AN ABSTRACT OF THE THESIS OF

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Title: Survival and Nest Site Characteristics of Translocated Mountain Quail on Steens Mountain, Oregon

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W. Douglas Robinson

Mountain Quail (*Oreortyx pictus*) populations have declined in the eastern portion of their range during the last century. However, few studies have investigated the nesting habitat and survival of Mountain Quail translocated into an area from which they have been extirpated. We translocated 217 wild Mountain Quail (*Oreortyx pictus*) from southwestern Oregon to Steens Mountain in southeastern Oregon to re-establish a population in this former part of their range. We measured habitat characteristics at 45 nest sites and 90 random sites to identify which habitat characteristics are important in Mountain Quail nest site selection. We found that canopy cover of shrubs, trees, and rocks, and shrub height 8 m from the nest were the 2 most important characteristics influencing Mountain Quail nest-site selection. Mean shrub height at nest sites was approximately 1 m tall and mean canopy cover was 28%. Managing habitat for shrubs of this height and a similar density of canopy cover will increase habitat suitable for Mountain Quail reproduction. When selecting future release sites, shrub height and canopy cover should be of primary consideration.

In addition to determining what habitat attributes Mountain Quail select for nesting, we also estimated survival rates for 135 radio-collared Mountain Quail for the 5-month period following translocation and looked at the effects of year, sex, time, linear and quadratic time trends, body condition, and weather covariates to see if they explained variation in survival rates. Year, sex, and a quadratic time trend were the most important factors explaining variation in survival in this study. Survival was higher in 2005 than 2006 and was higher for females in both years of the study. Survival was lowest during the first 2 weeks after the release suggesting that improving survival during this initial time period may improve overall chances of a successful translocation. Selecting release sites that provide adequate cover from raptors and other predators may be critical for survival of Mountain Quail following a translocation.

Survival and Nest Site Characteristics of Translocated Mountain Quail on Steens Mountain, Oregon

by
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Approved:

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Jamie N. Nelson, Author

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CONTRIBUTION OF AUTHORS

Dr. W. Douglas Robinson and Dr. Michael D. Pope were involved in the study design, analysis, and writing of each manuscript.

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Survival and Nest Site Characteristics of Translocated Mountain Quail on Steens Mountain, Oregon

CHAPTER 1: INTRODUCTION

Mountain quail occupy some of the highest elevation ranges of quail in North America and may migrate seasonally to breeding ranges >30 km from winter ranges (Pope 2002). They occupy diverse habitats including hardwood, hardwood-coniferous, and coniferous-chaparral vegetation communities with a shrub understory in the western part of their range (Johnsgard 1973, Vogel and Reese 1995) and shrub communities often associated with riparian areas that may or may not have an open coniferous forest overstory in their eastern ranges (Ormiston 1966, Brennan 1989, Vogel and Reese 1995). Across their range, Mountain Quail are generally found in shrub-dominated communities and early-successional mixed conifer-shrub vegetation usually found after disturbances such as fire and logging (Johnsgard 1973, Guitierrez and Delehanty 1999, Pope 2002).

Mountain Quail (Oreortyx pictus) populations have declined in the eastern portion of their range during the last century, likely as a result of habitat loss resulting from overgrazing and fire suppression (Brennan 1994). Mountain Quail were once found throughout Oregon and continue to be abundant in the Coastal and western Cascade forests. However, they are now restricted to isolated populations east of the Cascade Range (Figure 1). As a result of these declines, conservation groups filed a petition to list Mountain Quail in the northern and western Great Basin and Interior

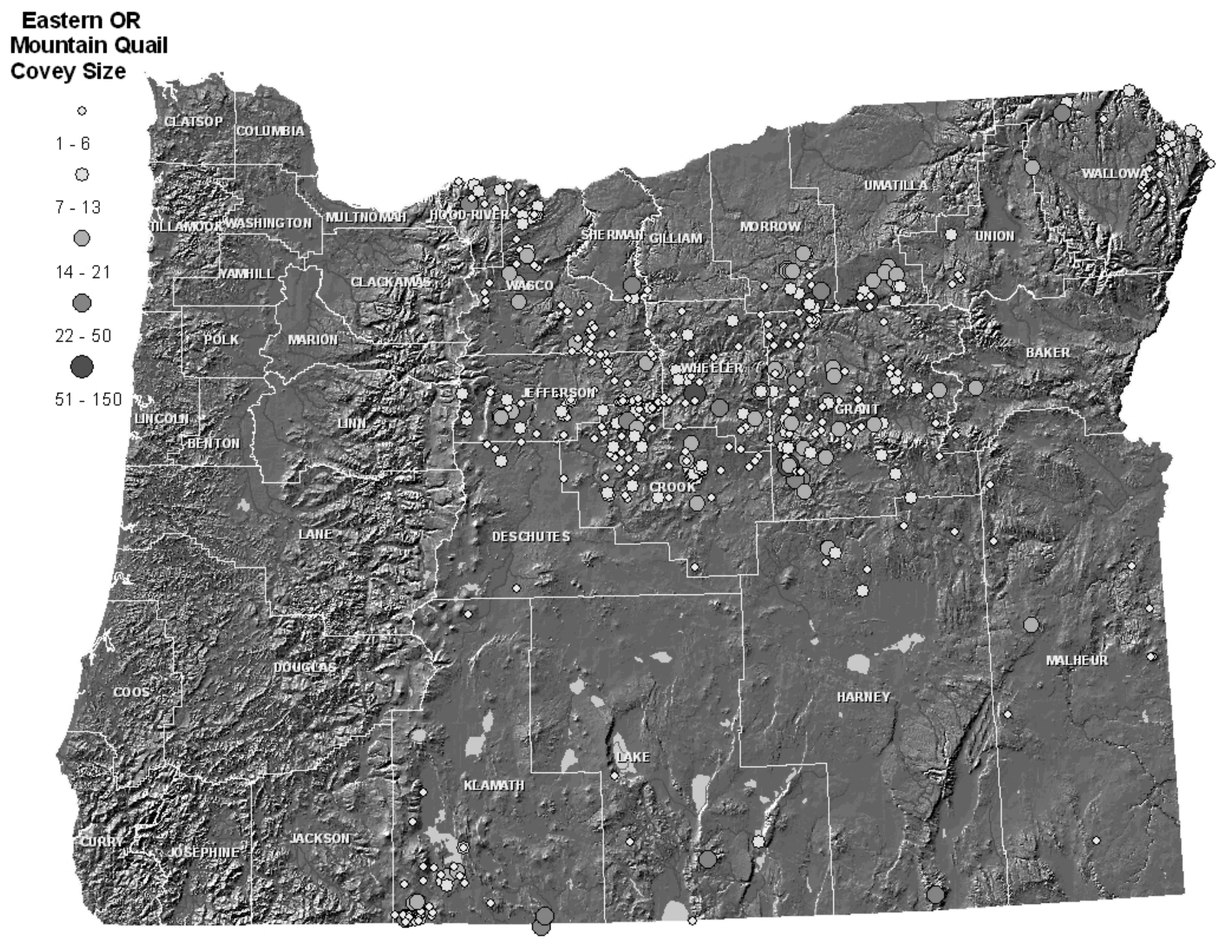

Figure 1.1. Mountain Quail locations in eastern Oregon as of 2006. (Courtesy of ODFW)

