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Nest and Brood Site Characteristics of Mountain Quail in West-Central Idaho

Abstract

Mountain quail populations across the interior Pacific Northwest have declined substantially and information on their reproductive habitats is largely unavailable. Our study provides information on nest and brood-rearing habitats used by mountain quail in west-central Idaho. During 1992 and 1995 we located radio-marked mountain quail in the Little Salmon River drainage, Idaho and measured habitat components at nest sites and brood locations at macrohabitat and microhabitat scales. We examined microhabitat vegetation at overstory (>3 m), understory (0.5–3 m), and ground cover (<0.5 m) levels. At the macrohabitat scale, 71% of nests were located in open-canopied, conifer-shrub cover types, while broods were observed using a wider variety of shrub cover types. Mallow ninebark, black hawthorn, common snowberry, Saskatoon serviceberry, and wild rose were important shrubs in nest and brood microhabitat understory. Analyses incorporating macro- and microhabitat variables revealed that mountain quail used habitat components at nest and brood locations in response to yearly conditions. There was 1.6-times more cumulative summer precipitation in 1995, a wetter than average year, than in 1992, a drier than average year. During the dry year, quail apparently relied more on the structure provided by woody communities to rear broods when herbaceous ground cover was limited. Conservation and enhancement of large contiguous areas of shrubby and conifer-shrub communities near streams and in riverine canyons is of utmost importance in promoting population productivity and restoration of mountain quail populations in the interior Pacific Northwest.

Introduction

Mountain quail (*Oreortyx pictus*) are the most northerly distributed North American quail, and inhabit a diversity of shrub-dominated communities across their range (Gutiérrez and Delehanty 1999). They are currently found from the Baja Peninsula in Mexico, north to Vancouver Island in British Columbia, and east to west-central Idaho and northern Nevada (Gutiérrez and Delehanty 1999, Crawford 2000). The historical range of mountain quail may have been limited northward by the Columbia River (Crawford 2000). Although poorly documented, translocations during the 19th century established populations in Washington, British Columbia, western Idaho, and northeastern Oregon (Aldrich and Duvall 1955, Crawford 2000), and probably in central, northern, and western Nevada (Aldrich and Duvall 1955, Johnsgard 1973). Archaeological evidence suggests mountain quail are native to Idaho (Gruhn 1961, Murphey 1991) and it is likely that translocations augmented many indigenous populations (Vogel and Reese 1995) or repopulated areas where populations became extinct prior to European settlement (Crawford 2000).

Populations of mountain quail in Idaho have declined considerably over the past several decades and are currently restricted to the Little Salmon River, and small portions of the lower Salmon and Snake rivers and the Boise River drainage (Murray 1938, Ormiston 1966, Robertson 1989, Vogel and Reese 1995, Crawford 2000). Mountain quail habitat in Idaho consists primarily of shrubby draws along creeks and in river breaks (Ormiston 1966). Limited availability of shrubby habitats within a matrix of grasslands and forests restricts mountain quail in many interior populations to narrow strips, rather than broad expanses of mountain shrub habitat common in populations west of the Sierra-Cascade Crest (Brennan 1990). Critical factors affecting habitat and that ultimately may be responsible for the decline of mountain quail in Idaho include: (1) loss of wintering areas along creeks and in riparian shrub communities due to development of hydroelectric dams along the Snake River and tributaries, (2) agricultural development along the Snake River corridor, and (3) excessive cattle grazing that degrades creek-side shrub communities (Brennan 1990, 1994). Road building, ranchettes, and housing developments in and near shrubby draws, and accompanying activities including predation by dogs and cats, are additional concerns leading to

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further fragmentation and degradation of mountain quail habitat in Idaho (Odell and Knight 2001, Maestas et al. 2003).

Male and female mountain quail form monogamous pair bonds with males commonly participating in uniparental incubation and brood rearing (Heekin 1993; Delehanty 1995, 1997; Pope and Crawford 2001). Mountain quail exhibit a behavior singular among North American quail by migrating across elevational gradients to access seasonal habitats (Pope 2002). In summer, mountain quail often use conifer habitats on steep slopes at higher elevations and with thick shrub understories (Edminster 1954, Gutiérrez 1980). In winter, mountain quail may migrate to more open shrub cover at lower elevations (Edminster 1954). Mountain quail nests are typically concealed by herbaceous vegetation near protective shrub or tree cover (Gutiérrez and Delehanty 1999); however, mountain quail will nest in relatively open areas (Michael D. Pope, Oregon State University, personal communication). Much of the literature available on reproductive habitats used by mountain quail is anecdotal and empirical studies on nesting and brooding habitats across the range of mountain quail are needed (Gutiérrez and Delehanty 1999, Pope 2002). The secretive nature of mountain quail and the rugged, densely vegetated terrain they inhabit may account for the lack of studies (Gutiérrez and Delehanty 1999).

