdseed and opened about 1-2 hours before sunset. I checked traps early the following morning. Rodents that I found in the traps were identified, weighed, sex determined, and marked either with a felt-tipped marker (heteromyids) or by clipping a patch of hair on the flank of the rear leg (murids). When I caught a rodent that I had previously marked, I only recorded which species it was and its sex. All animals were released at the site of capture after they were recorded. Traps remained closed during the day. I trapped for three or four nights at each site: 21-23 August 1996 at Crystal Cove (300 trap nights [TN]) and Pelican Hill (270 TN); 6 – 9 August 1996 at Wire Mountain (200 TN), River Mouth North (200 TN), and Lemon Grove (200 TN); 4 – 6 September 1996 at Torrey Pines State Reserve (270 TN) and Tijuana Estuary (300 TN).

Vegetation Analysis

I characterized the vegetation at the sites I trapped except Pelican Hill, River Mouth North, and Lemon Grove. I also characterized vegetation at two additional sites, Dana Point Headlands and San Mateo (Fig. 1), sites at which rodents had been trapped contemporarily by personnel of the U. S. Fish and Wildlife Service (Carlsbad Field Office, unpublished data) and by Michael Brandman Associates and LSA Associates (unpublished report), respectively. The Dana Point site is southeast of Crystal Cove State Park and just northwest of Camp Pendleton. The San Mateo site is on the northwestern edge of Camp Pendleton and is part of a much larger expanse of native vegetation to the north and east. Both sites are within 1 km of the ocean.

At each site at which vegetation was characterized, I randomly placed five 100 x 1-m belt transects in coastal sage scrub. The only exception was at the Wire Mountain site on Camp Pendleton, where I ran only three transects because it was a small area. Transects were intended to characterize the shrub component of the habitat in detail and the herbaceous cover in general. The 100-m belt was subdivided into ten 10-m lengths. Along each transect I recorded the length of transect covered by shrub canopy, which shrub species were encountered, the number of individuals of each shrub, and the amount of open space (bare ground) encountered. These data yielded species composition, frequency, density (number / 100 m), and percentage cover of shrubs. I estimated cover of grasses and herbaceous plants separately in each 10-m belt segment. I averaged data from the five transects to yield shrub values, described above, percentage grass cover, percentage forb cover, and percentage bare ground for each site. The effort here was to determine the horizontal vegetation complexity, which was found to correlate with rodent diversity in the Great Basin Desert (Germano and Lawhead 1986). Transects were sampled from August to October 1996. I did not conduct vegetation surveys in the spring because of delays in obtaining permits to work on sites. Several shrubs and most herbaceous plants were not readily identifiable in the field, and specimens were taken back to the lab for identification by a botanist.

Patch Size

For most of the sites, I approximated total habitat size from aerial maps (GoogleEarth, 2007), but I could not measure actual extent of coastal sage scrub. For the Torrey Pines State Reserve, I used the acreage estimate published on its web site (http://www.torreypine.org). At three of these sites, Pelican Hill, San Mateo, and the Tijuana Estuary, the areas I sampled were part of a much larger habitat expanse. I estimated habitat size at these three sites only to order of magnitude, and the estimates are not precise.

Statistical Analyses

I used the Simpson index (Simpson 1949, as used by Cox 1985) to determine the diversity (N_2) and evenness values (V) of rodents and shrubs. Diversity was calculated as $N_2 = N(N-1) / \Sigma n_i(n_i-1)$, where N is the total number of rodents captured and n_i is the abundance of individual species. Evenness was determined as N_2 /

N_{2max}, where N_{2max} is calculated using the same number of species but with equal abundances for each. Additionally, I computed the physiognomic complexity index (PCI) of vegetation at each site following Tomoff (1974) and Germano and Lawhead (1986). PCI was calculated using the equation $PCI = 1 / \Sigma (p_i^2)$, where p_i equals the proportional cover values of each physiognomic component in the habitat (i.e., shrubs, grass, forbs, bare ground). A site with only one or two of these components comprising the majority of cover of the vegetation will have low horizontal heterogeneity compared to a site that has a more even mixture of components.

I compared rodent diversity and relative abundance at each site to cover values of component vegetation, shrub diversity, PCI, and patch size using least squares regression ($\alpha = 0.05$). Relative abundance was the total number of captures of rodents divided by total trap nights. I also used step-wise multiple regression ($\alpha = 0.05$) to determine if a linear combination of vegetation cover values significantly explained diversity and abundance of rodents.