Columbia Basin as a threatened or endangered distinct population segment, but this petition was denied (Federal Register 58:14 2003).

Aside from habitat loss, a major impediment to successful recovery efforts for Mountain Quail populations is the lack of information on basic life history characteristics such as survival and reproduction. The secretive nature of Mountain Quail and the steep and rugged terrain they inhabit are just two of the factors limiting the number of studies conducted (Gutierrez and Delahanty 1999). In addition, federal and state wildlife agencies are generally reluctant to fund research or restoration unless a species is listed as threatened or endangered. However, in a survey of 198 reintroduction programs, Griffith et al. (1989) found that restoration efforts have a much greater chance of success if action is taken before populations reach crisis levels.

In 2001, Oregon State University, Oregon Department of Fish and Wildlife and the U.S. Forest Service initiated a Mountain Quail translocation and research program for eastern Oregon. The primary goal of this program is to restore Mountain Quail to their former range. Additional objectives are to collect information on basic natural and life history of Mountain Quail to assist in evaluations of translocation efforts and refine protocols for future translocations. Mountain Quail are good candidates for translocations with translocated birds exhibiting similar survival rates to wild birds (Pope 2002). Oregon has abundant Mountain Quail populations west of the Cascades that provide a close source population for translocations. The chances of a reintroduction being successful are much higher when wild-caught birds are used, rather than captive-raised birds (Griffith et al. 1989).

Like much of eastern Oregon, Steens Mountain has been affected by anthropogenic habitat alterations such as overgrazing and consequent alteration of the fire regime. Consequently, Steens Mountain has seen a decline in Mountain Quail over the past 50 years, with the last sighting occurring in 1982 (Matt Obradovich, BLM, personal communication). If remnant populations of Mountain Quail still persisted on Steens Mountain, they were too rare to be detected and unlikely to recover without human intervention. The designation of Steens Mountain as a wilderness area in 2000 has ensured that habitat for Mountain Quail will be protected for years to come. In addition, its considerable distance from urban areas made Steens Mountain a promising Mountain Quail restoration site. Studying Mountain Quail on Steens Mountain also allowed us to gather information on Mountain Quail life history in a unique sagebrush ecosystem where Mountain Quail previously had not been studied.

This thesis contains two primary chapters reporting data from a two-year field study. Chapter 2 reports reproductive parameters and nest site characteristics of male and female Mountain Quail on Steens Mountain and describes a model of nest site selection. Descriptions of habitat requirements for nest sites will assist managers in the identification and restoration of suitable habitat for future translocations. Chapter 3 discusses factors associated with adult survival of translocated Mountain Quail on Steens Mountain. Examination of survival correlates for translocated Mountain Quail will enable wildlife managers and biologists to identify factors associated with the success or failure of reintroduction. This knowledge will be used to refine protocols for restoration programs and increase the chances of success for future translocations.

CHAPTER 2: NEST SITE CHARACTERISTICS OF TRANSLOCATED MOUNTAIN QUAIL ON STEENS MOUNTAIN, OREGON

ABSTRACT

Translocations are an important tool for restoring populations of extirpated species to their former range. Mountain Quail were historically found throughout Oregon but their range has been significantly reduced due to habitat alterations such as overgrazing and fire suppression. Identifying habitat characteristics associated with Mountain Quail nest sites is needed to identify potential Mountain Quail habitat and inform future restoration efforts. To gain a better understanding of the habitat factors that influence Mountain Quail reproduction, we evaluated the habitat characteristics surrounding Mountain Quail nests. In 2005 and 2006, 217 wild Mountain Quail were translocated from western Oregon to Steens Mountain in eastern Oregon, a former part of Mountain Quail range. Habitat data was measured at Mountain Quail nest sites and at adjacent unoccupied sites to develop resource selection models of nest site attributes. A priori model selection procedures based on habitat measurements at each nest location were used to estimate the odds that a site would be selected as a nest site. We also compared differences in habitat characteristics between male-incubated nests and female-incubated nests. We used logistic regression and Akaike's Information Criterion (AIC) with a correction term for small sample size (AICc) to identify the best approximating model(s). Perimeter shrub height (shrub height 8 m from the nest center) was the habitat characteristic most predictive of Mountain Quail nest site selection. As perimeter shrub height increased, the odds of a site being selected as a nest site also increased. The presence of percent canopy cover in several of the

competing models suggests that this variable may also be important in the selection of Mountain Quail nest sites. There was little difference in habitat attributes between nests of males and females. Strategies for translocating Mountain Quail should include considerations of available shrub cover and canopy cover for nest sites.

INTRODUCTION

Translocations have become a widely used conservation tool. However, few translocations have incorporated post-release monitoring into management plans (Griffiths et al. 1989). A good measure of short-term success after translocations is the percentage of individuals that survive to reproduce (Griffiths et al. 1989). In order to maximize chances of success, we should choose release sites that provide the resources necessary for successful reproduction. Identifying nest site habitat requirements will assist managers in the identification and restoration of suitable habitat for future translocations.

Mountain Quail (*Oreortyx pictus*) have experienced significant declines in the eastern portion of their range during the last century. The cause of these declines is not entirely clear. However, a variety of causes have been implicated including overgrazing and alteration of fire regimes (Brennan 1994). While Mountain Quail were once found in every county in Oregon, they are now common only in western, northeastern, and central Oregon (Pope 2002). Mountain Quail were once found on Steens Mountain in southeastern Oregon, however, they have been absent since at least 1982 (M. Obradovich, pers. comm.). As a result of these population declines, a petition was submitted to list these birds under the Endangered Species Act (1973) as a threatened or endangered distinct population segment (Beck et al. 2005), however, the petition was denied (Federal Register v. 58 # 14 2003).

