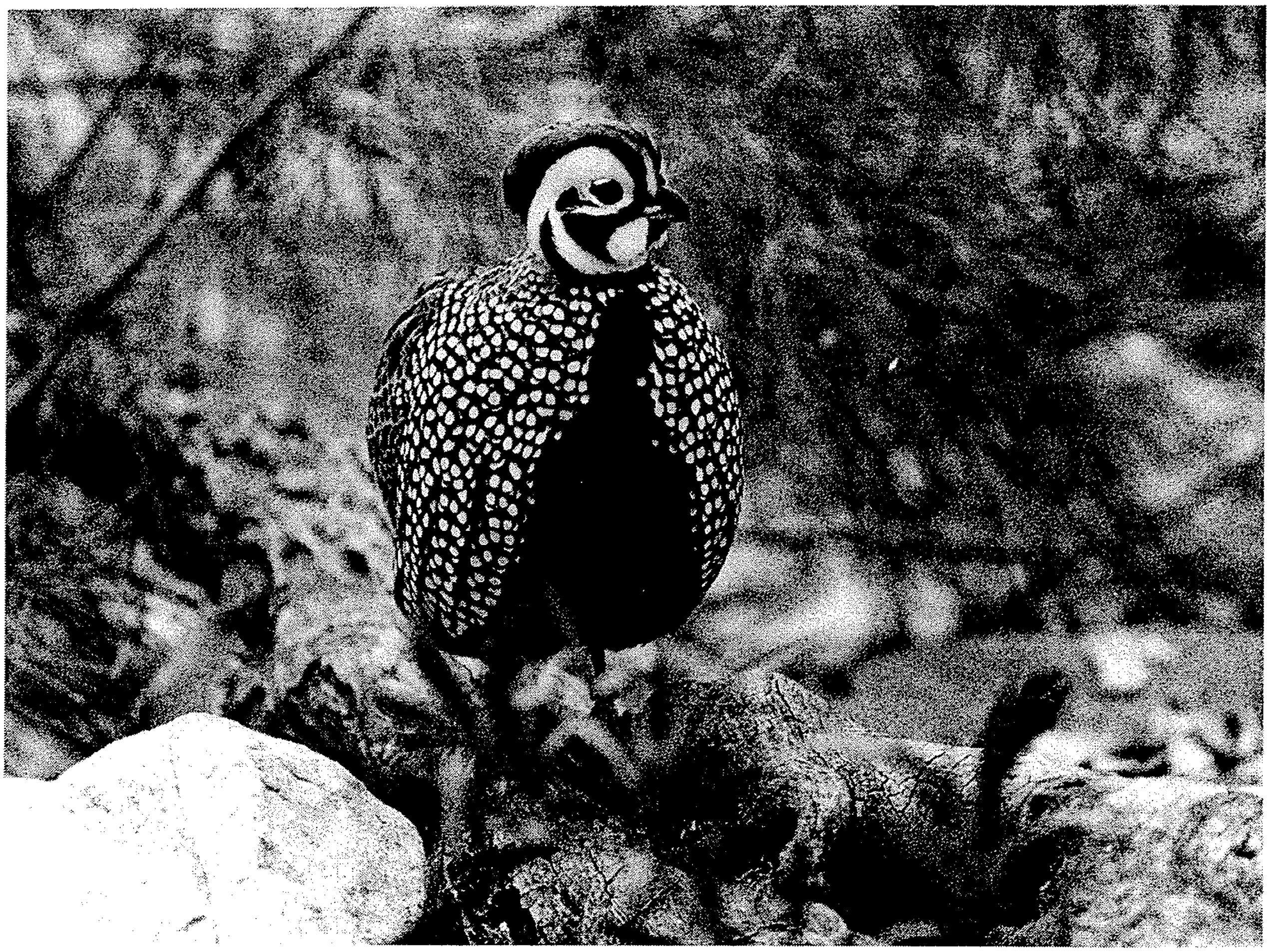

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Effects of Human Activity and Habitat Conditions on Mearns' Quail Populations

Federal Aid in Wildlife Restoration
Project W-78-R

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Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

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INTRODUCTION

Mearns' quail (*Cyrtonyx montezumae mearnsi*), the northernmost subspecies of the Montezuma quail, is a popular gamebird species in Arizona. The largest of the 5 quail species in Arizona, Mearns' quail are exotic looking birds that hold tight when danger is near, typically flushing only at the last minute. Their unique looks and behavioral characteristics add substantially to their status among hunters and bird watchers.

Mearns' quail occur in limited distribution in Arizona, with their primary range in the foothills of southeastern mountain ranges. Limited populations also occur throughout central and east-central Arizona, in local areas that meet their habitat requirements. The main vegetation associations supporting Mearns' quail populations are Madrean evergreen woodlands and oak-pine (*Quercus* spp.- *Pinus* spp.) forests with abundant grass cover. The U.S. Forest Service's (USFS) Coronado National Forest manages most suitable Mearns' quail habitat. Brown (1989) summarizes the characteristics, behavior, distribution, habitats, and harvest history of the species.

In the mid-1990s, public concerns were raised about the effects of land-use practices on Mearns' quail abundance, potential over-harvest on populations, effects of non-resident hunters on the harvest, the distribution of hunters within available habitat, and the quality of current management data. Further, natural resource managers needed a reliable adequate survey method. Methods used for Gambel's (*Callipepla gambelii*) and scaled (*C. squamata*) quail, the 2 most abundant quail in Arizona, did not perform well when used on Mearns' quail.

The Coronado National Forest Plan (USFS 1996) identified 3 major land uses that could impact Mearns' quail: livestock grazing, fuelwood cutting, and recreation. Recreational uses included off-highway vehicle use, concentrated camping, and trail riding, which can all result in reduced vegetation and increased soil compaction. Reduced vegetative cover and soil compaction are important because Mearns' quail use dense grass cover for security and thermal cover, and forage primarily by digging for underground tubers, such as nutsedges (*Cyperus* spp.) and woodsorrels (*Oxalis* spp.).

Livestock grazing removes security and thermal cover. Although previous research showed that heavy grazing levels increased Mearns' quail food resources, loss of dense grass cover made the habitat unsuitable (Brown 1982). Fuelwood cutting could impact Mearns' quail because they are seldom found far from tree cover. While historical tree removal in southeastern Arizona was often severe (Bahre 1991), the Coronado National Forest Plan does not include substantial tree removal in Mearns' quail habitat.

The effects of sport hunting on Mearns' quail have not been clearly resolved. Early reports suggested that hunting does not negatively impact Mearns' quail populations, and hunting has long been considered a compensatory rather than additive impact (Leopold and McCabe 1957, Bishop 1964). Lack of an adequate survey method has hindered investigations into effects of Arizona Game and Fish Department's (AGFD) hunting management program on Mearns' quail. Further, lack of preference and demographic data from Mearns' quail hunters has resulted in misperception or conjecture attempting to influence management decisions.

STUDY AREA

We conducted this study within the core of Mearns' quail range in southeastern Arizona (Fig .1). The study area included the 4 most popular Game Management Units (34A, 35A&B, and 36B) among Mearns' quail hunters. The area contained several mountain ranges that rise to 1,000-3,000 m. We concentrated most of our efforts in the Madrean evergreen woodlands of the Canelo Hills and Atascosa, Huachuca, and Santa Rita mountain ranges, where Mearns' quail densities and hunting effort have historically been high. This foothill topography consists of rolling hills broken by numerous canyons. Average annual precipitation is 37 cm, with seasonal peaks in winter and late summer. Seasonal temperatures average 24 C in summer and 10 C in winter.

Although Mearns' quail are found in other habitats, their densities are highest in the oak

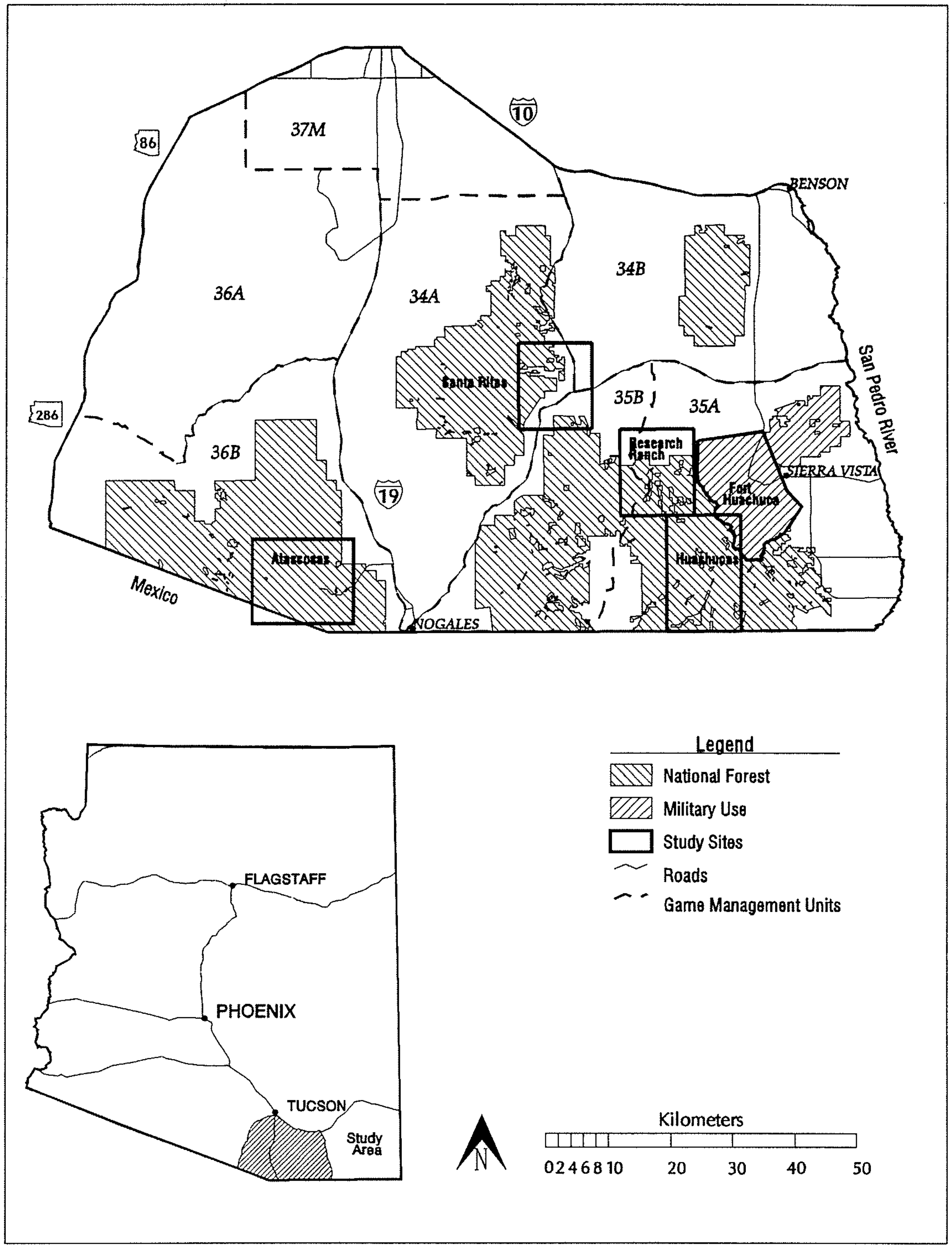


Figure 1. Location of Mearns' quail study area with the 5 primary study sites, southeastern Arizona, 1996-2000.

woodlands (Brown 1989). These oak woodlands occur between 1,200 and 1,500 m and are dominated by various live oaks, including Mexican blue (*Q. oblongifolia*), Emory (*Q. emoryi*), and Arizona white (*Q. arizonica*) oak. Alligator juniper (*Juniperus deppeana*) and mesquite (*Prosopis juliflora*) are found on drier sites. Trees and shrubs, such as mimosa (*Mimosa* spp.) and manzanita (*Arctostaphylos* spp.), dominate north-facing slopes, whereas perennial bunchgrasses, like three-awn (*Aristida* spp.), grama (*Bouteloua* spp.), lovegrasses (*Eragrostis* spp.), and sprangletop (*Leptochloa* spp.), dominate south-facing slopes and flats.

