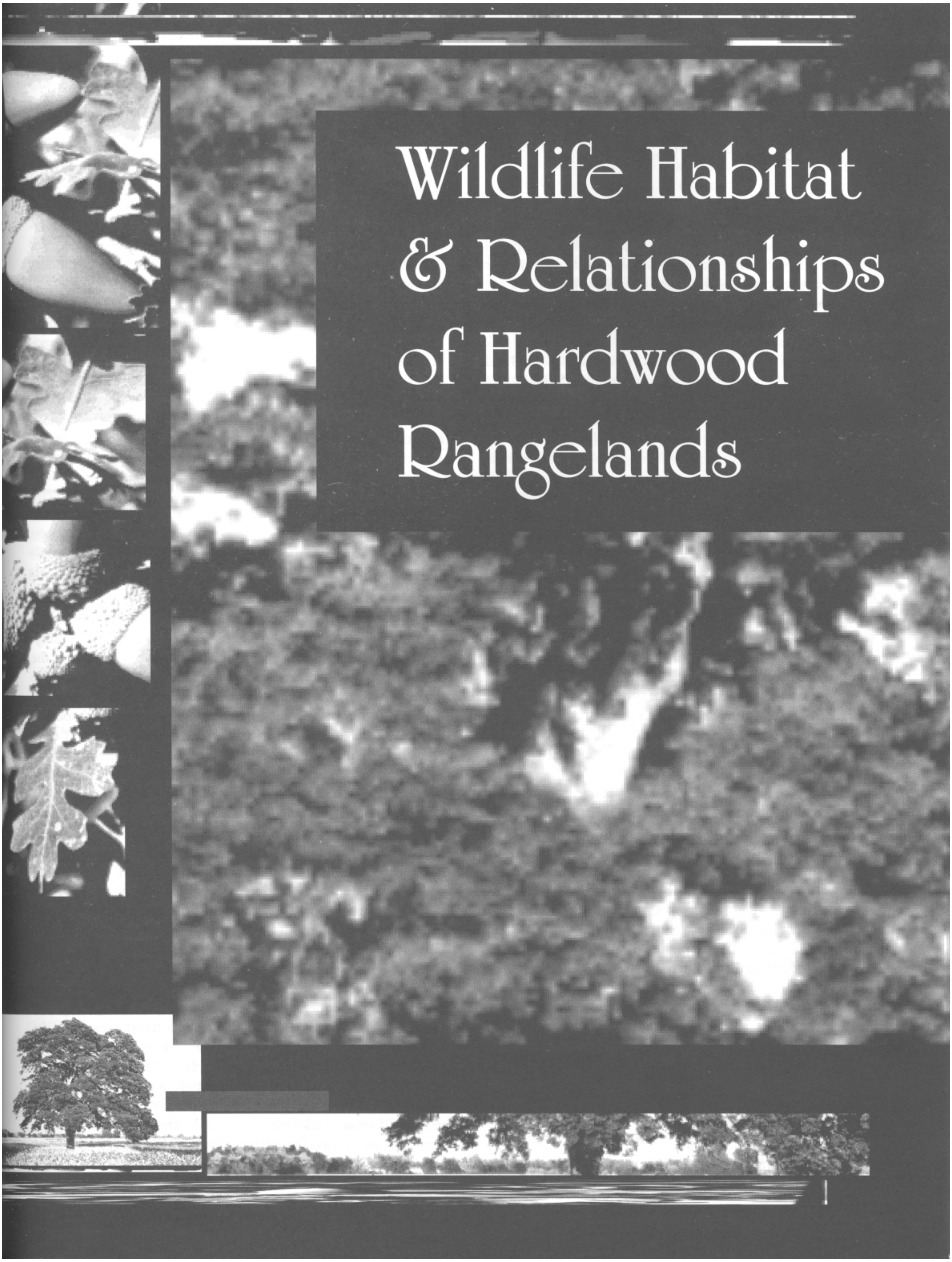
Wildlife Habitat & Relationships of Hardwood Rangelands



Influence of Scale on the Management of Wildlife in California Oak Woodlands[1]

William M. Block Michael L. Morrison[2]

Abstract: Distributions, abundances, and patterns of resource use of amphibians, reptiles, birds, and small mammals varied spatially and temporally in California oak woodlands. Spatial variations occurred within stands, between stands of a similar type (e.g., canyon live oak [*Quercus chrysolepis*], blue oak [*Q. douglasii*], or valley oak [*Q. lobata*]), between stand types, and between geographic areas. Temporal variations occurred between seasons and years. Management of wildlife in oak woodlands should be based on research that details seasonal and temporal variations in habitat and resource use. Species that exhibit pronounced geographic variations in habitat use will require different management strategies, depending on location. Providing favorable conditions for breeding will not ensure that requirements for species occurring during nonbreeding periods will be met as well.