Mountain Quail are usually found in coveys consisting of 1-2 adults and their offspring (Johnsgard 1973, Delehanty 2001). Mate selection begins in March or April when birds are still in coveys (McLean 1930, Johnsgard 1973). Mountain Quail are monomorphic and both sexes display elaborate courtship behavior (Guitierrez and Delahanty 1999). Both sexes will breed during their first year and females will generally produce 1-2 clutches annually given adequate resources (Guitierrez and Delehanty 1999). Mountain Quail are monogamous and both sexes incubate nests (Delehanty 1995, 1997, Gutierrez and Delehanty 1999, Pope and Crawford 2001). Mountain quail are known to exhibit simultaneous multiple clutching (Heekin 1993, Delehanty 1997, Pope and Crawford 2001, Pope 2002). Females lay eggs in two nests generally less than 200 m apart and will lay between 7 and 15 eggs in each nest (Pope and Crawford 2001, Pope 2002). Males and females will incubate their nests without assistance from their mate and may brood chicks separately until after 10 days post-hatch and then combine broods (Heekin 1993, Pope and Crawford 2001, Pope 2002).

Nests of Mountain Quail are shallow depressions on the ground and generally lined with vegetation such as grass, leaves and pine needles (Gutierrez and Delehanty 1999). Mountain Quail exhibit a low rate of nest abandonment and may continue incubating a nest with only 1 egg (Pope 2002). Average incubation length for Mountain Quail was 30 days with a nest success rate of 70% for 57 nests in Oregon (Pope and Crawford 2001). Pope (2002) also found that clutch size averaged 11.3 eggs (range = 6-17) and did not differ significantly between nests of males, females, translocated or native birds.

The objectives of this study were to 1) describe habitat characteristics at nests selected by translocated nesting Mountain Quail on Steens Mountain, 2) compare nest site characteristics with habitat characteristics at randomly selected sites, and 3) compare characteristics of nests incubated by males with nests incubated by females. Understanding the relationship between Mountain Quail nest site selection and habitat characteristics will aid managers in identifying potential Mountain Quail habitat and inform future restoration efforts.

METHODS

Study Area

Steens Mountain is a 30-mile long fault block mountain located approximately 90 km south of Burns, Oregon (Figure 2.1). The mountain has a steep eastern face (nearly 1.5 km) and a gentle west slope dissected by steep canyons and glacial gorges. Elevation ranges from 1280-2980 m. Habitat types on Steens Mountain are very diverse and follow an elevational gradient ranging from arid sagebrush (a mix of big sagebrush (*Artemisia tridentata*) and low sagebrush (*Artemisia arbuscula*)) at the base to subalpine grassland at the top. Intermediate vegetation zones include western juniper (*Juniperus occidentalis*)(1524-1829 m), mountain mahogany (*Cercocarpus ledifolius*) (1829-2438 m), mountain big sagebrush (*Artemisia tridentata vaseyana*) (1981-2591 m), and quaking aspen (*Populus tremuloides*) (1829-2438 m). Understories are primarily bunchgrasses. Temperatures during 1971-2000 had a monthly mean high of 29.3º C in July and a low of –6.9º C in January. Annual precipitation during that same period was 34.2 cm (Oregon State Climate Center, Oregon State University).

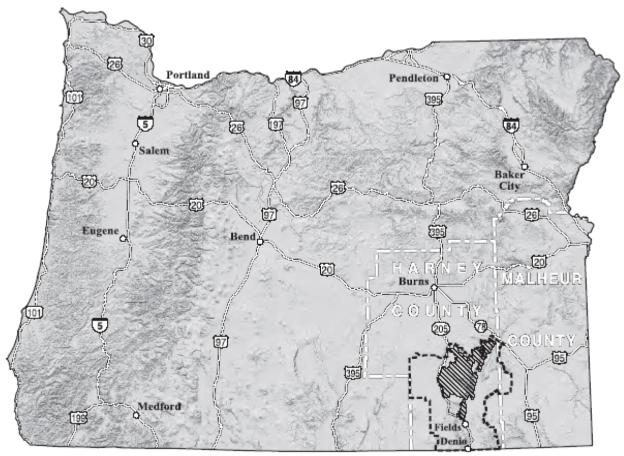

Figure 2.1. Location of 2005-2006 Mountain Quail translocation study area in Steens Mountain, Oregon.

Study Design

We captured 217 Mountain Quail during the winters of 2005 and 2006 from Douglas and Jackson Counties in southwestern Oregon, using treadle traps baited with grain. Captured birds were weighed, banded, identified by plumage as hatch year (HY) or after hatch year (AHY) (Leopold 1939), and blood was extracted for gender identification (Veterinary Diagnostic Center, Fairfield, Ohio) from birds selected for radio-marking. Captured quail were held over winter in a holding facility specifically constructed for captive wild Mountain Quail at the Southwest Regional office of Oregon Department of Fish and Wildlife (ODFW) in Roseburg, Oregon. One hundred thirty-six Mountain Quail were fitted with necklace-style radio transmitters that weighed approximately 4.3 g (Model PD2C, Holohil System Ltd., Woodlawn Ontario, Canada). We released 56 radio-collared quail with leg bands and 34 quail with only leg bands on Steens Mountain in March 2005. We released another 80 radio-collared and leg-banded birds and 47 birds only with leg bands on Steens Mountain in March 2006.

Nest sites were located by visually identifying radio-marked Mountain Quail that were incubating clutches. Quail were flushed off the nest initially to count the number of eggs being incubated. In July, after chicks hatched and left a nest site, eggshells were counted to determine the number of chicks hatched and 12 habitat measurements were recorded at each nest site. Protocols for nest-site measurements were adapted from Pope (2002). Measurements were recorded within an 8-m radius circle centered on each nest. Proportion of ground-level characteristics (shrubs, forbs, grass, litter, bare ground, rock) were obtained from 20 x 50 cm Daubenmire frames centered on the nest and placed at 2 and 4 m points from the nest center in each of the 4 cardinal directions (Pope 2002). Canopy cover of all trees, shrubs, and rock was measured with a convex spherical densiometer held at elbow height. Readings were taken at nest center and at 8 m from nest center in each of the 4 cardinal directions. From these 5 readings an average value was derived to estimate percent canopy cover for each nest site. Height was recorded for the tallest and shortest shrub within 1 m of nest center and at points 4 m in each cardinal direction and the 5 values were averaged for each site. Shrub perimeter height was measured using 300 cm Robel poles placed 8m from the nest in 4 cardinal directions and those four values were averaged to obtain one value for each site. Shrub cover was measured using line-intercept estimates for 8 m transects in 4 cardinal directions from nest center. Distance to nearest water was calculated using ARCVIEW GIS (Environmental Systems Research Institute 1999). For each nest site, we also sampled, using identical protocols, 2 randomly selected sites for comparison with nest sites. Random sites were selected using Excel random number generator (Microsoft Corporation 2001) to select two random bearings (1-360˚) and two random distances less than 300 m from each nest site.

