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POPULATION TRENDS OF QUAILS IN NORTH AMERICA

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Abstract: We used North American Breeding Bird Survey data (1966–91) to estimate distribution, relative abundance, and population trends of quails. Population trends in grassland/shrub birds sympatric with northern bobwhite (*Colinus virginianus*) were also examined. Northern bobwhite and scaled quail (*Callipepla squamata*) populations have declined since 1966. Rates of decline for these quails have increased during the past decade. California quail (*C. californica*), Gambel's quail (*C. gambelii*), and mountain quail (*Oreortyx pictus*) populations have been stable over the long-term (1966–91). However, the short-term (1982–91) trend for California quail is positive, whereas Gambel's quail appear to be declining. Patterns in trends indicate similar factors may be negatively affecting breeding populations of grassland/shrub birds throughout the bobwhite's range. We discuss plausible hypotheses to explain population trends and recommend future action.

Key words: abundance, Breeding Bird Survey, California quail, distribution, Gambel's quail, mountain quail, North America, northern bobwhite, population trends, quail, scaled quail.

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Monitoring abundance and distribution of a species is basic to wildlife conservation. As a result, most state conservation agencies conduct species-specific surveys to monitor nonmigratory game populations. However, not all states survey quail populations, and survey methods frequently differ. Consequently, data are lacking pertaining to the geographic magnitude and pattern of population change associated with each species of quail throughout its range in North America.

The North American Breeding Bird Survey (BBS) has been conducted in a systematic manner throughout North America for >25 years (Droege 1990). These data provide an opportunity to measure long-term changes in distribution and relative abundance of breeding birds among states, provinces, and physiographic regions. Furthermore, examining patterns of population trends among sympatric species may help to identify common factors affecting wildlife over large geographic areas.

We analyzed BBS data to describe distribution, relative abundance, and population trends of 5 species of quail in North America. In addition, we examined population trends of 2 common raptors and numerous passerines sympatric with northern bobwhite.

We acknowledge the conscientious and skilled efforts of the thousands of volunteers responsible for gathering BBS data. S. Clark and J. S. Taylor provided comments that improved the manuscript.

METHODS

The U.S. Fish and Wildlife Service and the Canadian Wildlife Service coordinate the BBS which consists of approximately 3,500 routes throughout North America, of which 2,400 are conducted each year during June (Droege 1990). Routes are 39.4 km, and contain 50 evenly-spaced observation stops along secondary roads. At each stop, observers count all birds heard or seen during a 3-minute interval. The total number of each species observed on the route is used as an annual index of abundance.

We used route-regression analysis to estimate long-term (1966-91) and short-term (1982-91) population trends (Geissler and Sauer 1990). Composite annual indices of abundance were determined by estimating year effects from residual variation remaining after the trend analysis (Sauer and Geissler 1990). Trends were estimated for individual states and physiographic strata (Butcher 1990) where a species was observed on >13 routes. Populations were considered stable when trends did not differ from 0 ($P < 0.10$).

We identified a priori a guild of 13 passerines that occupy grassland/shrub habitats within the range of northern bobwhite. Then, we compared population trends of the guild within states where these species were sympatric with bobwhite. We used chi-square analyses to determine whether the percentage of sympatric species that had

trend estimates <0 in a state was significantly $<50\%$. Similarly, for regions where bobwhite declined, we determined the percentage of physiographic strata in which 9 passerines and 2 predators also had declining populations.

RESULTS

Quail Populations

Northern Bobwhite.—Northern bobwhite are the most widely distributed (39 states and Ontario) and abundant quail in North America (Fig. 1). Highest densities occur in Oklahoma, Missouri, Texas, Kansas, and Georgia. The continental population has declined ($-2.4\%/year$) since the mid-1960's (Table 1). We analyzed long-term trends for 28 states; only in Wisconsin were there increasing populations. Five states observed stable populations, and 22 decreased. Similarly, we analyzed long-term population trends within 28 physiographic strata. Only the Driftless stratum indicated a long-term increasing trend, 6 strata were stable, and 21 populations declined.

The continental population declined over the short-term (1982-91) at a slightly more accelerated rate ($-3.5\%/year$) than that observed for the entire time period (Table 1). Populations in 5 states increased, and 5 were stable. Populations in 16 of 26 states exhibited population declines. Likewise, trends were positive for 3 of 25 strata, 6 were stable, and populations in 16 strata declined.

California Quail.—California quail are the second most widely distributed (5 states and British Columbia) and abundant species of quail in North America (Fig. 2). California has the highest densities. The continental population has been relatively stable since 1966 (Table 2). We analyzed long-term population trends in 3 states and 7 physiographic strata. All states and strata had stable populations. However, since 1982, the continental population has shown a slightly positive trend ($3.2\%/year$), due primarily to increased abundance of quail in the California Foothills stratum.

