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# RODENT COMMUNITIES IN CISMONTANE CALIFORNIA: COMPOSITION, DIVERSITY, AND SPECIFIC STUDY LOCATIONS FOR FUTURE REFERENCE

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**Abstract.**—We investigated composition and species diversity of rodent communities in six vegetation types on the cismontane slope of the San Jacinto Mountains, Riverside County, California. The Deer Mouse (*Peromyscus maniculatus*) occurred in all vegetation types, and we captured the Western Harvest Mouse (*Reithrodontomys megalotis*) in five and the Agile Kangaroo Rat (*Dipodomys agilis*) in four of the six vegetation types. The California Vole (*Microtus californicus*), California Mouse (*Peromyscus californicus*), Brush Mouse (*P. boylii*), Pinyon Mouse (*P. truei*), Desert Woodrat (*Neotoma lepida*), Dusky-footed Woodrat (*N. fuscipes*), and California Pocket Mouse (*Perognathus californicus*) were less abundant and far more restricted in occurrence. We captured all 10 species in the Interior Live Oak vegetation type, but only the Deer Mouse, Western Harvest Mouse, and Agile Kangaroo Rat were captured in the Graminoid vegetation type. Species diversity of rodents was greatest in the Black Oak and Interior Live Oak vegetation types; slightly lower, but similar to each other, in the Chamise-Manzanita, Graminoid, and Riparian vegetation types; and least in the Coast Live Oak vegetation type. We provide precise locations for each of the study plots to ensure the sites can be relocated by future investigators interested in the long-term effects of a warming climate or anthropogenic manipulation of those vegetation types.

**Key Words.**—baseline data; climate; habitat; history; San Jacinto Mountains; succession.

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## INTRODUCTION

Data collected nearly half-a-century earlier seldom appear in a contemporary journal but as prophesized by Bob Dylan (Gray 2006), “The times, they are a-changin’.” Indeed, the planet has been experiencing a warming trend and, despite the skepticism of some (Smith and Leiserowitz 2012), there is increasing interest in the ways that ecosystems will be altered and how the biota will adapt or evolve in response (Millien et al. 2006; Hoffman and Sgro 2011; and many others). Additionally, there is a pressing need to minimize impacts of habitat loss or resource exploitation (Caro et al. 2021) and, if biodiversity existing today is to be conserved, it is essential that contemporary threats to habitat be a primary concern so that issues remain to be addressed in the future (Caro et al. 2022). In addition, all of this has been compounded by a substantial decline in the recognition of natural history as a respected discipline in wildlife education, wildlife science, and conservation (Noss 1996; Kessler and Booth 1998; Bleich and Oehler 2000; Bury 2006). As a result, acquisition of information that may serve as baseline data against which to assess future changes, whether climate-related or otherwise the result of anthropogenic meddling, has received little attention in the recent past. Much of the data upon which future ecological comparisons may be based was obtained during basic natural history investigations or observations, but few site-specific locations for such investigations appear in the literature.

Southern California is characterized by exceptional levels of biodiversity (Chen et al. 2005; Mooney and Zavaleta 2016) and cismontane southern California is rapidly being developed (Erickson and Patten 1999). Anticipated ecosystem-level changes will include distributional shifts in plants and animals, species extirpations, range expansions, altered life-history strategies, and behavioral adaptations, among others (Ostberg et al. 2013; and references therein). Additionally, anthropogenic activities will continue to transform habitats in profound ways, including increased frequency of fires that will continue to convert native shrublands to nonnative grasslands (Keeley 2001; Klinger et al. 2006; Keeley et al. 2011; Keeley and Safford 2016). Moreover, long-term shifts in management prescriptions will continue to affect community structure within and among habitat types (Bowyer and Bleich 1980, 1984; Bleich 2021).

Nearly 50 y have passed since a devastating wildfire (the Soboba Burn) occurred on the western slope of the San Jacinto Mountains, Riverside Co., California (Moore et al. 1979). That conflagration burned nearly 7,300 ha in 1974, of which almost 4,700 ha were within the San Bernardino National Forest (SBNF). Following that event, personnel representing the SBNF and the California Department of Fish and Game (CDFG; now California Department of Fish and Wildlife) cooperated on the development of a vegetation management plan for what was known as the Soboba Management Area (SMA). Although our investigation occurred after 4 y of