The success of mountain quail restoration efforts will be enhanced by knowledge of key habitat components, including characteristics of nesting and brood-rearing habitat. We predicted that mountain quail nest and brood habitat characteristics reflect general requirements for the species, with specific distinctions apparent at selection scales. Our objectives were to (1) evaluate mountain quail nest sites and brood locations at macrohabitat and microhabitat scales, (2) explore habitat relationships between nest sites and brood locations, and (3) discuss how a better understanding of reproductive habitats may be applied to conservation and management of mountain quail in the interior Pacific Northwest.

Study Area

Our study area (45° 17' N, 116° 22' W) encompassed nearly 2,200 ha south of Riggins, Idaho along the Little Salmon River and its tributaries. Elevations ranged from 716 to 1,537 m with topography characterized by steep, dissected slopes with basaltic outcrops and ridges. Climatic data were obtained from a weather station in Riggins, Idaho situated at 549 m (Western Regional Climate Center 2004). Average monthly temperatures from April through September were 19.1°C in 1992 and 17.3°C in 1995. Average temperatures were 3% warmer and 7% cooler in 1992 and 1995, respectively, than the 30-year (1971–2000) average of 18.5°C. April through September cumulative precipitation was 18.7 cm in 1992 and 30.0 cm in 1995, corresponding to 18% less and 32% more cumulative precipitation, respectively, than the 22.8 cm, 30-year average.

Common shrubs in small draws and on mesic north-facing slopes were black hawthorn (*Crataegus douglasii*), chokecherry (*Prunus virginiana*), common snowberry (*Symphoricarpos albus*), currant (*Ribes* spp.), mallow ninebark (*Physocarpus malvaceus*), and wild rose (*Rosa* spp.). Common shrubs along stream bottoms, and near springs and seeps included aspen (*Populus tremuloides*), blue elderberry (*Sambucus cerulea*), and red-osier dogwood (*Cornus sericea*). Saskatoon serviceberry (*Amelanchier alnifolia*) was found on dry upland sites and oceanspray (*Holodiscus discolor*) and mallow ninebark typically grew under conifers. Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) occurred along the Little Salmon River. Grasses inhabiting xeric, south-facing slopes included bluebunch wheatgrass (*Pseudoroegneria spicata*), cheatgrass (*Bromus tectorum*), Idaho fescue (*Festuca idahoensis*), and prairie junegrass (*Koeleria macrantha*). Ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*) occupied mesic and higher elevation sites.

Most of the study area was privately owned, with homesteads or small ranches situated in bottomlands and on benches. Smaller amounts of land were owned and managed by the Bureau of Land Management (BLM) and U.S. Forest Service (USFS). Predominant land uses in the area and on surrounding USFS lands were livestock grazing and logging.

Methods

Trapping and Radio-Tracking

To trap quail we used modified, rectangular, Stoddard quail traps (Shultz 1950, Gooden 1953, Smith et al. 1981) and circular traps placed under shrubs. All traps had 1 or 2 funnel openings, and were baited with mixed grains and seeds consisting of cracked corn, wheat screenings, Austrian pea screenings, black sunflower seeds, milo, and millet. All traps included soft, net tops to prevent injury to captured quail. We trapped birds from mid-January through mid-March, 1992 and 1995. We recorded age, sex, and mass for each bird and fitted birds with a size 4 aluminum leg-band. We classified quail as juvenile or adult based on plumage characteristics (Leopold 1939). In 1992 we used the standard technique to sex mountain quail based on hind-neck coloration (McLean 1930), but we found it impossible to sex some birds according to this technique. In 1995 we determined sex genetically from blood extracted from a medial metatarsal vein (Longmire et al. 1993, Delehanty et al. 1995).

We equipped quail captured in 1992 with a poncho-mounted, solar-powered radio transmitter (Advanced Telemetry Systems, Inc., Isanti, Minnesota) or a necklace-mounted, battery-powered radio transmitter (Holohil Systems Ltd., Woodlawn, Ontario, Canada; Pyrah 1970, Amstrup 1980). We equipped all quail captured in 1995 with necklace-mounted transmitters. The radio transmitter/poncho combination and necklace-mounted transmitters weighed <4% (7.1 g) and <2% (3.4 g), respectively, of the body mass of males and females (Reese, unpublished data).

We relocated quail once or twice per week with radiotelemetry from March through September in 1992 and 1995. Universal Transverse Mercator coordinates were recorded from USGS 1:24,000 topographical maps at nest and brood locations. We identified nest sites by observing incubating radio-marked birds on nests or flushing radio-marked incubating birds from nests. To reduce disturbance, we returned to sample habitat characteristics following hatching. To locate brood locations, we circled within 2–5 m of radio-marked adult quail with broods during the June through September brood-rearing season. We only sampled brood locations for broods that did not flush or move. The plot center for broods that did not flush or move was the location where the adult quail was first observed.