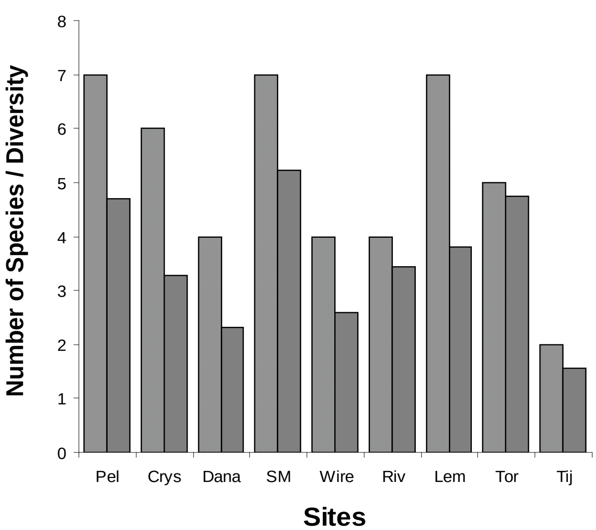

Figure 2. Comparison of the number of species (hatched bars) and Simpson diversity index (gray bars) of nocturnal rodents captured at nine sites of coastal Southern California in 1996. Sites are arranged left to right from the most northwest site to the most southeast site and are Pelican Hills (Pel), Crystal Cove State Park (Crys), Dana Point (Dana), San Mateo (SM), Wire Mountain (Wire), River Mouth North (Riv), Lemon Grove (Lem), Torrey Pines State Reserve (Tor), and Tijuana River Es-

RESULTS

I captured two heteromyid and eight murid species at seven coastal sites (Table 1). Personnel of the U.S. Fish and Wildlife Service caught four murids, mostly *Reithrodontomys megalotis* (western harvest mouse), and *Neotoma lepida* (desert woodrat) at the Dana Point site (unpublished data). In the first three nights of trapping at the San Mateo site (standardized to my trapping effort), one heteromyid and six murid species were caught (unpublished report). The greatest number of species (7) was caught at the Pelican Hills, San Mateo, and Lemon Grove sites, with the fewest species (2) caught at the Tijuana Estuary site (Fig. 2). Abundance, based on percentage trapping success, was also highest at Pelican Hills (33.7%) and Lemon Grove (33.5%), but was lowest at the Tijuana Estuary (5.3%), Wire Mountain (8.5%), and San Mateo (6.6%) sites. Rodent diversity ranged from 1.55 to 5.23, and was highest at the Pelican Hill, San Mateo, and Torrey Pines sites (Fig. 2). The Torrey Pines site also had the highest evenness value (Table 1). The Tijuana Estuary site scored the lowest in rodent diversity and evenness (Table 1).

At the six sites at which I characterized vegetation, the number of shrub species at sites ranged from 4 – 19 (Table 2), but only two shrubs were common to all sites (Appendix Table). Frequency of *Artemisia californica* ranged from 28.0 – 96.0%, whereas *Lotus scoparius* ranged from 2.0% at the Tijuana Estuary site to 56.7% at the Wire Mountain site (Appendix Table). *Eriogonum fasciculatum* was found at relatively high frequencies and *Opuntia littoralis* at low frequencies at all sites except at Wire Mountain and Tijuana Estuary. The only other shrub found at at least four sites was *Encelia californica*, which was not found at the San Mateo or Wire Mountain sites (Appendix Table). Shrub cover was highest at Dana Point and lowest at Wire Mountain, grass cover was highest at the Tijuana Estuary and lowest at Dana Point, and forb cover was highest at Wire Mountain and lowest at the Tijuana Estuary (Table 2). Percentage bare ground was greatest at Dana Point and least at the Tijuana Estuary (Table 2). The complexity of the habitat, as measured by PCI, was greatest at the Torrey Pines site and was lowest at the Dana Point site (Table 2). The Torrey Pines site also had the greatest shrub diversity, which was twice the value of the next highest diversity at San Mateo (Table 2). However, Torrey Pines only had the second highest evenness value for shrubs with the Wire Mountain site having the highest value (Table 2). Both shrub diversity and evenness was lowest at the Tijuana Estuary site (Table 2).

