

Habitat Associations of Translocated and Native Mountain Quail in Oregon

Abstract

We examined habitat associations for 235 radio-tagged native and translocated mountain quail in the Cascade Mountains of southwestern Oregon and Hells Canyon National Recreation Area in northeastern Oregon from 1997 to 1999. Home-range size was estimated for 12 mountain quail from the Cascade Mountains and 21 quail from Hells Canyon. Mean home range size for combined areas was 141 ± 31 ha. Compared with Hells Canyon, home ranges were significantly larger in the Cascade Mountain, and similar in size for males and females. In Hells Canyon, > 73% of mountain quail locations were found in 7 plant associations: black cottonwood/snowberry, Douglas-fir/mallow ninebark, talus garland, ponderosa pine/snowberry, red alder/dogwood, smooth sumac/wheatgrass, and dogwood. In comparison to random sites, black cottonwood/snowberry, talus garland, ponderosa pine/snowberry, red alder/dogwood, and smooth sumac/wheatgrass were used more than expected. In Hells Canyon, males used ponderosa pine/snowberry and wheatgrass less than females. Mountain quail captured in the Cascades and translocated to Hells Canyon used mallow ninebark/snowberry Douglas-fir/mallow ninebark, and Douglas-fir/mountain ash/mallow ninebark associations more than native quail. In the southwestern Cascades, >80% of all locations were in early-successional (shrub/sapling) vegetation. Males used clear-cut/shrub and closed-pole areas more than females. Compared to random sites, mountain quail used grass/forb/shrub and sapling stands more and mid- to late-successional (small saw-timber, old-growth) less than expected.

Introduction

Mountain quail (*Oreortyx pictus*) are distributed from the Baja Peninsula north to southwestern British Columbia and east to western Nevada and Idaho (Crawford 2000). Historically, they ranged north to the Columbia River with primary population centers in the western Cascade, Coast, and Sierra Nevada Mountain ranges of western Oregon and California (Gutiérrez and Delehanty 1999, Crawford 2000). They are the most northerly distributed of New World quail, and occupy some of the highest elevation ranges of quail in North America (Gutiérrez and Delehanty 1999). Mountain quail may migrate seasonally to breeding ranges >30 km from winter ranges (Pope 2002). In the Pacific Northwest, translocations of mountain quail began in 1860 and continued for several decades with birds introduced into parts of British Columbia, western Idaho, and eastern Oregon (Crawford 2000). More recently, mountain quail have been translocated to supplement populations in eastern Oregon and western Nevada (Eric Rickerson, Upland Game Bird Program Manager, Oregon Department of Fish and Wildlife and San Stiver, Nevada Department of Wildlife, personal communications).

Mountain quail populations have declined in major portions of their geographic range, particularly in the Intermountain Regions of eastern Oregon, western Idaho, and Nevada (Brennan 1994). Much of their life-history is relatively unknown. They inhabit many different plant communities, but typically have been associated with shrub-dominated communities, including mixed-desert scrub, chaparral, and early-successional mixed conifer-shrub vegetation usually found after fire, logging or some other disturbance (Gutiérrez and Delehanty 1999). In the Coast Range of northern California, mountain quail were located most often in mixed evergreen forest or chaparral shrublands characterized by dense canopy cover and steep slopes (Gutiérrez 1980). Mountain quail in the northern Sierra Nevada Mountains, Klamath Mountains, and the northern California Coast Range selected vegetated cover types in proportion to availability, but 95% of the mountain quail locations were in mixed-forest and brush cover types (Brennan 1984). At the microhabitat level, five habitat variables (distance to water, distance to cover, minimum shrub height, maximum shrub height, and percent shrub cover) were the most important habitat components for mountain quail (Brennan 1984, Brennan et al. 1987). Additionally, mountain quail are opportunistic foragers that consume a diverse array of seeds, flowers, insects,

¹Author to whom correspondence should be addressed. E-mail: popem@onid.orst.edu

and fruits, but will concentrate seasonally on prevailing abundant foods (Ormiston 1966, Gutiérrez 1977).