Nest Site and Brood Location Habitat Evaluation

We evaluated habitat at mountain quail nest sites and brood locations at the macrohabitat (across cover types) and microhabitat (within cover types) scales (Brennan et al. 1987). Microhabitat vegetation at nest and brood locations was examined at 3 levels: overstory (>3 m), understory (0.5–3 m), and ground cover (<0.5 m). Macrohabitat variables we recorded at each location included cover type, degrees aspect, elevation, percent slope, and distance to nearest water source (seep, spring, creek, or river). To maintain a small number of categories representative of the study area, we characterized cover types as conifer-shrub, grass-scattered shrub, hay fields, mountain shrub, residential (residential landscaping in Pollock, Idaho), and riparian-shrub. We approximated elevation and distance to nearest water source from topographical maps and aerial photos. We measured aspect and slope with a compass and clinometer and categorized aspects as: N–E = 0–90°; E–S =91–180°; S–W = 181–270°; and W–N = 271–359°.

We placed four 8-m tapes in the cardinal directions from the center of each nest depression and brood location to establish a 0.02 ha microhabitat plot. At the microhabitat overstory level we recorded percent overstory canopy closure and diameter-at-breast-height (dbh) of trees. Microhabitat understory variables we recorded were percent cover of shrub and tree species, height (cm) of tallest and shortest shrubs, and visual obstruction. At the microhabitat ground cover level we recorded percentages of ground cover classes and ecological condition. We evaluated ecological conditions at each location according to 4 categories provided in BLM guidelines relative to erosion conditions and percentage of vegetation species at each location considered to be late successional: poor (0–25%), fair (26–50%), good (51–75%), and excellent (76–100%; Bureau of Land Management 1979).

We estimated canopy closure by averaging densiometer measurements at plot centers and at the 8-m points of each tape (Lemmon 1957, Strickler 1959). We measured dbh of trees nearest to the nest or brood plot center and those nearest 4-m and 8-m points along each tape with a logger tape. We recorded percent cover of shrubs and trees intercepting tapes to estimate understory canopy cover (Canfield 1941). We computed species richness for all shrubs and trees encountered along intercept tapes and report mean percent canopy cover (± SE) for those species occurring at ≥5 nest and/or brood locations. We defined shrub species considered important to mountain quail at nest and brood locations as those where mean coverage was ≥5%. We recorded species of the tallest and shortest shrub nearest the plot center and nearest the 4-m points along each tape, measured heights of these shrubs with a meter stick, and then averaged these heights for each plot. We measured visual obstruction in decimeter increments up to 1.5 m with a Robel pole (Robel et al. 1970) placed in the center of each plot with obstruction recorded from each 4-m point along tapes. We visually estimated percent ground cover for bare ground, herbaceous vegetation, litter, rock, and woody debris in 0.5-m × 0.5-m quadrats (Bonham 1989) placed at 9 points: at plot centers, at 2-m points, and at 4-m points along 8-m each tape. We calculated averages for each ground cover category from these 9 quadrats at each location.

Statistical Analyses

We used univariate and multivariate statistics to evaluate habitat characteristics and assess differences between nest sites and brood locations. We assessed the strength of the relationship in relative frequencies of shrub and tree species at nest sites and brood locations with a Spearman's rank correlation (r_s; Proc CORR; SAS Institute 2001). We used independent sample *t*-tests on raw data to test for differences in habitat variables at quail nest sites and brood locations (Proc TTEST; SAS Institute 2001). We evaluated equality of variances with the Folded F method and used the Satterthwaite (1946) method to calculate *t*-values in those instances where variances were unequal. The Satterthwaite statistic is an approximate *t* statistic, and is used if the population variances of two groups are unequal. We computed degrees of freedom for this statistic with the Satterthwaite (1946) approximation.

We removed bare ground, litter, and rock from our ground cover data set to account for the unit sum constraint (i.e., data sum to 1) inherent in compositional data prior to multivariate analyses. Furthermore, these 3 components typically represented the smallest proportion of ground cover. We did not include aspect and dbh in multivariate analyses because aspect is a categorical variable and dbh was not readily measurable in all microhabitat plots. We transformed some variables after assessing all variables for normality and equal variance with appropriate plots (Proc UNIVARIATE; SAS Institute 2001). We assessed collinearity in the remaining set of continuous variables with a Pearson correlation matrix and determined that no pair of variables was highly correlated ($r < 0.60$; Proc CORR; SAS Institute 2001). We used a multivariate analysis of variance (MANOVA; Proc GLM; SAS Institute 2001) with year and site (nest or brood) as single main effects and the year × site interaction to evaluate differences between yearly nest site and brood location selection to justify pooling data across the 2 years of our study (Schooley 1994).

