Relative Abundance and Habitat Associations of Vertebrates in Oak Woodlands in Coastal-Central California[1]

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Abstract: *We estimated relative abundance and assessed habitat associations of small mammals, birds, amphibians, and reptiles in oak (*Quercus *spp.) woodlands from 1993 to 1995 at Camp Roberts in California's central coast. Within taxa, relative abundance was highest for dusky-footed woodrats (*Neotoma fuscipes*) (9.7 percent trap success), plain titmice (*Parus inornatus*) (49.4 territories per 40 ha), slender salamanders (*Batrachoseps *spp.) (2.2 percent detection rate) and skinks (*Eumeces *spp.) (3.1 percent detection rate). Percent cover of shrubs, grass, and downed wood were the three strongest correlated habitat components (mean of the absolute value of all correlation coefficients [$|r_s|$] = 0.64, 0.62, and 0.59, respectively) for abundant species of small mammals. Percent shrub cover and litter weight were correlated with abundant birds, and herpetofauna, respectively (mean $|r_s|$ = 0.57 and 0.49, respectively). Within taxa, woodrats, dark-eyed juncos (*Junco hyemalis*), and slender salamanders exhibited the strongest habitat associations across all habitat components (mean $|r_s|$ = 0.74, 0.73, and 0.44, respectively). Dense oak woodlands with shrubby understory and downed woody material supported the greatest numbers of vertebrate fauna.*

Only limited information is available about the characteristics that make oak (*Quercus* spp.) woodland valuable wildlife habitat. Previous research has developed some fundamental information on wildlife-habitat relationships in oak woodlands (Block 1989; Block and Morrison 1987, 1990; Block and others 1988; Morrison and others 1991; Verner and Ritter 1985, 1988). This paper attempts to add to the existing body of information by summarizing 2.5 years of wildlife habitat-relationships data collected before conducting an experimental treatment to assess the effects of fire on oak woodland biodiversity. This study also identifies habitat components of particular importance to several common species of terrestrial vertebrates in blue oak woodlands of the California central coast, where wildlife-habitat relationships are little studied.

Landowners, land-use planners, and other land managers can use information from this study to develop management strategies for California's oak woodlands. In addition, the information generated may serve as input to the model validation needs of the California Wildlife Habitat Relationships (CWHR) System (Airola 1988), which frequently is used to predict the effects of environmental and anthropogenic perturbations on wildlife.

Study Area

Camp Roberts, a military facility of the California Army National Guard, is located in northern San Luis Obispo County 18 km north of Paso Robles, California. The northern portion of Camp Roberts is in Monterey County. The facility comprises 17,800 ha, of which approximately 7,200 ha are classified as oak woodland (Camp Roberts 1989). The dominant tree species in the overstory is blue oak (*Quercus douglasii*) with a variable contribution of coast live oak (*Q. agrifolia*). Where it occurs, understory is comprised of toyon (*Heteromeles*

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arbutifolia), redberry (*Rhamnus crocea*), bigberry manzanita (*Arctostaphylos glauca*), ceanothus (*Ceanothus* spp.), poison oak (*Toxicodendron diversilobum*), and, infrequently, chamise (*Adenostoma fasciculatum*). On the woodland floor, wild oats (*Avena* spp.), bromes (*Bromus* spp.), and fescues (*Festuca* spp.) predominate. Common forbs include deerweed (*Lotus scoparius*), filaree (*Erodium* spp), and hummingbird sage (*Salvia spathacea*).

Methods

Experimental Design

Using topographic maps and ground reconnaissance, we selected oak stands within the southern half of Camp Roberts where there is the least potential for interference with military activities and where most of the dense oak woodlands at Camp Roberts occur. To accommodate a treatment, we selected blue oak stands with varying contributions of coast live oak that were >16 ha in size and had an estimated canopy cover of >50 percent. Within these stands, we established nine, square 5.8-ha plots in the summer of 1993. We used a compass and meter tape to lay out a 17 × 17 sampling grid (289 intersections every 15 m in two directions).