Estimates of home range sizes for individually-marked mountain quail are lacking (Gutiérrez and Delehanty 1999). An objective of this study was to estimate home range for mountain quail in two ecologically different areas. We hypothesized that in the semi-arid portion of their range where resources (food, water, cover) are concentrated in discrete patches, home ranges would be smaller than western Oregon where the same resources are more homogeneously distributed across the landscape.

No studies have examined habitat associations of native mountain quail in Oregon or compared habitat associations of translocated and native populations of mountain quail. An additional objective of this study was to compare habitat use by a translocated sample of mountain quail with native quail in an area where mountain quail are declining. We hypothesized that translocated mountain quail would use a diverse but comparable (to native quail) array of habitats in eastern Oregon. We also hypothesized that in western Oregon mountain quail would be associated primarily with early-successional shrub habitats, and would select these habitats disproportionately to their availability.

Study Areas

We studied mountain quail habitat use in Hells Canyon National Recreation Area (HC) on the Columbia Plateau of northeastern Oregon and in the lower western Cascade and Coast Mountain ranges (CR) of southwestern Oregon. Mountain quail populations in Hells Canyon are typically found in isolated, disjunct riparian zones in steep canyons. In southwestern Oregon, quail are generally abundant with populations distributed throughout coniferous forests above 600 m. The 1,400-km² study site in CR is dominated by dense conifer forests with floristically diverse forest overstories of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and other conifers, or by Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*) (Franklin and Dyrness 1988). Common understory shrubs are manzanita (*Arctostaphylos* spp.), ceanothus (*Ceanothus* spp.), vine maple (*Acer circinatum*), salal (*Gaultheria shallon*), poison oak

(*Rhus diversiloba*), and Oregon grape (*Berberis* spp.). Historically, natural or anthropogenic fires were the primary disturbance mechanism and created many of the diverse vegetation communities used by wildlife. Currently, extensive logging has replaced fires as the major disturbance, and on public and private lands in CR, has resulted in a patchy mosaic of early- to late-successional forest habitats (Franklin and Dyrness 1988). Elevations range from 600 to 1,800 m, and climate conditions are generally mesic with hot, dry summers and cool, moist conditions in fall, winter, and spring. Mean monthly temperatures in 1999 ranged from 9°C in January to 29°C in August and average annual precipitation was 76 cm (Climate Center, Oregon State University, Corvallis, Oregon).

Our 2,000-km² study site in Hells Canyon is adjacent to the Snake River and is considered a separate ecoregion in the Columbia Basin (Crowe and Clausnitzer 1997). The area is characterized by steep, rugged canyons with grass dominated uplands dissected by stream valleys with diverse shrub communities. Forests dominated by ponderosa pine (*Pinus ponderosa*), Douglas-fir, and grand fir (*Abies grandis*) occur above 1,600 m. Canyon lowlands are dominated by common understory and transition zone shrubs including hawthorns (*Crataegus* spp.), snowberry (*Symphoricarpos albus*) and mallow ninebark (*Physocarpus malvaceus*). Grassy uplands primarily contain Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*) (Pelren 1996, Crowe and Clausnitzer 1997). Elevations range from 900 to 2,000 m. Climatic factors, topographic, and elevational features result in highly variable xerophytic zones where moisture is the major environmental constraint that influences the distribution of plant communities (Franklin and Dyrness 1988, Crowe and Clausnitzer 1997). Mean annual precipitation in 1999 was 40 cm and temperatures ranged from an average monthly low of 0°C in January to an average monthly high of 26°C in August (Climate Center, Oregon State University, Corvallis, Oregon).