We used principal components analysis (PCA) on the habitat variable correlation matrix to reduce the dimensionality and identify meaningful underlying variables in our set of habitat variables. We selected the first 3 principal components (PC) to interpret our data matrix because they provided a balance between interpretability of results and the amount of variability explained (Johnson 1998). We relativized our habitat variable matrix by column maximums to reduce large coefficients of variation between habitat variables. We plotted PC scores for each nest site and brood location on PC axes according to years to assess whether each group could be placed in different dimensional spaces.

We used a non-parametric, multi-response permutation procedure (MRPP; Biondini et al. 1985, Zimmerman et al. 1985), to test the hypothesis of no difference between yearly nest and brood groups. We used the Euclidean distance and natural weighting formula for the MRPP algorithm to calculate mean within-group distances (Mielke 1984). The MRPP provided a test statistic (*T*), similar to a *t*-test, that describes separation between groups, and a corresponding *P*-value to determine how likely the observed difference between nests and brood locations was due to chance. It also provided a description of effect size, referred to as the chance-corrected within-group agreement statistic (*A*), which is independent of sample size. The within-group agreement statistic equals 1 when all observations are identical within groups, 0 when heterogeneity equals that expected by chance, and <1 when there is more heterogeneity within groups than expected by chance. We conducted PCA and MRPP in PC-ORD software, version 4.07 (McCune and Mefford 1999). All reported estimates are mean ± SE, unless otherwise noted. We set statistical significance at $P = 0.05$ before our research began.

Results

We trapped 66 quail in 1992 and 46 in 1995; of these quail, we placed radio transmitters on 42 in 1992 and 30 in 1995. No quail captured in 1992 was recaptured in 1995. We evaluated characteristics at 21 nest sites (11 in 1992 and 10 in 1995) and 16 brood locations (9 in 1992 and 7 in 1995). Two broods incidentally located in 1992 were included in our analysis. Of the nests, 12 (57%) were incubated by females, 5 (24%) by males, and 4 (19%) by birds of unknown gender. Eight (50%) broods were attended by females, 4 (25%) by males, and 4 (25%) by birds of unknown gender. In 1992 we identified 6 females, 1 male, and 4 birds of unknown gender on nests, and 4 females, 1 male, and 4 birds of unknown gender with broods. Our inability to identify gender of all birds in 1992 precluded us from evaluating differences between male and female nest and brood characteristics that year.

In 1995 we identified 6 females and 4 males on nests. In 1995, males nested closer to water (44 ± 15 m; $t_8 = 2.33$, $P = 0.048$) than females (143 ± 33 m) and in areas with greater canopy closure (59 ± 2%; $t_8 = -2.67$, $P = 0.028$) than females (38 ± 6%). In 1995 we observed 4 broods attended by females and 3 broods with males. Males selected brood habitat in areas with more bare ground (5.2 ± 0.7%; $t_5 = -3.61$, $P = 0.015$) than females (2.2 ± 0.5%).

We did not observe mountain quail nesting in grass-scattered shrub, hay fields, or residential cover types. Fifteen (71%) nests were located in conifer-shrub, 4 (19%) in mountain-shrub, and 2 (10%) in riparian-shrub. Seven (44%) broods were located in conifer-shrub cover, 5 (31%) in mountain shrub, 3 (19%) in grass-scattered shrub, and 1 (6%) in riparian-shrub. No broods were observed in hay fields or residential cover types.

Fourteen nests (67%) were on N–E aspects, 3 each (14%) on E–S and W–N aspects, and 1 (5%) on S–W aspects. Eight broods (50%) were located on N–E aspects, 3 each (19%) on E–S and S–W aspects, and 2 (12%) on W–N aspects. Average aspect at mountain quail broods in both years and at nests in 1992 was southeasterly; average aspect at nests switched to northeasterly in 1995 (Table 1). In both years, litter ground cover was significantly higher at nests than at brood locations and woody debris ground cover was significantly less at nests than at brood locations (Table 1).

We reduced our set of habitat variables to distance to water, elevation, slope, canopy closure, tallest shrub, shortest shrub, visual obstruction, herbaceous ground cover, and woody debris ground cover. Natural log transformations of distance to water, tallest shrub, and visual obstruction and arcsine square root transformations of herbaceous and woody debris ground cover proportions normalized these variables and homogenized variances. Results from MANOVA indicated no differences in site and the site × year interaction, but demonstrated a difference between years (Wilk's $\Lambda = 0.19$, $F_{9,25} = 12.19$, $P < 0.001$), which precluded pooling 1992 and 1995 data. Univariate ANOVAs indicated yearly differences in elevation ($F_{1,33} = 14.95$, $P < 0.001$) and herbaceous ground cover ($F_{1,33} = 88.38$, $P < 0.001$). A univariate ANOVA for site indicated that canopy closure was higher in 1992 and 1995 at nests than at brood locations ($F_{1,33} = 4.52$, $P = 0.041$; Table 1).