Statistical Analyses

We used logistic regression to analyze differences in habitat characteristics between Mountain Quail nests and random sites and differences between male-incubated nests and female-incubated nests (SAS Institute 2003). We assessed multicollinearity in the set of explanatory variables with a Spearman correlation matrix. Height of tallest shrub and height of shortest shrub were highly correlated ($R > 0.7$). We excluded height of shortest shrub from the analysis because we felt that height of tallest shrub was a better representation of stand structure.

An *a priori* model set of biologically plausible models were developed based on combinations of habitat variables described in the literature on Mountain Quail. We developed 26 models to predict nest sites (vs. random sites) and 24 models to predict male-incubated nests (vs. female-incubated nests). We used Akaike's Information Criterion (AIC) with the additional bias correction term for small sample sizes (AIC_c) to select the best approximating model (Burnham and Anderson 2002).

Parameter estimates from the top model(s) were exponentiated and reported as log odds ratios.

RESULTS

We sampled 26 nests in 2005 and 19 nests in 2006. For each nest site, we also sampled two random sites for a total of 90 non-nest sites. Of the 45 nests, 23 were incubated by males and 22 were incubated by females. Nest success was similar between years and slightly higher for females in both years (table 2.1). Mean clutch size was similar between years and slightly higher for males in both years (table 2.1). Mean hatch size was higher in 2006 and male nests hatched slightly more chicks, whereas male and female nests produced a similar number of chicks in 2005. Western juniper was the current vegetation at 98% of the nest sites (table 2.2).

Table 2.1. Nest success, clutch size, and hatch size by gender and year for Mountain Quail translocated to Steens Mountain, Oregon.

	2005			2006		
	Males	Females	Both	Males	Females	Both
Nest success	76.92	84.62	80.77	70.00	80.00	75.00
Mean clutch size	10.77	9.08	9.92	11.33	9.6	10.42
(SE)	(0.76)	(0.60)	(0.49)	(0.67)	(0.73)	(0.53)
Mean hatch size	7.60	7.27	7.43	11.0	9.13	10.0
(SE)	(1.06)	(0.78)	(0.78)	(0.82)	(0.85)	(0.62)

Table 2.2. Current vegetation at nest sites for translocated Mountain Quail on Steens Mountain, Oregon, 2005-2006.

Overstory / understory	# nests
Juniper / big sagebrush	26
Juniper / low sagebrush	6
Juniper / bitterbrush	5
Cut juniper / big sagebrush	4
Juniper / bunchgrass	3
Big sagebrush / bunchgrass	1
Total	45

The top model (AIC_c = 157.53) included perimeter shrub height as the only explanatory variable (Table 2.3). Five additional competing models had $\Delta AIC_c < 2.0$. All 6 competing models included the variable perimeter shrub height. Four of the 6 competing models also included canopy cover, indicating that variable may also be important in explaining the presence of nest sites. Parameter estimates are reported from the best approximating model. For every 10-cm increase in perimeter shrub height, the odds of a site being a nest site increased by 13.1% (95% CI 6.2, 21.3%). Table 2.4 shows mean values for habitat variables measured at nest sites and random sites.

Table 2.3. Results of AIC_c model selection for nest site selection

Model*	K	AIC_c	ΔAIC_c	w_i
R	2	157.53	0.00	0.16
C + R	3	157.72	0.19	0.15
C + R + GS	4	157.96	0.43	0.13
C + GG + GS + R	5	158.32	0.79	0.11
C + GG + R	4	158.76	1.23	0.09
GG + R + GS	4	159.11	1.58	0.07
R + DW	3	159.60	2.08	0.06
R + SH	3	159.62	2.09	0.06
C + R + DW	4	159.84	2.31	0.05
R + C + R*C	4	159.84	2.31	0.05
SC + R + SH	4	161.25	3.72	0.02
SC + GS + R + SH	5	161.71	4.18	0.02
C + SC + R + SH	5	161.78	4.25	0.02
GB	2	162.70	5.17	0.01
C	2	165.43	7.90	0.00
C + DW	3	166.61	9.08	0.00
C + GS + GS*C	4	167.51	9.98	0.00
GB + GF + GG + GL + GR + GS + GW	8	168.43	10.90	0.00
C + GL + GS + C*GS	5	169.35	11.82	0.00
Null	1	170.88	13.35	0.00
GR	2	172.03	14.50	0.00
DW	2	172.34	14.81	0.00
SC + DW	3	172.58	15.05	0.00
SC + SH	3	172.66	15.13	0.00
GG	2	172.79	15.26	0.00
Global	15	175.52	17.99	0.00

*DW=Distance to water (m), R=Perimeter shrub height, C=Canopy cover (%), SH =Height of tallest shrub, SC=Shrub cover (%), GB=Bare ground (%), GF=Forb (%), GG=Grass (%), GL=Litter (%), GR=Rock (%), GS=Shrub (%), GW=Woody debris (%)

Table 2.4. Mean values for habitat variables measured at 45 nest sites and 90 random sites on Steens Mountain, Oregon, 2005-2006.

	Random Sites		Nest Sites	
	Mean	SE	Mean	SE
Distance to water (m)	291.07	1.61	324.84	2.37
Perimeter shrub height (cm)	66.77	0.76	111.02	1.26
Canopy cover (%)	17.92	0.46	27.87	0.66
Height of tallest shrub (cm)	42.29	0.60	41.55	0.88
Shrub cover (%)	17.02	0.04	20.52	5.78
Bare ground (%)	30.39	0.51	17.73	0.64
Forb (%)	3.48	0.19	3.07	0.24
Grass (%)	16.54	0.43	15.45	0.54
Litter (%)	6.46	0.31	10.17	0.51
Rock (%)	23.68	0.53	27.95	0.73
Shrub (%)	9.13	0.35	11.42	0.46
Woody debris (%)	3.74	0.23	5.85	0.47

The top model for the comparison of male- and female-incubated nests included proportion of rock as the only explanatory variable and was twice as likely as the null model ($w_i = 0.19$) (Table 2.5). However, the null model was also competitive ($\Delta AIC_c = 1.36$), indicating that the habitat variables we measured did not adequately explain the differences between male- and female-incubated nests.