Methods

From 1997-99, we captured 235 mountain quail in HC and CR in baited, treadle traps. Captured birds were fitted with flexible, necklace-style

transmitters weighing 3.6 g, and all birds were banded, weighed, and blood was extracted and analyzed for gender identification by Wildlife Genetics, Ontario, Canada and PE AgGen, Davis, California. Eighty-six birds captured in CR were fitted with transmitters and released at the trap sites in late winter and early spring 1997–99. Seventy-five birds captured in CR were transported to HC, fitted with transmitters, and released in two drainages in late winter 1997–98. Seventy-four native mountain quail in HC were captured, equipped with transmitters, and released at their trap sites in the fall and spring 1998–1999. Captured birds were held for < 1 wk before release at translocation or trap sites. Radio-marked birds were relocated visually from the ground at least twice a month to determine locations and habitat relationships.

We identified 33 plant associations for the HC study area based on Johnson and Simon (1987) and Crowe and Clausnitzer (1997) (Table 1). These associations were used to classify quail locations based on dominant vegetation and environmental factors (Crowe and Clausnitzer 1997). Descriptions of habitats in CR were based on 15 plant cover types recognized by Brown (1985) and described by O'Neil et al. (2001). These habitats are mostly characterized as seral stages of mixed coniferous forests (Table 2).

Home range estimates were generated at the 100% contour level using the minimum convex polygon method (Mohr 1947) with program CALHOME (Baldwin and Kies 1992). We observed that some birds remained in winter ranges during the breeding season, while others migrated from winter ranges beginning in early April (Pope 2002). To avoid including migration routes in home ranges, we limited home range estimation to quail that remained within winter ranges through the breeding season, and that survived through most of the projected life of the transmitters (4–6 mos). We tested for differences between HC and CR quail home ranges and between males and females home ranges with a *t*-test ($P < 0.05$).

Because of the limited number of locations and high mortality of individuals, all locations for radio-marked mountain quail were pooled to estimate observed habitat use for HC and CR. For HC, availability of habitat categories was estimated by generating 768 random Universal Transverse Mercator (UTM) coordinates in the study area and classifying habitat categories by visual ob-

TABLE 1. Number and frequency of mountain quail locations ($n = 1,259$) associated with 33 plant associations in Hells Canyon National Recreation Area, 1997–99, Oregon.

| Plant Association | Number of Observations | Frequency |
|---|------------------------|-----------|
| Black cottonwood/ common snowberry | 257 | 20.4 |
| Douglas-fir/mallow ninebark | 154 | 12.2 |
| Talus garland | 151 | 12 |
| Ponderosa pine/common snowberry | 116 | 9.2 |
| Red alder/red osier dogwood | 94 | 7.5 |
| Smooth sumac/wheatgrass | 90 | 7.1 |
| Mallow ninebark/ common snowberry | 66 | 5.2 |
| Blucbunch wheatgrass series | 45 | 3.6 |
| Douglas-fir/mountain alder/ mallow ninebark | 43 | 3.4 |
| Hackberry/wheatgrass | 32 | 2.5 |
| Red alder/pacific ninebark | 30 | 2.4 |
| Western serviceberry | 29 | 2.3 |
| Black hawthorn | 28 | 2.2 |
| Wild Rose/common snowberry | 24 | 1.9 |
| Black cottonwood/mountain alder/ red osier dogwood | 19 | 1.5 |
| Douglas-fir/common snowberry | 13 | 1.0 |
| Mountain alder/common snowberry | 11 | 0.9 |
| Mountain alder/red osier dogwood | 11 | 0.9 |
| Ponderosa pine/wheatgrass | 10 | 0.8 |
| Disturbed habitats | 10 | 0.8 |
| Water birch/mesic forbs | 6 | 0.5 |
| Idaho fescue | 5 | 0.4 |
| Ponderosa pine/Idaho fescue | 5 | 0.4 |
| Willow/mesic forb | 5 | 0.4 |
| Red osier dogwood | 4 | 0.3 |
| Black cottonwood/mountain alder | 1 | 0.1 |