California oak woodlands extend from the northern to the southern boundaries of the state and encompass over 2.5 million hectares. Within this area exists a number of vegetation types distinguished by differences in the composition and structure of the woody vegetation (Allen 1990). This vegetative diversity provides a wide spectrum of conditions suitable for occupancy by many species of wildlife (Block and Morrison 1990, Block and others 1990). Actual occupancy of suitable habitat is further influenced by historic distributional patterns and modified by various biotic (e.g., food abundance and availability, density of the species, competition, predation) and abiotic (e.g., weather, fire, anthropogenic) processes.

Occupancy and specific resource-use patterns of wildlife are not static through time and space (Block 1989, Block and others 1988). With birds, for example, some species occur in a location throughout the year, whereas other species may be present only during breeding, winter, or migration. Resource-use patterns of many amphibians, reptiles, birds, and mammals shift within and between seasons (Block and Morrison 1990, Block and others 1988). These shifts may be responses to changing needs during different phases of species' life histories or responses to shifts in the quantity and quality of the resource base.

Knowledge of spatial and temporal variations in habitat use is needed to elucidate variations in populations, habitat associations, and community structure and to provide a basis for predicting effects of environmental perturbations on individual species and entire assemblages of species.

This paper examines spatial and temporal relationships of wildlife in oak woodlands. We draw upon three years of field data collected on population numbers and macrohabitat associations of amphibians, reptiles, birds, and small mammals from four study areas, three primary and one ancillary, representing a diversity of oak-woodland ecosystems. Our objectives are to categorize species according to general macrohabitat associations and to determine the spatial patterns in species distributions.

STUDY AREAS

The three primary study areas were: (1) San Joaquin Experimental Range, Madera County; (2) Sierra Foothill Range Field Station, Yuba County; and (3) Tejon Ranch, Kern County. Both San Joaquin and Sierra Foothill are in the foothills of the Sierra Nevada with Sierra Foothill lying northeast of Marysville and San Joaquin north of Fresno. Tejon Ranch is located in the Tehachapi Mountains east of the town of Lebec. The topography, and structure and composition of the vegetation of each study area differs from the others. San Joaquin is characterized by a relatively flat terrain with rolling hills on a general southwest-facing slope. The overstory is dominated by blue oak, interior live oak (*Q. wislizenii*), and gray pine (*Pinus sabiniana*) with buckbrush (*Ceanothus cuneatus),* chaparral whitethorn (*C. leucodermis*), redberry (*Rhamnus crocea*), coffeeberry (*R. californicus*), and poison oak (*Toxicodendron diversiloba*) comprising the woody understory. Annual grasses and forbs dominate the herbaceous layer. Topography is steeper at Sierra Foothill with moderate slopes facing in a general westerly direction. Dominant overstory trees include blue oak, interior live oak, gray pine, California black oak (*Q. kelloggii*), valley oak, and ponderosa pine (*P. ponderosa*). Major shrubs are buckbrush, coffeeberry, toyon (*Heteromeles arbutifolia*), and poison oak; annual and perennial grasses and forbs comprise the herbaceous layer. Terrain at Tejon Ranch is more mountainous than at Sierra Foothill or San Joaquin, consisting of steep slopes facing in all cardinal directions. This topography contributed to a more diverse flora as blue oak, interior live oak, canyon live oak, California black oak, valley oak, and Brewer's oak (*Q. garryana* var. *breweri*) contributed to the overstory. The woody

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[2]Research Wildlife Biologist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Tempe, Ariz.; and Associate Professor, Department of Forestry and Resource Management, University of California, Berkeley. Previous address of WMB: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Fresno, CA.

understory consisted of buckbrush, redberry, chamise (*Adenostoma fasciculatum*), big-berry manzanita (*Arctostaphylos glauca),* and mountain mahogany (*Cercocarpus betuloides*). Annual and perennial grasses and forbs comprised the herbaceous understory. More detailed descriptions of the study areas are given by Block (1989).