The first 3 eigenvalues in our PCA analysis were greater than 1 and accounted for 56.1% of the total variation explained by the variables in the nest and brood PCA. The first axis had the largest eigenvalue (2.407) accounting for 26.7% of the total variation, followed by the second axis (eigenvalue = 1.489; 16.6% of variation), and the third axis (eigenvalue = 1.152; 12.8% of variation). Results from MRPP indicated that heterogeneity within the 4 groups was equal to chance alone ($T = -6.52$, $A = 0.087$, $P < 0.001$), suggesting that groups were best interpretable on a case-by-case basis. Nest and brood PCA scores plotted by years along the first and second PC axes indicated that year most influenced nest sites and brood locations along axis gradients (Figure 1). Nests and broods were more similar in 1992 and 1995 to each other than when considered as unique groups (Figure 1).

Elevation ($r = -0.83$) was the only macrohabitat variable highly correlated with the first PC axis (Table 2). Nests and broods were located at higher elevations in 1995 than in 1992 (Table 1), which is reflected in separation of groups along PC axis 1 (Figure 1). Of the microhabitat overstory variables, canopy closure was highly correlated with the first PC axis ($r = 0.58$; Table 2). Canopy closure was higher in 1992 than in 1995 at nests and broods (Table 1). At the microhabitat understory level, visual obstruction ($r = 0.58$) was highly loaded on the first PC axis (Table 2). Broods were found in areas with less visual obstruction in 1995 than in

TABLE 1. Mean habitat characteristics at mountain quail nest sites (1992, $n = 11$; 1995, $n = 10$) and brood (1992, $n = 9$; 1995, $n = 7$) locations, Little Salmon River, Idaho. Independent sample *t*-tests evaluated differences between nest and brood locations.

Habitat variables	Year	Nests	Broods	***t***	*df*	P
Macrohabitat						
Aspect (°)	1992	154 ± 45	140 ± 39	-0.22	18	0.825
	1995	78 ± 18	148 ± 38	1.85	15	0.084
Elevation (m)	1992	1,002 ± 59	950 ± 51	-0.64	18	0.528
	1995	1,148 ± 40	1,193 ± 26	0.84	15	0.411
Slope (%)	1992	58 ± 9	42 ± 3	-1.71	11.6	0.113
	1995	45 ± 6	37 ± 6	-0.88	15	0.393
Water (m)	1992	219 ± 58	168 ± 64	-0.60	18	0.559
	1995	104 ± 26	140 ± 41	0.79	15	0.442
Microhabitat overstory						
Canopy closure (%)	1992	62 ± 8	43 ± 9	-1.62	18	0.122
	1995	46 ± 5	33 ± 8	-1.50	15	0.153
dbh (cm)	1992	23.9 ± 10.8	0.0 ± 0.0	-2.21	10	0.052
	1995	16.4 ± 6.4	11.0 ± 5.4	-0.61	15	0.552
Microhabitat understory						
Shortest shrub (cm)	1992	30.2 ± 5.0	31.0 ± 6.2	0.10	18	0.920
	1995	71.7 ± 47.5	40.0 ± 10.4	-0.65	9.85	0.529
Tallest shrub (cm)	1992	163.9 ± 25.3	136.5 ± 26.6	-0.74	18	0.467
	1995	191.7 ± 41.2	203.3 ± 56.5	0.17	15	0.868
Visual obstruction	1992	4.2 ± 0.8	5.5 ± 1.1	1.00	18	0.333
	1995	4.0 ± 0.7	2.2 ± 0.5	-1.93	15	0.073
Microhabitat ground cover						
Bare ground (%)	1992	6.7 ± 1.9	5.4 ± 1.6	-0.50	18	0.627
	1995	7.1 ± 2.8	3.5 ± 0.7	-1.25	10.1	0.239
Herbaceous (%)	1992	13.9 ± 2.8	12.9 ± 4.9	-0.18	18	0.862
	1995	52.2 ± 4.3	57.9 ± 4.5	0.88	15	0.395
Litter (%)	1992	66.1 ± 5.3	9.4 ± 3.9	-8.25	18	< 0.001
	1995	30.4 ± 3.8	12.0 ± 2.9	-3.55	15	0.003
Rock (%)	1992	0.2 ± 0.2	10.8 ± 5.3	1.98	8.01	0.082
	1995	2.7 ± 2.1	1.0 ± 0.8	-0.78	11.3	0.450
Woody debris (%)	1992	12.0 ± 2.6	60.6 ± 5.7	8.29	18	< 0.001
	1995	12.7 ± 2.5	30.8 ± 6.0	3.13	15	0.007

1992. Tallest shrub ($r = 0.84$) was the only habitat variable highly correlated with PC axis 2 (Table 2). Tallest shrubs in nest and brood microhabitat plots were taller in 1995 than in 1992 (Table 1; Figure 1). Shortest shrubs ($r = -0.73$) in microhabitat plots was the only habitat variable highly correlated with PC axis 3 (Table 2). Shortest shrubs in nest and brood microhabitat plots were taller in 1995 than in 1992 (Table 1).