Vegetation Sampling

Vegetation surveys were conducted in the spring and summer of 1995. Densities of living and dead trees were determined by the point-centered quarter method (Cottam and Curtis 1956). Distance (≤10 m) to the nearest living and dead trees ≥5.1 cm dbh (diameter at breast height [1.4 m above ground level]) and their species were recorded. On trees that bifurcated at or below breast height, the distance to the nearest stem ≥5.1 cm dbh was measured. We also recorded the number of saplings ≥1.4 m in height and <5.1 cm dbh that occurred within 5 m of the center point. Forty-five sapling and tree samples were taken per plot.

At alternate intersections on all plot grid lines (145 intersections per plot), percent cover of tree canopy, shrub foliage, ground vegetation, and downed woody material were derived from vertical interceptions ("hits") at six points spaced 1.7 m along each of the ropes (12 points per intersection × 145 intersections per plot × nine plots = 15,660 points); occurrence of downed wood >5.1 cm diameter was recorded when within 30 cm of points. We collected all herbaceous material within a 30-cm by 30-cm frame centered on one randomly selected point along one of the ropes. Litter (i.e., organic material lying on the ground before the previous season's production) was separated from the current season's production of herbaceous material, air dried, and weighed to the nearest 1 g.

Animal Sampling

Small Mammal Trapping

Small mammal trapping was conducted in the fall (3 October to 18 November) of 1993, the spring (8 May to 3 June) and fall (10 October to 11 November) of 1994, and the spring (9 May to 10 June) and fall (9 October to 10 November) of 1995 by placing a single Sherman live trap (trap size: 7.6 cm by 9.5 cm by 30.5 cm) at each of the 289 intersections on each plot. Traps were baited with a mixture of corn, oats, and barley laced with molasses and checked for 5 consecutive days. Captured animals were ear-tagged and released. Species, capture location, sex, age (juvenile or adult), and tag number were recorded. After the fall 1993 trapping bout, two study plots were shifted four lines (i.e., line E became line A), resulting in the loss of 680 trap-nights (17 traps per line × four lines × five nights × two plots). These 680 points were not used for summaries or analyses. Total trapping effort on the nine study plots was 64,345 trap nights (1,445 trap nights per bout × five trapping bouts per study plot × nine study plots - 680 trap nights).

Bird Census

Two or three field biologists, trained to identify birds by sight and sound, recorded pairs of breeding birds during 1994 (6 April to 4 May) and 1995 (27 March to 26 April) by spot mapping. To facilitate consistent sampling effort within each plot, we mapped territories along four evenly-spaced grid lines. The initial line and direction walked was alternated clockwise around the plot for each visit. Two to three plots per person were visited each day. The first visit began within 30 minutes of sunrise. We recorded the grid location and activity of each detected bird. Ten to 12 separate visits per plot were conducted each year. Following guidelines from Bibby and others (1992:58), we updated and interpreted individual species maps after each visit. Bird territories by species and plot were delineated each year after the field season.

Amphibian and Reptile Monitoring

In January and February 1994, we placed a single 1.3-cm by 61.0-cm by 61.0-cm plywood coverboard (Grant and others 1992) flush with the ground within 2 m of each intersection on alternate lines on each plot (136 coverboards per plot). Once weekly, during 24 January to 26 April 1995, we recorded species and number of amphibians and reptiles observed under the coverboards.

Data Analyses

We pooled habitat data and animal data by taxa within plots. Data were assessed for normality using Shapiro-Wilks tests (Conover 1980:363) and visual inspection of normal-probability plots and histograms in PROC UNIVARIATE of PC-SAS (SAS Institute Inc. 1988:627-628, Schlotzhauer and Littell 1987:117-119). Although all habitat variables and most response variables were normally distributed, nonparametric analyses were used because sample sizes were small (n = 9) after pooling. Consequently, we used Spearman rank correlation (r_s) (Zar 1984:318) in PROC CORR of PC-SAS (SAS Institute Inc., 1988:209-235) to assess habitat associations for the six most abundant (≥100 individuals captured per five bouts) small mammal species, four most abundant (≥10 territories occurring on ≥8 plots) bird species, and four most abundant (≥60 observations) amphibian and reptile species. To determine which habitat components were most important for each taxa, we averaged absolute values ($| \; |$) of correlation coefficients (therefore, mean $|r_s|$) for each habitat component across species within taxa). To determine the average strength of each species' habitat associations, we averaged absolute values of correlation coefficients for each species across habitat components. Differences were considered significant when $P \leq 0.05$. Power ($1 - \beta$) is reported for significant coefficients (Zar 1984:312).