servation based on the location of these coordinates. For CR, availability of habitats was estimated from the Umpqua National Forest's Geographic Information System with an accuracy level >80% (Terry Stone, Umpqua National Forest, personal communication) and ARCVIEW with 308 randomly generated UTM coordinates. A chi-square goodness-of-fit test was used to determine if observed use was different ($P < 0.01$) from expected use for mountain quail locations (Neu et al. 1974). A Bonferroni *Z*-statistic was used to test if observed use of habitat variables was more or less than expected ($P < 0.01$) based on

TABLE 2. Cover types used to classify mountain quail locations in the Cascade Mountain Range, southwestern Oregon, 1997-99.

| Cover type | Characteristics |
|---------------------|--|
| Clear-cut/no shrubs | Slash piles, no saplings, forbs and grass only |
| Clear-cut/shrubs | Slash piles, no saplings, low-medium shrubs |
| Grass/forb/shrub | Canopy cover < 30%, low shrubs, understory grass and forb mix |
| Shrub/open-sapling | Canopy cover < 30%, low-high shrubs, conifer saplings < 15 yr old |
| Closed-sapling | Canopy cover > 60%, low shrubs, sapling 10-20 yr old |
| Open-pole | Canopy cover < 30-60%, low-high shrubs, pole size trees 20-30 yr old |
| Closed-pole | Canopy cover 60-100%, no shrubs, pole size trees 13-27 cm dbh, 25-35 yr old |
| Small saw-timber | Canopy cover 70-90%, few shrubs, commercial grade timber 27-55cm dbh, 30-60 yr old |
| Large saw-timber | Canopy cover 70-80%, low-high shrubs, trees 55-90 cm dbh, 60-90 yr old |
| Old-growth | Canopy cover 70-90%, low-high shrubs, trees 90-120+ cm dbh, 90-200+ yr old |
| Edge | Low to high shrub transition |
| Hardwoods/savannah | Oak-poison oak or madrone/manzanita mix some low-high shrubs |

availability derived from random locations (Byers et al. 1984).

Results

Home range estimates were generated for 12 mountain quail in CR and 31 quail in HC. Mean home range for the combined areas was 141 ± 31 ha. Home ranges sizes for HC were significantly smaller ($P = 0.02$) than CR, but males and females had similar home range sizes (Table 3). We were unable to compare native and translocated mountain quail home ranges because of limited sample sizes.

Of 1,259 mountain quail observations in HC, >73% were found in 7 plant associations; 257 (20%) were in black cottonwood (*Populus trichocarpa*)/common snowberry habitats, 154 (12%) were in Douglas-fir/mallow ninebark, 151 (12%) in talus/garland, 116 (9%) in ponderosa pine/common snowberry, 94 (8%) in red alder (*Alnus rubra*)/dogwood (*Cornus stolonifera*), 90 (7%) in smooth sumac (*Rhus glabra*)/bluebunch

TABLE 3. Home range sizes for mountain quail in Hells Canyon National Recreation Area (HC) and the southwestern Cascade Mountain Range (CR).

| Category | Mean (ha) | n |
|-----------|--------------|----|
| HC and CR | 142 ± 31 | 43 |
| HC | 97 ± 30 | 31 |
| CR | 257 ± 75 | 12 |
| Males | 134 ± 46 | 21 |
| Females | 148 ± 44 | 22 |

wheat grass, and 66 (5%) in dogwood plant associations (Table 1). In comparison with random sites, black cottonwood/common snowberry, ponderosa pine/common snowberry, talus/garland, smooth sumac/wheatgrass, and red alder/dogwood were used more than expected, and the bluebunch wheatgrass series, Douglas-fir/mallow ninebark, and Douglas-fir/mountain alder (*Acer incana*)/mallow ninebark associations were used less than expected (Table 4). Males used ponderosa pine/common snowberry and the bluebunch wheatgrass series less than females (Table 5).