Habitat patch size varied considerably among sites. I estimated the habitat size at Crystal Cove to be about 55 ha, at Dana Point 18.5 ha, River Mouth North 48.5

Table 1. The number of individual rodents trapped (total captures) in August and September 1996 at seven sites of coastal southern California, and the Simpson diversity index (N_2) and equability of abundance (V) for each site. Sites trapped were Pelican Hill (Pelican), Crystal Cove State Park (Crystal), Wire Mountain (Wire), River Mouth North (River), Lemon Grove (Lemon), Torrey Pines State Reserve (Torrey), and the Tijuana Estuary (Tijuana).

Species	Pelican	Crystal	Wire	River	Lemon	Torrey	Tijuana
Chaetodipus californicus	10 (16)	4 (7)	8 (11)	2 (2)	8 (13)	3 (6)	---
Chaetodipus fallax	---	---	1 (1)	6 (19)	---	7 (21)	8 (14)
Peromyscus eremicus	9 (9)	7 (7)	2 (2)	1 (1)	3 (3)	---	---
Peromyscus maniculatus	23 (38)	27 (47)	2 (2)	1 (1)	17 (23)	---	---
Peromyscus californicus	---	---	---	---	18 (21)	8 (10)	---
Reithrodontomys megalotis	3 (4)	5 (6)	---	---	---	---	2 (2)
Microtus californicus	4 (5)	---	---	---	2 (4)	---	---
Mus musculus	---	5 (6)	---	---	---	---	---
Neotoma fuscipes	2 (2)	---	---	---	1 (2)	7 (13)	---
Neotoma lepida	10 (17)	4 (5)	---	---	1 (1)	2 (2)	---
Total	61 (91)	52 (78)	13 (16)	10 (23)	50 (67)	27 (52)	10 (16)
N_2	4.70	3.28	2.60	3.44	3.81	4.74	1.55
V	0.604	0.493	0.488	0.469	0.478	0.803	0.344

Table 2. Vegetation characteristics at six sites of coastal southern California, including mean percentage cover values (± standard error), Physiognomic Complexity Index (PCI), Simpson diversity index (N_2), and equability of abundance (V) of shrubs. Sites at which vegetation were sampled were Crystal Cove State Park (Crystal), Dana Point (Dana Pt.), San Mateo, Wire Mountain (Wire), Torrey Pines State Reserve (Torrey), and the Tijuana Estuary (Tijuana). Total cover value at Torrey Pines State Reserve was < 100% because areas covered by litter (downed and dead shrubs) were not included. See Appendix Table 1 for the list of shrubs and their frequency and density at each site.

Vegetation Characteristics	Crystal	Dana Pt.	San Mateo	Wire	Torrey	Tijuana
% Cover						
Shrubs	27.0 (29.3)	64.2 (9.1)	47.4 (9.3)	23.9 (12.4)	38.2 (17.3)	36.2 (17.7)
Grass	48.5 (34.2)	9.3 (4.9)	38.5 (17.6)	41.7 (7.1)	16.9 (18.4)	54.6 (14.0)
Forb	11.1 (16.9)	5.3 (3.3)	5.7 (4.9)	14.7 (4.2)	10.0 (5.2)	4.3 (3.2)
% Bare Ground	17.8 (11.1)	25.7 (10.8)	15.5 (11.5)	19.7 (3.7)	16.1 (13.8)	10.6 (5.2)
PCI	2.84	2.04	2.50	3.43	4.75	2.26
Shrub Richness (No. species)	13	9	15	4	19	8
Shrub Diversity (N_2)	4.06	3.47	5.75	2.51	11.50	1.56
Shrub Evenness (V)	0.305	0.379	0.368	0.620	0.513	0.139

ha, Lemon Grove 23 ha, Wire Mountain 100 ha, and Torrey Pines 810 ha. Order of magnitude estimates for habitat size at the Tijuana Estuary site (excluding estuary habitat) was 1,000 ha, at Pelican Hill 5,000 ha, and at San Mateo 10,000 ha.