post-fire vegetation succession, a variety of anthropogenic manipulations (Bleich and Holl 1982) were planned to improve wildlife habitat and simultaneously to reduce, or otherwise manage, fuels across the variety of low-elevation habitat types within the SMA (Berg 1978; Blong et al. 1978; Roberts 1980, 1981; Quinn 1983). A similar project, the Laguna-Morena Demonstration Area (LMDA) in San Diego County, also was initiated following a series of disastrous wildfires of the early 1970s, but with an emphasis on fuel reduction on chaparral-dominated ranges and secondarily on habitat enhancement for large mammals inhabiting that vegetation type (Bowyer 1981; White et al. 1982). Thus, the SMA differed from the LMDA in that there was an emphasis on: (1) the management of multiple types of vegetation; (2) the creation and improvement of wildlife habitat as a primary goal; and (3) habitat management for both game and nongame species (Quinn 1983).

The multiple vegetation types in the SMA promulgated several intensive resource inventories (Blong et al. 1978). During May 1978, we investigated the distribution and relative abundance of small mammals occurring among a diversity of vegetation types in the SMA. Published reports detailing the mammalian fauna of the San Jacinto Mountains were few and remain so; to add to the sparse information in that area, we report the results of our 1978 survey and the locations at which the investigations were conducted. Such information is especially relevant given current concerns about continued habitat loss, resource

exploitation, and a warming climate, and their respective effects on the biodiversity of small mammals and the paucity of specific study locations in the published literature.

## METHODS

The Soboba Management Area (approximate centroid 36.87°N, 116.87°W) was located on the San Jacinto Ranger District of the San Bernardino National Forest, Riverside Co., California, proximate to the San Gorgonio Pass (36.92°N, 116.76°W; Fig. 1), an area of long-standing biogeographic interest (Grinnell 1908; Grinnell and Swarth 1913). We selected and defined a single study plot in six distinct vegetation types (Table 1) representative of those within the SMA (Berg 1978; Paysen et al. 1980). We placed an emphasis on the vegetation types most apt to be subjected to manipulation pending implementation of the management plan for the SMA (Berg 1978). Thus, we established trapping plots in those vegetation types deemed most suitable for habitat modification by methods involving: (1) direct rehabilitation of ranges whose capability had declined because of natural processes or past management strategies; (2) direct enhancement of existing habitat; or (3) modification of other resource management practices (Scotter 1980) using manual, mechanical, chemical, or pyrotechnic methods, or by manipulation with livestock (Green 1977a,b; Bleich and Holl 1982; Bleich et al. 2020).



**FIGURE 1.** The Soboba Management Area (SMA) encompassed 4,735 ha and was located on the San Jacinto Ranger District of the San Bernardino National Forest, Riverside County, California (Berg 1978). Shown in red is the approximate boundary of the SMA and its juxtaposition to the city of Banning and to San Gorgonio Pass, which separates the San Bernardino Mountains from the San Jacinto Mountains and is a topographic feature long of interest to mammalogists and biogeographers (Grinnell 1908; Grinnell and Swarth 1913).

**TABLE 1.** Species of rodents and the vegetation type in which each was captured to establish baseline data on the composition of small mammal communities in the Soboba Management Area, San Bernardino National Forest, Riverside County, California, May 1978. Total numbers of each species (n) captured in six vegetation types are presented, followed parenthetically by the relative abundance (captures/100 trap-nights) in each type of vegetation. As ordered in the table, species captured were the Deer Mouse (*Peromyscus maniculatus*), California Mouse (*P. californicus*), Pinyon Mouse (*P. truei*), Brush Mouse (*P. boylii*), Desert Woodrat (*Neotoma lepida*), Dusky-footed Woodrat (*N. fuscipes*), California Vole (*Microtus californicus*), Western Harvest Mouse (*Reithrodontomys megalotis*), Agile Kangaroo Rat (*Dipodomys agilis*), and California Pocket Mouse (*Perognathus californicus*). The Chamise-Manzanita Association refers to the Chamise or Manzanita Vegetation Series of Paysen et al. (1980) and the Chamise-Manzanita Association of Berg (1978); Interior Live Oak, Graminoid, Riparian, Black Oak, and Coast Live Oak vegetation types are those described by Paysen et al. (1980).