TABLE 4. Plant associations used more or less than expected ($P < 0.01$) by mountain quail in Hells Canyon.

| Plant association | Available (%) | Observed use (%) | Observed compared to expected use |
|--|---------------|------------------|-----------------------------------|
| Bluebunch wheat-grass series | 60 | 4 | Less |
| Douglas-fir/mallow ninebark | 19 | 15 | Less |
| Douglas-fir/mountain alder/mallow ninebark | 10 | 4 | Less |
| Talus garland | 1 | 15 | More |
| Black cottonwood/common snowberry | 1 | 25 | More |
| Ponderosa pine/common snowberry | 1 | 11 | More |
| Smooth sumac/wheatgrass | 1 | 8 | More |
| Red alder/red osier dogwood | 1 | 9 | More |

TABLE 5. Plant associations used by males significantly more or less ($P < 0.01$) than females in Hells Canyon.

| Plant association | Male use (%) | Female use (%) | Observed compared to expected use |
|---------------------------------|--------------|----------------|-----------------------------------|
| Ponderosa pine/common snowberry | 13 | 9 | Less |
| Bluebunch wheatgrass series | 6 | 2 | Less |

Translocated quail used mallow ninebark/common snowberry, Douglas-fir/mallow ninebark, and Douglas-fir/mountain alder/mallow ninebark more than native quail, and black cottonwood/common snowberry, talus/garland, smooth sumac/wheatgrass, and red alder/dogwood habitats less than natives (Table 6). Talus/garland, smooth sumac/wheatgrass, and red alder/dogwood were used more by translocated and native quail during the spring and summer than the fall and winter, and ponderosa pine/common snowberry, mallow ninebark/common snowberry, the wheatgrass series, Douglas-fir/mallow ninebark, and Douglas-fir/mountain alder/mallow ninebark associations were used less than fall and winter (Table 7).

Of 555 mountain quail locations in CR, 188 (34%) were in shrub/sapling habitats, 83 (15%) in edge areas, 74 (13%) in open-pole, 52 (9%) in grass/forb/shrub habitats, 38 (7%) in late successional old-growth, and 35 (6%) in clear-cuts/shrub

TABLE 6. Plant associations used by translocated mountain quail more or less ($P < 0.01$) than native quail in Hells Canyon.

| Plant association | Native quail (%) | Translocated quail (%) | Observed compared to expected use |
|--|------------------|------------------------|-----------------------------------|
| Black cottonwood/common snowberry | 28 | 19 | Less |
| Talus garland | 16 | 11 | Less |
| Smooth sumac/wheatgrass | 13 | .03 | Less |
| Red alder/red osier dogwood | 13 | .03 | Less |
| Mallow ninebark/common snowberry | 5 | 11 | More |
| Douglas-fir/mallow ninebark | 6 | 37 | More |
| Douglas-fir/mountain alder/mallow ninebark | 3 | 8 | More |

TABLE 7. Plant associations used by mountain quail more or less ($P < 0.01$) in spring-summer compared with fall-winter in Hells Canyon.

| Plant association | (%) | (%) | Observed compared to expected use |
|--|-----|-----|-----------------------------------|
| Douglas-fir/mountain alder/mallow ninebark | 60 | 2 | Less |
| Douglas-fir/mallow ninebark | 20 | 11 | Less |
| Ponderosa pine/common snowberry | 14 | 10 | Less |
| Black cottonwood/common snowberry | 9 | 4 | Less |
| Bluebunch wheatgrass series | 7 | 2 | Less |
| Talus garland | 7 | 21 | More |
| Smooth sumac/wheatgrass | 6 | 11 | More |
| Red alder/red osier dogwood | 3 | 13 | More |

areas (Table 8). Greater than 70% of all locations were in habitats <30 yr old. Males used clear-cut/shrub and closed-pole areas less than females (Table 9). To compare random and mountain quail habitat locations, the 14 habitat categories were combined into 5 classes (grass/forb/shrub, sapling, pole/small saw-timber, large saw-timber/