We also report additional data collected from a fourth site, Mad River, located in southern Humboldt County near the town of Dinsmore. Vegetation pattern was a mosaic consisting of stands of California black oak and Oregon white oak (*Quercus garryana*) interspersed among Douglas-fir (*Pseudotsuga menziesii*) forests.

METHODS

Sampling intensity for amphibians, reptiles, and small mammals described below was greater at Tejon Ranch than at San Joaquin or Sierra Foothill. Because San Joaquin and Sierra Foothill were relatively small in total area (1,800-2,200 ha), we were limited in the placement of spatially-independent sampling grids and surveys. In contrast, oak woodlands covered about 40,000 ha at Tejon Ranch, consequently we had a greater area to place more grids and conduct more surveys. Moreover, stands of major oak species at Tejon Ranch were often monotypic providing an opportunity to test for differences among these distinct stand types.

Time-constraint searches (Welsh 1987) were done at all four study areas to locate amphibians and reptiles during spring and fall. This method entailed searching randomly for animals under, on, or in logs, rocks, leaf litter, trees, and bare ground for 4-person hours. The amount of area covered during each search varied, depending on the abundance of suitable substrates. Once an animal was located, time was halted temporarily while the animal was identified and measured, and general characteristics of the macrohabitat were recorded. We conducted 28 time-constraint searches at Tejon Ranch, nine at Sierra Foothill, and seven each at Mad River and San Joaquin. Searches at Tejon Ranch were done within five distinct stand types: blue oak (four searches), valley oak (7), canyon live oak (7), interior live oak (5), and California black oak (5). Searches at the other study areas were done in a variety of stand types representative of the variations in vegetation that occurred there. Because the number of searches within all study areas but Tejon Ranch was relatively small (seven to nine), we did not separate stand types for statistical analyses. Searches conducted within these areas were pooled to provide a general description of the herpetofauna present. We first compared captures among stand types at Tejon Ranch to determine if species were closely associated with a specific vegetation type. We then pooled all searches from Tejon Ranch and compared captures among study areas. We compared capture frequencies among stand types at Tejon Ranch and among the four study areas using *G*-tests (Sokal and Rohlf 1969; p. 559).

Amphibians, reptiles, and small mammal populations were also sampled using pitfall traps. These traps consisted of 3.8-liter buckets that were sunk to ground level and covered with a square piece of plywood elevated 5-10 cm above the lip of the bucket (Block and others [1988] provide a more detailed discussion of the methods). Traps were in 6 x 6 grids with 20-meter spacing between buckets. We placed 13 grids at Tejon Ranch, and four each at Sierra Foothill and San Joaquin for a total of 740 traps. Traps were monitored at Tejon Ranch from 4 January to 20 May 1987, 10 December 1987 to 20 June 1988, and 10 November 1988 to 30 April 1989; traps were monitored at Sierra Foothill and San Joaquin from mid-January to mid-March 1988, and from 10 November 1988 to 15 January 1989. The total trapping effort included 98,592 trap days and nights. Traps were checked periodically for captured animals. Captures were identified and removed from the trapping grid. We used *G*-tests to compare frequencies of captures among study areas. To determine plant associations of individual species and of each major taxon (amphibian, reptile, and small mammal), we estimated cover by woody vegetation within each grid using the point-intercept method (Heady and others 1959) centered at each trapping station. We placed a 10-meter long intercept along a random bearing with 1-meter spacings between points. Percent cover by each major tree species (blue oak, interior live oak, canyon live oak, California black oak, valley oak, and gray pine) was calculated as the percentage of the points (360 per grid) covered by that species. We calculated product-moment correlations (Sokal and Rohlf 1969; p. 498-508) to measure associations of different species of amphibians, reptile, and small mammals and for each major taxon (amphibian, reptile, small mammal) to these tree species.