Species	Vegetation Type						Total (n)	Total (%)
	Chamise-Manzanita Association	Interior Live Oak Series	Graminoid Subformation	Riparian	Black Oak Series	Coast Live Oak Series		
<i>P. maniculatus</i>	11 (2.04)	41 (6.51)	8 (1.27)	1 (0.32)	2 (1.75)	1 (0.16)	64	25.8
<i>P. californicus</i>	10 (1.85)	22 (3.49)	0	0	1 (0.88)	1 (0.16)	34	13.7
<i>P. truei</i>	3 (0.55)	3 (0.48)	0	0	0	0	6	2.4
<i>P. boylii</i>	4 (0.74)	2 (0.32)	0	13 (4.13)	3 (2.63)	16 (2.54)	38	15.3
<i>Peromyscus</i> sp.	1 (0.18)	1 (0.16)	0	0	0	0	2	0.8
<i>N. lepida</i>	1 (0.18)	4 (0.63)	0	2 (0.63)	0	0	7	2.8
<i>N. fuscipes</i>	0	1 (0.16)	0	0	0	0	1	0.4
<i>M. californicus</i>	0	2 (0.32)	0	0	0	0	2	0.8
<i>R. megalotis</i>	0	3 (0.48)	2 (0.32)	1 (0.32)	1 (0.88)	1 (0.16)	8	3.2
<i>D. agilis</i>	32 (5.92)	29 (4.60)	6 (0.95)	0	0	2 (0.32)	69	27.8
<i>P. californicus</i>	1 (0.18)	16 (2.54)	0	0	0	0	17	6.9
Captures (n)	63	124	16	17	7	21	248	
Captures (%)	25.4	50.0	6.5	6.8	2.8	8.5		100.0
Trap Nights	540	630	630	315	114	630		
Relative Abundance	11.7	19.7	2.5	5.4	6.1	3.3		

At each sampling location we established two parallel trap-lines separated from each other by 15 m, and placed trap-stations at 15-m intervals along each trap-line. We placed two Museum Special traps (Woodstream Corporation, Lititz, Pennsylvania) and a Victor rat trap (Woodstream Corporation) at each station, and the total number of stations per vegetation type ranged from 19 to 70. We baited each trap with moistened rolled oats each evening, and traps were active for three consecutive nights on each study plot 10–19 May 1978. We visited every study plot early each morning, collected specimens and placed them in plastic bags on ice, and rebaited or re-set each trap as necessary. We relied on our extensive familiarity with the taxa encountered (Bleich 1973, 1977) and identified all but 13 individual specimens to species; these were submitted to the Bird and Mammal Museum, California State University Long Beach (unpubl. report, 27 August 1978), where experts used morphological and cranial attributes to identify those individuals (David G. Huckaby, unpubl. report, 11 September 1978; David R. Bontrager, unpubl. report, 24 August 1979). Several taxonomic or nomenclatural changes have occurred since the field work was completed (Bradley et al. 2014; Blood 2021), but we have retained the common and scientific names in use during our research and shortly thereafter

(Jones et al. 1973, 1975, 1979) because much of the literature cited herein relied on the earlier nomenclature. We have summarized systematic or nomenclatural revisions that have occurred since 1978 (Appendix).

We expressed relative abundance of the various species as captures/100 trap-nights. We calculated Simpson's (1949) Diversity Index (D) as a measure of rodent species diversity for each habitat type, where D ranges from 0 to 1, but increases as species diversity declines (Simpson 1949) and, as a result, is counter intuitive. Thus, we present the Gini-Simpson Index of Diversity (1-D), which also ranges from 0 to 1 but has a positive relationship with species diversity (Guiasu and Guiasu 2010). We also used that metric to index rodent species diversity among the six vegetation types. Calculation of the Simpson Index (and the Gini-Simpson Index) is not dependent solely on the number of species detected but, instead, is an overall index to species diversity and incorporates both the number of species present and the relative abundance of each (Simpson 1949).

## RESULTS

We captured 248 specimens representing 10 species in 2,859 trap-nights for an overall capture rate of 8.67

animals/100 trap-nights, including two mice (*Peromyscus* sp.) that could not be identified because they had been partially consumed (Table 1). We captured Deer Mice (*Peromyscus maniculatus*) in all six vegetation types, and Western Harvest Mice (*Reithrodontomys megalotis*) and Agile Kangaroo Rats (*Dipodomys agilis*) in five and four of the habitats, respectively. The California Vole (*Microtus californicus*), California Mouse (*P. californicus*), Brush Mouse (*P. boylii*), Pinyon Mouse (*P. truei*), Desert Woodrat (*Neotoma lepida*), Dusky-footed Woodrat (*N. fuscipes*) and California Pocket Mouse (*Perognathus californicus*) were less abundant and far more restricted in distribution (Table 1). We captured all 10 species of rodents in the Interior Live Oak vegetation type, but we only caught Deer Mice, Western Harvest Mice, and Agile Kangaroo Rats in the Graminoid vegetation type. The Gini-Simpson Index of Diversity was greatest for rodents in the Black Oak and Interior Live Oak vegetation types; slightly lower but similar to each other in the Chamise-Manzanita, Graminoid, and Riparian vegetation types; and lowest in the Coast Live Oak vegetation type (Table 2).