Scaled Quail.—Scaled quail were observed in 5 states (Fig. 3). The highest densities are found in Texas. The continental population declined ($-3.8\%/year$) since the mid-1960's (Table 2). We analyzed 2 states and 2 physiographic strata. Specifically, long-term populations in New Mexico, Texas, and the Chihuahuan Desert have decreased. Moreover, the rate of decline since 1982 has been twice as rapid ($-8.2\%/year$) as that which has occurred over the long-term.

This short-term change reflects decreasing populations in the Staked Plains stratum.

Gambel's Quail.—Gambel's quail were reported in 5 states (Fig. 4). Arizona has the highest densities. The long-term continental population trend has been stable (Table 2). Likewise, populations in the individual states and the Sonoran Desert showed no change. However, the continental trend during the last 10 years was negative ($-4.6\%/year$).

Mountain Quail.—Mountain quail were observed in 3 states (Fig. 5). The highest densities occur in California. Both the long- (1966-91) and short-term (1982-91) population trends in the U.S. have been stable (Table 2).

Sympatric Species of Northern Bobwhite

In general, long-term population trends of the grassland/shrub guild (13 passerine species) declined where sympatric with northern bobwhite (Table 3). Specifically, $>50\%$ of these species showed declining populations similar to bobwhite in 23 of 26 states. Of these, 6 states reported $>87\%$ of the passerines were declining ($P < 0.10$). In physiographic strata where bobwhite populations were decreasing, each of the 9 sympatric passerines also declined in more strata ($>56\%$) than they increased (Table 4). Declines occurred in $>72\%$ of the strata for 6 species ($P < 0.10$). Conversely, red-tailed hawks and great horned owls increased in $>70\%$ of the strata where bobwhite declined ($P < 0.10$).

DISCUSSION

Population trends indicate marked long-term declines for northern bobwhite and scaled quail. The rate of decline has been greater for both species during the last 10 years. In comparison, long-term trends for more western species appear stable. Although short-term trends of California quail are increasing, those for Gambel's quail are decreasing.

In general, our results concur with independent estimates of population trends by others. Brennan (1991, 1993a) analyzed Audubon Christmas Bird Count data (1960-88) and reported declining populations of northern bobwhite and scaled quail, and stable trends for Gambel's and mountain quail. He also reported declining populations of California quail, and a reduction in the range of mountain quail. Schemnitz (1993) noted scaled quail populations declined 53% in the Oklahoma