Within the entire study area, we selected 3 treatment and 2 control sites based on land uses and management strategies. Treatment sites were on USFS property, being open to hunting and public land livestock grazing. The 3 treatment areas were the Santa Rita Mountains (GMU 34A), Atascosa Mountains (GMU 36B), and Huachuca Mountains (GMU 35A). Within the Santa Rita Mountains (i.e., Santa Ritas), we concentrated our activities in Hog, Gardner, and Fish canyons. The primary Atascosa Mountains (Atascosas) sites included Calabasas, Pesqueria, Sycamore, and Walker canyons, and the Summit Motorway area. Parker, School, Sunnyside, and Jones canyons were the primary canyons within the Huachuca Mountains (Huachucas). These sites contained some of the most popular Mearns' quail hunting areas in Arizona. Range conditions varied from overused to lightly used, with some pastures temporarily deferred from grazing.

The 2 control sites had been protected from livestock grazing and had either no hunting or very low hunting pressure on portions of the sites. The Research Ranch (Research Ranch) of The National Audubon Society (GMU 35A) represented 1 control site. The Research Ranch, managed in cooperation with the U. S. Bureau of Land Management and USFS, had not been grazed by livestock or hunted since 1968. The second control site was the Fort Huachuca Army Garrison (Fort Huachuca) in the Huachuca Mountains (GMU 35A). Fort Huachuca is the headquarters for the U.S. Department of Defense Army Communications Command. Electronic equipment testing, small arms and artillery firing, and field training activities are conducted at Fort Huachcua. The post has been closed to livestock grazing since 1946. Although hunting by military personnel is allowed on the post, hunting pressure on Mearns' quail has historically been minimal.

SURVEY METHODOLOGY

Early population estimates of Mearns' quail were unreliably based upon the occasional flushing of coveys. In the 1960s, taped recordings of calling females were first used to locate and survey Mearns' quail (Bishop 1964, Levy et al. 1966). Brown (1976) tested this method, but met with limited success. Although breeding season call counts are sometimes used for surveying Gambel's, scaled, and masked bobwhite (*Colinus virginianus ridgwayi*) quail in Arizona, erratic or lack of calls by Mearns' quail results in unreliable data. Other survey methods, such as mark-recapture and using indirect scratch sign, also proved unsuccessful for Mearns' quail (Brown 1976).

The pointing dog survey method seemed to be the best option, and it had some use in Arizona (Brown 1976) and New Mexico (Holdermann 1992). Based upon such early efforts, we believed that pointing dog surveys could produce a useful index to Mearns' quail relative abundance. By relative abundance, we mean being able to determine whether there are more, similar, or less numbers of coveys or birds among various areas, seasons, or years.

However, before the method could be used to assess the effects of land-use practices and hunter harvest, additional testing was needed. Our objectives for this segment of our study were to determine: 1) the minimum number of routes necessary to stabilize likely response variables ($\bar{x}$-coveys-flushed/route, $\bar{x}$-birds-flushed/covey, and $\bar{x}$-time-in-minutes-to-first-flush); 2) an efficient amount of time or length for survey routes; 3) minimum sample sizes needed and minimum detectable differences in $\bar{x}$- coveys-flushed/route between sites; and 4) effects of season, time of day, number of observers and dogs, and weather conditions on response variables.

Field Efforts

In November 1996, we established 15 survey routes, with 5 at Research Ranch, 5 in the Santa Ritas, and 5 at Fort Huachuca to evaluate pointing dog surveys. After surveying the 15 routes and plotting running averages of our response variables, variation was high and we added 4 more routes in the Santa Ritas, 4 more at Research Ranch, and 10 more at Fort Huachuca to conduct further tests. We also established 9 routes in the Huachucas and 9 in the Atascosas.

Before we started each route, we recorded the study site, transect number, date, temperature, wind speed, relative humidity, start time, and number of dogs and observers. Each dog had a beeping collar that indicated when the dog was on point and an electronic training collar to help us maintain control. As a covey (≥ 1 bird) was flushed, we recorded the time, location, covey size, and sex and age of each bird identified. Typically, if more than 1 dog was used, we paired them by contrasting experience, sex, and hunting style.

We ran an early morning route, switched dogs and did a second route in mid-morning, then finished with an evening route using a different combination of dogs. For dog safety, we did not run survey routes if the starting temperature exceeded 30 C. Each route consisted of approximately 45 minutes of coverage along 1 side of a drainage, then a return along the opposite side. Dogs were allowed to search side drainages and slopes as their experience dictated. Occasionally, handlers directed dogs into likely habitat. At a covey point, handlers positioned themselves to best count and determine the age-sex of each flushed bird.

Number of Routes

Since we had 15 routes at Fort Huachuca, it was our best site to determine the number of routes necessary to stabilize x̄-number-of-coveys-flushed/route (COVEYS/ROUTE), our principal estimator. We calculated and plotted running averages and 95% confidence intervals (CI) of the number of coveys flushed at sample sizes between 2-15 routes to graphically assess data stability during February 1997; for the other sites, we only plotted running averages. Visual inspection of the Fort Huachuca plot indicated stability in COVEYS/ROUTE and the 95% CI occurred only after 7 routes were done for a replicate (Fig. 2). After 9 routes, the 95% CI narrowed slowly. Plots for other sites suggested likewise. Further testing indicated that random order replicates (February 1997, November-December 1997) of the 15 routes at Fort Huachuca stabilized at 5-7, however, a non-random replicate during September 1997 did not stabilize until ≥9 routes were completed. For the non-random replicate, routes were run for efficiency and cost savings. This non-random sampling scheme negatively affected the data, resulting in several more routes needed for stability. To randomize the order in which routes are run would be time and cost inefficient. The best strategy would be to add a few more routes.

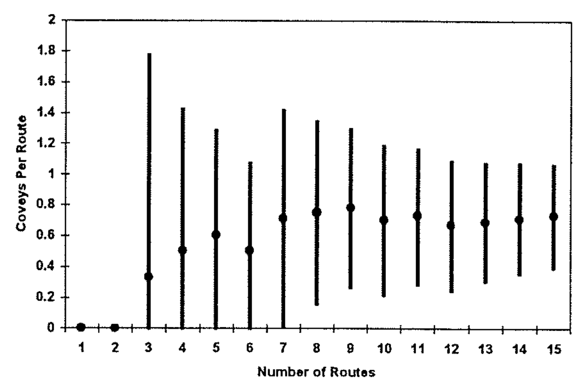


Figure 2. Running average and 95% confidence interval of Mearns' quail coveys flushed by number of survey routes completed at Fort Huachuca, southeastern Arizona, 1997.

To help determine the minimum sample size to stabilize x̄-birds-flushed/covey (COVEY SIZE), our second response variable, we calculated running averages at Fort Huachuca and the Research Ranch during the brood season (September-October 1997) and the fall pre-hunt season (October-November 1997). Visual inspection of the plotted running averages indicated that stability in COVEY SIZE occurred at >5 coveys flushed (Fig. 3). By >6 coveys, the brood and pre-hunt season indices were similar for both Fort Huachuca and Research Ranch. Since the number of coveys flushed per route is

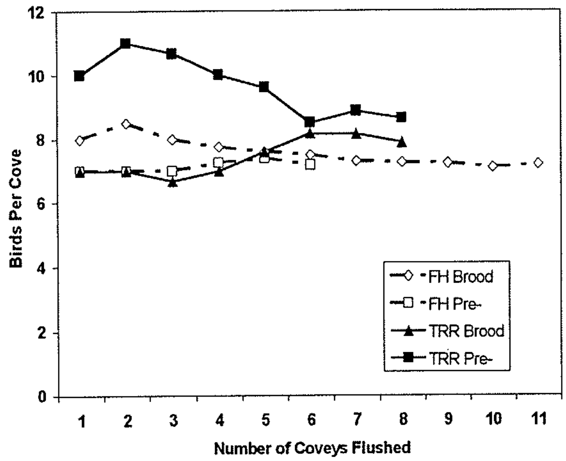


Figure 3. Running averages of Mearns' quail per covey by number of coveys flushed on survey routes at Fort Huachuca and Research Ranch, southeastern Arizona, during brood (September-October) and pre-hunt (October-November) seasons, 1997.

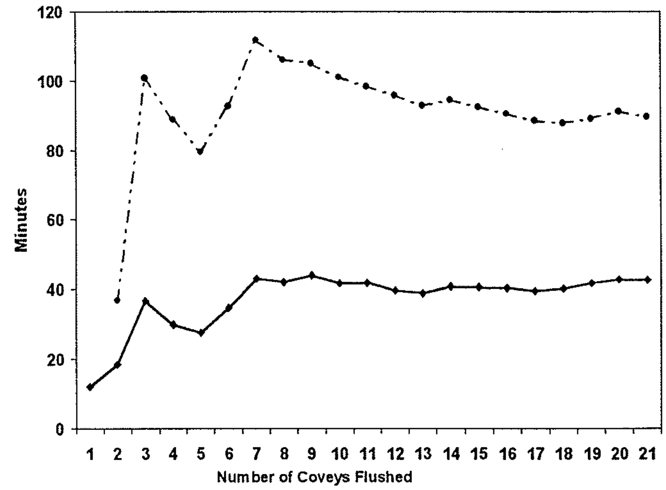


Figure 4. Running average of the time (solid line) to the first Mearns' quail covey flushed on a survey route by number of coveys flushed at Fort Huachuca and Research Ranch, southeastern Arizona, 1997. Two Standard Deviations (dashed line) were plotted to estimate time needed to observe ~96% of first flushes.

~1, COVEY SIZE would likely stabilize before COVEYS/ROUTE. If a minimum of 9 routes were completed, both response variables stabilize.

Time to Spend on Routes

Our third response variable, $\bar{x}$ time-to-the-first-flush (MEAN TIME; = time first covey located – route start time in minutes) on a route, helped us determine the most efficient amount of time to spend on routes. We flushed 21 coveys on 26 routes at 3 sites during the post-hunt season (February-March) in 1997. Plotted running means (±2 Standard Deviations) indicated that MEAN TIME stabilized at approximately 40 minutes after 7 routes (that actually had flushed coveys), and approximately 95-96% of the first flushes occurred within 90 minutes (Fig. 4). However, approximately 20% (5 of 26 routes) of the time, we did not flush a covey along the transect route. Because the problem of not encountering coveys within 90 minutes prevented us from calculating an unbiased mean, we thought switching to the distribution of time-to-first-flush values instead of running averages may serve as a possible index to relative abundance.

However, we believe dog efficiency decreased as time progressed in a 1.5-hr survey, as dogs reduced their coverage, returned for water quicker, and walked along with handlers more often, particularly after 75-80 minutes. This may partially explain why as each 30-minute block occurred in our 1.5-hr transects, a lower percentage of first coveys were located. After 1 year of replicates (n = 260 routes) among the 5 study sites, time-to-first-flush occurred 85 (32.7%) times within the first 30 minutes and 68 (26.1%) times during the 31-60 minute period. But only 42 (16.2%) occurred during the 61-90 minute period, when we started to notice performance declines in the dogs. No flushes occurred on 65 (25%) of the routes. Although using such a distribution as time-to-first-flush may reflect the actual density of coveys within any given site, we suspected that decreasing dog efficiency was partially responsible for the pattern observed.

Given the aforementioned data, we conclude that pointing dog surveys for Mearns' quail should be standardized to be from 1 to 1.5 hours in time. A loop of 45 minutes along 1 side of a drainage and a return along either the bottom or opposite side covers an area thoroughly enough to compensate for possible differences in habitat selection by Mearns' quail. The dogs remain more active, are less stressed, and more routes can be completed in a day, when routes are within that time range. Actual length of a route covered in that time depends on the terrain, hunting style and speed of individual dogs, number of coveys actually encountered, and other variables.

Minimum Sample Sizes to Detect Differences

The number of routes needed to estimate the variability of a response variable and calculate an accurate mean depends on the level of confidence we desire and the probabilities we accept for making errors. We decided to calculate required sample sizes and minimum detectable differences at our sample sizes for Type I errors of 5% and 10% (i.e., the probability of saying a difference exists between estimates when there actually is no difference at $\alpha = 0.05, 0.10$; Zar 1984:43). We also wanted to hold Type II errors (β or the probability of not detecting a difference when a true difference is present) to 10% and 25%. This allowed us to approximate the statistic power ($1-\beta$; in this case 90% and 75% power) of using pointing dog flush counts to detect changes in abundance (i.e., COVEYS/ROUTE).