TABLE 8. Number and frequency of mountain quail locations ($n = 555$) associated with cover types in southwestern Cascade Mountains.

| Cover types | Number of observations | Cumulative |
|---------------------|------------------------|------------|
| Shrub/open sapling | 188 | 33.7 |
| Edge | 83 | 14.9 |
| Open-pole | 74 | 13.3 |
| Grass/forb/shrub | 52 | 9.3 |
| Old-growth | 38 | 6.8 |
| Closed-pole | 37 | 6.6 |
| Clear-cut/shrubs | 35 | 6.3 |
| Small saw-timber | 16 | 2.9 |
| Large saw-timber | 16 | 2.9 |
| Clear-cut/no shrubs | 8 | 1.4 |
| Closed-sapling | 7 | 1.3 |
| Hardwoods/savannah | 1 | 0.2 |

TABLE 9. Cover types used by males more or less ($P < 0.01$) than female mountain quail in the southwestern Cascade Range.

| Cover type | Males (%) | Females (%) | Observed compared to expected use |
|-----------------|-----------|-------------|-----------------------------------|
| Clear-cut/shrub | 10 | 4 | Less |
| Closed-pole | 9 | 5 | Less |

TABLE 10. Cover types used by mountain quail more or less than expected ($P < 0.01$) in the southwestern Cascade Range.

| Cover Type | Available % | Observed use (%) | Observed |
|-----------------------|-------------|------------------|----------|
| Old-growth | 39 | 7 | Less |
| Pole/small saw-timber | 24 | 17 | Less |
| Sapling | 23 | 56 | More |
| Grass/forb/low shrub | 4 | 10 | More |

mature, and old-growth forests). Mountain quail used grass/forb/shrub and sapling habitats more, and pole/small saw-timber and old-growth stands less than available (Table 10).

Discussion

As predicted, estimates of mean home range size for mountain quail in the Cascade Mountains of southwestern Oregon were larger than Hells Canyon in northeastern Oregon (Table 3). In Hells Canyon, home range sizes were likely determined by the availability of water, forage, and shrub cover concentrated along narrow, disjunct canyon bottoms. In the western Cascade Mountains, mountain quail home ranges were generally associated with the distribution of early-successional shrub habitats created by logging operations or fires and uniformly distributed across the landscape. We were unable to detect factors that may influence home range shape or size because of large variations in home ranges in both study areas. Males and females had similar home range sizes. Male territoriality in wild mountain quail is poorly known, but in other quail species males typically do not defend specific territories (Schemnitz 1994, Brown et al. 1998, Calkins et al. 1999).

In Hells Canyon, mountain quail primarily selected areas with overstories dominated by mixed hardwoods or conifers that contained well-developed and diverse shrub communities. Greater than 20% of observations were in black cottonwood/snowberry associations (Table 1). These communities typically occur on lower elevation terraces adjacent to riparian areas with gentle slopes and southeastern aspects (Crowe and Clausnitzer 1997). In addition to snowberry, common shrubs associated with black cottonwood/snowberry associations include western serviceberry (*Amelanchier alnifolia*), hawthorn, and rose (*Rosa* sp.). Subdominant trees are usually ponderosa pine and grand