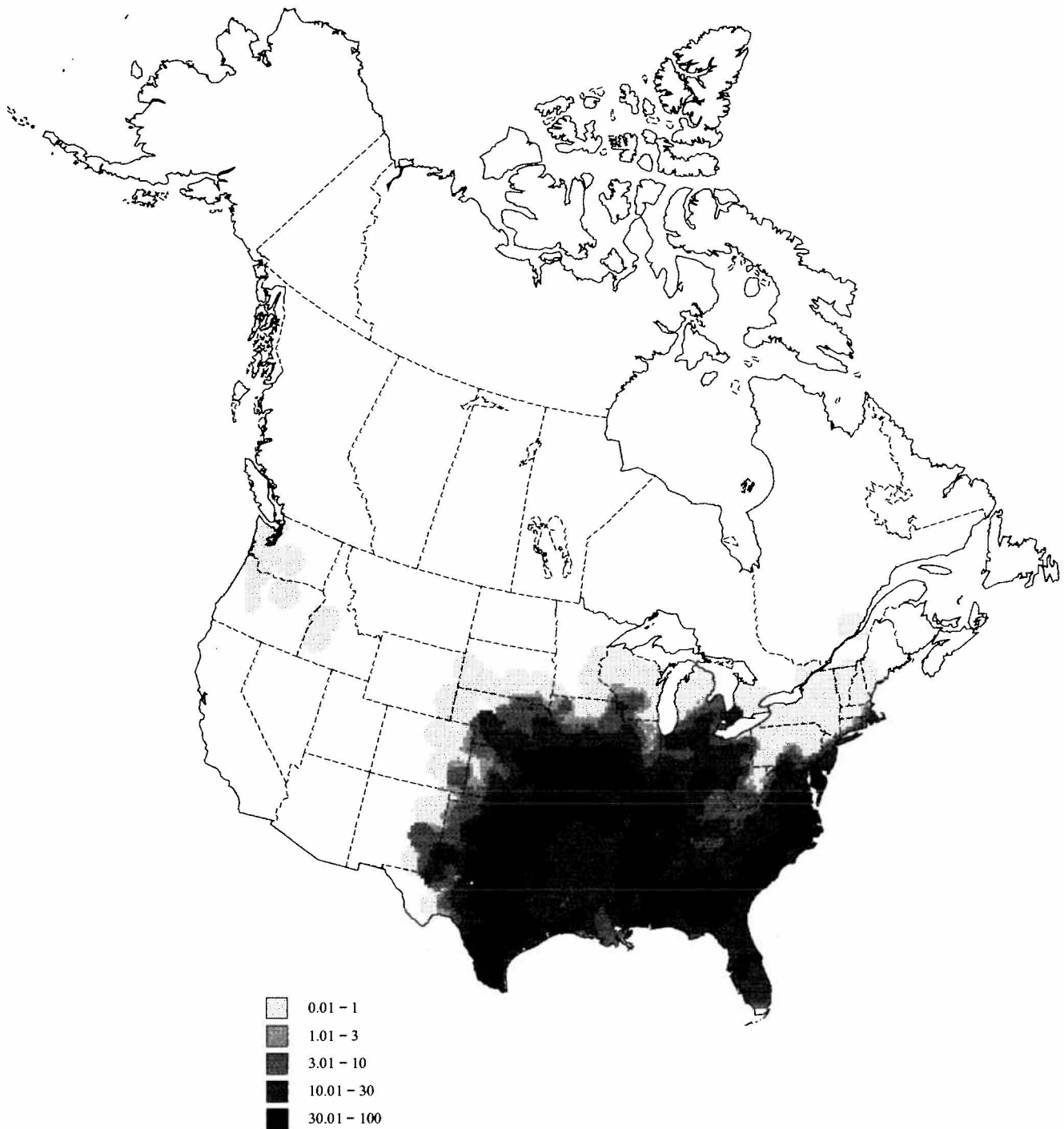


Fig. 1. Distribution and relative abundance (\bar{x} number of birds/Breeding Bird Survey route) of northern bobwhite in North America, 1966-91. Shaded patterns define uniform regions of relative abundance.

Table 1. Long-term (1966-91) and short-term (1982-91) population trends and relative abundance (\bar{x} -birds/route) of northern bobwhite based on the North American Breeding Bird Survey.

State/stratum	Long-term		Short-term	
	Trend	Abundance	Trend	Abundance
Alabama	-3.0*** ^a	36.48	-6.7***	28.27
Arkansas	-2.4***	25.34	-5.4***	21.10
Florida	-2.5**	19.52	-6.3***	16.08
Georgia	-3.5***	36.92	-4.4***	30.43
Illinois	-3.3***	23.65	1.5	20.17
Indiana	-2.3**	20.19	5.7**	17.94
Iowa	-4.1***	8.68	6.1**	7.25
Kansas	-1.9	30.45	1.8	30.79
Kentucky	-2.2***	26.37	-2.4**	24.72
Louisiana	-5.3***	15.08	-7.6***	9.84
Maryland	-4.0***	31.07	-9.2***	23.36
Massachusetts	-10.9**	5.67		
Michigan	-10.7**	5.99	21.9***	3.26
Mississippi	-3.9***	38.36	-5.8***	26.78
Missouri	-0.8	44.25	1.7	43.24
Nebraska	-0.6	8.95	5.3*	8.85
New Jersey	-5.2***	10.90	-12.6***	7.73
New York	-6.4***	0.71		
North Carolina	-3.6***	29.72	-6.2***	22.70
Ohio	-7.1***	15.97	-1.1	5.86
Oklahoma	0.2	48.45	-1.9**	48.30
Pennsylvania	-11.0***	0.92	5.2*	0.21
South Carolina	-4.4***	38.51	-5.7***	29.32
Tennessee	-3.1***	27.54	-5.0***	22.49
Texas	-1.5**	37.89	-6.9***	34.89
Virginia	-3.1***	27.42	-6.6***	20.83
West Virginia	-5.3	5.60	-8.0***	2.63
Wisconsin	5.5**	1.51	2.7	2.02
Floridian	-2.7*	22.20	-5.8***	18.82
Coastal Flatwoods	-3.0***	28.40	-6.1***	22.22
Upper Coastal Plain	-3.3***	37.58	-5.7***	28.54
Mississippi Plain	-2.8***	17.41	-8.4***	13.84
Coastal Prairies	-3.2**	27.36		
South Texas Brushlands	-0.9	77.51	-8.6***	62.47
East Texas Prairies	-5.3***	38.03	-11.7***	28.99
Northern Piedmont	-11.1***	10.71	-11.9***	6.23
Southern Piedmont	-3.6***	30.90	-7.4***	23.97
Southern New England	-10.7***	2.65	-11.9**	1.01
Ridge and Valley	-3.6***	14.45	-5.6***	10.36
Highland Rim	-2.3***	33.03	-3.0***	29.64
Lexington Plain	-3.6***	30.57	-1.6	27.93
Great Lakes Plain	-9.9***	6.31	20.4***	2.90
Driftless Area	4.6*	5.09	1.7	5.22
Ozark-Ouachita Plateau	-1.8***	30.29	-1.6	26.77
Great Lakes Transition	-3.1**	0.09		
Cumberland Plateau	-4.3***	6.86		
Ohio Hills	-11.0***	6.62	-7.0**	1.33
Blue Ridge Mountains	-4.7***	7.09		
Allegheny Plateau	-2.6	1.17	6.2**	0.48
Till Plains	-3.7***	24.84	2.0	20.55
Dissected Till Plains	-2.9***	24.81	6.3***	23.97
Osage-Cross Timbers	-0.8	64.89	-1.6**	62.52
High Plains Border	-2.1	19.78	2.4	18.78
Rolling Red Prairies	0.9	48.62	1.8	52.55
High Plains	-3.3	1.20	-29.0*	1.22
Edward's Plateau	-2.4**	41.01	-6.1***	36.00
Continental	-2.4***	18.14	-3.5***	16.62

^a* = $P < 0.10$, ** = $P < 0.05$, *** = $P < 0.01$.