Rodent diversity was not significantly related to any of the cover values of vegetation ($F_{1,4\,[0.05]} = 0.013 – 0.288$, $P = 0.62 – 0.91$), PCI ($F_{1,4\,[0.05]} = 1.24$, $P = 0.33$), or patch size ($F_{1,7\,[0.05]} = 5.06$, $P = 0.059$). Relative abundance of rodents also was not significantly related to any of the cover values of vegetation ($F_{1,4\,[0.05]} = 0.001 – 0.914$, $P = 0.39 – 0.98$), PCI ($F_{1,4\,[0.05]} = 0.329$, $P = 0.40$), or patch size ($F_{1,7\,[0.05]} = 0.180$, $P = 0.684$). Additionally, neither rodent diversity nor relative abundance was explained by a linear combination of habitat components. However, rodent diversity was significantly related to log values of shrub diversity ($F_{1,4\,[0.05]} = 13.28$, $P = 0.022$; Fig. 3).

DISCUSSION

The composition of the rodent community at sites I trapped was similar to what had been found decades earlier. Rodents captured between 1968 – 1971 at Spyglass Hill in Orange County, just northwest of Pelican Hill and Crystal Cove, included the same species I caught (M'Closkey 1972, Meserve 1976) except I did not capture any *Dipodomys agilis* (agile kangaroo rat) or *Perognathus longimembris pacificus* (Pacific pocket mouse).

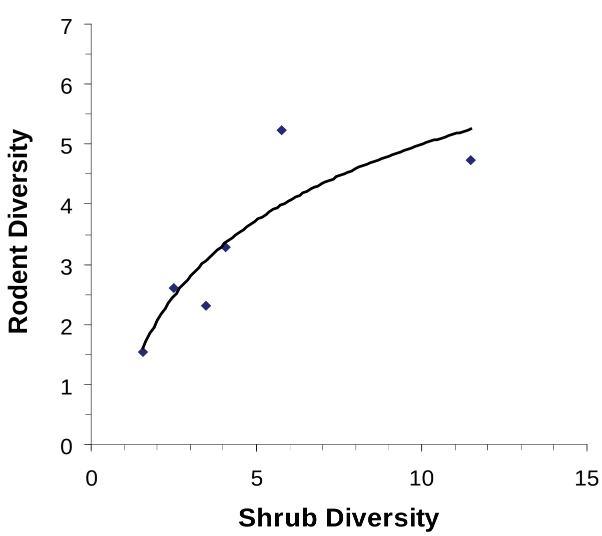

Figure 3. The relationship between diversity of nocturnal rodents and the log value of shrub diversity ($R^2 = 0.769$, rodent diversity = 1.83 log (shrub diversity) + 0.77) at six sites in native habitat of coastal Southern California in 1996.

However, *P. l. pacificus* were caught at both the Dana Point (U.S. Fish and Wildlife Service, unpublished data) and San Mateo sites (Michael Brandman Associates and LSA Associates, unpublished report). I caught *Chaetodipus californicus* (California pocket mouse), *Microtus californicus* (California vole), and *Mus musculus* (house mouse), which were not caught at the Spyglass Hill site. The addition of these species and the lack of *D. agilis* probably indicate that grasses now cover a larger area of habitat than previously. Recent trapping in coastal sage scrub and chaparral habitats in the San Diego area also did not capture *D. agilis*, but did include *M. californicus* and *M. musculus*, but not *C. californicus* or *Peromyscus californicus* (California mouse: Bolger et al. 1997). In addition, they also caught *Rattus rattus* (house rat), which I did not find.

At coastal sage scrub / chaparral sites farther inland from the coast, similar mixes of rodents were caught in the past. All three species of *Peromyscus* that I found, both *Neotoma*, as well as *C. fallax* (San Diego pocket mouse) and *D. agilis* were caught at a site near Claremont, California in the early 1960s (MacMillen 1964). Rodents captured in the 1980s at a coastal sage scrub site 24 km south of Riverside, California included *P. eremicus* (cactus deermouse), *P. maniculatus* (North American deermouse), *N. lepida*, *R. megalotis*, *M. californicus*, *C. fallax*, *P. longimembris*, and *D. agilis* (Price and Waser 1984). M'Closkey (1972) noted that *N. lepida* was found in areas where *Opuntia littoralis* (coastal beavertail) occurred. I found this was still the case as this species was only caught at sites with this cactus. Overall, with the exception of the loss of the kangaroo rat, *D. agilis*, coastal sage scrub sites along coastal California still retain the same rodent community that they did decades earlier. The invasion of sites by grasses, which is occurring throughout western North America, probably has led to the loss of *D. agilis* because kangaroo rats rely on open ground for foraging and to escape predators (Bartholomew and Caswell 1951, Rosenzweig and Winakur 1969, Price et al. 1994, Goldingay et al. 1997). Even though most of the sites I sampled were relatively small habitats surrounded by human development, the rodent community was basically intact.