fir (Crowe and Clausnitzer 1997). Talus garland, Douglas-fir/mallow ninebark, ponderosa pine/snowberry, and red alder/dogwood were other important habitat associations used by mountain quail (Tables 1 and 4). Talus garland areas are characterized by steep canyon side slopes dominated by bunchgrass and rocks taluses bordered by clumps of shrubs (Johnson and Simon 1987). Mean slope angles are 32° and aspects are usually southwest or southeast. Common shrubs include ocean-spray (*Holodiscus bicolor*), mock orange (*Philadelphus lewisii*), cherry (*Prunus* sp.) and mountain alder (Johnson and Simon 1987). Douglas-fir/mallow ninebark communities are forested stringers found generally on steep, north-facing canyon slopes below 1,800 m (Johnson and Simon 1987). In these communities, Douglas-fir and ponderosa pine are the dominant trees with understories usually a mosaic of ninebark and pine grass-elm sedges (*Calamagrostis rubescens*-*Carex geyeri*) and associated shrubs that include snowberry and spirea (*Spiraea betulifolia*) (Johnson and Simon 1987). Ponderosa pine/snowberry plant associations are found between 1,100-1,800 m on moderately steep slopes (5 - 29°) with southwest aspects. Ponderosa pine dominates all overstory levels, and common snowberry and pine grass are the primary understory species (Johnson and Simon 1987). Red alder/dogwood are dense shrub communities found in valleys along riparian areas on gentle gradients (1 - 4°) and have associated vegetation that include western thimbleberry (*Rubus parviflorus*) and common cow parsnip (*Heracleum lanatum*) (Crowe and Clausnitzer 1997).

In Hells Canyon, males and females generally used most plant associations in the same proportions, but there was a slight difference in male and female use of ponderosa pine/snowberry and the wheatgrass series (Table 5). The wheatgrass series are found on moderate to steep slopes, and in elevations that range from 600-1,800 m. A few shrubs may occur in these perennial grassland communities, but most areas are dominated by bluebunch wheatgrass and seasonal forbs (Johnson and Simon 1987). The most important habitats for translocated quail were black cottonwood/snowberry and Douglas-fir/mallow ninebark (Table 6). However, when compared to native quail, black cottonwood/snowberry associations were used less, and the Douglas-fir/mallow ninebark were used six times more frequently. The differences in use

for native and translocated quail may be related to the extensive movements that translocated quail made during the breeding season.

The most frequently used plant communities in the Cascade Mountains were early-successional shrub and sapling stands (Tables 8 and 10). Less than 20% of mountain quail observations occurred in forested stands >30 yr of age. Males used clear-cut shrub and closed-pole stands less than females, but locations in these habitat categories accounted for <13% of all observations (Table 9). Contrary to Brennan (1994) and Gutiérrez (1980), mountain quail in the Cascades did not use habitats in proportion to availability. Mountain quail selected early seral and avoided mid- to late-successional stands (Table 10). Extensive timber harvesting has created most of the early successional stands in the lower Cascades. Shrub communities in the Cascades are generally 2-10 yr old, but may be 20-30 yr old if tree regeneration was retarded (Brown 1985). Habitat conditions in shrub communities are variable with many different structural combinations ranging from low to tall shrubs and open to closed single layered canopies (O'Neil et al. 2001). Trees in sapling stands are generally conifers that are <3.5 m high, and similar in height to tall shrub stands. Canopy closure varies from 10-30% closure with abundant understory vegetation to >70% closure with limited understory development (O'Neil et al. 2001).

Brennan (1994) advocated a community-level approach as a response to habitat alterations and for restoration of quail populations. He suggested that management strategies for wild quail populations should focus on maintaining the integrity and functional processes of ecosystems, and identifying linkages between species of quail and other

terrestrial vertebrates. Gutiérrez (1980) and Brennan (1984) have identified some of the structural components common to mountain quail habitats. We identified frequently used plant communities associated with mountain quail in mesic and semi-arid habitats, but current management and conservation strategies for mountain quail are still based on inadequate information. Additional habitat assessments and comparisons are needed to identify factors that may influence temporal and spatial variability in mountain quail distributions and abundance. We suggest that further investigations of mountain quail habitat relationships include habitat manipulations and experimentally based studies to better understand environmental factors that affect distribution and abundance.

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