We also used Sherman live traps to sample small mammal populations. Traps were in 8 x 8 grids with 15-meter spacings between traps. Twelve grids were placed at Tejon Ranch and four each at San Joaquin and Sierra Foothill. We trapped small mammals at Tejon Ranch from July through December 1986; March, April, November, and December 1987; November and December 1988; and January through March 1989. Trapping was done at Sierra Foothill during April 1987, March 1988, and December 1988 and at San Joaquin during April 1987, December 1988, and from October 1989 through April 1990. Total trapping effort was 21,392 trap nights. Captures were identified, aged, measured, marked by toe clipping, and released. We measured vegetation using the same point-intercept method used in pitfall grids except that 640 points (10 points at 64 stations) were sampled within each grid. Analytic methods for live-trap data followed those described for pitfall traps.

Bird populations were sampled using a point-count procedure (Verner 1985). This method entailed an observer recording all birds detected by sight or sound within a 100-meter radius of the counting station. We sampled birds at 100 counting stations at each of the three study areas. More detailed descriptions of the methods for the establishment of stations and of the actual counting procedures are described in detail by Block (1989). Each point was sampled three times during each breeding season and five times during each nonbreeding season. We counted birds at Tejon Ranch during the 1986, 1987, and 1988 breeding seasons and the 1986-87 and 1987-88 nonbreeding seasons. Counts were done at Sierra Foothill and San Joaquin during the 1987 and 1988 breeding and the 1987-88 nonbreeding seasons. A total of 4040 point counts were conducted over the duration of the study. To compare the rankings of total counts (i.e., numbers of detections) of species between study areas, years, and seasons, we calculated Spearman rank-correlation coefficients (Marascuilo and McSweeny 1977; p. 431-439). We restricted the species used in the analyses to those for which >100 total detections across all study areas were recorded. We so restricted our analyses because including uncommon and incidental species would have increased sample sizes and rendered the chance of observing significant correlations an artifact of sample size alone.

We also collected data pertaining to tree-species use by common species of birds found at each study area. We limited this analysis to common species to ensure adequate samples for statistical analysis (cf. Block and others 1987, Morrison 1988). We used log-linear analyses (Fienberg 1980; p. 13) to compare the frequency of use of major tree species by these birds among study areas, seasons, and years. Analyses done on birds present only during breeding or winter examined effects of study area, year, and their interaction.

RESULTS

Time-constraint Surveys

We located 428 individuals representing 17 species of herpetofauna during time-constraint searches including three salamanders, one frog, seven lizards, and six snakes (table 1). Significantly more salamanders were captured at Tejon Ranch (102) than at all of the other areas combined (21). These salamanders at Tejon Ranch occurred in association with canyon live oak, valley oak, and California black oak. Few salamanders were caught in association with blue oak or interior live oak at Tejon Ranch. Western fence lizards were the most frequently captured lizard at all study areas (table 1). Gilbert's skinks were captured frequently at Tejon Ranch and Sierra Foothill, whereas western skinks were captured at Sierra Foothill and Mad River (table 1). Southern alligator lizards were captured frequently at Sierra Foothill, whereas northern alligator lizards were common at Mad River. We found southern alligator lizards at Tejon Ranch, but caught none at San Joaquin even though they were observed at the field station during other times. Few snakes of any species were captured (table 1). Failure to capture snakes was a reflection of the inadequacy of this method to sample their populations.

Pitfall Traps

We captured 1,363 individuals representing 27 species during pitfall trapping including three salamanders, one newt, two frogs, two toads, seven lizards, one snake, and 11 small mammals (table 2). Western fence lizards, Gilbert's skinks, brush mice, deer mice, and pinyon mice were the most frequently captured animals accounting for about 73 percent of all captures. Relative frequencies of species captured differed significantly among grids within each study area (G-tests, $P < 0.01$). Relative frequencies of captures also differed significantly among the three study areas (G-test, $P < 0.01$). Amphibians were most closely associated with canyon live oak ($r = 0.67$, $P < 0.01$) and captures of mammals were significantly correlated with valley oaks (r=0.67, P<0.01). We found no significant associations of reptiles with stand type or species of tree. Black-bellied slender salamanders ($r = 0.66$) and yellow-blotched ensatinas (*Ensatina eschscholtzii croceater)* ($r = 0.69$) were both positively associated ($P < 0.01$) with canyon live oak. The California slender salamander (r=0.72) was positively associated ($P < 0.01$) with gray pine. Western fence lizards ($r = 0.69$) and western skinks (r= 0.59) were both positively associated (P<0.01) with blue oak. Brush mice ($r = 0.56$) and deer mice ($r = 0.82$) were positively associated ($P < 0.01$) with valley oak, and brush mice ($r = 0.59$) also showed a positive association ($P < 0.01$) to California black oak. The western harvest mouse was positively associated ($P < 0.01$) with blue oak. No other species was significantly associated or disassociated with tree species.