Table 2.5. Model selection results for comparison of male and female nest site characteristics.

Model	K	AIC_c	ΔAIC_c	w_i
GR	2	61.73	0.00	0.19
Null	1	63.09	1.36	0.09
GW	2	63.83	2.09	0.06
GR + R	3	63.91	2.18	0.06
GB + GR	3	64.00	2.27	0.06
SC	2	64.38	2.64	0.05
GL	2	64.46	2.72	0.05
GB	2	64.62	2.89	0.04
R	2	64.67	2.94	0.04
GS	2	64.68	2.95	0.04
GG	2	64.79	3.06	0.04
C	2	65.08	3.35	0.03
GL + GW	3	65.22	3.49	0.03
SH	2	65.28	3.55	0.03
GF	2	65.28	3.55	0.03
GB + GL	3	65.52	3.79	0.03
GW + SH	3	66.13	4.41	0.02
SC + GG	3	66.41	4.69	0.02
C + R	3	66.44	4.71	0.02
SC + SH	3	66.61	4.89	0.02
C + GS	3	66.89	5.16	0.01
GF + GS	3	66.98	5.26	0.01
GF + GG	3	67.09	5.37	0.01
C + SC	12	82.22	20.49	0.00

DISCUSSION

Across their range, Mountain Quail are generally found in shrub-dominated communities and early-successional mixed conifer-shrub vegetation (Pope 2002). Our results support the findings of Pope's (2002) study of native and translocated Mountain Quail in the Cascade Range and Hells Canyon region of Oregon, that perimeter shrub height (shrub height 8 m from the nest) is an important habitat attribute explaining the difference between Mountain Quail nest sites and non-nest sites. Pope (2002) found all 3 of his top competing models contained the variable perimeter shrub height and shrub height was greater at nest sites than at random sites. Similarly, we found all 6 of our competing models included perimeter shrub height and the odds of a site being selected as a Mountain Quail nest increased as perimeter shrub height increased. Canopy cover did not have a strong effect on the odds of a site being chosen as a nest site based on confidence intervals. However, the presence of canopy cover in 4 of the 6 competing models suggests that this variable may also be important in nest site selection. Pope (2002) also found that canopy cover was present in 2 of 3 competing models and reported that nest sites had greater canopy cover than random sites.

The occurrence of greater perimeter shrub height and canopy cover at nests probably improves concealment of nests. Perimeter shrub height may represent the concealment of the nest from the perspective of an approaching terrestrial predator or structural concealment from aerial predators. Canopy cover also obscures the view of aerial nest predators that might detect nests as they fly overhead. Nest predators of Mountain Quail include ground squirrels (*Spermophilus* spp.), striped skunks (*Mephitis mephitis*), snakes, and corvids (Edminster 1954, Miller and Stebbins 1964, Rue 1973, Vogel and Reese 1995).

Mountain Quail may also be choosing nests with tall shrubs and canopy cover for thermal and wind protection. Other studies have shown that microclimate can influence nest site selection (Petersen and Best 1985, With and Webb 1993). In particular, species that nest later in the season choose sites with greater shade cover and lower temperatures (With and Webb 1993). Mountain Quail have a relatively late nesting period with the majority of nests hatching in late June and early July. Choosing sites with canopy cover would prevent nests from becoming overheated during the hottest part of the day. Sites with taller shrubs would provide protection from the wind that could desiccate eggs in the semi-arid environment found on Steens Mountain. More research is needed into the mechanisms that drive Mountain Quail nest site selection.

Our top model included proportion of rock as the only variable explaining differences between male and female nest sites. However, the null model was also competitive, indicating there is little difference between male- and female-incubated nests in this study. Pope (2002) found that height of shortest shrub and perimeter shrub height were different between male- and female-incubated Mountain Quail nests. The differences in shrub height observed by Pope (2002) could be a result of the more diverse composition and structure of shrubs in southwestern and northeastern Oregon compared to Steens Mountain. It is still unclear as to whether nest sites are selected by the male, the female, or both.

Pope and Crawford (2001) reported nest success ranging from 62% in Wallowa County, Oregon to 83% in Douglas County, Oregon. Our estimates of 80% in 2005 and 75% in 2006 fall within that range. This indicates that Steens Mountain has the habitat components critical for successful nest production for Mountain Quail.

MANAGEMENT IMPLICATIONS

When selecting future translocation sites, we recommend locating release sites in areas with adequate shrub height and canopy cover. Mean perimeter shrub height for nest sites in this study was approximately 1 m tall. Selecting translocation sites with a high proportion of shrubs close to this height should increase suitable nesting habitat for Mountain Quail.

Mean canopy cover for nest sites in our study was 28%. Selecting release sites with a similar density of trees should increase suitable nesting habitat. Western juniper was the dominant tree species at 98% of our nest sites. Although it is a native species, western juniper is considered an invasive species in many parts of the Great Basin where it outcompetes other trees and shrubs and alters hydrologic function and nutrient cycling (Wall et al 2001). Currently, western juniper is being managed on Steens Mountain by the Bureau of Land Management by various methods including thinning, cutting, and burning. Thinning the juniper and leaving some portion of the canopy intact would likely be more beneficial for nesting Mountain Quail than other methods that leave no standing trees. Several Mountain Quail in this study nested in a juniper management area where trees had recently been cut and left on the ground. Leaving cut junipers on the ground 1-2 years after cutting while the needles are still on the trees, provides structure for Mountain Quail to nest under. This would be a better alternative than burning the trees, which removes all the needles and leaves little cover for nesting Mountain Quail.

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CHAPTER 3: SPRING AND SUMMER SURVIVAL OF TRANSLOCATED MOUNTAIN QUAIL ON STEENS MOUNTAIN, OREGON

ABSTRACT

In response to the decline of Mountain Quail across the eastern portion of their range, we translocated 217 Mountain Quail from southwestern Oregon to Steens Mountain, a former part of their range in southeastern Oregon where Mountain Quail have been absent for at least 25 years. We used program MARK to estimate breeding-season survival of 135 radio-collared, translocated Mountain Quail and examine factors that may be associated with their survival. We evaluated the effects of year, sex, time, linear and quadratic time trends, body condition, and weather covariates to determine if they explained variation in survival rates. For the 5-month monitoring period following translocation, survival rates in 2005 were 57% for females and 42% for males. In 2006, the survival rate was 20% for females and 9% for males. Year, sex, and a quadratic time trend were the most important factors explaining variation in survival in this study. Survival was lowest during the first 2 weeks after the release suggesting that improving survival during this initial time period may improve overall chances of a successful translocation. Selecting release sites that provide adequate cover from raptors and other predators is critical for survival of Mountain Quail following a translocation.