Results

Habitat

Across all nine plots, density of live stems (including saplings) ranged from 130.4 to 461.1 stems per ha, and density of snags ranged from 9.4 to 35.7 per ha (*table 1*). Live tree canopy and shrub cover ranged from 40.2 to 70.1 and 0 to 35.4 percent of plots, respectively. Grass, forbs, downed wood, and unvegetated ground comprised 38.1 to 71.6 percent, 1.4 to 6.3 percent, 1.1 to 6.5 percent, and 8.4 to 14.8 percent of ground cover, respectively. Stem density, snag density, tree canopy cover, shrub cover, and percent ground cover of downed wood were proportionally related. Grass cover was approximately inverse to live tree canopy cover and shrub cover. Litter weight varied from 8.5 g per 900 cm^2 to 27.8 g per 900 cm^2 (*table 1*).

Table 1—Habitat characteristics of nine vegetation variables used to assess habitat associations of small mammals, birds, reptiles, and amphibians on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring and summer 1995.

	Plot range[1]								
Habitat characteristic	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Live tree density (stems/ha)[2,3]	130.4	181.8	224.8	233.4	241.9	274.2	330.5	423.6	461.1
Snag density (stems/ha)[2]	9.4	15.2	16.6	22.5	22.8	24.4	28.6	34.8	35.7
Tree canopy cover (pct)	40.2 (2.1)	45.3 (2.5)	53.2 (2.8)	53.7 (2.7)	55.9 (2.6)	56.3 (2.6)	61.7 (2.4)	67.8 (2.5)	70.1 (2.6)
Shrub cover (pct)	0 (0)	2.4 (0.8)	3.8 (0.9)	8.3 (1.3)	9.9 (1.5)	13.2 (1.7)	20.8 (2.5)	24.3 (2.6)	35.4 (2.7)
Grass cover (pct)	38.1 (2.2)	43.9 (2.3)	46.7 (1.9)	48.7 (2.2)	50.0 (2.5)	56.9 (1.8)	58.3 (1.6)	67.1 (1.8)	71.6 (1.5)
Forb cover (pct)	1.4 (0.3)	2.1 (0.6)	2.2 (0.5)	2.7 (0.4)	3.2 (0.5)	3.2 (0.6)	3.2 (0.6)	3.9 (0.7)	6.3 (0.8)
Downed wood cover (pct)	1.1 (0.4)	2.2 (0.5)	2.6 (0.5)	3.4 (0.6)	3.6 (0.6)	3.6 (0.7)	3.7 (0.6)	3.8 (0.6)	6.5 (0.8)
Unvegetated ground (pct)	8.4 (0.7)	8.9 (0.7)	9.6 (0.9)	10.2 (0.9)	10.7 (0.9)	12.4 (1.1)	12.9 (0.9)	13.3 (0.9)	14.8 (1.1)
Litter weight (g)	8.5 (0.9)	13.4 (1.5)	13.7 (1.5)	14.6 (1.9)	14.9 (1.5)	21.6 (1.9)	23.0 (2.4)	27.8 (2.2)	27.8 (3.1)

[1] Means from the nine plots are ranked from least to greatest, left to right, within rows.

[2] Live tree density and snag density were determined using the point-centered quarter method (Cottam and Curtis 1956). Standard errors are not associated with either density estimate because a formula for calculating standard error was not presented in the paper.

[3] Includes saplings, which were measured using fixed-radius plots and therefore have an associated standard error. Mean saplings/ha ranged from 0 ± 0 stems/ha to 121.7 ± 26.2 stems/ha. Maximum standard error (on a mean of 99.0 stems/ha) was 30.5 stems/ha.