If we wished to determine the required sample size to detect annual differences of 0.25 and 0.50 COVEYS/ROUTE, during either the pairing season (April-May) or the fall pre-hunt season (October-November), the following formula (Zar 1984:110) would be used:

$$n = s^2/\delta^2\ (t_{\alpha,v} + t_{\beta(1),v})^2$$

Where s^2 is the estimated variance, δ is the difference we wish to detect, α is the probability of a Type I error, β is the probability of a Type II error, and v is n-1. During the pairing season of 1997, we completed 35 routes and flushed 47 coveys ($\bar{x} = 1.34 \pm 0.97$ SD). To detect a difference of 0.25 COVEYS/ROUTE between years with 90% power at the 5% level of significance, a total of ~390 routes would be required. To detect a change of 0.50 COVEYS/ROUTE would only require ~97 routes. By reducing our power to 75% and level of significance to 10%, the number of routes to detect changes of 0.25 and 0.50 would be ~161 and ~40, respectively. Certainly, with the variability observed during the test phase, obtaining an adequate sample size to detect pairing season changes of <0.50 COVEYS/ROUTE is a formidable task, unless Type I and Type II error levels are relaxed.

A similar situation occurs during the fall pre-hunt period. We completed 81 routes during fall 1997 and flushed 93 coveys ($\bar{x} = 1.15 \pm 0.92$). To detect a change of 0.25 COVEYS/ROUTE (approximately a 20-25% change), 90% of the time at 5% significance, ~355 routes would be needed. Only ~88 routes would be needed if we wished to detect a 0.50 COVEYS/ROUTE change 90% of the time at 5%. Reducing the power of detection to 75% of the time, to detect changes of 0.25 and 0.50 COVEYS/ROUTE, would require ~147 and ~37 routes, respectively.

We needed to determine the minimum detectable difference we could observe between sites or years, if during the pairing season only ~35 routes could be completed. At 5% significance and 90% power, we could detect a minimum difference of 0.55 COVEYS/ROUTE. By increasing the significance to 10% error, 90% of the time a difference of 0.49 COVEYS/ROUTE could be detected. Reducing power to 75% of the time and holding significance at 10% error, a difference of 0.39 COVEYS/ROUTE could be detected.

The minimum detectable difference for the fall pre-hunt season, with 81 routes completed, would be 0.34 COVEYS/ROUTE 90% of the time at a significance of 5%. Increasing the significance error to 10%, we could have detected a difference of 0.30 COVEYS/ROUTE 90% of the time. By reducing power to 75% of the time, at 10% error, we could have detected a difference of 0.24 COVEYS/ROUTE.

Season and Time of Day

Because of Mearns' quail seasonal behavioral patterns, using COVEYS/ROUTE and COVEY SIZE as population indicators can be misleading if season is not considered. Typically, Mearns' quail coveys start to break up in March and individuals pair together for breeding during April and May, but don't nest until the onset of summer rains in July (Bishop 1964). Broods are hatched and raised from August through October. Thus, the timing of pointing dog surveys to estimate relative abundance of Mearns' quail, by using COVEYS/ROUTE, can be influenced by covey break up. COVEY SIZE during a post-hunt survey can easily be affected by covey break up if some coveys initiate break up in late February or early March. Conversely, determining the number of mated pairs in April or May would be affected by coveys that did not break up yet.

When we investigated the seasonal pattern of COVEY SIZE, the low point occurred during April-May, as most birds were in pairs. During pairing season 1997 on Research Ranch, 41 (87.2%) coveys flushed had 2 paired birds, 4 had only 1 bird, 1 covey had 3, and 1 covey still had 6 birds. In general, using pointing dog surveys in April-May is sufficient to annually produce an index to the number of pairs available to nest.

COVEY SIZE increased during the fall, between September and October, as broods were hatched and became more active. COVEY SIZE continued to increase into late fall (November), even after most clutches of eggs should have been hatched and chicks fully developed. Either coveys joined together or non-breeders entered some brood coveys. Nonetheless, to estimate Mearns' quail recruitment productivity, we believe pointing dog surveys would best be done in late October to just prior to the hunting season opening in late November. Post-hunt surveys should be conducted prior to mid-March.

Since we found little difference in the probability of encountering coveys in the morning, mid-morning, or evening, time of day is not important in conducting survey routes. By running 3 routes a day, a survey team can complete a sufficient number of routes in 1 week to accurately estimate response variables for a site.

Number of Observers and Dogs

We suspected that using ≥2 observers would greatly increase the likelihood of detecting coveys, however this did not seem to be the case. The difference in survey efficiency that we detected was not substantial. Beeper collars maximize the ability of a single handler to maintain contact with the dogs, negating the need for a second observer.

Although it seemed logical that ≥2 pointing dogs could locate more coveys than a single dog, we found no evidence to indicate that assumption was true. However, we did find that a young, inexperienced dog should be teamed with a more experienced dog. In the Santa Ritas during November 1997, 2 independent teams of experienced handlers and dogs estimated a similar number of COVEYS/ROUTE (1.67 vs. 1.56) over the 9 routes. Another observer with a young (2-yr old) inexperienced dog and an over-mature (>10-yr old) dog, also relatively inexperienced with Mearns' quail, estimated fewer ($\bar{x} = 1.00$) COVEYS/ROUTE. This test, conducted under similar weather conditions, indicated that the experience of handlers and dogs affects survey efficiency and success.

Weather Conditions

Weather conditions, such as ambient temperature, wind speed, or relative humidity are commonly believed to affect a dog's ability to scent and point coveys. We investigated whether such factors were significantly influencing COVEYS/ROUTE. We found no correlation between wind speed (<32 kph) or relative humidity (range 11-88%) and number of coveys flushed on a route. A slight negative correlation ($r = -0.106$) existed between coveys flushed on a route with ambient temperature (range 1-33 C). However, that slight negative relationship did not affect the probability of encountering either 0, 1, 2, or ≥3 coveys on a route.

EFFECTS OF USFS LIVESTOCK GRAZING PROGRAM

Mearns' quail are historically associated with dense grass cover (Leopold and McCabe 1957, Bishop 1964, Brown 1982). Livestock grazing, because it reduces grass cover, is considered an important factor affecting the distribution and abundance of Mearns' quail. The Coronado National Forest currently uses management guidelines, based primarily on recommendations from Brown (1982), to help maintain the current distribution and abundance of Mearns' quail on USFS lands.

Brown (1982) found that Mearns' quail were absent from otherwise suitable habitat where available grass cover had been reduced by more than 55% of standing annual biomass. He recommended that livestock use rates of ≤ 40% of standing annual biomass were necessary to maintain Mearns' quail in an area. We believe this recommendation may be inappropriate because the amount of cover remaining can vary with annual herbaceous production (standing annual biomass). Cover requirements of Mearns' quail are likely consistent regardless of annual production. We believe that information on minimum grass cover height and density requirements for Mearns' quail is essential for habitat management.

Habitat Selection

We investigated Mearns' quail habitat selection in grazed (Santa Ritas) and ungrazed (Research Ranch) oak woodland sites. We used pointing dogs to locate and flush Mearns' quail coveys, then we collected data on vegetative cover and substrate at each flush site. We compared these data to similar data collected at random plots to establish selection and identify important components of Mearns' quail habitat. These data were collected during 2 biologically important seasons, pairing (April-early June), and brood rearing (late August-October) in 1998 and 1999. The pairing season occurs just prior to summer rains, which provide the growing season for most bunchgrasses. Pairing season is a critical period because livestock grazing has its greatest cumulative impact just prior to summer rains. Brown (1982) concluded that "residual cover" during the pairing season was critical to Mearns' quail adult survival and subsequent nesting. Brood season habitat conditions are critical for recruiting young into the population.

We described landform and substrate of flush sites by measuring slope, aspect, and soil compactness, and by classifying terrain type. We described vegetative species composition and structure around flush sites by estimating: species richness, percent ground cover, percent canopy cover, and visual obstruction. We used a 50-cm x 50-cm visibility board and a 20-cm Robel pole (Robel et al. 1970) to estimate visual obstruction. Weather variables, such as temperature, soil temperature, wind speed, and relative humidity, were also collected. We measured these habitat and weather variables in the same manner at the flush sites and associated (<100 m) random plots we set up for comparative purposes.

Within oak woodlands, substrate, vegetative species richness, and cover affected habitat selection of Mearns' quail. Flush site characteristics were different from random plots for the majority (65%) of the habitat variables we measured (Table 1). In general, our modeling analyses indicated that Mearns' quail used cooler areas with loose soils, more plant species, and greater amounts of cover than occurred at random. This habitat is typical of what is found on more mesic north-facing slopes of oak woodlands. Several of these habitat components can be affected by public land uses on the Coronado National Forest or elsewhere.

Vegetation at flush sites had more forb and grass species present than did random plots. Since Mearns' quail are using grasses primarily for security cover, actual species present are likely less important than the amount of cover present. In general, though, areas that had greater amounts of grass canopy cover also had more grass species. Flush sites also had fewer shrubs and cactus than did random plots, probably due to more xeric conditions at random plots.

The number of forb species present was important to Mearns' quail habitat use, probably due to their dietary requirements. Forbs such as Yellow nutsedge (*C. esculentus*) and Gray's woodsorrel (*O. grayi*) comprise a substantial portion of Mearns' quail diets, and these plants are associated with relatively mesic, deep loamy soils (Bishop and Hungerford 1965, Holdermann and Holdermann 1997). This is important to livestock grazing practices, because Brown (1982) found that grazed areas in oak woodlands had higher forb densities than ungrazed areas. This implies that if security cover requirements for Mearns' quail are met, appropriate livestock grazing may actually improve their habitat.

Livestock grazing can, however, increase soil compactness (Anderson 1993), and we found soil compaction at flush sites was less than at random plots. Because Mearns' quail obtain a majority of their foods by digging for underground tubers, their affinity for loose soils is probably diet related. However, we suspect livestock numbers would have to be excessive to substantially increase the amount of soil

Table 1. Means and standard deviations of habitat variables at Mearns' quail flush sites (n = 120) that differed from associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999.

	Mean		Standard deviation		
Variable	Flush	Random	Flush	Random	P^a
Temperature (C)	25.1	26.8	4.8	4.7	0.006
Soil temperature (C)	19.0	26.6	4.5	7.7	<0.001
Soil compactness (tons/m^2)	14.4	18.8	11.1	11.7	0.003
Grass species richness	5.3	4.4	1.5	1.6	<0.001
Forb species richness	6.4	4.8	2.9	2.7	<0.001
No. of shrubs > 0.3 m tall	3.4	5.1	6.8	8.3	0.084
No. of shrubs < 0.3 m tall	1.8	3.9	3.7	8.7	0.014
Percent cactus ground cover	0.0	0.1	0.1	0.3	0.029
Percent shrub ground cover	1.1	1.7	1.9	2.9	0.072
Percent grass canopy cover	60.3	53.9	17.1	19.9	0.008
Robel pole 10-cm (m)[b]	6.1	10.3	3.8	6.2	<0.001
Robel pole 20-cm (m)[c]	9.6	14.1	5.2	7.7	<0.001
Maximum 50% obstruction[d]	20.4	12.3	15.1	11.9	<0.001

[a] Differences determined by 2 sample t-tests.
[b] Distance to visual obstruction of 10-cm band.
[c] Distance to visual obstruction of 20-cm band.
[d] Maximum height at which the average visual obstruction ≥50%.

compaction in Mearns' quail habitat. The effects of cover removal would likely supersede those of soil compaction at moderate grazing levels.

Adequate security cover is critical to Mearns' quail survival (Brown 1979). Flush sites had more grass canopy cover than did random plots. We used Bonferroni confidence intervals and Jacobs' D selectivity indices to determine what is adequate grass canopy cover for Mearns' quail. We found that Mearns' quail avoid sites with grass canopy cover ≤50% (Table 2). This method allowed us to determine that Mearns' quail favor sites that have >50% grass canopy cover, with their greatest preference for 51-75%.

Both methods used to estimate vertical cover indicated that flush sites had greater visual obstruction than did random plots (Fig. 5, Table 1). Greater visual obstruction occurred at all height categories tested, up to 50 cm. Mearns'

Table 2. Use of percent grass canopy cover classes at Mearns' quail flush sites (n = 120) compared to associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999.