Live Traps

Live trapping resulted in 1,412 captures of 728 individuals representing 11 species of small mammals. Brush, pinyon, and deer mice, accounted for about 82 percent of all captures (table 3). Relative frequencies of captures differed among grids within and among study areas. Only two species were positively associated with a plant species: deer mice which were found in greater numbers in valley oak stands ($r = 0.74$, $P < 0.01$), and California pocket mice which appeared closely associated with gray pine ($r = 0.74$, $P < 0.01$). No other species exhibited a significant association ($P < 0.05$) with stand type.

Birds

Bird counts resulted in 33,798 detections of 124 species. Three general trends emerged from comparisons of rankings of species by numbers of detections (table 4). First, rankings were significantly correlated ($P < 0.05$) for 16 of 21 breeding season comparisons. The exceptions to this trend were for uncorrelated rankings of birds between Tejon Ranch and Sierra Foothill (table 4). Second, rankings of species were significantly correlated for all nonbreeding comparisons. Third, there was a general lack of concordance in rankings of bird species between seasons as no r_s was >0.41. The only significant correlations were between breeding birds at San Joaquin and nonbreeding birds at Tejon

Table 1—***Captures of amphibians and reptiles during time-constraint searches at four oak-woodland study areas in California from 1987 through 1990***

	Study area				
Species	Tejon Ranch	San Joaquin	Sierra Foothill	Mad River	Total
Amphibians					
Ensatina (*Ensatina eschscholtzii*)	76			6	82
Black-bellied slender salamander (*Batrachoseps nigriventris*)	26				26
California slender salamander (*Batrachoseps attenuatus*)		3	12		15
Pacific treefrog (*Hyla regilla*)			3	2	5
SUBTOTAL					128
Reptiles-lizards					
Side-blotched lizard (*Uta stansburiana*)		1			1
Western fence lizard (*Sceloporus occidentalis*)	49	30	49	57	185
Gilbert's skink (*Eumeces gilberti*)	25	16			41
Western skink (*Eumeces skiltonianus*)			7	11	18
Southern alligator lizard (*Elgaria multicarinata*)	5		22		27
Northern alligator lizard (*Elgaria coerulea*)				15	15
Legless lizard (*Anniella pulchra*)	3				3
SUBTOTAL					290
Reptiles-snakes			1	1	2
Racer (*Coluber constrictor*)					
California whipsnake (*Masticophis lateralis*)			1		1
Ringneck snake (*Diadophis punctatus*)			1	1	2
Gopher snake (*Pituophis melanoleucus*)	1	1		1	3
Sharp-tailed snake (*Contia tenuis*)				1	1
Western rattlesnake (*Crotalus viridis*)			1		1
SUBTOTAL					10
TOTAL	185	51	97	95	428
Number of searches	28	7	9	7	51
Number of search hours	112	28	36	28	204

Table 2—***Captures of amphibians, reptiles, and small mammals in pitfall traps at three oak-woodland study areas in California from 1987 through 1990***