Small Mammals

Richness and Numbers

During 64,345 trap-nights of effort, we recorded 14,076 captures of 5,767 individuals of 10 species of small mammals (*table 2*). Dusky-footed woodrats (*Neotoma fuscipes*), piñon mice (*Peromyscus truei*), California pocket mice (*Perognathus californicus*), brush mice (*Peromyscus boylii*), deer mice (*Peromyscus maniculatus*), and California mice (*Peromyscus californicus*) were the six most abundant species captured with 32, 19, 18, 16, 10, and 2 percent of total individual captures, respectively (*table 2*). Among these species, trap success was greatest for woodrats (9.7 percent of total captures) and least for California mice (0.5 percent of total captures); average captures per animal were greatest for woodrats (3.3) and least for deer mice (1.6). Four species had <100 individual captures per five bouts (*table 2*). We also captured ground squirrels (*Spermophilus beecheyi*) on three study plots and pocket gophers (*Thomomys bottae*) on two plots; we did not record these captures.

Habitat Relationships

Percent shrub cover was the strongest correlated habitat component for California mice (r_s = 0.97), woodrats (r_s = 0.95), piñon mice (r_s = 0.83), and California pocket mice (r_s = 0.51) (*table 3*). Percent tree canopy cover and percent unvegetated ground cover were the strongest correlates for brush mice and deer mice, respectively (r_s = 0.68 and 0.82, respectively). All species were negatively correlated with percent grass cover (r_s = -0.12 [deer mice] to -0.88 [woodrats]) and positively correlated with percent shrub cover (r_s = 0.08 [deer mice] to 0.97 [California mice]) and percent unvegetated ground cover (r_s = 0.05 [brush mice] to 0.82 [deer mice]). Across all habitat components, woodrats exhibited the

***Table 2**—Capture statistics of 10 species of small mammals captured in Sherman live traps on nine 5.8-ha plots (64,345 trap-nights) in oak woodlands, Camp Roberts, California, spring and fall, fall 1993 to fall 1995.*

Species	Total captures	Individual captures	Total trap success[1]	Percent of individuals captured[2]	Average captures per animal[3]
Dusky-footed woodrat (*Neotoma fuscipes*)	6,207	1,871	9.65	32.44	3.32
Piñon mouse (*Peromyscus truei*)	2,798	1,119	4.35	19.40	2.50
California pocket mouse (*Perognathus californicus*)	1,799	1,014	2.80	17.58	1.77
Brush mouse (*Peromyscus boylii*)	1,762	916	2.74	15.88	1.92
Deer mouse (*Peromyscus maniculatus*)	929	597	1.44	10.35	1.56
California mouse (*Peromyscus californicus*)	341	108	0.53	1.87	3.16
California vole (*Microtus californicus*)	105	81	0.16	1.40	1.30
Merriam's chipmunk (*Tamias merriami*)	73	27	0.11	0.47	2.70
Heermann's kangaroo rat (*Dipodomys heermanni*)	46	18	0.07	0.31	2.56
W. harvest mouse (*Reithrodontomys megalotis*)	16	16	0.02	0.28	1.00
Total	14,076	5,767	21.88	100.00	2.44

[1] Total captures expressed as a percent of total trap-nights (64,345).
[2] Individual captures expressed as a percent of total number of individuals captured (5,767).
[3] Total captures ÷ individual captures.

***Table 3**—Spearman rank correlations (r_s) between total individual captures of six relatively abundant species of small mammals and six habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring and fall, fall 1993 to fall 1995.*

Habitat characteristic	Dusky-footed woodrat	Pinon mouse	California pocket mouse	Brush mouse	Deer mouse	California mouse
Tree canopy cover (pct)	0.62	0.72*	0.13	0.68*	-0.17	0.72*
P[1]	0.08	0.03	0.73	0.04	0.67	0.03
Shrub cover (pct)	0.95*	0.83*	0.51	0.47	0.08	0.97*
P	<0.01	0.01	0.16	0.21	0.83	<0.01
Grass cover (pct)	-0.88*	-0.80*	-0.36	-0.67*	-0.12	-0.86*
P	<0.01	0.01	0.34	0.05	0.77	0.01
Forb cover (pct)	0.61	0.54	-0.12	0.41	0.44	0.44
P	0.08	0.13	0.76	0.28	0.24	0.23
Unvegetated groundcover (pct)	0.47	0.47	0.30	0.05	0.82*	0.14
P	0.21	0.21	0.43	0.90	0.01	0.71
Downed wood cover (pct)	0.90*	0.73*	0.37	0.55	-0.02	0.96*
P	<0.01	0.03	0.32	0.12	0.97	<0.01