We identified 20 shrub or tree species as well as ponderosa pine slash and dead shrubs at mountain quail nest and brood locations (Table 3). Mean shrub species richness at nests was 5.6 (range = 0–10) and at brood locations was 5.2 (range = 1–8). Eighteen shrub and tree species as well as dead shrubs and ponderosa pine slash were observed at nests and 14 shrub and tree species as well as dead shrubs were observed at brood locations (Table 3). Relative frequency of shrub and tree species at mountain quail nest and brood locations was strongly correlated ($r_s = 0.73$, $n = 22$, $P < 0.001$; Table 3). Nine shrub species as

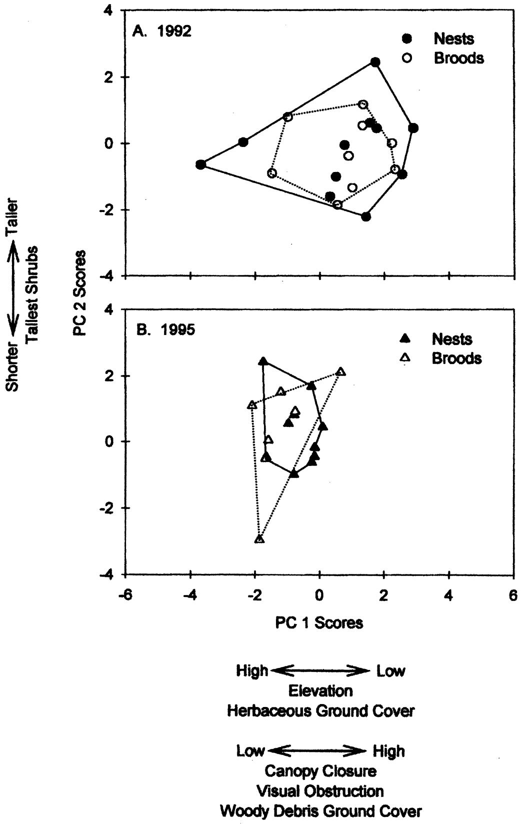

Figure 1. Ordination of principal component scores for mountain quail nest sites and brood locations along the first 2 principal component axes, Little Salmon River, Idaho, 1992 (A) and 1995 (B).

TABLE 2. Pearson correlation coefficients for habitat variables at mountain quail nest sites and brood locations with the first 3 principal component axes, Little Salmon River, Idaho, 1992 and 1995.

Habitat variables	PC1	PC2	PC3
Macrohabitat			
Elevation (m)	-0.83*	0.05	-0.26
Slope (%)	0.48	-0.48	-0.33
Water (m)[1]	-0.29	-0.44	-0.17
Microhabitat overstory			
Canopy closure (%)	0.58*	0.29	0.41
Microhabitat understory			
Shortest shrub (cm)	0.26	0.23	-0.73*
Tallest shrub (cm)[4]	0.07	0.84*	-0.22
Visual obstruction[5]	0.58*	0.22	-0.29
Microhabitat ground cover			
Herbs (%)[2]	-0.61*	0.06	-0.25
Woody debris (%)[3]	-0.55*	0.40	0.22

*Correlation coefficients $r \geq 0.55$ indicating habitat variables highly correlated with respective principal component axes.

[1] Natural log of distance to nearest source of water (m).

[2] Arcsine square root of proportion of herbaceous vegetation ground cover.

[3] Arcsine square root of proportion of woody debris ground cover

[4] Natural log of tallest shrubs (cm) in microhabitat plots.

[5] Natural log of Robel pole measurements from microhabitat plot centers.

well as dead shrubs occurred at ≥5 nest site and brood locations. No shrub exceeded a mean of 20% canopy coverage at nests or broods (Figure 2). Mallow ninebark was highest in coverage at nest sites. Other important shrubs at nests were black hawthorn, common snowberry, dead shrubs, Saskatoon serviceberry, and wild rose. Six shrubs were considered important at brood locations. Dead shrubs were highest in coverage at brood locations and other important shrubs were black hawthorn, common snowberry, currant, Saskatoon serviceberry, and wild rose (Figure 2).