I found that rodent diversity at coastal sage scrub sites in southern California was not correlated with habitat complexity involving various components of the plant community or with patch size, but was related specifically to shrub diversity. The structure of the habitat has been found to affect rodent diversity at desert sites in the western United States (Rosenzweig and Winakur 1969, Hafner 1977, Germano and Lawhead 1986), at sites near San Diego, California (Bolger et al. 1997), and at a site in coastal Virginia (Dueser and Brown 1980). In Arizona, densities of kangaroo rats, pocket mice, and mice correlated with plant growth form and foliage density, and the diversity of the rodent community correlated with habitat complexity involving horizontal and vertical complexity of foliage and measures of soil quality (Rosenzweig and Winakur 1969). At six sites in the western Mojave Desert, rodent abundance was not correlated with vegetation complexity, but rodent density increased directly with an increase in percentage shrub cover (Hafner 1977). Similar to what I found in coastal sage scrub sites, though, rodent diversity increased at these Mojave sites with an increase in shrub diversity (Hafner 1977). Rodent diversity in the Great Basin Desert of southwestern Utah increased with an increase in habitat complexity as measured by PCI (Germano and Lawhead 1986). The relationship of increasing rodent diversity with an increase in habitat complexity also has been shown at sites on barrier islands in Virginia, although rodent diversity was also affected by island size and elevation (Dueser and Brown 1980).

Habitat fragment size was found to be related to the number of rodent species in coastal sage scrub and chaparral habitats near San Diego, California (smaller the habitat, the fewer the number of species), but the area of shrub habitat in the fragment was found to be the most significant predictor of rodent diversity (Bolger et al. 1997). I did not find that patch size affected rodent diversity, but I did not sample as small of patches as did Bolger et al. (1997) in the San Diego area (21 sites < 10 ha). They found comparable numbers of rodent species in patch sizes similar to what I sampled. Also, I only sampled one short period in one year, and this might have affected results. However, the number of trap nights I used and the total number of species of rodents I found are comparable to the study by Bolger et al. (1997), even though they sampled over several years.

Although other factors seem to play a part in structuring rodent communities in some areas, such as differential use of mirco-sites (Price 1978, Brown 1989), predation (Longland and Price 1991), and plant productivity (Brown 1975, Whitford 1976, Owen 1988), some aspect of habitat complexity also are important. Ultimately, long-term survival of populations of native rodents in southern California likely depends on the protection of the remaining habitats along the coast from development. Although patch size can become too small to support native rodents, it is encouraging that parcels as small as 20 ha have supported a rodent community similar to that found decades earlier. However, protection of sites also requires that non-native grasses be controlled.

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Appendix Table 1. Frequency (percentage occurrence in 50 sections) and average density (number of shrubs per 100 m - in parentheses) of shrubs encountered at 6 sites in coastal southern California. Plant nomenclature follows Hickman (1993). Averages are for 5 transects per site except for the Wire Mountain site, which had 3 transects.

Species	Crystal Cove	Dana Pt.	San Mateo	Wire Mt.	Torrey Pines	Tijuana Estuary
Adenostoma fasiculatum (Chamise)	----	----	----	----	24.0 % (6.2)	----
Artemisia californica (California sagebrush)	58.0 % (41.8)	96.0 % (45.0)	57.4 % (23.0)	46.7 % (18.3)	30.0 % (6.6)	28.0 % (5.2)
Astragalus trichopodus (Astragalus)	----	----	----	----	----	6.0 % (1.2)
Atriplex canescens (Shadscale)	12.0 % (2.0)	----	----	----	----	12.0 % (1.8)
Atriplex lentiformis (Quailbush)	2.0 % (0.2)	----	----	----	----	----
Baccharis pilularis (Coyote bush)	40.0 % (10.0)	24.0 % (7.0)	8.5 % (1.5)	----	----	----
Ceanothus verrucosus (Wart-stemmed ceanothus)	----	----	----	----	20.0 % (2.0)	----
Encelia californica (California encelia)	26.0 % (7.6)	40.0 % (9.0)	----	----	14.0 % (2.4)	4.0 % (0.4)
Ericameria spp. (Goldenbush)	----	----	----	----	----	8.0 % (0.8)
Eriodictyon crassifolium (Yerba Santa)	----	----	---	----	10.0 % (2.8)	----
Eriogonum fasciculatum (California buckwheat)	46.0 % (24.6)	62.0 % (11.4)	23.4 % (4.9)	----	46.0 % (11.0)	----

Appendix Table 1. Cont.