[1] *P*-value of correlation coefficients. Power of significant coefficients ranged from 0.5080 ($r_s = 0.67$) to 0.9992 ($r_s = 0.97$). All $n = 9$. Asterisks denote significance at $P \leq 0.05$.

strongest habitat correlations (mean $|r_s| = 0.74$, range = -0.88 to 0.95), whereas deer mice were least strongly correlated (mean $|r_s| = 0.28$, range = -0.17 to 0.82) (*table 3*). Only California pocket mice were not significantly correlated with at least one habitat component (all correlation $P > 0.05$).

Birds

Richness and Numbers

We delineated territories of 24 bird species during 212 visits in spring 1994 and 1995. Territories were not delineated for 50 other species because fewer than three detections were recorded or the species' behavior precluded such delineation (e.g., western scrub-jays [*Aphelocoma californica*]). Plain titmice (*Parus inornatus*), dark-eyed juncos (*Junco hyemalis*), house finches (*Carpodacus mexicanus*), and white-breasted nuthatches (*Sitta carolinensis*) were the most frequently observed species with an annual average of 49.4, 21.5, 13.0, and 10.2 territories, respectively (*table 4*).

Table 4—Average (annual) number and density of breeding-bird territories (derived from spot-mapping observations) of 24 bird species on nine 5.8-ha study plots in oak woodland, Camp Roberts, California, spring 1994 and spring 1995.

Species	Mean no. territories	SE	No. territories/40 ha
Plain titmouse (*Parus inoratus*)	64.5	6.5	49.4
Dark-eyed junco (*Junco hyemalis*)	28.0	0.5	21.5
House finch (*Carpodacus mexicanus*)	17.0	0.5	13.0
White-breasted nuthatch (*Sitta carolinensis*)	13.3	1.8	10.2
Lesser goldfinch (*Carduelis psaltira*)	8.5	1.5	6.5
Anna's hummingbird (*Calypte anna*)	6.5	0.5	5.0
Blue-gray gnatcatcher (*Polioptila caerulea*)	5.3	1.8	4.1
Lawrence's goldfinch (*Carduelis lawrencei*)	5.3	1.3	4.1
California towhee (*Pipilo crissalis*)	4.5	2.0	3.5
Common bushtit (*Psaltriparus minimus*)	4.5	4.5	3.5
Hutton's vireo (*Vireo huttoni*)	4.3	1.8	3.3
Western bluebird (*Sialia mexicana*)	3.8	1.3	2.9
Bewick's wren (*Thryomanes bewickii*)	3.0	0.5	2.3
Lark sparrow (*Chondestes grammacus*)	3.0	0	2.3
Nuttall's woodpecker (*Picoides nuttallii*)	3.0	0.5	2.3
Spotted towhee[1] (*Pipilo maculatus*)	2.8	0.3	2.2
House wren (*Troglodytes aedon*)	1.8	0.3	1.4
Orange-crowned warbler (*Vermivora celata*)	1.8	0.8	1.4
Northern flicker (*Colaptes auratus*)	1.0	0	0.8
Bullock's Oriole (*Icterus bullockii*)	1.0	0.5	0.8
California quail (*Callipepla californica*)	0.5	0.5	0.5
Acorn woodpecker (*Melanerpes formicivorus*)	0.3	0.3	0.2
Brown-headed cowbird (*Molothrus ater*)	0.3	0.3	0.2
Cooper's hawk (*Accipiter cooperii*)	0.3	0.3	0.2
Total	183.8	24.3	140.8

[1]Formerly rufous-sided towhee.