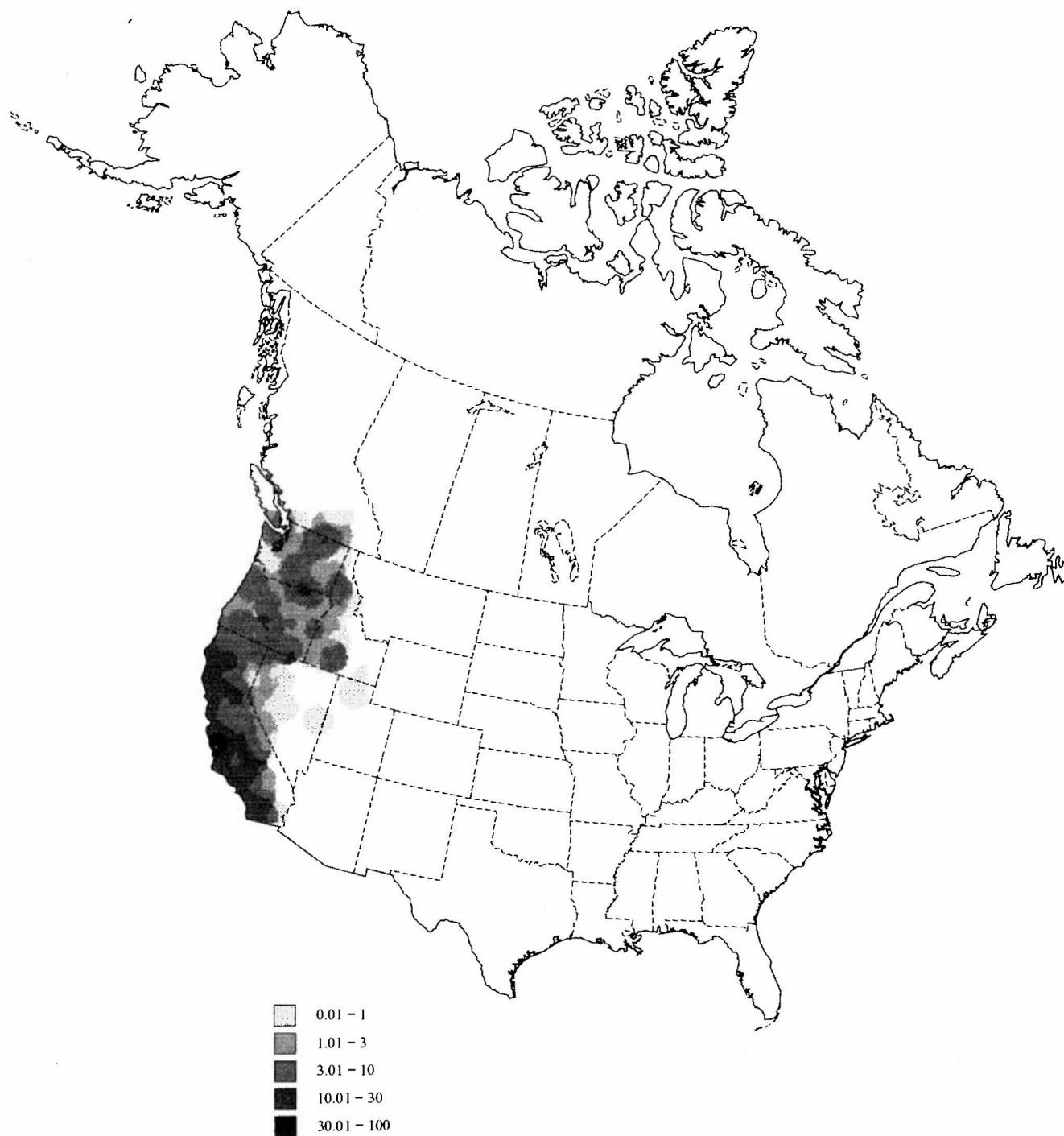


Fig. 2. Distribution and relative abundance (\bar{x} number of birds/Breeding Bird Survey route) of California quail in North America, 1966-91. Shaded patterns define uniform regions of relative abundance.