Both microhabitat ground cover variables, herbaceous (r = -0.61) and woody debris (r = -0.55), had high loadings on the first PC axis (Table 2). Nests and broods were located in areas with higher herbaceous ground cover in 1995 than in 1992. Woody debris at nests was essentially equal between years, while broods in 1992 were in areas with nearly 2-fold greater woody debris ground cover than in 1995 (Table 1). Ecological condition, recorded at 20 nests, was poor at 6 nests (30%), fair at 4 (20%), good at 4 (20%), and excellent at 6 (30%). Ecological condition was poor at 4 brood locations (29%), fair at 5 (36%), good at 3 (21%), and excellent at 2 (14%).

Discussion

Cover types used by mountain quail for nesting and brood-rearing were quite similar. Although some broods were found in grass-scattered shrub cover, most brood locations were in shrubby communities (81%). Mountain quail habitat suitability models suggest water is an important variable to include in habitat models (Brennan et al. 1986, Brennan 1991). In our study, distance to water was not significantly different between nests and broods in univariate or multivariate analyses. Mountain quail nested closer to water in northeastern Oregon

TABLE 3. Relative frequency (%) of shrub and tree species located in mountain quail nest (n = 21) and brood (n = 16) microhabitat plots, Little Salmon River, Idaho, 1992 and 1995.

Common name	Scientific name	Relative frequency (%) Nests	Relative frequency (%) Broods
Apple	*Malus* spp.	0	6
Birch-leaf spiraea	*Spiraea betulifolia*	5	0
Bittercherry	*Prunus emarginata*	10	0
Black hawthorn	*Crataegus douglasii*	38	50
Blue elderberry	*Sambucus cerulea*	14	6
Chokecherry	*Prunus virginiana*	29	31
Common snowberry	*Symphoricarpos albus*	86	63
Currant	*Ribes* spp.	33	69
Dead shrubs		24	50
Douglas fir	*Pseudotsuga menziesii*	14	0
Mallow ninebark	*Physocarpus malvaceus*	67	31
Oceanspray	*Holodiscus discolor*	29	0
Ponderosa pine	*Pinus ponderosa*	19	6
Ponderosa pine slash		19	0
Redosier dogwood	*Cornus sericea*	0	6
Rocky Mountain maple	*Acer glabrum*	29	19
Saskatoon serviceberry	*Amelanchier alnifolia*	43	69
Subalpine fir	*Abies lasiocarpa*	5	0
Syringa	*Philadelphus lewsii*	19	19
Thimbleberry	*Rubus parviflorus*	5	0
Western poison ivy	*Toxicodendron rydbergii*	5	6
Wild rose	*Rosa* spp.	67	88

where breeding and winter ranges overlapped than in southwestern Oregon where shrubby communities were more extensive (Pope 2002). Proximity to water in our study area may be an artifact of quail selecting shrubby communities that are associated with water to nest and rear young. These shrubby habitats are used intensively due to their limited availability and because they provide food, hiding cover, roost sites, and thermal protection. Mountain quail are known to range up to 3.2 km from water (MacGregor 1950) and galliform birds obtain water from food metabolism, succulent vegetation, dew, and free water (Payne and Bryant 1998), suggesting frequent use of shrubby communities in proximity to water does not reflect water requirements.

The relative frequency and richness of shrub and tree species at nest sites and brood locations was very similar. Mallow ninebark provided more nesting cover than other shrubs, while dead shrubs, black hawthorn, and common snowberry were particularly important sources of cover for broods. Most mountain quail nests in northeastern Oregon were found in conifer forests with understories dominated by mallow ninebark and common snowberry or in mallow ninebark-shrub communities (Pope 2002), similar to our study where mountain quail typically nested in open-canopy ponderosa pine with a ninebark understory.

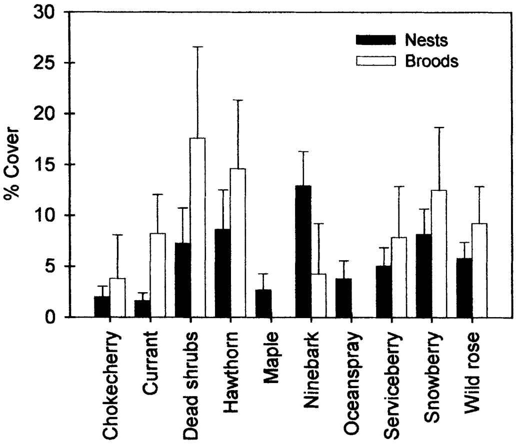

Figure 2. Percent shrub cover (mean ± SE) at mountain quail nest sites and brood locations, Little Salmon River, Idaho. Cover was averaged across 1992 and 1995 and represents estimates for woody species found at 5 or more nest sites or brood locations. Important shrub species at nest sites and brood locations are those where mean coverage was ≥5%.