Percent grass canopy	No. of Locations	Bonferroni 90% CI	No. of locations expected	Jacobs' D^a
0 - 25%	2	0.0 – 4.3	11	-0.71
26 - 50%	30	22.4 – 37.6	38	-0.17
51 - 75%	64	55.3 – 72.6	53	+0.18
76 -100%	24	17.0 – 31.0	18	=

[a] + denotes selection for
- denotes avoidance or used less than expected
= denotes use consistent with expected.

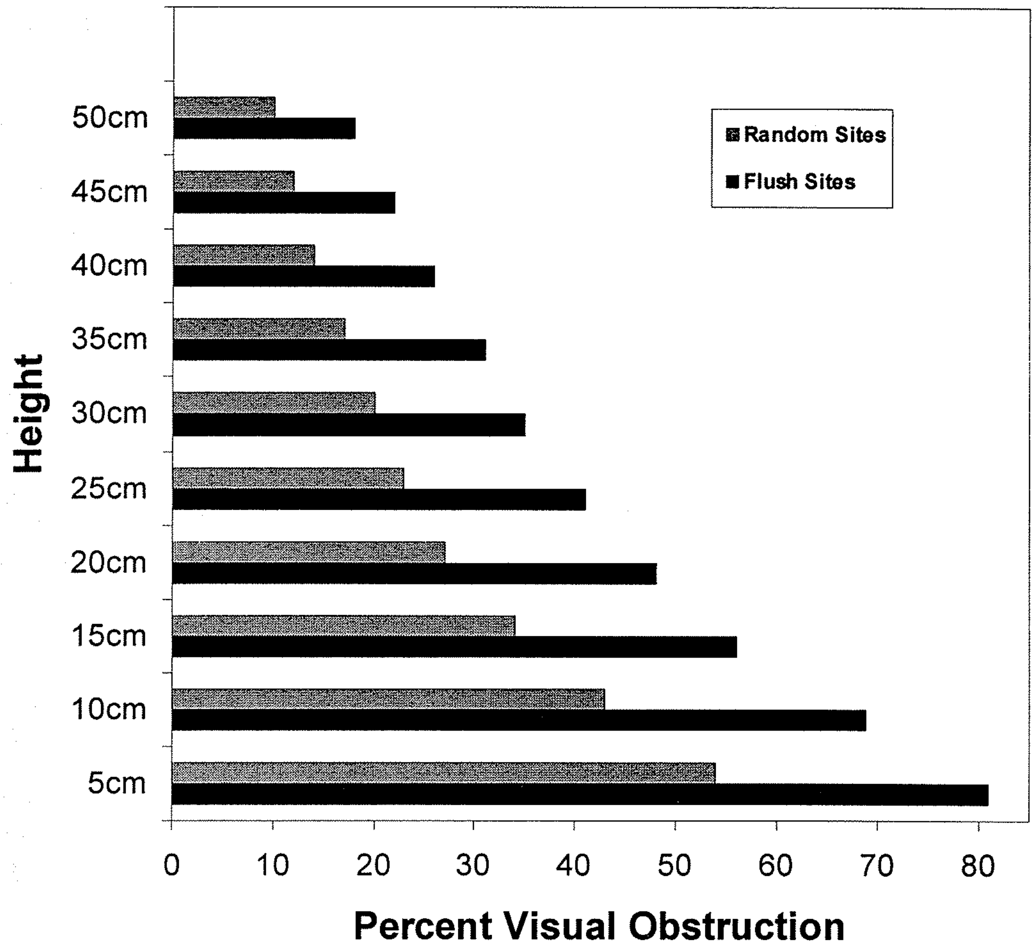


Figure 5. Average visual obstruction by height class determined by visibility board readings taken at Mearns' quail flush sites (n = 120) compared to associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999. All differences significant ($P \leq 0.10$) according to 2 sample *t*-tests.

quail are probably selecting areas with greater cover to avoid predators. The primary predator avoidance strategy of Mearns' quail is to remain motionless, relying on cryptic coloration to avoid detection. This behavior is only effective when there is sufficient cover to hide birds. Raptor predation is the greatest source of natural mortality for Mearns' quail (Stromberg 1990). Our data suggest that substantial higher (>20 cm) visual obstruction could be important to Mearns' quail to prevent detection by aerial predators.

Most Mearns' quail security cover is associated with perennial bunchgrasses. Since livestock are selective in their feeding, grazing pressure does not affect grass cover consistently across an area. Furthermore, perennial bunchgrasses typically occur in a patchy distribution, and moderate livestock grazing may further promote patchiness. While our study area encompassed both grazed and ungrazed study sites, the amount of visual obstruction at flush sites was consistent between study sites. Thus, Mearns' quail were still able to find suitable security cover from grasses in areas under moderate grazing pressure in the Santa Ritas. However, Mearns' quail in grazed areas probably spend more time in areas where grazing pressure and cover removal is minimal.

Removal of livestock grazing increases vegetative diversity and coverage over time, such that taller grasses become more predominant in oak woodlands and associated grasslands (Brady et al. 1989). These taller grasses, typically the perennial bunchgrasses, provide most of the visual obstruction that Mearns' quail need for security and thermal cover. Northern bobwhite and scaled quail also select for areas with greater vertical structure than that found at random (Stormer 1984, Johnson and Guthery 1988, King 1998). The key to managing Mearns' quail habitat seems to be determining how much livestock grazing can occur, while still providing adequate security and thermal cover. The results of our habitat selection analyses, particularly in regards to visual obstruction, provide more tools to add to the USFS standards and guidelines to ensure grazing levels are compatible with the long-term survival of Mearns' quail.

Mearns' Quail Abundance

To evaluate the effects of the current USFS livestock grazing program on Mearns' quail abundance, we compared relative Mearns' quail numbers from 2 control (ungrazed) and 3 treatment (grazed) sites during 1997-2000. We set up our pointing dog survey routes (see **SURVEY METHODOLOGY**) to ensure similar sample sizes between grazed ($n = 27$) and ungrazed sites ($n = 24$). We recorded the number of coveys and birds per covey encountered on each survey route. We conducted spring (February-March) surveys as an estimate of the potential breeding populations, and fall (October-November) surveys as an estimate of recruitment.

In spring, COVEYS/ROUTE in grazed sites were similar to ungrazed, except in spring 1999, when there were more COVEYS/ROUTE in grazed than in ungrazed sites (Fig. 6). Grazed areas had consistently higher COVEYS/ROUTE in the fall. This suggests that grazed sites we surveyed produced more coveys than did the ungrazed sites. However, habitat conditions not related to grazing could partially explain these results. Therefore, we also looked at COVEY SIZE to see if differences existed between grazed and ungrazed sites. Seasonal COVEY SIZE was similar between grazed and ungrazed sites (Fig. 7), suggesting that sites we selected were comparable in habitat quality.

Quail were already paired on some of our surveys as early as February. Because of this, areas surveyed after covey break up would have higher number of coveys and smaller covey sizes. Therefore, we believed that total number of birds observed per route (QUAIL NUMBERS) was the best estimator of relative Mearns' quail abundance.

QUAIL NUMBERS in ungrazed sites remained fairly stable during the 3 survey years (Fig. 8). QUAIL NUMBERS in grazed sites fluctuated considerably between seasons and years, but were generally higher than that observed at ungrazed sites. The differences in quail numbers observed between grazed and ungrazed sites were usually due to differences in the number of coveys observed, rather than due to differences in covey sizes.

The impact of increased predation would be most acute during the spring when Mearns' quail are beginning to form pairs and security cover is typically at its lowest point. Brown (1982) observed that the loss of a member of a Mearns' quail pair often results in lost breeding opportunity. This implies that removal of security cover by land management practices could increase predation, thus affecting the number of coveys in the fall. If so under the current grazing program, we would expect a greater percent change in bird numbers between spring and fall in ungrazed sites. However, we found a greater difference in QUAIL NUMBERS among years, rather than due to land use (Fig. 9). This suggests that most of the differences in bird numbers we observed were due to localized climatic conditions, not land-use practices such as livestock grazing.

While it is unclear whether any differences we observed were solely due to grazing, it is clear that ungrazed areas were not able to support more quail year to year than grazed areas. This is not to say that grazing does not impact Mearns' quail. Rather, it is the level of grazing that is key. Severe overgrazing can cause localized population declines (Brown 1982). Nonetheless, we found that the Coronado National Forest public-land grazing program, as

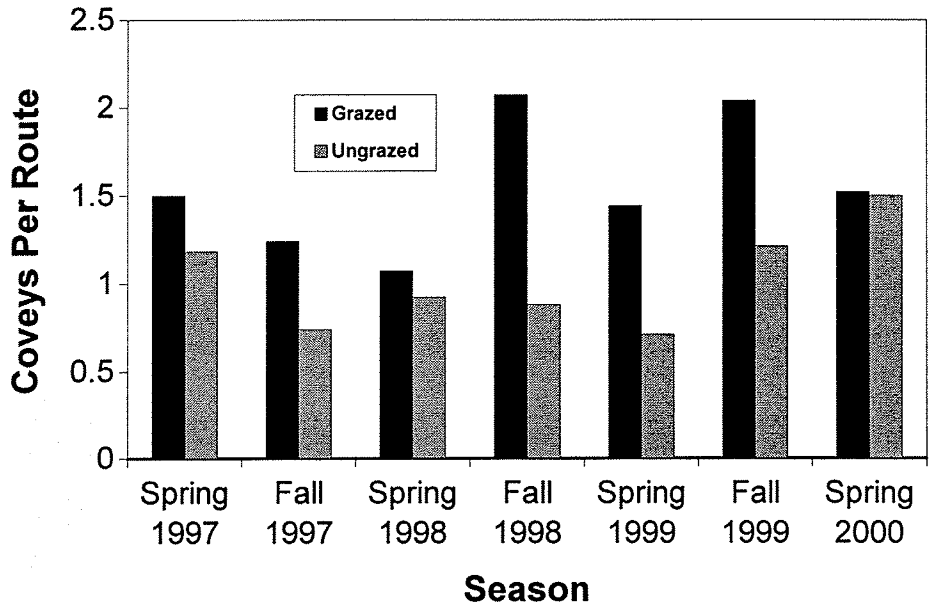


Figure 6. Average number of Mearns' quail coveys encountered on grazed ($n = 27$) and ungrazed ($n = 24$) survey routes during spring (February-March) and fall (October-November) surveys in southeastern Arizona, 1997-2000.

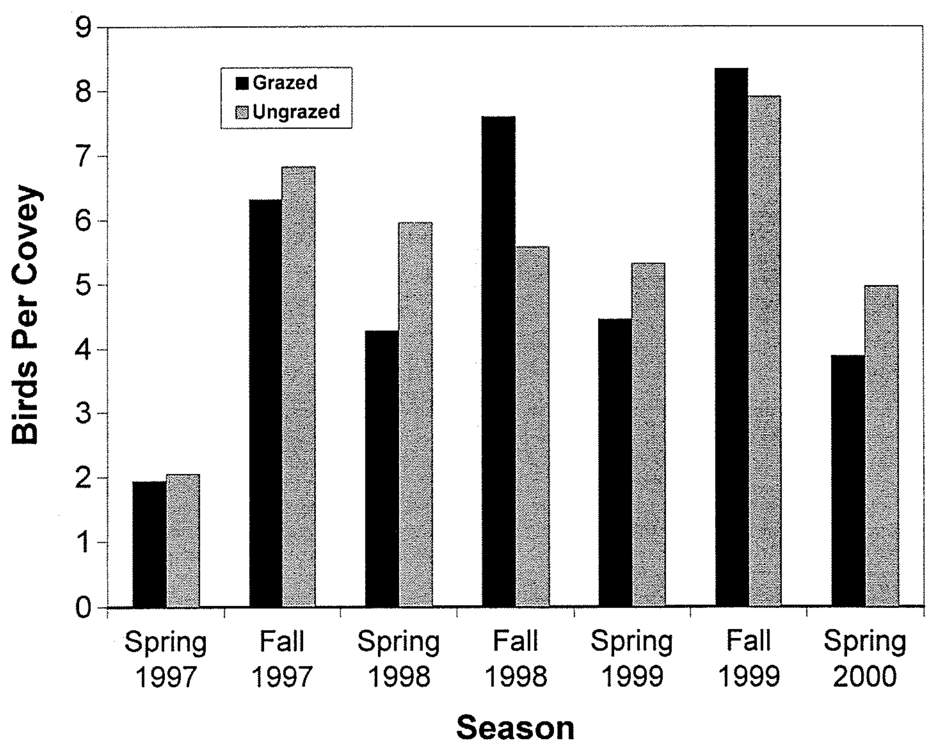


Figure 7. Average size of Mearns' quail coveys encountered on grazed ($n = 27$) and ungrazed ($n = 24$) survey routes during spring (February-March) and fall (October-November) surveys in southeastern Arizona, 1997-2000.