INTRODUCTION

Mountain Quail (Oreortyx pictus) have experienced significant declines in the eastern portion of their range during the last century. The cause of these declines is not entirely clear. However, a variety of habitat alterations such as overgrazing and alteration of fire regimes have been implicated in their decline (Brennan 1994). While Mountain Quail were once found in every county in Oregon, they are now common only in western, northeastern, and central Oregon (Pope 2002). Formerly common on Steens Mountain in southeastern Oregon, Mountain Quail have been absent since at least 1982 (M. Obradovich, pers. comm.). As a result of these population declines, a petition was submitted to list these birds under the Endangered Species Act (1973) as a threatened or endangered distinct population segment, but the petition was denied (Federal Register v. 58 # 14 2003).

Few studies provide accurate estimates of Mountain Quail survival. Like other northern species of New World quail, adult annual survival of Mountain Quail is generally less than 50% (Delehanty 2001). Pope and Crawford (2004) reported a 5-month survival rate of 42% for a sample of 232 native and translocated Mountain Quail in northeast and southwest Oregon, and found no significant difference in survival between years, seasons, or study areas. The same study found no difference in survival between native and translocated birds, suggesting that wild Mountain Quail are good candidates for reintroductions. Pope (2002) did find a significant difference between survival of males and females (49% vs. 32%). Other species of New World quail have positively male-biased sex-ratios and strong sexual dimorphism. Mountain Quail, however, have high male parental investment and sexual monomorphism, characteristics that are often correlated with lower differences in survival of the sexes (Brown and Gutierrez 1980). Other studies have found that additional intrinsic factors, such as individual body condition (Haramis et al. 1986), and extrinsic factors such as weather are important factors influencing avian survival rates (Marti and Wagner 1985).

Our objectives were to 1) estimate survival rates of Mountain Quail translocated from southwestern Oregon to Steens Mountain in southeastern Oregon during the 5-month period following translocation, and 2) determine which of the following covariates best explained variation in survival rates of translocated Mountain Quail: year, sex, time, linear and quadratic time trends, body condition, minimum temperature, and precipitation. By understanding factors that influence survival of translocated birds, we can provide guidelines to improve successes of future translocation efforts.

METHODS

Study Area

Steens Mountain is a 30-mile long fault block mountain located approximately 90 km south of Burns, Oregon. The mountain has a steep eastern face (nearly 1.5 km) and a gentle west slope dissected by steep canyons and glacial gorges. Elevation ranges from 1280-2980 m. Habitat types on Steens Mountain are very diverse and follow an elevational gradient ranging from arid sagebrush (a mix of big sagebrush (*Artemisia tridentata*) and low sagebrush (*Artemisia arbuscula*)) at the base to subalpine grassland at the top. Intermediate vegetation zones include western juniper (*Juniperus occidentalis*)(1524-1829 m), mountain mahogany (*Cercocarpus ledifolius*)(1829-2438 m), mountain big sagebrush (*Artemisia tridentata* *vaseyana*)(1981-2591 m), and quaking aspen (*Populus tremuloides*) (1829-2438 m). Understories are primarily bunchgrasses. Temperatures during 1971-2000 varied from a monthly mean high of 29.3º C in July to a low of –6.9º C in January. Annual precipitation during that same period was 34.2 cm (Oregon State Climate Center, Oregon State University).

Field Techniques

We captured 217 Mountain Quail from November-February in 2004/2005 and 2005/2006 in Douglas and Jackson Counties, Oregon, using treadle traps baited with grain. Captured quail were held over winter at a facility at the Southwest Regional office of Oregon Department of Fish and Wildlife in Roseburg, Oregon. Prior to release, birds were weighed, banded, length of tarsus measured, identified by plumage as hatch year (HY) or after hatch year (AHY) (Leopold 1939), and blood was extracted for gender identification (Veterinary Diagnostic Center, Fairfield, Ohio). In March of 2005 and 2006, the quail were transported in crates by truck to the release sites on Steens Mountain near Frenchglen, Oregon. The 2006 release site was several km from the 2005 release site. Quail were released in March to avoid harsh winter weather but still have adequate time to select mates and nest sites. Ninety birds were released in 2005, of which 56 were fitted with necklace-style radio transmitters that weighed approximately 4.3 g (Model PD2C, Holohil System Ltd., Woodlawn Ontario, Canada). In 2006 we released 127 birds, of which 80 were fitted with radio-collars. Each radio-collared bird was located at least biweekly for five months following their release. For each time interval, a bird was confirmed alive by a visual or auditory identification, or in the case of mortality, by locating the radio-collar. Cause of death was determined whenever possible by examining the site for tracks, scat, pluck-sites, or other predator sign. A bird was recorded as censored for each time interval during which it was not located, either due to radio-failure or long-range movements.

Data Analysis

We used known-fate models in program MARK (White and Burnham 1999) to estimate biweekly survival rates and examine variation in survival relative to several covariates. We created individual encounter histories for each quail, placing each bird into 1 of 4 classification groups based on 2 years and 2 sexes. We developed an *a priori* set of 19 candidate models based on factors that have been shown to influence galliform survival. Our a priori model set included the effects of year, sex, time, and quadratic and linear time trends.

MARK uses corrected Akaike's Information Criterion (AIC_c) values to select the most parsimonious model from the set of candidate models. The best approximating model was used to obtain estimates of survival probability, the probability that a bird alive at the start of an interval is alive at the end of the interval. We considered all models within 2 AIC_c values of the best approximating model and we used AIC_c weights (w_i) as evidence of a particular model being the best model in the candidate set (Burnham and Anderson 1998).

We followed *a priori* model tests with an exploratory analysis where we examined whether variation in survival could be better explained by adding an individual covariate to the best approximating model from the *a priori* model set. We used the bird's weight (g) at release to see if body mass further explained variation in survival rates. To determine if variation in survival over time could be better explained by time-specific weather covariates including the number of days during an interval that had precipitation and lowest minimum temperature during an interval, we substituted the time effect in the top model from the *a priori* model set with one or both weather covariates to see if model fit improved. Weather data was obtained from a Snotel Weather Station located near the release sites (Natural Resource Conservation Service, United States Department of Agriculture). We included 11 models in the exploratory model set.