Habitat Relationships

Percent shrub cover was the strongest correlated habitat component for dark-eyed juncos (r_s = 0.79), white-breasted nuthatches (r_s= -0.64), and house finches (r_s= 0.46) (*table 5*). Tree canopy cover was the strongest correlated habitat component for plain titmice (r_s = 0.40). Juncos exhibited the strongest habitat correlations across all habitat components (mean $|r_s|$ = 0.73, range = 0.65 to 0.79); titmice exhibited the weakest habitat correlations across all habitat components (mean $|r_s|$ = 0.28; range = -0.16 to 0.40). Only dark-eyed juncos were significantly ($P \leq 0.05$) correlated with any habitat component.

Table 5—Spearman rank correlations (r_s) between average number of territories (derived from spot-mapping observations) of four relatively abundant songbird species and four habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring 1994 and spring 1995.

Habitat characteristic	Plain titmouse	Dark-eyed junco	House finch	White-breasted nuthatch
Live stem density (trees/ha)	0.15	0.71*	0.14	-0.38
P[1]	0.70	0.03	0.73	0.31
Standing snag density (stems/ha)	-0.16	0.65	0.07	-0.29
P	0.68	0.06	0.86	0.44
Tree canopy cover (pct)	0.40	0.78*	0.44	-0.50
P	0.28	0.01	0.24	0.17
Shrub cover (pct)	0.39	0.79*	0.46	-0.64
P	0.29	0.01	0.21	0.06

[1] *P*-value of correlation coefficients. Power of significant coefficients ranged from 0.5793 (r_s = 0.71) to 0.7454 (r_s = 0.79). All n = 9. Asterisks denote significance at $P \leq 0.05$.

Amphibians and Reptiles

Richness and Numbers

We recorded 1,516 observations of 15 to 17 species of amphibians and reptiles during 17,136 coverboard checks in 1995: five or six species of lizards, two or three salamanders, six snakes, one toad, and one frog species (*table 6*). Skinks (*Eumeces* spp.), western fence lizards (*Sceloporus occidentalis*), Slender salamanders (*Baltrachoseps* spp.), and gopher snakes (*Pituophis melanoleucus*) were the four most relatively abundant species with 35, 26, 25, and 4 percent of total observations, respectively, and 3.1, 2.3, 2.2, and 0.4 percent of total possible observations, respectively (*table 6*). Eleven species had <60 total observations.

Habitat Relationships

Percent tree canopy cover, percent shrub cover, percent forb cover, and litter weight were the strongest correlated habitat components for slender salamanders, gopher snakes, skinks, western fence lizards, respectively (r_s = 0.82, 0.59, 0.46, and 0.59, respectively) (*table 7*). All species were positively correlated with percent shrub cover (r_s = 0.10 [fence lizards] to 0.59 [gopher snakes]), percent forb cover (r_s = 0.06 [gopher snakes] to 0.46 [skinks]), percent downed wood cover (r_s = 0.15 [fence lizards] to 0.58 [gopher snakes]), and litter weight (r_s = 0.28 [skinks] to 0.62 [slender salamanders]), and negatively correlated with percent grass cover (r_s = -0.05 [fence lizards] to -0.53 [slender salamanders]). Slender salamanders exhibited the strongest habitat correlations across all habitat components (mean $|r_s|$ = 0.44, range = -0.53 to 0.82); western fence lizards exhibited the weakest habitat correlations across all habitat components (mean $|r_s|$ = 0.20, range = -0.05 to 0.59). Only slender salamanders were significantly (P ≤ 0.05) correlated with any habitat component.

Table 6—Amphibians and reptiles observed under 136 coverboards during 14 consecutive weeks on each of nine 5.8-ha plots (17,136 board checks), Camp Roberts, California, 24 January to 26 April, 1995.