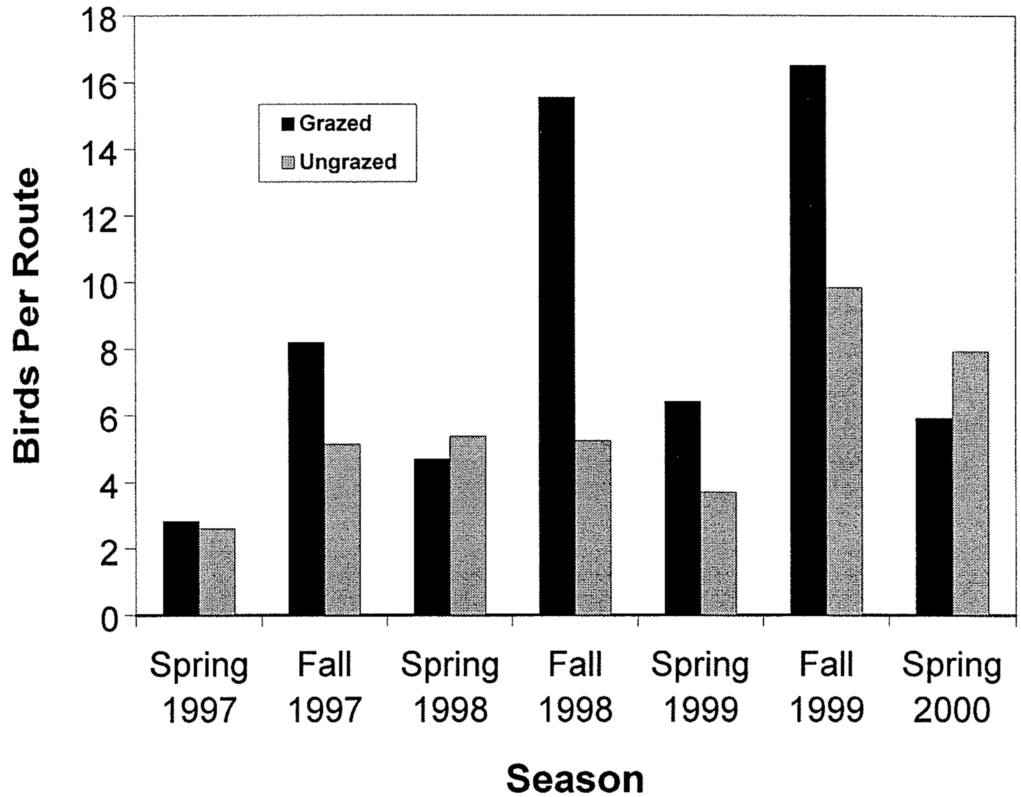


Figure 8. Average number of Mearns' quail encountered per survey route on grazed (n = 27) and ungrazed (n = 24) survey routes during spring (February-March) and fall (October-November) surveys in southeastern Arizona, 1997-2000.

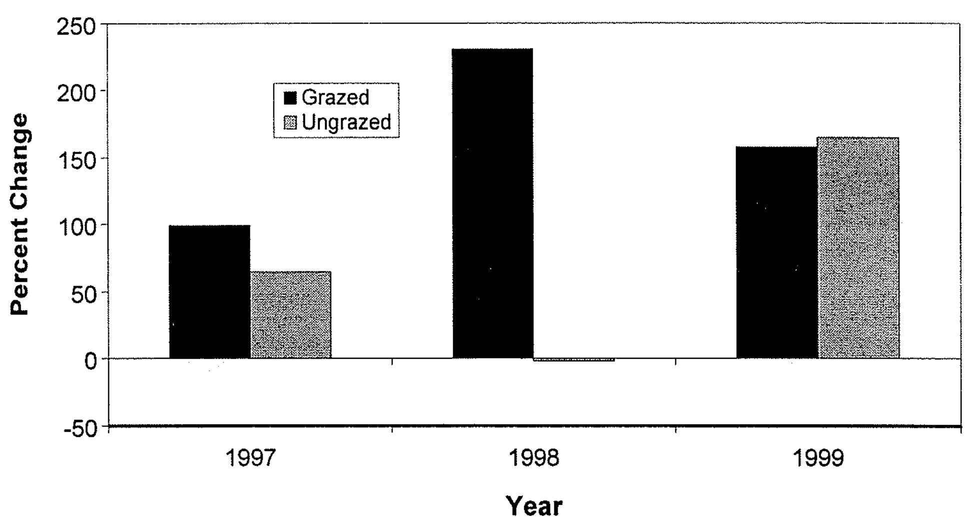


Figure 9. Percent change between average number of Mearns' quail encountered during spring (February-March) and fall (October-November) surveys conducted on grazed (n = 27) and ungrazed (n = 24) survey routes in southeastern Arizona, 1997-2000.

it was currently administered across the study area, was not significantly affecting the Mearns' quail population on the sites we measured.

POTENTIAL EFFECTS OF TREE REMOVAL

Most accounts of Mearns' quail consider oak trees to be an important indicator of their habitat (Miller 1943, Wallmo 1954, Brown 1978). Tree canopy is likely an important component of security cover and may be essential in providing the proper microclimate for the forb species that Mearns' quail feed on. Based on estimates of relative Mearns' quail densities in oak woodlands, Brown (1982) arbitrarily suggested that tree canopy cover of >20% was needed to support Mearns' quail. He believed that areas with ≥30% would support more quail than areas at 20% canopy cover. Current tree stand guidelines in Mearns' quail habitat on the Coronado National Forest allows fuelwood cutting only when canopy cover is >10%.

To provide better forest management guidelines, and to predict potential effects of tree removal on Mearns' quail habitat, we investigated habitat selection of Mearns' quail (see ***Habitat Selection***) relative to forest-stand characteristics during 1998 and 1999. We collected information on tree species composition, percent tree canopy cover, distance to and diameter of the nearest tree, and tree densities associated with Mearns' quail flush sites and associated random plots within oak woodland habitats.

Mearns' quail used areas with more tree species, greater tree canopy cover, and greater tree densities than at random plots (Table 3). The mean tree canopy cover we found at flush sites roughly concurred with Brown's (1982) suggestion of >30% tree cover being optimum. By using Bonferroni confidence intervals and Jacobs' *D* selectivity indices, we found that Mearns' quail prefer areas with 26-75% tree canopy cover, with the greatest selection for 26-50% (Table 4). Mearns' quail avoided areas when tree canopy cover was ≤25%.

Mearns' quail flush sites were also closer to trees and the closest trees were larger than those in random plots. Temperature can affect habitat selection and behavior of quail (Goldstein 1984), and Mearns' quail are probably selecting areas near trees for both thermal cover and the presence of food resources. Mearns' quail flush sites also had more shade, lower soil temperatures, and higher amounts of litter than did random plots; these habitat components are related to the proximity to trees.

Oak trees were the most abundant tree species in proximity to Mearns' quail flush sites, and they avoided juniper and riparian trees (Table 5). Bishop and Hungerford (1965) found that mast from various species of oaks were seasonally important in Mearns' quail diets. While Mearns' quail feed on acorns seasonally, the microclimate associated with oak trees may be more important to the habitat selection pattern that we observed. A likely reason Mearns' quail avoid juniper trees is that juniper are typically found in sites that are warmer and drier than areas dominated by oaks.

Mearns' quail can exist in areas with relatively few oak trees, although quail densities are often lower than typical of oak woodland habitats (Brown 1973). Some mesquite grassland habitats contain viable Mearns' quail populations. During years of optimal rainfall, these areas contain the proper microclimate for the forbs that Mearns' quail feed on (Bishop 1964). While tree species is an important indicator of the microclimate, the presence of important food items is probably more critical to Mearns' quail survival than the particular tree species itself.

Fuelwood cutting that reduces tree canopy cover below 25% would negatively impact habitat quality for Mearns' quail. Tree removal to reduce canopy cover that is greater than 75% should benefit the species. Based on the Coronado National Forest Plan and our observations, current tree removal levels on the Forest seem inconsequential relative to the impacts of other land-use practices.

EFFECTS OF HUNTING PROGRAM

Mearns' quail have been hunted annually in Arizona since 1960. Starting with a 2-day season restricted to the Santa Rita Mountains, the hunting program has gradually expanded in season, bag limit, and geographical area. Today,

Table 3. Means and standard deviations of tree-stand characteristics at Mearns' quail flush sites (n = 120) that differed from associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999.

	Mean		Standard deviation		
Variable	Flush	Random	Flush	Random	P
Tree species richness	0.9	0.5	0.7	0.6	<0.001
No. of trees > 2 m tall	1.4	0.5	2.1	1.2	0.001
Percent tree canopy cover	32.9	22.3	19.6	20.3	<0.001
Distance to nearest tree (m)	6.6	11.5	7.3	10.7	<0.001
DBH of nearest tree (cm)	12.1	9.1	9.0	8.8	0.009

[a] Differences determined by 2 sample t-tests.

Table 4. Use of percent tree canopy cover classes at Mearns' quail flush sites (n = 120) compared to associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999.

Percent tree canopy	No. of locations	Bonferroni 90% CI	No. of locations expected	Jacobs' D[a]
0 - 25%	48	39.5 - 56.5	78	-0.47
26 - 50%	49	40.3 - 57.5	26	+0.43
51 - 75%	21	14.4 - 27.6	14	+0.23
76 -100%	2	0.0 - 4.3	2	=

[a] + denotes selection for
- denotes avoidance or used less than expected
= denotes use consistent with expected.

Table 5. Use of species of nearest tree at Mearns' quail flush sites (n = 120) compared to associated random plots (n = 120) in the Santa Rita and Huachuca mountains, southeastern Arizona, 1998 and 1999.

Tree species	No. of locations	Bonferroni 90% CI	No. of locations expected	Jacobs' D[a]
Oak	107	101 - 113	91	+0.45
Juniper	1	0.0 - 2.5	10	-0.84
Mesquite	6	2.0 - 10.0	8	=
Riparian	2	00 - 4.3	5	-0.43
Other	4	0.7 - 7.2	6	=

[a] + denotes selection for
- denotes avoidance or used less than expected
= denotes use consistent with expected.

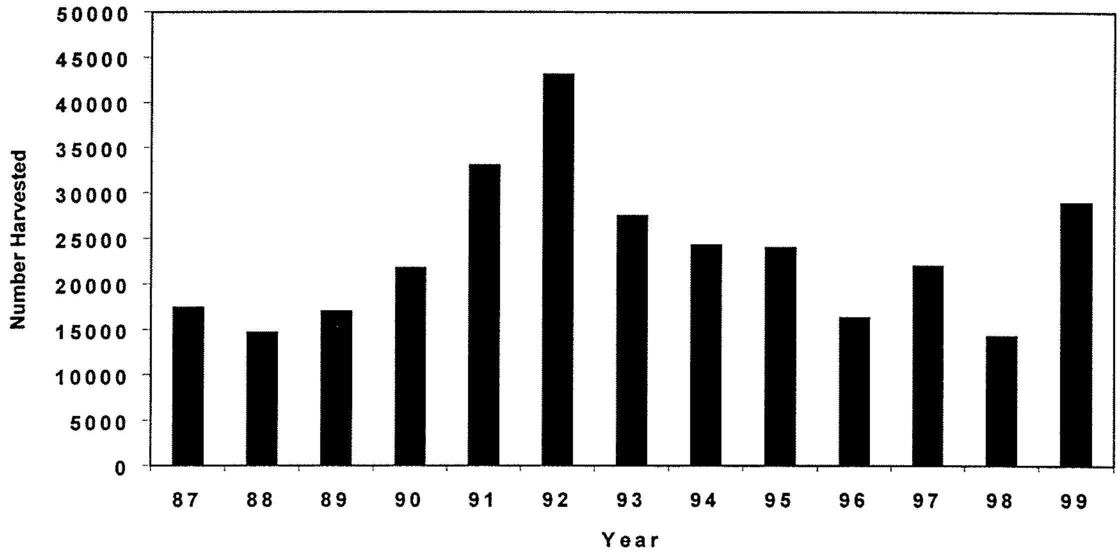


Figure 10. Annual statewide harvest of Mearns' quail in Arizona as estimated by the small game questionnaire, 1987-1999.

the season extends from late November through early February. The bag limit has fluctuated between 8 and 15 birds per day, with the 1999-2000 season at 8 birds per day. The open area is basically statewide, with limited exceptions.