## DISCUSSION

Our purpose here was to memorialize descriptions of the rodent communities following a severe conflagration and is based on an intensive trapping effort at a specific place and time following that event; in addition, we ensure the locations of those efforts are available to future investigators. Although there has been some historical interest in the composition of rodent communities in cismontane Southern California, much of the early work centered on biotic surveys of specific mountain ranges (Grinnell 1908; Grinnell and Swarth 1913; Pequegnat 1951; Vaughan 1954; Kolb and White 1974) or nearby geographic areas (Bleich 1973; Bontrager 1973; Quinn 1979, 1983; Wirtz 1982). More recent efforts have, however, concentrated on changes in rodent communities shortly after fires in vegetation types subject to periodic conflagrations, and particularly in chaparral (Quinn 1979; Wirtz 1982; Price and Wasser 1984; Schwilk and Keeley 1998; Borchert et al. 2014).

It has become clear that the effects of fire on small mammals vary spatially, temporally, with habitat type, and by species (Brehme et al. 2011; Bond 2015), but those effects generally are of short duration. Moreover, few study plots have been described adequately to ensure they can be located by future investigators (Pequegnat 1951; Bleich 1973; Kolb and White 1974; Quinn 1979, 1983), but references to permanent grids occasionally appear in the literature (Price and Wasser 1984). Information presented herein adds to this list of true permanent study sites, which will become of increasing interest in view of upward-trending ambient temperatures and their anticipated long-term effects in Southern California (Dong et al. 2019).

**TABLE 2.** Location (quarter section, section, township, and range, San Bernardino Base and Meridian) and elevation (Elev.) of study plots; trapping effort (total number of trap nights); number of rodent species (n) caught per vegetation type; and rodent species diversity (SpD; expressed as the Gini-Simpson Index of Diversity [1-D] and also known as Simpson's Index of Diversity or the Dominance Index) for six vegetation types in the Soboba Management Area, San Bernardino National Forest, San Jacinto Mountains, Riverside County, California. The Chamise-Manzanita Vegetation Type includes the Chamise or Manzanita Series of Paysen et al. (1980) and the Chamise-Manzanita Association of Berg (1980). The Graminoid Vegetation Type was dominated by a variety of annual grass species, but a specific series was not identified by Paysen et al. (1980). The Riparian, Black Oak, Interior Live Oak, and Coast Live Oak vegetation types were defined by Paysen et al. (1980).

Vegetation Type	Location of Study Plot	Elev. (m)	Trap-Nights	n	SpD
Chamise-Manzanita	SE¼, 13, 4S, 1E	1,095	540	7	0.68
Interior Live Oak	NW¼, 7, 4S, 2E	1,527	630	10	0.79
Graminoid	NW¼, 12, 4S, 1E	1,290	630	3	0.63
Riparian	SE¼ 24, 4S, 1E	932	315	5	0.63
Black Oak	SW¼, 6, 4S, 2E	1,510	114	4	0.81
Coast Live Oak	SW¼, 13, 4S, 1E	1,097	630	5	0.47

The trending shift away from natural history as an academic discipline, increasing fascination with, and reliance on, technology (Bleich 2018), and the tendency of what is considered old data to be of little interest to contemporary investigators all contribute toward the ubiquity of what has been described as generational amnesia (Robert Fisher. 2021. *The Memory Loss that Harms the Planet*. British Broadcasting Corporation, London, UK. Available from <https://www.bbc.com/future/columns/wise-words> [Accessed 31 December 2021]). As a result, well-documented historical data are becoming increasingly meaningful and more important to future investigators (Bleich et al., in press). Fortunately, there is renewed enthusiasm for the important role that natural history has played, currently plays, and will play in the future in terms of its relevance to ecological science (Tewksbury et al. 2014; Barrows et al. 2016; Callaghan et al. 2017; McKeon et al. 2020).