Species	Study area: Tejon Ranch	San Joaquin	Sierra Foothill	Total
Amphibians				
California newt (*Taricha torosa*)		1		1
Ensatina	105			105
Black-bellied slender salamander	40			40
California salamander		13	2	15
Western spadefoot (*Scaphiopus hammondii*)		3		3
Western toad (*Bufo boreas*)	1	1		2
Foothill yellow-legged frog (*Rana boylii*)	1			1
Pacific treefrog	2			2
SUBTOTAL				169
Reptiles-lizards				
Side-blotched lizard		1		1
Western fence lizard	174	46	122	342
Gilbert's skink	117	56		173
Western skink			18	18
Southern alligator lizard	5		10	15
Legless lizard	1			1
Western whiptail (*Cnemidophorus tigris*)		46		46
SUBTOTAL				596
Reptiles-snakes				
Ringneck snake	1			1
Small mammals				
Ornate shrew (*Sores ornatus*)	30	2	8	40
Broad-footed mole (*Scapanus latimanus*)	1			1
California pocket mouse (*Perognathus californicus*)	11			11
San Joaquin pocket mouse (*Perognathus inornatus*)		1		1
Botta's pocket gopher (*Thomomys bottae*)	23	8	1	32
Western harvest mouse (*Reithrodontomys megalotis*)	7		9	16
Brush mouse (*Peromyscus boylei*)	234	13	16	263
Pinyon mouse (*Peromyscus truei*)	59	18	14	91
Deer mouse (*Peromyscus maniculatus*)	107	10	4	121
California mouse (*Peromyscus californicus*)	1			1
California vole (*Microtus californicus*)	12		9	21
SUBTOTAL				598
Total captures	931	219	213	1363
Total trapnights	65,850	17,280	15,462	98,592

Table 3—*Captures of small mammals in live traps at three oak-woodland study areas in California from 1987 through 1990. First number presented is the number of individuals; second number is total number of captures including recaptures*

Species	Study area			
	Tejon Ranch	San Joaquin	Sierra Foothill	Total
Ornate shrew			1/1	1/1
Beechey ground squirrel (*Spemophilos beecheyi*)		10/10		10/10
Merriam chipmunk (*Eutamias merriami*)		2/2		2/2
California pocket mouse	11/22	14/28		25/50
Heermann kangaroo rat (*Dipodomys heermanni*)	3/5	1/5		4/10
Brush mouse	118/242	97/195	66/127	281/564
Pinyon mouse	119/229	166/268	27/47	312/544
Deer mouse	58/161	8/21	7/11	73/193
California mouse	2/2			2/2
California vole	1/1	1/1		2/2
Dusky-footed woodrat (*Neotoma fuscipes*)	4/8	8/21	2/5	14/34
Total captures	318/670	307/551	103/191	728/1412
Trapnights	8,996	8,758	3,638	21,392

Table 4—*Spearman rank-order correlations comparing rankings of total counts of common birds found at three California oak woodlands—Tejon Ranch (TR), Kern County; San Joaquin Experimental Range (SJER), Madera County; and Sierra Foothill Range Field Station (SFRFS), Yuba County—between years (1986,1987,1988), seasons (B =breeding; N=nonbreeding), and study areas. For example, TRB86 vs. SJER/B87 compares 1986 breeding at TR with 1987 breeding at SJER*

	TR/ B86	TR/ B87	SJER/ B87	SFRFS/ B87	TR/ B88	SJER/ B88	SFRFS/ B88	TR/ N87	TR/ N88	SJER/ N88
TRB87	0.88 **[1]									
SJERB87	0.65 **	0.64 **								
SFRFS/B87	0.27	0.29	0.54 **							
TRB88	0.89 **	0.94 **	0.69 **	0.28						
SJERB88	0.61 **	0.54 **	0.90 **	0.52 **	0.64 **					
SFRFS/B88	0.34 *	0.26	0.53 **	0.90 **	0.25	0.57 **				
TR/N87	0.12	0.27	0.37	-0.01	0.28 *	0.29	-0.06			
TR/N88	0.13	0.28	0.33 *	0.01	0.29	0.30 *	-0.02	0.91 **		
SJER/N88	0.06	0.13	0.41 **	0.10	0.16	0.35 *	0.09	0.74 **	0.79 **	
SFRFS/N88	0.04	0.02	0.21	0.22	0.04	0.20	0.24	0.42 *	0.48 **	0.53 **

[1] * r_s significant at $P < 0.05$ (n=44); ** r_s significant at $P < 0.01$ (n=44).