Mearns' quail exist at relatively moderate densities over a limited distribution. This, combined with behavioral traits that may make them more susceptible to harvest, has caused some people to raise concerns about the hunting program. The issue of the effects of hunting on Mearns' quail has not been clearly resolved, even though early investigations into possible impacts indicated no significant effect (Bishop 1964; AGFD, unpublished data). Leopold and McCabe (1957) suggested that Mearns' quail hunting was compensatory, not additive, to other sources of mortality. Most evidence since then suggests likewise. Nonetheless, public concerns continued to be raised over a number of issues revolving around the hunting program. These were perceived effects of non-residents on the harvest, hunter concentrations (i.e., hunter distribution), a lack of knowledge on who actually hunts Mearns' quail in Arizona, and effects of sport hunting on Mearns' quail abundance.

Harvest Characteristics

Harvest data on Mearns' quail has been collected annually since 1987 by AGFD via a small game questionnaire developed in the early 1960s. Prior to 1987, harvest data on Mearns' quail were collected by various non-standardized methods. The small game questionnaire is based on a 5% random sample of hunting license purchasers. Typically, >10,000 questionnaires are mailed out in the spring each year. This harvest information aids in setting future season dates and bag limits, and includes several questions relative to Mearns' quail hunting. Hunters are asked the number of days they pursued Mearns' quail, their total harvest of Mearns' quail, and the number of limits taken during the past season.

The response rate to the small game questionnaire is typically low, ranging from 30% to 35% between 1988 and 1997. That approximate rate has held since the 1960s. Few respondents ($\bar{x}$ = 52.3, Min = 36, Max = 75, n = 10 years) of the ~3,500 hunters who annually return their questionnaire report that they pursue Mearns' quail. The mean estimated number of Mearns' quail hunters statewide during the 1990s is 4,626 ± 923.

Indications of declining harvest in the mid-1990s prompted public concerns about the potential for over-harvesting Mearns' quail (Fig. 10). The legal bag limit for quail was a maximum of 15 quail of any combination of species. Thus, a hunter could potentially harvest 15 Mearns' quail a day throughout the season.

In 1996, pressure to reduce the bag limit resulted in a change to an 8-Mearns' quail limit/day, to start during the 1996-97 season. The question we asked is did the reduction in the bag limit from 15 to 8 modify harvest pressure?

To answer that question, we first compiled harvest records from 523 small game questionnaire respondents, from 1987-96,who hunted Mearns' quail. This allowed us to calculate a cumulative frequency distribution of their mean daily bag (i.e., BIRDS/DAY) as a base for comparison. Then, starting with the 1997-98 season, for the next 3 years in March after the quail season ended, we mailed out a 1-page survey to a list of suspected Mearns' quail hunters to compare against the 1987-96 base. The list of likely hunters came from a variety of sources. First, we used the names and addresses of 293 Mearns' quail hunters from 1992-96 small game questionnaire returns. Second, we canvassed non-profit organizations associated with quail management or clubs associated with pointing dogs for names of members who typically hunt Mearns' quail. Third, we had AGFD Game Rangers collect field contacts of Mearns' quail hunters encountered during routine law enforcement activities from 1996-99. Fourth, we searched the study area for hunters to field interview them. Lastly, we compiled names of hunters who AGFD employees knew had previously hunted Mearns' quail.

We mailed out over 400 1-page surveys each year, with a response rate >50%. Each year, approximately a third (36.7%, 32.5%, and 42.4%) of those surveyed did not hunt that season (i.e., 1997-98, 1998-99, 1999-2000). For those who responded, we calculated an estimate of BIRDS/DAY by dividing their estimated season harvest by the estimated number of days they said they hunted that season. We then calculated a cumulative frequency distribution of BIRDS/DAY for each year that the daily bag limit was 8 Mearns' quail instead of 15 (Fig. 11).

Few Mearns' quail hunters averaged >4 birds per day over the season, regardless of the daily bag limit. Most differences in yearly harvest were changes in the frequency of hunters that harvested on average 0, ≤1, ≤2, or ≤3 birds per day. Changes in the frequency of Mearns' quail hunters harvesting ≥4 birds per day were

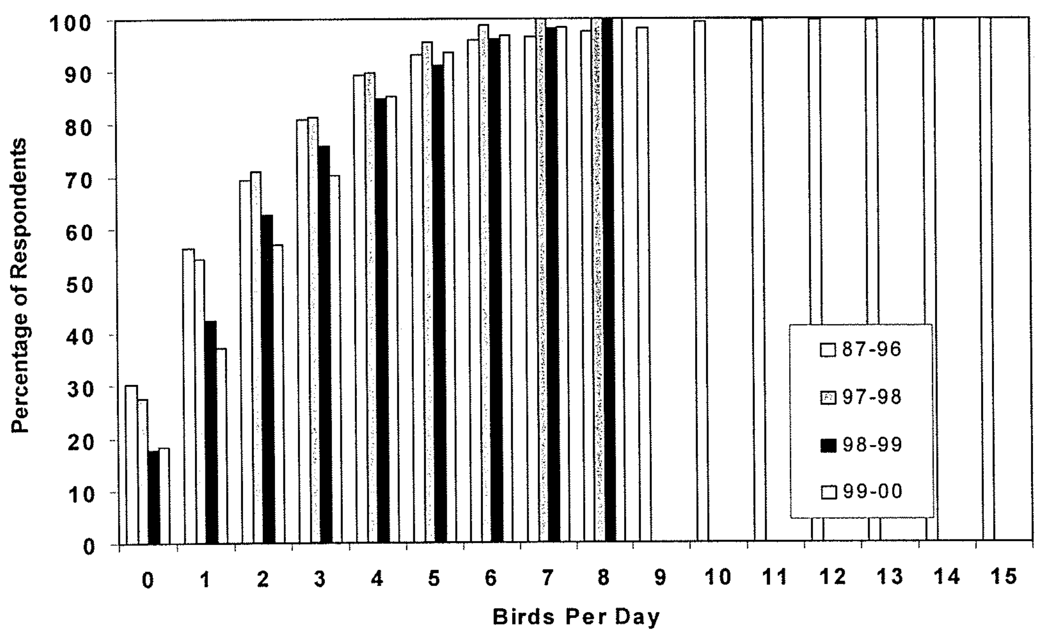


Figure 11. Cumulative curves of the average number of Mearns' quail taken daily by hunters as estimated by Arizona Game and Fish Department's small game questionnaire (1987-96; legal bag limit of 15 quail) and mail surveys to known hunters (1997-98, 1998-99, 1999-2000; legal bag limit of 8).

slight. Effectively, the change in regulation that decreased the daily bag limit from 15 to 8 had no impact. In 1970, the bag limit for Mearns' quail had been reduced from 15 to 10, apparently with little or no effect, and returned back to 15 per day in 1973 (AGFD, unpublished data).

The daily bag limit for Mearns' quail has little, if any, affect on the number of hunters afield or the annual harvest. For quail species, the bag limit must be <8 to affect total harvest (F. S. Guthery, Oklahoma State University, personal communication). For example, the situation is similar for northern bobwhite quail in Texas (Peterson 1996). The Texas studies documented that bobwhite hunters typically hunted only 2.5-3 days, harvested few birds per day, and hunter success or harvest was not affected by changes in the daily bag limit. Texas Parks and Wildlife Department (TPWD) predicted that decreasing the northern bobwhite or scaled quail daily bag from 15 to 8 in Texas would only result in a 27% and 15% decrease in the respective annual harvests (M. J. Peterson, TPWD unpublished data). The cumulative frequency distribution of scaled quail harvest in Texas is more similar to that of the Mearns' quail harvest in Arizona. On average, Mearns' quail hunters do not do as well as scaled quail hunters in Texas, so a 15% decrease would be an overestimate of the possible effect of changing the daily bag limit from 15 to 8 for Mearns' quail.

Mearns' quail hunters in Arizona spend few days afield, as 88.3% of the 523 small game questionnaire respondents hunted less than 10 days a season during 1987-96, and nearly 75% hunted less than 5 days. The median (i.e., 50% point) days afield was only 3. For the 3 years of 1-page mail surveys, the medians were similar to the small game questionnaire data (Table 6). The most common answer to the number of days spent afield was only 1-2.

Another indicator of generally low harvest of Mearns' quail is the number of limits taken by hunters during the season. During the 3 past years (1997-98, 1998-99, 1999-2000), the average number of limits taken per hunter was only 0.16, 0.30, and 0.15/hunter per year. Respondents from our 3 years of 1-page mail surveys suggested similarly low success (Table 6). From these data, we conclude that few hunters average ≥4-5 birds per day and limits are rarely taken.

Table 6. Summary of statistics for 1-page mail survey respondents who reported pursuing Mearns' quail in Arizona.

Variable	Year	$\bar{x}$	Min	Max	Median	*n*
DAYS afield	97-98	6.8	1	50	4	155
	98-99	6.0	1	40	3	158
	99-00	6.7	1	43	4	121
Birds harvested for season	97-98	11.5	0	93	4	155
	98-99	14.6	0	158	6	158
	99-00	16.4	0	120	8	121
Limits taken[a]	97-98	0.2	0	6	0	154
	98-99	0.5	0	12	0	158
	99-00	0.6	0	11	0	121
BIRDS/ DAY	97-98	1.6	0	7.0	1.0	155
	98-99	2.0	0	7.6	1.5	158
	99-00	2.2	0	8.0	2.0	121
Years hunted[b]	97-98	10.2	1	38	6.5	154
	98-99	11.8	1	38	10.0	157
	99-00	14.4	1	38	13.0	121
Age	97-98	49.5	13	80	50	149
	98-99	52.6	20	80	53	125
	99-00	53.0	12	81	55	87

[a] Limit was 8 birds/day each year.
[b] Number of years respondent had previously hunted Mearns' quail.

Aside from the public concern over potential over-harvest, concern was also voiced about the impacts of non-resident hunters on Mearns' quail populations. Non-residents were thought to spend more days afield and harvest more Mearns' quail per day than residents. By dividing our data into non-resident and resident hunters, we found evidence to indicate that non-residents actually spend fewer days afield than residents. Non-resident respondents to the small game questionnaire from 1992-96 reported spending an average of 3.2 ± 1.9 days afield compared to the 5.1 ± 5.6 days afield reported by residents. This difference also occurred for respondents to our 1-page mail surveys. For example, in 1999-2000, non-residents reported that they hunted on average 4.9 ± 5.0 days, less than the 7.1 ± 7.8 days reported by residents. Thus, public concern about non-residents spending more days afield hunting Mearns' quail than residents was unfounded.

In terms of average hunter success on Mearns' quail, we found no differences in the mean number of birds taken per day between non-residents and residents. Non-resident respondents to the small game questionnaire, from 1987-96, reported harvesting on average 1.7 ± 2.4 birds per day, nearly identical to the 1.8 ± 2.4 birds per day from the residents. Overall, mean hunter success was 1.7 ± 2.2 between 1987-96. The same situation occurred for our mail surveys. In 1999-2000, non-residents averaged 2.4 ± 1.9 birds per day, whereas residents averaged 2.2 ± 1.9. As with days afield, public concern about non-residents harvesting more birds per day than residents was unwarranted.