The portending increase in global temperature and its effect on ecosystem structure or function further enhances the value of the information presented here. Thus, the relative abundance and species diversity of these small mammals, at a specific time and at permanent locations memorialized in the formal literature, have the potential to serve as baselines regarding alteration of habitat, whether the result of a warming climate or of anthropogenic manipulation (Hope et al. 2017; Caro et al. 2021). Given these changing times, interest in those data and location information will increase, because it complements other, albeit less-detailed, data from a region of Southern California that long has been at the forefront

of interest in mammalian biogeography (Grinnell and Swarth 1913). Indeed, our study area was proximate to the San Gorgonio Pass of Riverside County, an area that has been of substantial interest to recent investigators (Best et al. 1986; Sullivan and Best 1997; Erickson and Patten 1999; Patton et al. 2014). Had a greater number of earlier investigators provided information of the type included here many additional specific locations at which to assess changes rodent community composition would be available in the literature.

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## APPENDIX

Several systematic or taxonomic revisions have occurred since completion of the survey of small mammals occupying the Soboba Management Area, Riverside County, California, in 1978. These changes are noted here to ensure readers are aware that specimens collected during our research have been subjected to systematic or taxonomic review, and that identifications of specimens obtained during our research should be reviewed and confirmed. Common and scientific names of these species that were in use during our research precede each discussion.

Desert Woodrat (*Neotoma lepida*). The *Neotoma lepida* group of woodrats was revised by Patton et al. (2007). We have retained the nomenclature existing at the time of our survey, but specimens obtained during our investigation may represent either, or both, of the two species, *N. lepida*, and Bryant's Woodrat, *N. bryanti*, as currently recognized and occur in the vicinity of San Geronio Pass (Patton et al. 2007).

Dusky-footed Woodrat (*Neotoma fuscipes*). The *Neotoma fuscipes* species complex was revised by Matocq (2002). In this paper, we retained the nomenclature existing at the time of our survey, but what we refer to in the text as *N. fuscipes* now is recognized as *Neotoma macrotis*, the Big-eared Woodrat. The Dusky-footed Woodrat, *N. fuscipes*, occurs north of the range of *N. macrotis* as currently understood.

Agile Kangaroo Rat (*Dipodomys agilis*). In this paper, we have retained the nomenclature existing at the time of our survey, but the species *Dipodomys agilis* has been revised and split into two separate species, *D. agilis* and *D. simulans* (Sullivan and Best 1997), the latter being referred to as the Dulzura Kangaroo Rat (Bradley et al. 2014). Similar to specimens that we identified as *Neotoma lepida*, specimens of kangaroo rats collected during our investigation and identified at the time as *D. agilis* may represent *D. agilis*, *D. simulans*, or both species.

California Pocket Mouse (*Perognathus californicus*). In this paper, we have retained the nomenclature existing at the time of our survey. Since then, the subgenus *Chaetodipus* has been elevated to full generic status, and this species now is recognized as *Chaetodipus californicus* (Hafner and Hafner 1983; Bradley et al. 2014).



**VERNON C. BLEICH** was employed by the California Department of Fish and Game (CDFG) for 34 y, during which time he worked extensively with large mammals occupying the Great Basin, Mojave, and Sonoran deserts of California. He received B.S. and M.A. degrees from California State University Long Beach, and a Ph.D. from the University of Alaska Fairbanks. He currently is Research Professor at the University of Nevada Reno, and remains actively involved in conservation and research activities. He currently serves on the Advisory Board of the Texas Bighorn Society and is the Science Advisor for the Society for the Conservation of Bighorn Sheep, is a member of the Professional Resource Advisory Board of the Wild Sheep Foundation, and recently completed a 3-y appointment to the Wild Horse and Burro Advisory Board of the Bureau of Land Management, on which he represented wildlife conservation issues. In 2023, Vern received the Aldo Leopold Award from the American Society of Mammalogists in recognition of his lasting contributions to the conservation of mammals and their habitats. (Photographed by 'Stasia Mitzel).



**BONNAR BLONG** was employed by the California Department of Fish and Game (CDFG) for 34 y, during which he became well known as an advocate for conservation, particularly with respect to Mule Deer (*Odocoileus hemionus*) occupying the chaparral-dominated mountains of southern California and the Desert Bighorn Sheep (*Ovis canadensis nelsoni*) inhabiting the Santa Rosa Mountains and other Sonoran Desert areas. Bonnar was a veteran of World War II, during which time he served in the U.S. Marine Corps. Following an honorable discharge from military service, he completed his education at Washington State University, Pullman, before joining CDFG. Among his earliest assignments was an investigation of food habits of Mule Deer in Santa Barbara County, California, following which he became the Biologist for the San Jacinto Wildlife Management Unit of CDFG, and rose to the rank of Field Supervisor prior to retirement. (Photograph courtesy of The Riverside Press-Enterprise).