Table 5—***Summary from log-linear analyses of use of tree species by breeding and nonbreeding birds found in three California oak woodlands-Tejon Ranch, Kern County; San Joaquin Experimental Range, Madera County; and Sierra Foothill Range Field Station, Yuba County-from 1986 to 1988***

Species	Area	Year	Season	Area x Year	Area x Season	Year x Season	Area x Year x Season
Resident birds							
Acorn woodpeckers (*Melanerpes formicivorus*)	212.1 **[1]	8.6	9.1	1.4	5.1	4.8	0.0
Nuttall's woodpecker (*Picoides nuttalli*)	186.4 **	8.4	18.6 *	14.6	1.4	5.1	7.3
Scrub jay (*Aphelocoma coerulescens*)	124.2 **	21.2 **	11.7	6.6	6.4	8.5	1.8
Plain titmouse (*Parus inornatus*)	280.4 **	16.4 *	33.3 **	21.1	12.2	7.6	7.2
Bushtit (*Psaltriparus minimus*)	10.8 **	28.4 **	27.4	2.0	3.0	9.6	1.3
White-breasted nuthatch (*Sitta carolinensis*)	314.1 **	4.1	8.8	13.7	7.0	8.6	1.1
Bewick's Wren (*Thryomanes bewickii*)	37.0 **	12.0	12.3	5.5	5.2	6.4	7.5
Western bluebird (*Sialia mexicana*)	125.9 **	9.2	20.6 **	13.6	3.7	10.7	1.4
California towhee (*Pipilo fuscus*)	99.5 **	11.7	14.3	1.9	5.6	9.6	5.5
Hutton's vireo (*Vireo huttoni*)	—	14.9	7.8	—	—	7.6	—
Lesser goldfinch (*Carduelis psaltria*)	—	14.7	30.4 **	—	—	1.4	—
Wintering birds							
Ruby-crowned kinglet (*Regulus calendula*)	98.4 **	46.4 **	—	12.3	—	—	—
Yellow-rumped warbler (*Dendroica coronata*)	110.4 **	17.4 *	—	1.2	—	—	—
Rufous-sided towhee (*Pipilo erythrophthalmus*)	45.9 **	15.6 *	—	12.4	—	—	—
Dark-eyed junco (*Junco hyemalis*)	162.6 **	3.6	—	20.3	—	—	—
White-crowned sparrow (*Zonotrichia leucophrys*)	—	3.3	—	—	—	—	—
Golden-crowned sparrow (*Zonotrichia atricapilla*)	46.7 **	1.4	—	8.5	—	—	—
Breeding birds							
Western kingbird (*Tyrannus verticalis*)	26.0	6.9	—	3.7	—	—	—
Ash-throated flycatcher (*Myiarchus cinerascens*)	107.3 **	20.0	—	4.7	—	—	—
House wren (*Troglodytes aedon*)	105.2 **	7.7	—	5.3	—	—	—
Blue-gray gnatcatcher (*Polioptila caerulea*)	—	4.8	—	—	—	—	—
Orange-crowned warbler (*Vermivora celata*)	—	19.2	—	—	—	—	—
Wilson's warbler (*Wilsonia pusilla*)	—	11.8	—	—	—	—	—
Black-headed grosbeak (*Pheucticus melanocephalus*)	—	7.3	—	—	—	—	—
Northern oriole (*Icterus galbula*)	145.1 **	14.4	—	5.5	—	—	—

[1] * likelihood-ratio chi square significant at $P < 0.05$; ** likelihood ratio chi square significant at $P < 0.01$.

Ranch and San Joaquin, although the actual values of these correlations were relatively small; all rankings with Sierra Foothill birds were nonsignificant (table 4).

Spatial and temporal differences in tree-species use were attributable to main effects only (table 5). Of the birds occurring at more than 1 study area, all but the bushtit and western kingbird exhibited differences in tree-species use between or among study areas (table 5). Yearly differences in tree use were shown for the plain titmouse, scrub jay, bushtit, ash-throated flycatcher, ruby-crowned kinglet, rufous-sided towhee, and yellow-rumped warbler (table 5). Of the resident birds, the Nuttall's woodpecker, plain titmouse, western bluebird, bushtit, and lesser goldfinch showed seasonal differences in tree-species use (table 5). Detailed analyses of the specific trees used by each species at each study area and during each year and season are presented by Block (1989).

DISCUSSION

Distributions and habitat-use patterns of wildlife are not static in time or space and these phenomena are not peculiar to California oak woodlands. Variations in the types and relative abundances of wildlife are attributable to a number of factors. First, species have different historic distributional patterns as influenced by geologic events preceding human occupation of western North America (Landres and MacMahon 1983, Wright and Frey 1965). These patterns have been modified by humans and by continued changes in the natural environment during the Recent Epoch, resulting in an altered landscape. Local events resulting in both short- and long-term effects have further acted to influence the patterns that exist today.