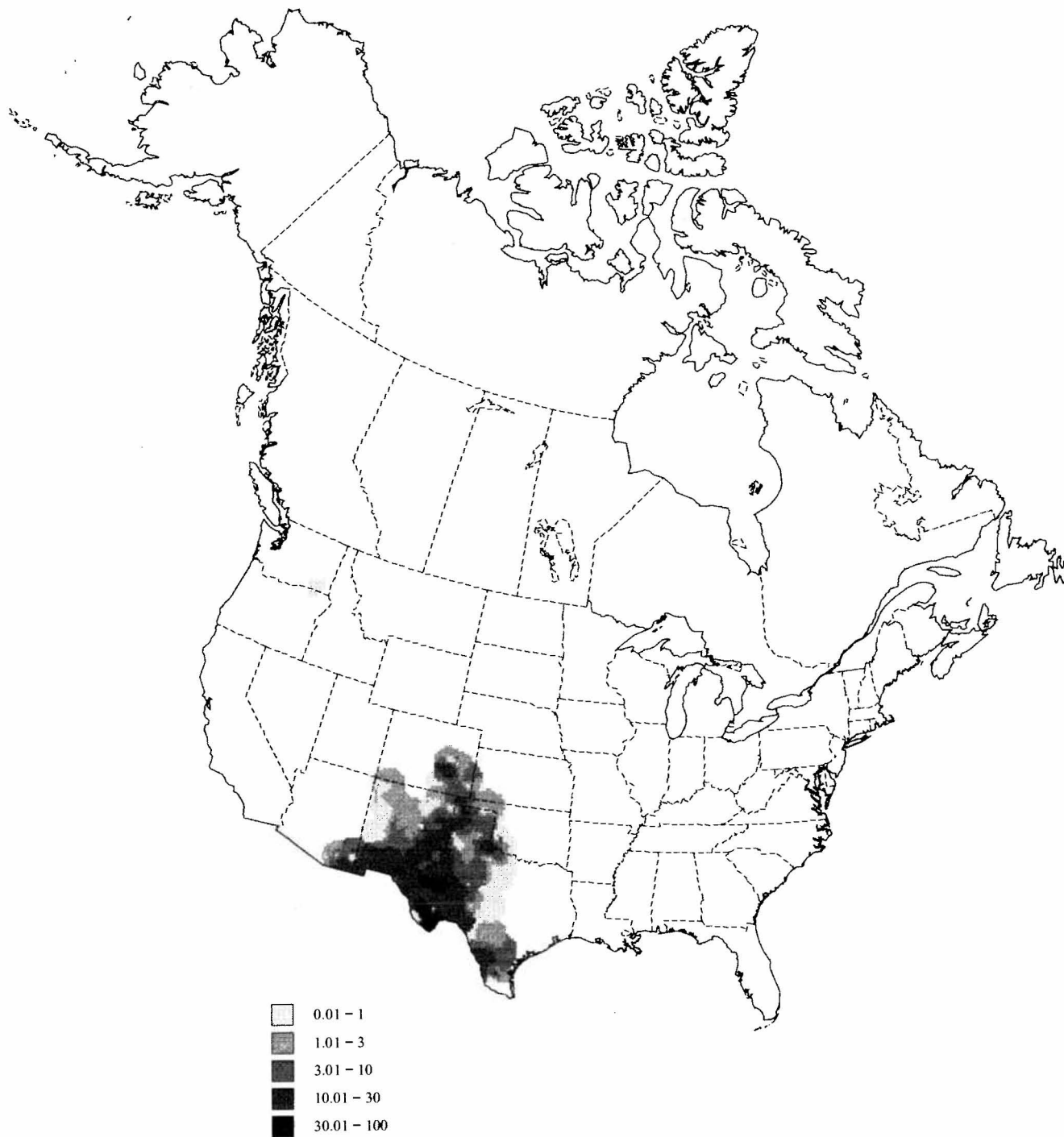


Fig. 3. Distribution and relative abundance (\bar{x} number of birds/Breeding Bird Survey route) of scaled quail in North America, 1966-91. Shaded patterns define uniform regions of relative abundance.