Hunter Distribution

To help resource managers better manage Mearns' quail in the future, we needed to provide information on how hunters distributed themselves on the Coronado National Forest. Most respondents from our 3 years of mail surveys indicated that they typically hunted in more than 1 GMU. Estimates of hunter effort by GMU were relatively stable by year, with the exception of GMUs 35A and 35B (Table 7). However, when combined, the percentage of hunter days in 35AB was stable across years. This was probably the result of hunters not clearly knowing the boundary between the 2 units, which was a dirt road. Most hunter effort was spent in GMUs 34A, 35A, and 36B. These 3 GMUs contain 3 of the main mountain ranges within Mearns' quail distribution in Arizona. These ranges are the Santa Rita Mountains, the Huachuca Mountains, and the Atascosa Mountains. Few hunters reported spending days afield east of the San Pedro River or north of I-10.

Mearns' quail season typically opens in late November and ends in early February. What started as a 2-day hunt in the Santa Rita Mountains in 1960, now extends to ~81 days.

Table 7. Percentage of mail survey respondents who reported days afield pursuing Mearns' quail in game management units (GMUs) in Arizona.

GMU	% Days afield		
	97-98	98-99	99-00
34A	19.4	20.6	19.4
34B	4.7	6.1	6.5
35A	27.9	16.8	30.0
35B	12.4	16.1	6.5
36A	2.5	4.4	2.1
36B	21.6	28.3	29.3
36C	0.4	1.3	1.3
Others	11.2	6.5	5.0
n[a]	1,018	957	710

GMU	% Hunters afield[b]		
	97-98	98-99	99-00
34A	31.0	34.8	31.8
34B	11.6	15.2	10.0
35A	40.0	24.7	38.2
35B	27.1	24.1	19.1
36A	5.8	7.0	6.4
36B	35.5	41.8	41.8
36C	1.3	2.5	2.7
Others	23.2	15.8	13.6
n[a]	155	158	110

[a] *n* = total number of days reported or number of respondents who hunted that year.

[b] Totals equal more than 100% because many hunters reported multiple GMUs.

We found that hunter effort varied little from expected by month (Table 8). There was minor selection for either the beginning (November) or the end (February) of the season, and minor avoidance during December. Basically Mearns' quail hunters distribute their effort equally across months.

In an attempt to determine the probability of encountering a Mearns' quail hunter in the field, we completed 193 driving routes throughout the 5 study sites (and surrounding areas) during the 1997-98 and 1998-99 seasons. The routes took

Table 8. Distribution of Mearns' quail hunter days by month between 1997 and 2000, Arizona.

	Percent of days	Bonferroni 90% C.I.	Percent available	Jacobs' D^a
1997-98				
Nov	17.0	14.4 - 19.6	12.4	+0.18
Dec	32.4	29.2 - 35.6	38.3	-0.13
Jan	37.1	33.8 - 40.4	38.3	=
Feb	13.4	11.0 - 15.7	11.1	=
	99.9		100.0	
1998-99				
Nov	15.3	12.7 - 17.9	13.5	=
Dec	31.4	28.0 - 34.8	38.3	-0.15
Jan	38.4	34.9 - 41.9	38.3	=
Feb	14.9	12.3 - 17.5	9.9	+0.23
	100.0		100.0	
1999-2000				
Nov	13.4	10.6 - 16.2	12.6	=
Dec	27.7	24.0 - 31.4	35.6	-0.18
Jan	39.4	35.3 - 43.5	35.6	=
Feb	19.5	16.2 - 22.8	16.1	+0.12
	100.0		99.9	

[a] + denotes hunted more days than expected
- denotes hunted less days than expected
= denotes same number of days as expected.

an average of 43.2 minutes to complete, surveying an average of 7.8 km of road per route. Hunters were difficult to locate during these random driving routes, suggesting that the density of Mearns' quail hunters afield on any given day is low. Hunters were seen on 15.0% of the routes, at a rate of 0.31 hunters per route. Because some hunters were already in the field and not visible near the roads, we also recorded how many vehicles we suspected belonged to Mearns' quail hunters. We used such evidence as dog kennels, water bowls, and equipment in vehicles to help us determine if the vehicle was likely owned by Mearns' quail hunters. Although somewhat higher than the actual number of hunters seen, the 0.44 vehicles per route also suggested low hunter densities. Vehicles likely used in Mearns' quail hunting were seen on 22.8% of the routes. Overall, using both hunters seen and likely vehicles, evidence of hunting was seen on 23.8% of the routes. More hunters were located on weekends, relative to hours available to hunt, than randomly found during weekdays.

The perception of high Mearns' quail hunter densities across available Mearns' quail habitat was not supported by our data. However, several times, multiple groups of Mearns' quail hunters were in the same canyon on the same day, even though nobody was located in adjacent canyons. Hog Canyon in the Santa Rita Mountains was an example of such a canyon. By hunting in popular canyons on the weekend, the probability of encountering other hunters increased.

Hunter Demographics

Better management and regulation of harvest requires basic knowledge of hunter demographics (Filion 1980, Duda et al. 1998). To effectively manage wildlife resources for human benefit, agencies must understand actions of people, as well as know associated values, needs, and perceptions. Although preferences and demographics of licensed hunters in Arizona are somewhat understood (Ockenfels 1989, Anon. 1995), characteristics of those hunting Mearns' quail are unknown.

To document Mearns' quail hunter demographics, we investigated the state of residency, age, gender, and size of community of respondents, using the small game questionnaire (1992-96), mail surveys (1997-2000), and field interviews. For field interviews, we also asked individuals about how they first learned about hunting Mearns' quail and questions about dog ownership. Lastly, we asked our 75 field contacts to give us what factors affected their efficiency and how they rated themselves as a Mearns' quail hunter. Such human dimension research avoids management based on speculation.

We obtained state of residency information for 293 small game respondents. Over three-quarters (77.8%) were residents of Arizona at the time of reporting. We found >80% (83.2, 82.0, and 85.2%) of mail survey respondents for the 3 years were resident each year. From our various efforts, we identified hunters coming from 25 states other than Arizona. Except for Hawaii, Nebraska, and North Dakota, hunters came from all western states. It is likely that hunters from most states pursue Mearns' quail in Arizona.

The mean age of Mearns' quail hunters who responded to our mail surveys (Table 6) was older than the mean age of licensed hunters in Arizona estimated in 1987 (36.8 years) and 1995 (37.8 years). All of these estimates are older than the general population in Arizona (Ockenfels 1989). Those interviewed in the field during the study, a subset of our mail surveys, averaged 45.6 years, somewhat closer to the estimate for general licensed hunters. The minimum age for a Mearns' quail hunter was 12, whereas the maximum age was 81. All of our data indicates an aging sampling of hunters, a pattern similar to, but older than, the aging of the general licensed hunting population in Arizona.

We could only identify gender of 55 of the 523 small game questionnaire respondents. Only four (7.3%) were female. For our 3 mail surveys, the dominance of males was even greater, as >95% of those who responded each year were male. Among the 75 hunters interviewed in the field, 98.7% were males. These estimates were expected, as nearly 95% of general licensed hunters in Arizona are male (Anon. 1995).

Often it is perceived that hunters come from a rural background. This is a misperception for Mearns' quail hunters in Arizona. The largest segment of our mail survey respondents came from medium to large communities, those >50,000 in size, with the majority (58.6% in 1998-99, 56.9% in 1999-2000) coming from communities >100,000. The percentage of Mearns' quail hunters coming from communities >100,000 increased from the first year. Arizona is a rapidly growing state, and many medium-sized communities (50,000-100,000) are quickly becoming larger. Few (6.1, 6.6, 4.6% estimates for 3 years) respondents of our mail surveys lived in small communities, those <1,000 people.

Typically, hunters learn about sport hunting at an early age from their father (Ockenfels 1989, Duda et al. 1998). This was not the case for Mearns' quail hunting. Most Mearns' quail hunters first learned about Mearns' quail hunting from friends (56.0%) rather than from a family member (13.3%). Other factors, such as magazines, books, hunting regulations, or television were less important sources of information to encourage hunters to pursue Mearns' quail in Arizona.

In general, the average licensed hunter starts hunting under the age of 20. This is not the case for Mearns' quail hunting. When we subtracted the mean number of years respondents reporting hunting Mearns' quail from the mean age of Mearns' quail hunters, most started hunting this subspecies around 40 (Table 6). We speculate that the time and cost of owning and training pointing dogs affects the likelihood of a hunter being able to pursue specialty hunts, such as Mearns' quail hunting. Also, with such a low return (birds per day harvested) on investment of time and finances, combined with the considerable travel to Mearns' quail habitat for most Arizona residents and for non-residents, pursuing Mearns' quail has limited appeal to the general hunting public.

Most (86.3%) Mearns' quail hunters we interviewed used dogs to pursue the subspecies. Nearly all (87.5%) owned their dogs, particularly German shorthaired pointers (32.1%), Brittany spaniels (20.8%), and English pointers (16.9%). Other breeds were far less common. With the exception of Brittany spaniels, longhaired breeds, like English or Irish setters, were seldom used. Brittany spaniels tend to work close to the hunter, a trait that is favorable when pursuing Mearns' quail.

Another concern raised by the public is that Mearns' quail hunters are better than they used to be, and therefore, they could have a greater impact on the statewide population. Since limited data are available prior to 1987 for comparative purposes, we asked the 75 hunters we field interviewed if they had hunted Mearns' quail ≥5 years, then continued to question those that responded positively. Nearly two-thirds (63.4%) of these 41 hunters believed they were more efficient hunters today than in previous years. Primary factors that these interviewed hunters believed made them a more efficient hunter were: 1) 86.7% cited that they were more experienced, 2) 73.3% believed they had better dogs, 3) 70.0% had more knowledge about

Mearns' quail hunting, 4) 13.3% believed they were better shots, and 5) 6.7% said they used paid guides. No one believed better equipment increased his or her efficiency.

Of the 75 hunters interviewed in the field, 37.3% rated themselves as a beginning Mearns' quail hunter, whereas 44.0% rated themselves as somewhat experienced. Only 18.7% rated themselves as very experienced or expert. Clearly, the hunters themselves believe the efficiency at which they hunt Mearns' quail has improved. However, the harvest indicators that may reflect efficiency don't suggest that such perceived changes are necessarily correct.

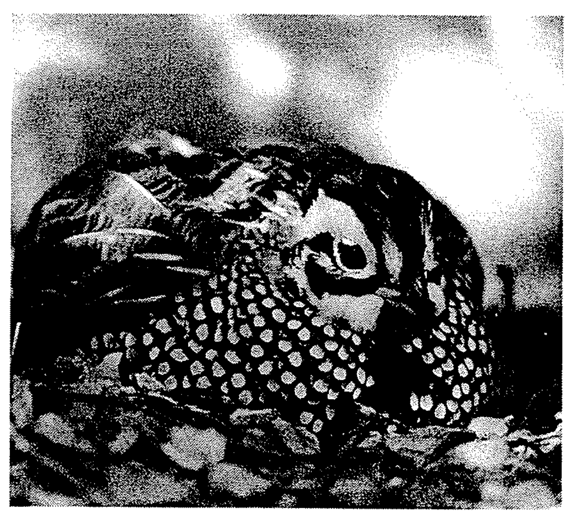
Mearns' Quail Abundance

Although harvest characteristics and demographics suggest that hunting should have minimal impact on Mearns' quail populations, we still needed to determine if hunting reduces Mearns' quail abundance. To evaluate effects of the statewide hunting program administered by the AGFD on Mearns' quail abundance, we compared relative quail numbers from 3 treatment (hunted) and 2 control (unhunted) sites during 1997-2000. We used pre-hunt (October-November) and post-hunt (February-March) season pointing dog surveys to estimate relative quail numbers (see **SURVEY METHODOLOGY**). We set up survey routes to ensure similar sample size between hunted (n = 27) and unhunted routes (n = 24). At hunted sites, we selected areas that we knew were historically frequented by hunters. Some portions of our unhunted sites (Research Ranch, Fort Huachuca) may have received minimal hunting pressure. The USFS portion of the Research Ranch was open to Mearns' quail hunting; of the 3 routes on USFS lands, we only noted evidence of hunting on 1. Fort Huachuca was open to military personnel, but post records indicated little if any hunting of Mearns' quail occurred. We used QUAIL NUMBERS (total number observed/route) as the most robust estimate of relative quail abundance.