RESULTS

Survival rates were estimated for 135 Mountain Quail. There were at least 23 individuals in each classification group. Twenty-nine birds were tracked until the end of the study, 76 were found dead, and 30 were right censored when they disappeared or their radio failed. Mean body weight was similar between years with an average of 251.57 g (SE = 0.55) in 2005 and 250.77 (SE = 0.45) in 2006. Males were slightly heavier than females, averaging 255.43 g (SE = 0.48) and 245.59 g (SE = 0.52) respectively. We were unable to positively assign cause of death in 46% of the mortalities we located. However, 46% of mortalities were attributed to raptor predation and 8% to bobcat predation.

There were 2 competing models in the *a priori* model set with $\Delta AIC_c < 2.0$. The highest ranking model included sex, year and a quadratic time trend ($w_i = 0.51$) (Table 3.1). The other competing model included year and a quadratic time trend, but did not include sex ($w_i = 0.35$). Survival to the end of the study was 57.0% (95% CI 39.8, 72.6) for females and 42.4% (95% CI 27.4, 59.1) for males in 2005. In 2006, the survival rate was 20.1% (95% CI 10.4, 35.1) for females and 9.0% (95% CI 3.8, 21.5) for males. In 2005 and 2006 survival was lowest for both sexes during the first two weeks post release and then began increasing until reaching a maximum 8-14 weeks post release, after which it began to decline (Figure 3.1).

In the exploratory analysis, adding a weight covariate did not improve the fit of the top model from the model set. However, the model with the additional weight covariate was competitive ($\Delta AIC_c = 0.71$) (Table 3.2). The confidence interval around the beta coefficient for weight included zero, providing little evidence for an effect of weight on survival. Substituting one or both weather covariates for the time trend did not explain the data any better than the top model and none of these models were competitive ($\Delta AIC_c \geq 6.56$).

Table 3.1. Model selection results for 19 a priori models used to estimate Mountain Quail survival during breeding season at Steens Mountain, Oregon, 2005-2006.

Model	K	ΔAIC_c	w_i
sex + year + T^2	5	0.00	0.51
year + T^2	4	0.72	0.35
sex + year + t	12	3.70	0.08
year + t	11	4.57	0.05
year * t	20	8.35	0.01
year + T	3	12.69	0.00
T^2	3	14.58	0.00
sex * t	20	15.24	0.00
sex + T^2	4	15.30	0.00
t	10	18.11	0.00
sex * year * t	40	18.34	0.00
sex + t	11	18.75	0.00
T	2	25.30	0.00
sex + T	3	25.89	0.00
sex + year	3	32.43	0.00
year	2	33.48	0.00
sex * year	4	34.45	0.00
null	1	50.32	0.00
sex	2	50.80	0.00

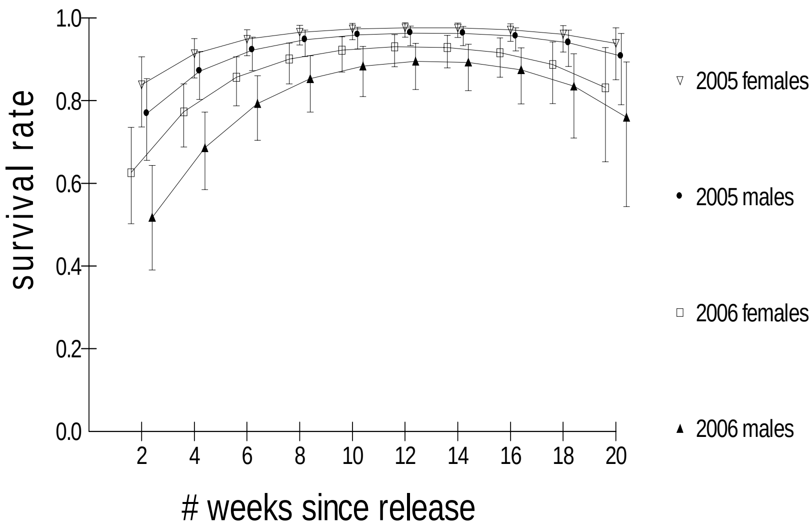

Figure 3.1. Survival of translocated Mountain Quail on Steens Mountain, Oregon, during spring and summer 2005-2006.

Table 3.2. Model selection results for 11 exploratory models for Translocated Mountain Quail survival during spring/summer at Steens Mountain, Oregon, 2005-2006.

Model	K	ΔAIC_c	w_i
yr + sex + T^2	5	0.00	0.56
yr + sex + T^2 + wt	4	0.71	0.39
yr + sex + prec	4	6.56	0.02
yr + sex + wt + prec	5	7.28	0.01
yr + sex + prec + temp	5	8.54	0.01
yr+ sex + wt + prec + temp	6	9.27	0.00
yr + sex + temp	4	16.24	0.00
yr + sex + wt + temp	5	17.03	0.00
precip	2	26.84	0.00
minimum temp	2	36.68	0.00
wt	2	50.47	0.00

DISCUSSION

Few studies have examined correlates of Mountain Quail survival during the breeding season. Survival estimates are quite variable, but like other species of quail, Mountain Quail may experience large fluctuations in annual survival. Pope and Crawford (2004) reported a survival rate of 42% for a sample of 232 native and translocated Mountain Quail for a 5 month period in northeastern and southwestern Oregon and found no difference in survival estimates between the 3 years studied. In contrast, our study found survival rates to be different between years. This difference is most pronounced during the first 4 weeks after release. In 2005 our survival rate of 57% for females and 42% for males is similar to that measured by Pope and Crawford (2004). However, our estimate of 20% for females and 9% for males in 2006 was lower than in other studies. We explore several hypotheses for this annual variation.

Total precipitation during the monitoring period was higher in 2005 than in 2006 with 56.6 cm and 36.3 cm, respectively (Natural Resource Conservation Service, United States Department of Agriculture). However, precipitation and temperature covariates were not significant factors explaining variation in Mountain Quail survival. The differences in survival rates could be attributed to differences in predator abundance. Steens Mountain lies in the path of a migratory route for raptors, predators known to kill Mountain Quail. The peak of raptor migration through the area could have been different between the 2 years, possibly as a result of differing weather conditions. If the peak of raptor migration in 2006 happened to coincide with the first 4 weeks following release, it could explain the lower survival rate during that initial time period. Another possibility is that differences in survival could be greatly affected by location of the release sites. We chose a different release site in 2006, and although it was only a few km from the 2005 release site, it may have been enough to expose the birds to different challenges during those first 4 weeks. Beyond the first several weeks after the release, the quail had dispersed from the release site and quail locations from 2005 and 2006 were similar.