Species	Total observations	Percent success[1]	Percent of total observations[2]
Reptiles—Lizards			
Skink (*Eumeces* spp.)	535	3.12	35.29
Western fence lizard (*Sceloporus occidentalis*)	388	2.26	25.59
California legless lizard (*Anniella pulchra*)	33	0.19	2.26
Southern alligator lizard (*Gerrhonotus coeruleus*)	15	0.09	0.99
Side-blotched lizard (*Uta stanburiana*)	13	0.08	0.86
Reptiles—Snakes			
Gopher snake (*Pituophis melanoluecus*)	60	0.35	3.96
Striped racer (*Coluber constrictor*)	33	0.19	2.18
Common king snake (*Lampropeltis getulus*)	28	0.16	1.85
Ring-necked snake (*Diadophis punctatus*)	18	0.11	1.19
Garter snake (*Thamnophis sirtalis*)	1	0.01	0.07
Nightsnake (*Hypsiglena torquata*)	1	0.01	0.07
Amphibians—Salamanders			
Slender salamander (*Batrachoseps* spp.)	383	2.24	25.26
Ensatina (*Ensatina eschscholtzii*)	1	0.01	0.07
Amphibians—Frogs and toads			
Western toad (*Bufo boreas*)	6	0.04	0.40
Unidentified frog	1	0.01	0.07
Total	1,516	8.85	100.00

[1]Total observations expressed as a percent of total coverboard checks (17,136).
[2]Total species observations expressed as a percent of total observations (1,516).

Table 7—Spearman rank correlations (r_s) between total observations of four relatively abundant amphibian and reptile species and seven habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, 24 January to 26 April, 1995.

Habitat characteristic	Slender salamander	Gopher snake	Skink	Western fence lizard
Litter weight (g)	0.62	0.47	0.28	0.59
P[1]	0.08	0.20	0.47	0.10
Tree canopy cover (pct)	0.82*	0.34	-0.15	0.22
P	0.01	0.37	0.70	0.58
Shrub cover (pct)	0.32	0.59	0.23	0.10
P	0.41	0.10	0.55	0.80
Grass cover (pct)	-0.53	-0.40	-0.08	-0.05
P	0.14	0.28	0.83	0.90
Forb cover (pct)	0.44	0.06	0.46	0.27
P	0.24	0.88	0.22	0.48
Unvegetated ground cover (pct)	0.02	-0.12	0.42	-0.03
P	0.97	0.76	0.26	0.93
Downed wood cover (pct)	0.35	0.58	0.31	0.15
P	0.35	0.10	0.42	0.70

[1]*P*-value of correlation coefficients. Power of the one significant coefficient was 0.8051. All $n = 9$. Asterisks denote significance at $P \leq 0.05$.

Discussion

Small mammal, reptile, and amphibian species richness was similar to that described in other published studies in oak woodlands in California. Compared to Block and Morrison (1991), small mammal species richness and composition at Camp Roberts was similar (12 species from Camp Roberts, including ground squirrels and pocket gophers, for which we did not specifically survey, versus 15 species from their study). We cannot compare our bird species richness data with those in other studies (Block 1989; Block and Morrison 1987, 1991; Verner 1987) because we spot mapped only selected species with at least three detections of a singing male. We found two fewer species of lizards and four fewer species of amphibians than Block and Morrison (1991). Differences in species composition between studies within the small mammal, amphibian, and reptile taxa likely can be attributed to different geographic areas and census methods.

When comparing relative abundance of small mammal species common to both studies, the list from Camp Roberts is similar to live-trapping capture rates of Block and Morrison (1991) with the notable exception of woodrats. Woodrats ranked fifth in the Block and Morrison (1991) study and first at Camp Roberts. Little is published on the density of breeding bird territories estimated from spot mapping. However, numbers are available for the plain titmouse, an abundant species at Camp Roberts, where density was one-and-a-half times the April estimate for an ungrazed oak woodland at the San Joaquin Experimental Range, Madera County (49.4 per 40 ha at Camp Roberts versus 31.2 per 40 ha in Madera County [Verner and Lyman 1988]). The ranked list of relative abundances in oak woodland of amphibian and reptile species collected with pitfall traps by Block and Morrison (1991) is similar to the list from coverboards used at Camp Roberts.

At Camp Roberts, many species of terrestrial vertebrates were associated with shrubby areas of dense oak woodland with downed wood: seven species were significantly ($|r_s| \geq 0.67$ [critical correlation coefficient when n = 9 and $\alpha = 0.05$ (two-tailed)], $P \leq 0.05$) associated with one or more of these habitat components. Although small mammals were strongly associated with dense woodlands, habitat relationships were less pronounced for birds, reptiles, and amphibians. A larger sample size may be needed to detect strong habitat associations, given the relatively low number of individuals present in these groups.

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