QUAIL NUMBERS observed on routes in unhunted sites remained fairly stable, while QUAIL NUMBERS in hunted sites fluctuated between seasons and years (Fig. 12). The 3 sites that were open to hunting usually contained more birds than the 2 unhunted sites during pre-season surveys. However, post-hunt QUAIL NUMBERS were not different between hunted and unhunted sites in 1998 and 2000. This suggests that unhunted areas had a greater potential to maintain quail over the course of the winter. To evaluate this perceived difference, we calculated the percent change in QUAIL NUMBERS between pre- and post-hunt seasons for 3 treatment sites and 2 control sites.

The average percent change in bird numbers between pre- and post-hunt seasons was greater in hunted sites for each of the 3 years of the study (Fig. 13). Hunting mortality is thought to be compensatory in quail populations. Quail have high reproductive rates that allow them to produce far more individuals than can survive in a given area. Hunting removes individuals that would have likely died of some other cause. While our data suggests that survival of quail in unhunted sites was higher than that of hunted sites, these differences in survey results could be due to differences in movement patterns and dispersal rather than survival.

Furthermore, our data on the relative abundance of mated pairs during the 1997 pairing season indicated similar numbers of pairs between unhunted and hunted sites. Basically, the number of pairs available to nest at the Research Ranch (unhunted) were the same as that found at Hog and Gardner canyons (hunted). Since QUAIL NUMBERS were usually higher in hunted sites each season, current levels of hunting pressure likely do not significantly impact Mearns' quail populations in southeastern Arizona. Clearly, by protecting areas from hunting, Mearns' quail are not stockpiled for future seasons.



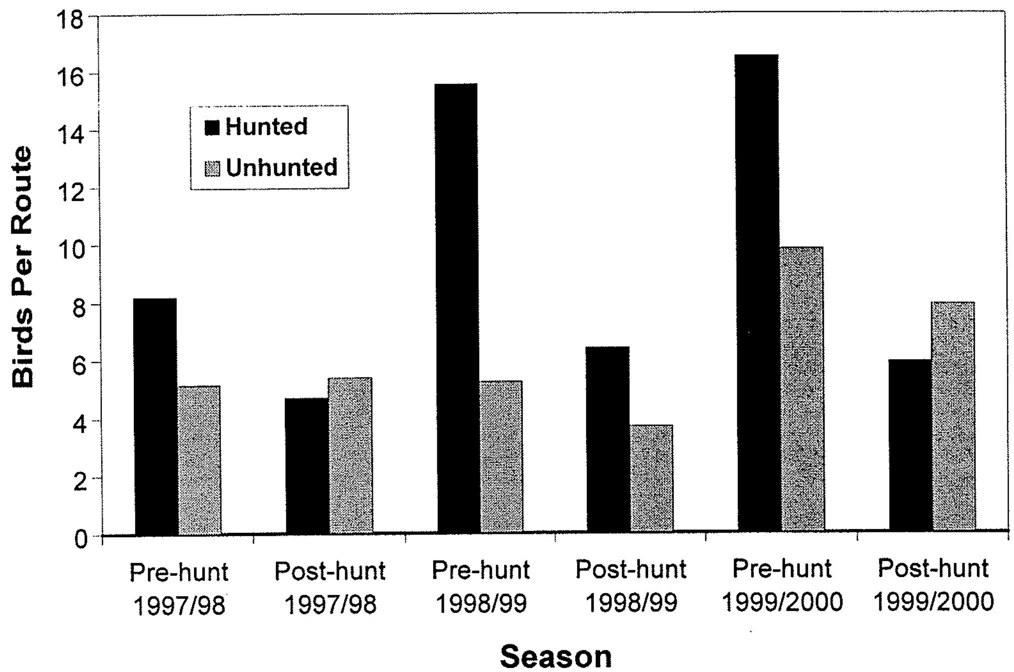


Figure 12. Average number of Mearns' quail encountered per survey route in hunted ($n = 27$) and unhunted ($n = 24$) areas during pre-hunt (October-November) and post-hunt (February-March) surveys in southeastern Arizona,

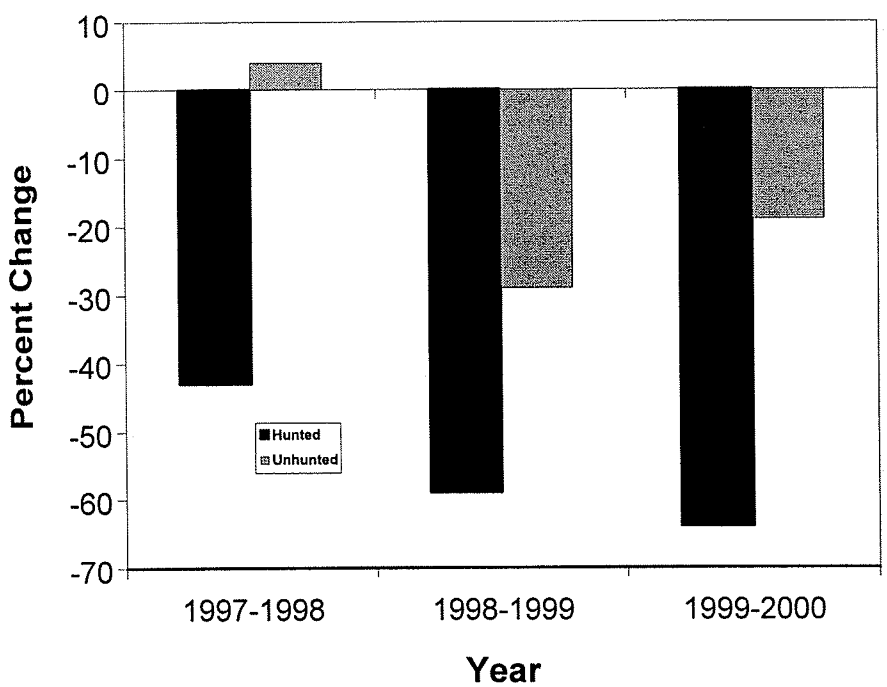


Figure 13. Percent change between average number of Mearns' quail encountered during pre-hunt (October-November) and post-hunt (February-March) surveys conducted in hunted (n = 27) and unhunted (n = 24) areas in southeastern Arizona, 1997-2000.

MANAGEMENT IMPLICATIONS

Management of Mearns' quail requires a combination of harvest and habitat management. We provide options to address each of these needs. Mearns' quail populations, like most small game species, seemingly fluctuate independently of hunting pressure. Harvest effects are generally localized. Nonetheless, information on harvest levels is necessary to ensure that management decisions are data based.

Proper habitat management requires a fundamental understanding of Mearns' quail habitat selection patterns. Habitat selection of Mearns' quail is largely affected by dietary and security requirements. These habitat requirements can be affected by land management practices that reduce visibility obstruction, increase soil compaction, alter vegetation diversity, and reduce canopy cover. Livestock grazing, tree removal, off-highway vehicle use, and road building all represent potential impacts to Mearns' quail habitats.

Survey Methodology

Harvest management of any game species can benefit from information on animal abundance. Pointing dog surveys provide ample evidence of presence/absence of Mearns' quail and, if done properly, an adequate estimate of relative abundance. We offer the following recommendations if pointing dog surveys are used to estimate the relative abundance of Mearns' quail:

1) Efforts should be made to standardize survey routes. A minimum of 9 routes per area is recommended to detect presence/absence of Mearns' quail. We recommend the routes be evenly distributed in <200 km^2 of homogeneous habitat. Surveys should be time constrained (≤ 1.5 hr) to ensure dogs actively search for birds throughout the entire survey period.
2) To detect population changes, a minimum of 35 routes should be conducted each season or year; using a minimum of 9 routes per site suggests that 4 sites would be needed. This will even allow the detection of moderate populations changes (<40%), albeit with reduced power (75%), but with an alpha level of 0.10. Larger changes (>40%), which are not uncommon in quail populations, could be detected with greater power (90%) at this sample size.
3) Primary surveys should be conducted just prior to the hunting season (late October-early November). These pre-hunt surveys provide a relative estimate of available coveys ($\bar{x}$-coveys-per-route), as well as reproductive output ($\bar{x}$-birds-per-covey).
4) To estimate annual reproductive potential, surveys can be conducted during the pairing season (April-May). These surveys provide an estimate of the number of breeding pairs ($\bar{x}$-coveys-per-route per area) available to nest. This can help monitor impacts of land-use practices, because the presence of bonded pairs is an indicator of adequate residual cover prior to nesting.
5) Experience of the dogs and observers should be considered. A standard survey team should include 1-2 observers and 1-2 dogs. Each survey team should have at least 1 observer and dog with experience in pursuing Mearns' quail. Using more observers or dogs increase costs without significant increases in efficiency.

Monitoring Habitat Conditions

Cover, typically provided by perennial bunchgrasses and oak canopy, is an important aspects of Mearns' quail habitat. In order to monitor oak woodlands to ensure Mearns' quail habitat requirements are being met, we recommend the following:

1) A minimum of 25 random sample sites per pasture (<10 km^2) is needed for monitoring many of the habitat variables important to Mearns' quail. This is based on characteristics of several of the variables we used in the field (AGFD, unpublished data). Actual plot size varies with the methods used.
2) Since average grass canopy cover at flush sites (60%) was typically provided by ≥ 5 species of grasses per 0.01 ha, the first step in monitoring oak woodlands is to ensure that adequate species richness is maintained.

3) Oak woodland habitats should contain 51-75% grass canopy cover ($\geq$10 cm high) to ensure optimum cover availability for Mearns' quail. Areas with >75% grass canopy cover also provide suitable habitat.
4) Based on our visual obstruction data, we believe a minimum grass height of 20 cm would provide adequate vertical cover to protect Mearns' quail from ground predators. Some obstruction of up to 50 cm is necessary to significantly decrease the risk of detection by aerial predators. A mosaic of grass heights between 20 and 50 cm closely approximates the habitat selection pattern of Mearns' quail. For optimum Mearns' quail habitat conditions, the distance at which a 20-cm band on a Robel pole is fully obstructed should average <9.6 m.
5) Given the importance of shade and tree canopy cover, a minimum tree canopy cover of 26% should provide the necessary thermal cover for Mearns' quail and the proper microclimate for the forbs that they feed on.

Monitoring Harvest Levels

We found no evidence to suggest current levels of hunting pressure significantly affect Mearns' quail populations across Arizona. Nevertheless, accurate information on harvest levels would help to ensure hunting does not impact Mearns' quail populations in the future. The current small game questionnaire provides reasonable harvest level information. However, to improve harvest information, we recommend:

1) Include measures other than the mean to describe the central tendency of harvest indicators. Given the skewed distribution of several important harvest indicators (quail taken per day, number of days afield), medians or selected percentiles (e.g., 75%) provide unbiased and more accurate estimates of central tendency.
2) Increase the sample size and focus of hunter surveys used in determining annual Mearns' quail harvest indicators. Previously, no-cost special use stamps have been used to accomplish this for other species. A special use stamp, requiring all Mearns' quail hunters to provide names and addresses, would result in a larger pool of hunters to sample from. Increasing the sample percentage of licensed hunters for the small game questionnaire greatly increases costs. Few respondents to the small game questionnaire, on average, report that they hunt Mearns' quail. Even doubling the sample rate from 5% to 10% of licensed hunters would still result in few Mearns' quail hunters sampled.

Future Research

Future research should focus on habitat conditions and quail behavior. Based on our work and that of others (AGFD, unpublished data), hunting effects under current management strategies are inconsequential to Mearns' quail populations. For example, previous changes in the daily bag limit have had no perceivable influence on harvest. To improve knowledge on Mearns' quail population dynamics, we recommend:

1) Investigate the relationship between habitat quality and population viability. This research should focus on relative bird densities and nesting success under different habitat conditions. For example, development of a regression curve between percentage of a pasture under suitable conditions and relative quail abundance would help identify potential habitat condition thresholds.
2) Develop and validate a simple and useful mathematical model to help identify and rate the quality of oak woodland habitats for Mearns' quail.
3) Investigate movements and dispersal patterns of Mearns' quail after covey break up (March-May). There were some seasonal differences in relative quail densities that were hard to explain, and dispersal characteristics may help explain population dynamics of Mearns' quail.
4) Determine cause-specific mortality rates of Mearns' quail relative to habitat conditions. A radio telemetry study of $\geq$20 birds should provide adequate information on mortality.

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For a more technical presentation of methods, including statistical analyses, results, and discussion for a specific section from this Technical Guidance Bulletin, the authors refer you to the following citations, which can be obtained by contacting:

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