Species	Crystal Cove	Dana Pt.	San Mateo	Wire Mt.	Torrey Pines	Tijuana Estuary
Ferrocactus viridescens (Barrel cactus)	----	----	----	----	2.0 % (0.4)	----
Hazardia squarrosa (Saw-toothed goldenbush)	12.0 % (2.4)	----	----	----	----	8.0 % (1.4)
Heteromeles arbutifolia (Toyon)	----	----	----	----	2.0 % (0.4)	----
Heterotheca sessiflora (Goldenaster)	----	----	----	----	----	96.0 % (82.4)
Isocoma acradenia (Goldenbush)	----	----	2.1 % (1.3)	3.3 % (1.3)	----	----
Isocoma menziesii (Goldenbush)	8.0 % (2.0)	10.0 % (4.0)	----	----	----	----
Isocoma spp. (Goldenbush)	----	----	----	----	8.0 % (2.2)	8.0 % (1.8)
Isomeris arboreus (Bladderpod)	2.0 % (0.4)	----	8.5 % (1.9)	----	----	----
Lotus scoparius (Deer brush)	14.0 % (5.6)	36.0 % 2 (15.0)	9.8 % (8.3)	56.7 % (20.3)	48.0 % (9.0)	2.0 % (0.4)
Machaeranthera canescens (Hoary aster)	----	8.0 % 3 (1.4)	8.3 % (12.1)	36.7 % (48.7)	----	----
Malosma laurina (Laurel sumac)	----	----	----	----	8.0 % (1.4)	----
Malosma ovata (Sugarbush)	6.0 % (0.4)	4.0 % (0.4)	14.9 % (1.3)	----	----	----

Appendix Table 1. Cont.

Species		Crystal Cove	Dana Pt.	San Mateo	Wire Mt.	Torrey Pines	Tijuana Estuary
Nicotiana glauca	(Tree tobacco)	----	----	6.4 % (0.9)	----	----	----
Opuntia littoralis	(Coastal beavertail)	8.0 % (1.2)	2.0 % (0.2)	10.6 % (1.1)	----	10.0 % (1.6)	----
Opuntia spp.	(Cholla)	----	----	----	----	4.0 % (0.4)	20.0 % (4.2)
Pinus torreyana	(Torrey pine)	----	----	----	----	14.0 % (1.6)	----
Quercus berberidifolia	(Scrub oak)	----	----	----	----	2.0 % (0.2)	----
Rhamnus californica	(Coffeeberry)	----	----	19.1 % (2.6)	----	----	----
Rhamnus crocea	(Redberry)	----	----	----	----	6.0 % (0.6)	----
Rhus integrifolia	(Lemonade Berry)	----	----	8.5 % (1.1)	----	12.0 % (3.0)	----
Ribes malvalceum	(Chaparral current)	----	----	6.4 % (0.6)	----	----	----
Salvia apiana	(White sage)	----	----	35.7 % (13.0)	----	----	----
Salvia melifera	(Black sage)	12.0 % (2.6)	----	----	----	30.0 % (6.0)	----

Appendix Table 1. Cont.

Species		Crystal Cove	Dana Pt.	San Mateo	Wire Mt.	Torrey Pines	Tijuana Estuary
Salvia spp.	(Sage)	----	----	----	----	20.0 % (3.8)	----
Sambucus mexicana	(Blue elderberry)	----	----	2.1 % (0.2)	----	----	----
Yucca schidigera	(Mojave yucca)	----	----	----	----	18.0 % (2.6)	----
Yucca whipplei	(Our Lord's Candle)	----	----	----	----	2.0 % (0.4)	----
unidentified	(small tree)	----	----	----	----	4.0 % (0.6)	----
unidentified	(bush composite)	----	----	----	----	----	20.0 % (3.8)