Our results suggest that mountain quail nest and brood site selection patterns reflected annual conditions related to weather patterns. April through September cumulative precipitation at the Riggins weather station was 1.6-times higher in 1995 than in 1992 and mean monthly temperatures from April through September were 9.4% cooler in 1995 than in 1992 (Western Regional Climate Center 2004). In addition, cumulative precipitation was substantially less in 1992 and greater in 1995 than 30-year average weather patterns. Vegetative standing crop responds strongly to increased precipitation in arid regions (Barbour et al. 1987). In our study herbaceous standing crop likewise responded to wetter and cooler weather in 1995. This provided mountain quail greater availability of herbaceous ground cover at higher elevations to nest and rear broods than in 1992, a warm and dry year. Visual obstruction at nests was equal between years, but it was 2.5-times higher at brood locations in 1992 than in 1995. Quail may have relied on areas with higher levels of woody cover to rear broods in 1992 in the absence of a strong herbaceous ground cover component. The shortest shrubs, as our PCA demonstrated, were also important in yearly selection patterns, with shortest shrubs being taller in 1995 than in 1992 at nests and broods.

As predicted, we found more differences between nests and broods at the microhabitat scale than at the macrohabitat scale. Although we detected no significant differences in canopy closure between nests and broods, nests had higher canopy coverage than broods at the microhabitat overstory level. Height of tallest and shortest shrubs and visual obstruction were the most important microhabitat characteristics at the understory level. However, differences were related to years, and not between nests and broods. At ground level, woody debris was higher at brood locations than nests, while herbaceous litter was lower at brood locations that at nests. Material at nest bowls in our study area was composed primarily of ponderosa pine needles and dead grass (Heekin et al. 1994). Similarly, mountain quail on the eastern slope of the Sierra Nevada nested in areas with abundant plant litter including pine needles, grass, and dried leaves (Miller 1967).

Quail inhabit two general types of habitats. Ephemeral habitats are occupied, for example, by bobwhite quail (*Colinus virginianus*) on agricultural lands or California quail (*Callipepla californica*) along disturbed streambanks. More stable habitats where resources fluctuate greatly with precipitation are occupied, for example, by scaled quail (*C. squamata*) in southwestern grasslands or mountain quail on Pacific Northwest mountain slopes (Gutiérrez 1980). Regardless, quail populations fluctuate greatly in response to seasonal rainfall (Leopold 1977). Food and cover for quail are clumped within a matrix of suitable habitat. Quail employ unique reproductive behaviors to maximize use of resources that vary greatly in abundance across time and space. In particular, mountain quail reproductive strategies allow them to be productive in habitats that are influenced by precipitation patterns and short growing seasons. Although our results did not provide a thorough analysis of nest and brood habitats selected by males and females, we believe that differences may not be pronounced because paired males and females maintained close associations throughout the nesting and brood-rearing periods. In addition, Pope (2002) found differences between male- and female-incubated nests in Oregon were only related to height differences in shrubs.

Our study suggests maintenance and enhancement of native shrub communities and shrub understories in conifer stands is paramount to maintaining quail populations in west-central Idaho as well as across the interior Pacific Northwest. Mountain quail typically reproduce and feed in early-to-mid successional communities with a strong shrub component (Thomas et al. 1979, Meslow 1980). In our study area, nesting and brooding mountain quail avoided dense conifer stands and selected relatively open conifer stands that had previously been logged. Favored reproductive habitats were typified by ponderosa pine and mallow ninebark and were mid-successional to Douglas fir.

March through September 1992–1995 mountain quail 65% core use home ranges in our study area averaged 16 ha (range = 1–63 ha; Herman et al. 2002). In addition, 33 broods moved a maximum 505 ± 70 m from nests from 1993 to 1995 (Reese, unpublished data). The area circumscribed by a circle with radius equal to 505 m is 80 ha suggesting conservation and enhancement of large unfragmented areas of shrub and conifer-shrub communities near streams and in riverine canyons is paramount to promoting population productivity and restoration of mountain quail populations in the interior Pacific Northwest.

Acknowledgements

We thank the Idaho Department of Fish and Game (Project W-160-R-24), Idaho Bureau of Land Management, USDA Forest Service, and Quail Unlimited for funding. We thank A. Utz, C. Vogel, A. Smasne, M. Sands, S. Sprague, R. Guse, and J. Lamb for field assistance. J. Manning provided help with statistical analyses. We thank L. Brennan and M. Pope for insightful reviews of our manuscript. The University of Idaho Animal Care and Use Committee granted approval of protocols to capture and mark mountain quail. This paper is contribution No. 1004 of the Idaho Forest, Wildlife and Range Experiment Station.

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Received 4 May 2004
Accepted for publication 14 October 2005