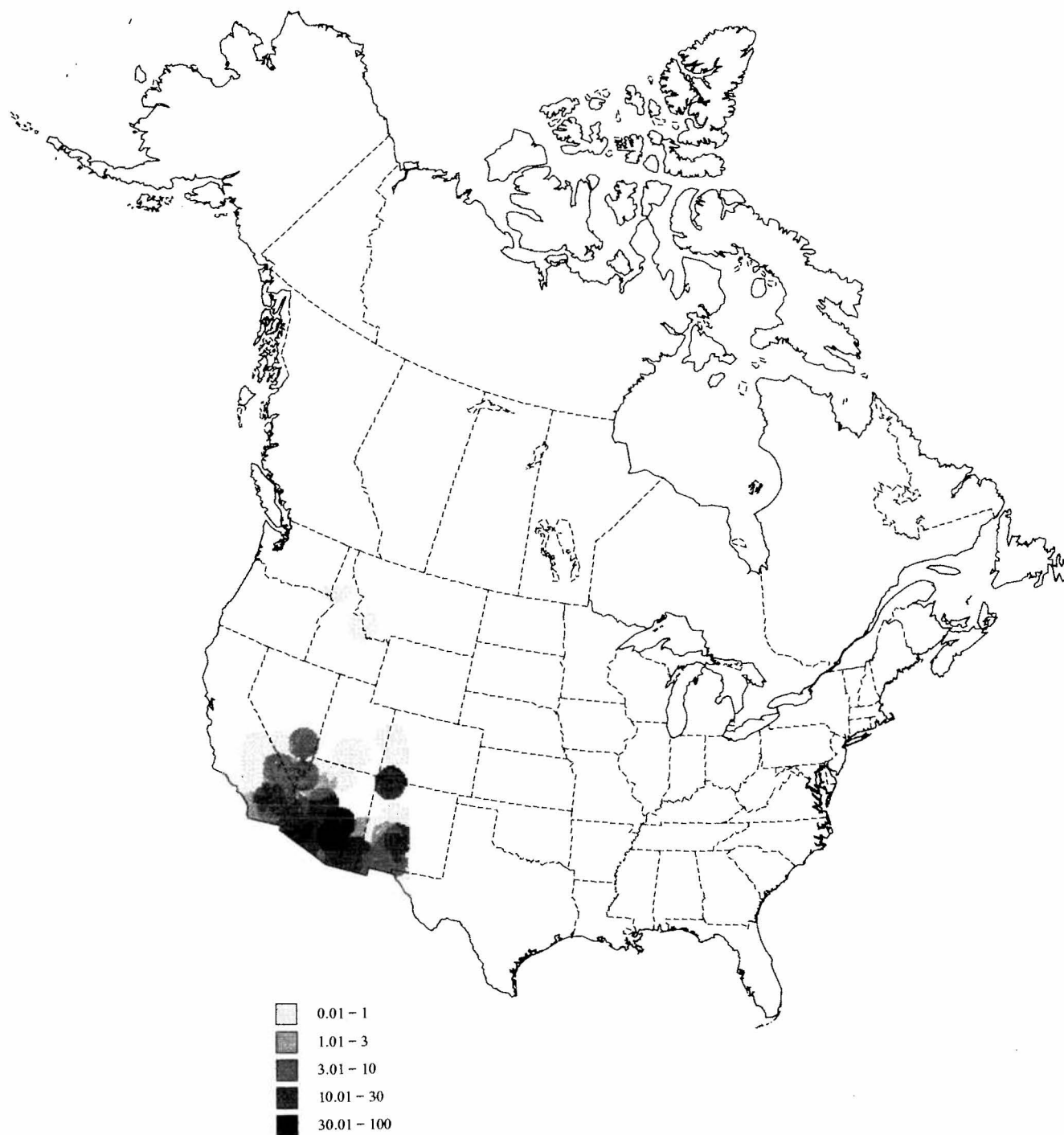


Fig. 4. Distribution and relative abundance (\bar{x} number of birds/Breeding Bird Survey route) of Gambel's quail in North America, 1966-91. Shaded patterns define uniform regions of relative abundance.