While the difference in survival between 2005 and 2006 is most pronounced during the first 4 weeks following release, the survival rate was consistently lower throughout the remainder of 2006 as well. It may be there were an overall higher abundance of raptors in 2006 and consequently a higher risk of predation throughout the season. It could also be that heavy spring rains in 2005 resulted in high grass and forb production, which resulted in increased body condition for quail throughout spring and summer and a subsequent increase in survival.

The difference in survival between sexes was most pronounced during the first 6 weeks of the study period. This is the period of time when males are crowing from perches to attract mates, making them more conspicuous to predators. If the lower survival rate in 2006 was a result of higher predator abundance, then males would have been disproportionately affected during this time period. In contrast, Pope and Crawford (2004) reported higher survival for male Mountain Quail in Oregon with a survival rate of 49% for males and 32% for females. More research is needed to establish a clear trend.

We found that survival during each of the 2 years exhibited the same pattern over time. This suggests that similar processes were driving fluctuations in survival between time periods during both years. In both years, survival was lowest during the first 2 weeks of the study and gradually improved over the following 8 weeks. It is likely that the low survival during the first two weeks of the study can be attributed to the quail not being familiar with the area. Survival then improves as the birds become familiar with the area. It is also at this time that birds begin to leave the release sites and choose sites of their own, which may offer better protection from predators and/or environmental factors.

The highest survival during the five month period occurs 8 -14 weeks after release and corresponds to when birds are incubating nests. Mountain Quail spend as many as 22 hours per day on the nest (Pope 2002). Other studies have found that birds are most vulnerable to predation while incubating nests (Devries et al. 2003). However, if the majority of Mountain Quail predators are raptors, then being concealed under a rock or bush should improve survival. This is substantiated by the fact that after the nests have hatched and quail begin moving again with their broods, the survival rate begins to decline.

MANAGEMENT IMPLICATIONS

Translocations have become a widely used conservation tool. However, few translocations have incorporated post-release monitoring into management plans (Griffith 1989). The percentage of released animals that survive to breed successfully in the wild is a good short-term indicator that a translocation has been successful (Scott and Carpenter 1987). By understanding correlates of survival in translocated Mountain Quail, we can identify factors associated with the success or failure of a reintroduction effort. Our study found a significant difference in survival between the 2 years. By further examining differences in release sites and/or predator abundance between the 2 years, we may be able to quantify specific factors associated with Mountain Quail survival. We can use this knowledge to inform decisions regarding release sites in order to increase chances of success for future translocations. More long-term monitoring is needed to understand how variations in survival rates influence population trends over time.

The lower survival rate for males in this study indicated that translocating a higher proportion of males would lead to a more balanced sex-ratio. However, trapping methods do not distinguish between sexes and it can be difficult to obtain a higher proportion of males.

The lower survival rate during the initial 2 weeks after release suggests that maximizing survival during the first 2 weeks might greatly increase the overall success of the reintroduction. It is often beneficial to conduct a “soft” release where the animals are confined at the release site until they become acclimated to their new environment (Scott and Carpenter 1987). However, enclosures at the release site are often too costly unless individuals available to translocate are extremely rare. This is probably not practical for Mountain Quail while we still have a reliable source population west of the Cascade Range from which to transplant birds. Predator control is also not an option if the majority of the predators are federally protected raptors. Choosing release sites with adequate cover should be a primary consideration, as should timing the release so as not to coincide with any major raptor migrations. The relatively high survival in 2005 suggests that translocated Mountain Quail can survive on Steens Mountain and the low survival in 2006 is not a result of poor habitat quality.

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CHAPTER 4: SUMMARY AND CONCLUSIONS

Translocations have become a common technique for wildlife conservation but few translocation programs incorporate post-release monitoring to evaluate the success or failure of the translocation (Griffith et al. 1989). The first indication a translocation is successful is the first cohort surviving long enough to reproduce (Griffeth et al. 1989). Translocated Mountain Quail on Steens Mountain were successful at reproducing in 2005 and 2006, providing a good indication of short-term success.

Mountain Quail on Steens Mountain primarily nested in western juniper/big sagebrush habitat types and preferred shrubs close to 1 m in height with some canopy cover. This requirement appeared to be the same for male and female Mountain Quail. While the sagebrush ecosystem on Steens Mountain is unique among systems where Mountain Quail have been studied, our results support the findings of Pope (2002) that canopy cover and perimeter shrub height were important in Mountain Quail nest site selection in the mesic montane forests of southwestern Oregon and semi-arid canyons in northeastern Oregon. Therefore, we should consider these factors when restoring or maintaining habitat for Mountain Quail and when planning future translocations.

While survival was considerably lower in 2006, there were still a sufficient number of birds that survived and successfully reproduced. This suggests that releasing close to 100 birds is a sufficient number for successful reproduction in years of lower survival. We found that survival was different between the 2 years of our study. Body condition and weather covariates did not explain the differences in survival. We hypothesized that other factors such as predator abundance or habitat quality resulting from differences in weather patterns between years may explain the difference in survival rates. Further examination of these factors may provide more insight into the mechanisms that drive year-to-year variation in survival rates.

We found that male Mountain Quail experienced higher mortality than females in this study. This is contrary to the results of Pope (2002) and warrants further investigation. Survival was highest for both sexes while they were incubating clutches. Many other avian species experience lower survival while incubating nests. It may be that raptors are more of a threat to Mountain Quail on Steens Mountain than mammalian predators and so being concealed under a rock or a bush increases their probability of survival. Survival was lowest for male and female Mountain Quail during the first two weeks following translocation. This suggests that anything we can do to minimize mortalities during this initial time period could increase overall survival for translocated Mountain Quail. Predator control is not an option for federally protected raptors. However, we should consider timing the release so as not to coincide with major predator movements through the area and choose release sites with sufficient cover for protection from predators.

In both years of this study, a high proportion of Mountain Quail were able to successfully reproduce, indicating that Mountain Quail may be able to colonize Steens Mountain once again. By restoring Mountain Quail to parts of their historic range such as Steens Mountain, we may prevent continued declines and increase population distributions in eastern ranges.

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