We found that spatial variations occurred among (1) sampling points within a stand, (2) floristically- and structurally-similar stands, (3) different stand types, and (4) geographic locations. Differences within stands may have been attributed to local environmental conditions. For example, a fallen tree provides a large volume of downed dead woody debris, clearly an important habitat component for many amphibians and reptiles (Block and Morrison 1990, Welsh and Lind, in press). Even a slight change in slope or aspect can result in a measurably different microclimate and soil regime well-suited to a particular species of amphibian, reptile, or small mammal. Distributions of birds within a stand can depend on the presence of suitable nest sites or other special habitat components. For example, the presence of a suitable granary tree provides an activity center for a group of acorn woodpeckers (Koenig and Mumme 1987).

Our pitfall and livetrap data demonstrate some general relationships of taxa or species within a taxon to specific stand types. Salamanders were closely associated with canyon live oak. This oak generally occurs on mesic, north-facing slopes. The persistent humus layer created from its sclerophyllous leaves provides a favorable environment for these amphibians. Mammals, particularly deer mice, were closely associated with valley oak. The two most common reptiles in oak woodlands, western fence lizards and Gilbert's skinks, demonstrated an affinity for blue oak stands which often occur on xeric south-facing slopes. Thus, macrohabitat differences among stands provide conditions suitable for different species of wildlife.

Temporal variations in habitat use can occur with changing patterns of resource abundance and distribution or according to requirements unique to each period of a species' life history (e.g., breeding vs. wintering). Temporal variations in resource use occurred for all taxa we studied. For example, many salamanders are subterranean for a large portion of their annual cycle, surfacing only during the wet part of the year. Habitat use by small mammals often differs during dispersal of juveniles from the natal area from habitat-use patterns during other periods. Many species of birds are present only for a short period of the year such as the breeding season or during winter and migration. The general lack of concordance of avifaunas that we found between breeding and nonbreeding seasons demonstrates that different assemblages of species extract resources from oak woodlands during different times of the year. For example, many insectivorous birds are present during the spring when insect larvae are abundant and new insects are emerging. Seed-eating birds, such as sparrows and towhees, winter in oak woodlands to take advantage of the abundant seed crops. Birds that occur throughout the year often shift foraging patterns or habitats between seasons or years to take advantage of available resources. Such shifts may be differences in tree-species use or even more subtle changes in the use of foraging substrates. Nuttall's woodpeckers, for example, use blue oaks extensively during breeding and expand their use of trees to other species during nonbreeding. Western bluebirds take insects from the ground during most of the year, but eat berries from shrubs when ripe during the fall and winter (Block 1989).

The implications of our study demonstrate that management cannot be based on data restricted in time and space. Data representative of variations in distributions and resource use must provide the bases for management decisions. Failure to incorporate such variation will restrict management options. A worse-case scenario is that management based on a restricted data set not representative of the ecology of a species may ultimately be more detrimental than beneficial to the well-being of that species.

Thus, what is the appropriate scale of research and of management? Clearly, the answer to this question depends on the research and/or management objectives. Species-specific research must be scaled to the variations in the biology of the organism of interest. For example, a species ubiquitous to oak woodlands in California might require that study be conducted at various locations throughout the range of that organism. Further, research must also incorporate temporal variations in resource use, as many species use different resources or different habitats during different times of the year (Block and others 1988, Block 1989). Only by examining a species' population and ecological responses along gradients that encompass environmental variations typically found within the range of the species can effective management be developed. Species that exhibit pronounced ecological differences among areas will likely require different types of management depending on location. Species that exhibit very specific habitat requirements that vary little across their range may require only one set of management strategies. We have begun analyses using our data set to develop predictive habitat models for many of the common species found in oak woodlands. Models will be developed initially using data from one time and place, and then tested and refined using data from other times and places. We think that our model development will represent the first step in defining species-specific management strategies. Additional data will be needed to further test the models that we develop. Also, we must get adequate data for the species about which we lack enough information. We believe that this strategy of adaptive management will eventually provide the necessary information to permit effective management of wildlife in oak woodlands.

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