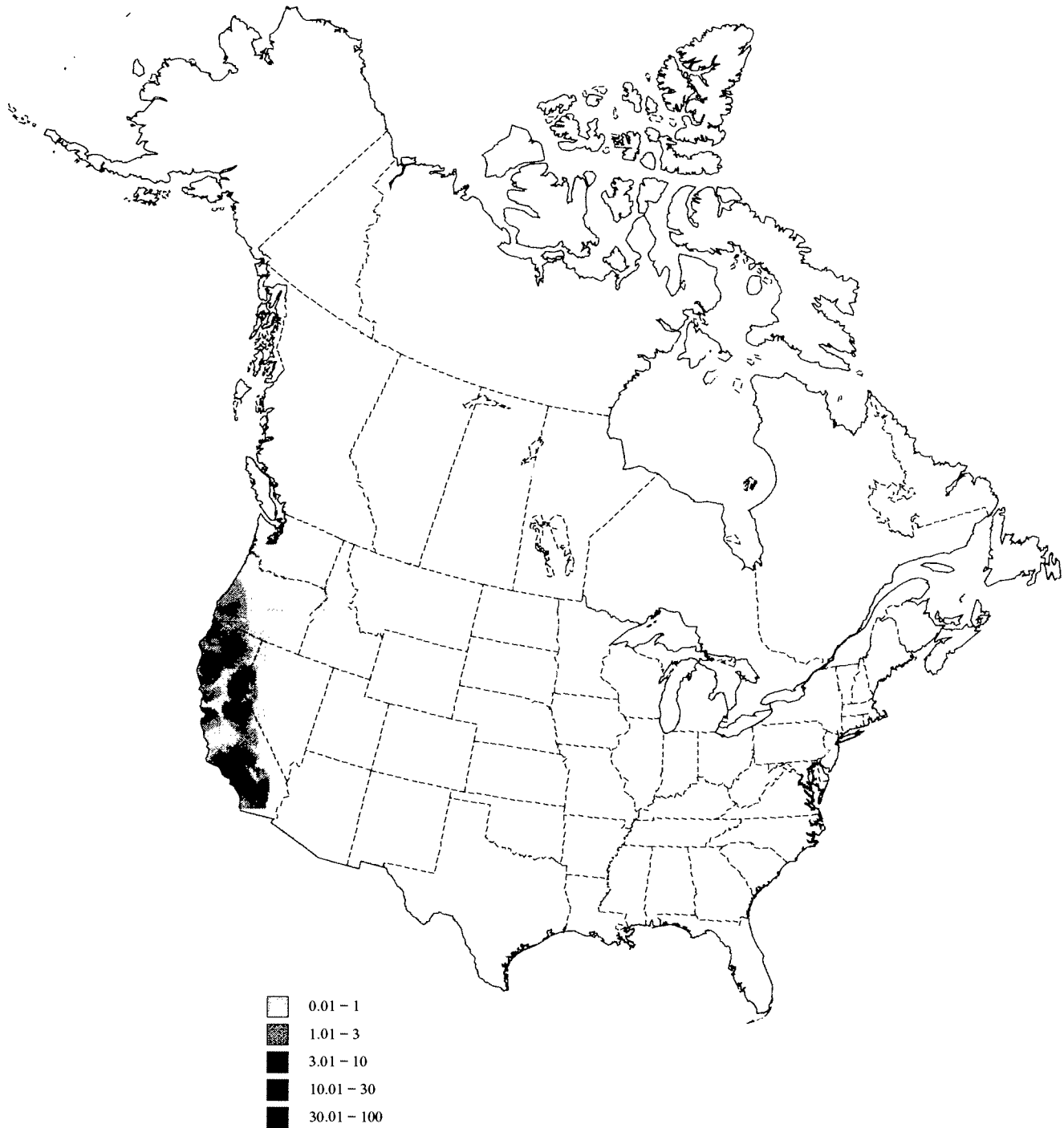


Fig. 5. Distribution and relative abundance (\bar{x} number of birds/Breeding Bird Survey route) of mountain quail in North America, 1966-91. Shaded patterns define uniform regions of relative abundance.

Table 2. Long-term (1966-91) and short-term (1982-91) population trends and relative abundance (\bar{x} -birds/route) of California, scaled, Gambel's, and mountain quail based on the North American Breeding Bird Survey.

State/stratum	Long-term		Short-term	
	Trend	Abundance	Trend	Abundance
<i>California quail</i>				
California	0.1	7.73	1.9	7.96
Oregon	-3.6	4.19	7.2	3.32
Washington	-0.6	2.10	2.8	2.10
Dissected Rockies	2.1	1.66	11.6	1.63
Pitt-Klamath Plateau	2.4	3.90	3.1	4.32
Columbia Plateau	-5.0	4.06	4.1	3.42
Southern California Grasslands	5.3	21.30	-5.7	20.47
Central Valley	2.2	3.79	-6.9	3.07
California Foothills	-0.5	19.65	3.9	19.71
Southern Pacific Rainforests	-0.7	4.41	-0.2	3.63
Continental	0.0	3.00	3.2	3.04
<i>Scaled quail</i>				
New Mexico	-4.0**** ^a	6.73	-11.0***	5.72
Texas	-3.9***	9.17	-7.6*	7.45
Staked Plains	-3.5	8.97	-8.6***	16.64
Chihuahuan Desert	-4.4***	20.99		
Continental	-3.8***	5.91	-8.2***	5.17
<i>Gambel's quail</i>				
Arizona	0.5	17.16	-3.3	25.53
California	1.9	3.09		
New Mexico	0.5	4.63		
Sonoran Desert	0.4	28.21	-0.3	26.22
Continental	0.6	5.87	-4.6***	9.09
<i>Mountain quail</i>				
California	1.3	5.00	-0.6	5.11
Oregon	1.0	0.57		
Sierra Nevada	-0.6	9.75	-0.8	10.89
Pitt-Klamath Plateau	1.9	1.06		
Southern California Grasslands	1.8	5.04	0.2	4.82
Southern Pacific Rainforests	1.0	1.38	0.6	1.26
Continental	1.1	2.81	-0.4	2.86

^a* = $P < 0.10$, *** = $P < 0.01$.

Panhandle based on covey counts in the mid-1950's and early 1990's. Kilbride et al. (1992) indicated California quail populations in Oregon have been stable since the early 1960's.

Our data indicate declining populations of bobwhite may be due to factors affecting all grassland/shrub birds. The factor most often identified as affecting population trends is habitat change. States in the central portion of the bobwhite's range, where forestry and farming practices have greatly altered habitat conditions, show the greatest number of declining species. In addition, the 6 passerines declining in the most regions are, like the bobwhite, relatively intolerant of urban landscapes. Land-use changes like urban sprawl could in part be responsible for

the decline of numerous species over a large geographic area.

Predators have long been recognized as major causes of mortality in bobwhite (Errington 1934, Beasom 1974). Great horned owls and red-tailed hawks are widely distributed predators exhibiting increasing populations where bobwhite are decreasing. Petersen et al. (1988:183) reported similar trends between these predators and pheasant populations. Furthermore, they noted: "Predation on pheasants [by red foxes, great horned owls, and red-tailed hawks] apparently has increased since the 1940's, most notably since 1960" (Petersen et al. 1988:191). Our data are not sufficient to allow us to conclude that declines in bobwhite populations are due to increased avian

Table 3. Proportion of declining populations among 13 passerines sympatric with northern bobwhite, 1966-91.

State	<i>n</i> ^a	<i>n</i> declining (%)	Bobwhite trend (%/year)
Alabama	10	8 (80)	-3.0*** ^b
Arkansas	11	10 (91)	-2.4***
Florida	8	5 (62)	-2.5**
Georgia	11	8 (73)	-3.5***
Illinois	8	7 (88)*	-3.3**
Indiana	8	5 (62)	-2.3**
Iowa	7	6 (86)	-4.1***
Kansas	10	8 (80)	-1.9
Kentucky	10	8 (80)	-2.2***
Louisiana	11	6 (55)	-5.3***
Maryland	8	8 (100)*	-4.0***
Massachusetts	7	3 (43)	-10.9**
Michigan	7	3 (43)	-10.7**
Mississippi	10	8 (80)	-3.9***
Missouri	11	10 (91)*	-0.8
Nebraska	7	4 (57)	-0.6
New Jersey	8	5 (62)	-5.2***
New York	8	5 (62)	-6.4***
North Carolina	9	6 (67)	-3.6***
Ohio	8	5 (62)	-7.1***
Pennsylvania	8	6 (75)	-11.0***
South Carolina	8	6 (75)	-4.4***
Tennessee	10	10 (100)*	-3.1***
Virginia	9	6 (67)	-3.1***
West Virginia	9	8 (89)*	-5.3
Wisconsin	6	3 (50)	5.5**

^aSpecies included in the analysis (field sparrow [*Spizella pusilla*], indigo bunting [*Passerina cyanea*], loggerhead shrike [*Lanius ludovicianus*], brown thrasher [*Toxostoma rufum*], Bewick's wren [*Thryomanes bewickii*], Bachman's sparrow [*Aimophila aestivalis*], gray catbird [*Dumetella carolinensis*], northern cardinal [*Cardinalis cardinalis*], yellow-breasted chat [*Icteria virens*], American goldfinch [*Carduelis tristis*], painted bunting [*Passerina ciris*], prairie warbler [*Dendroica discolor*], and scissor-tailed flycatcher [*Tyrannus forficatus*]) that were observed along the same routes as northern bobwhite.

^b* = proportion different ($P < 0.10$) than expected by chance (50%), ** = $P < 0.05$, *** = $P < 0.01$.

Table 4. Population trends in physiographic strata for passerines and predators sympatric with declining populations of northern bobwhite, 1966-91.

Species	<i>n</i> strata compared	<i>n</i> strata with declining populations (%)
<i>Passerines</i>		
Gray catbird	20	12 (60)
Brown thrasher	23	20 (87)* ^a
Prairie warbler	12	12 (100)*
Yellow-breasted chat	17	14 (82)*
Northern cardinal	25	14 (56)
Field sparrow	21	18 (86)*
Loggerhead shrike	14	12 (86)*
Indigo bunting	22	16 (73)*
American goldfinch	20	13 (65)
<i>Predators</i>		
Red-tailed hawk	23	3 (13)*
Great horned owl	21	6 (29)*

^a* = proportion different ($P < 0.10$) than expected by chance (50%).

predation, but they are consistent with Petersen et al.'s hypothesis for pheasant.

CONCLUSIONS

Quail populations in the east and central portions of North America are experiencing long-term declines that have been greater over the past decade. In contrast, quails in the western part of the continent are generally stable. It is noteworthy that there were too few observations of Montezuma quail (*Cyrtonyx montezumae*) along BBS routes for analysis. We encourage potential volunteers (e.g., state biologists) in the range of Montezuma quail to gather BBS data. In addition, we suggest state conservation agencies consider special population monitoring strategies (e.g., harvest surveys) for this species.

Our analysis of a grassland/shrub guild provides an alternative to conventional single-species approaches to habitat analysis. Although

none of these species completely match the life history characteristics of quail, it appears bobwhite may be a good indicator of wildlife-habitat interactions in grassland/shrub ecosystems (Farmer et al. 1988, Hays and Farmer 1990).

Quail are 1 of the most studied and intensively managed taxonomic groups of wildlife (Church and Taylor 1992). As a result, resource managers have assumed that our understanding of quail biology is relatively complete. However, our results indicate there is reason to question the efficacy of current management practices for bobwhite and scaled quail. Thus we support the design and implementation of a comprehensive approach to management and research at a national level such as outlined in Brennan (1993b).

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