Predicting Habitat Suitability for Wildlife in Southeastern Arizona Using Geographic Information Systems: Scaled Quail, a Case Study

Kirby D. Bristow, Susan R. Boe, and Richard A. Ockenfels
Arizona Game and Fish Department, Phoenix, AZ

Abstract—*Studies have used Geographic Information Systems (GIS) to evaluate habitat suitability for wildlife on a landscape scale, yet few have established the accuracy of these models. Based on documented habitat selection patterns of scaled quail (*Callipepla squamata pallida*), we produced GIS covers for several habitat parameters to create a map of potential habitat in southeastern Arizona. We found scaled quail coveys on 36% of surveys conducted inside of potential scaled quail habitat, and 80% of the scaled quail coveys found occurred within the potential habitat map. We developed a logistic regression model that predicted 70% of used and unused sites. Potential causes for the low accuracy of GIS models are discussed.*

Introduction

Several authors have used Geographic Information Systems (GIS) to predict habitat suitability for wildlife on a landscape scale (Boyce and Waller 2003). Few such studies have validated their models by comparing classifications to actual habitat selection or abundance estimates. Mapping wildlife habitat suitability (availability and relative quality) is important because it provides information for long-term planning and can illustrate impacts of past and future land management activities (Roseberry and Sudkamp 1998).

Scaled quail (*Callipepla squamata pallida*) are a good species to test the efficacy of modeling habitat suitability using GIS in Arizona because they: are habitat specialists that are relatively widely distributed (Brown 1989), are relatively easy to survey (Brown et al. 1978), and are sensitive to habitat parameters available on GIS covers. In Arizona, scaled quail are mainly restricted to relatively flat, open grassland and desert areas with a summer rainfall regime (Brown 1970).

Objectives of our study were to: (1) identify landscape-scale availability of scaled quail habitat in Arizona, (2) develop a model to predict use, and estimate relative quality of scaled quail habitat across southeastern Arizona, and (3) test the efficacy of our GIS modeling efforts. Although habitat use patterns of scaled quail are well understood in other States, level of knowledge in Arizona is less than ideal (Rosenstock et al. 1996). General habitat preferences of a given species are likely consistent throughout their range, but site-specific habitat selection can be greatly affected by the quality of available habitat (Arthur et al. 1996). If adequate accuracy can be verified, GIS modeling may provide a valuable shortcut to more traditional intensive field surveys and field mapping.

Study Area

We conducted field surveys across the major portion of scaled quail distribution in southeastern Arizona. The vegetation associations within this area consisted primarily of semi- desert grasslands and Chihuahuan and Sonoran desert scrub. Brown (1994) provides a thorough description of the dominant grasses, shrubs, cacti, and trees within these vegetative associations. Topography consisted of extensive valleys and flats continuing upward to rolling hills broken by small canyons and mesas; elevation ranged between 750-1,770 m. Annual precipitation was bimodal with peaks in winter and late summer, and averaged 30.6 cm at Wilcox, Arizona (central portion of the study area) between 1898-2003. Seasonal maximum temperatures averaged 34.0 °C in summer and 15.7 °C in winter between 1898-2003 (N.O.A.A. 2003). Most (78%) of our field surveys were on public land managed by the Arizona State Land Department, the remainder falling under the jurisdiction of the U.S. Bureau of Land Management (19%), and the U.S. Forest Service (3%).

Methods

We created maps to predict scaled quail habitat use in southeastern Arizona based on documented habitat preferences, as well as regional habitat selection patterns. Based on habitat selection patterns documented in the scientific literature, we established the range of conditions preferred by scaled quail for the following habitat variables: vegetation type, percent slope, elevation, land-use practices, and average precipitation between April and August. We then produced GIS covers for each variable and used overlay analysis (Arc/Info version 8.0.1) to develop a map of potential scaled quail habitat in Arizona.

To test the accuracy of this first level map, we conducted scaled quail surveys at randomly generated 2.6-km cells (n = 101) both within (n = 53) and outside (≤20 km from mapped potential, n = 48) the periphery of potential scaled quail habitat. To ensure that surveys did not cross between habitat types (within or outside potential habitat), we selected only those cells that were in the center of a 9-cell neighborhood of similar habitat. We conducted pointing dog surveys similar to

Bristow and Ockenfels (2000) and used visual observation, calls, or presence of indirect sign (Stormer 1984) to establish presence of scaled quail in the area. We compared presence of scaled quail from surveys to individual cell classification to establish accuracy of the map, and compared it to previous data (Brown 1970) on scaled quail distribution in Arizona to determine relative efficacy of the technique.

To create a GIS cover of relative quality of scaled quail habitat, we overlaid all scaled quail use sites and random unused sites on the GIS habitat characteristic covers and recorded values for each of the habitat variables. We developed logistic regression models (Hosmer and Lemeshow 1989) to predict habitat use of scaled quail. Our probable models were *a priori*, and we calculated a modified Akaike's Selection Criterion (AIC) to select the most parsimonious model (Burnham and Andreson 1992). We assigned 0.5 as the cutpoint for classification of flush sites and random plots.

Lastly we applied the final landscape scale logistic regression model to the GIS habitat characteristic covers, and used surface analysis to create a map predicting probability of occupation for each 1-km^2 cell within potential scaled quail habitat in Arizona. Each cell received a score of 0.0-1.0 based on the calculated probability of encountering scaled quail there. Based on these scores, each 1-km^2 cell received 1 of 4 habitat quality ratings (Poor = 0.0-0.25, Fair = 0.26-0.50, Good = 0.51-0.75, and Excellent 0.76 -1.0). We used a jackknife resampling procedure (Verbyla and Litvaitis 1989) to evaluate the classification bias of the final model.

Results

We found several authors reporting habitat preferences for scaled quail across their range in the Southwestern United States. To select range of habitat parameters we used references that presented data most appropriate to the available GIS covers. We used information on scaled quail preference for vegetation type, slope, and elevation by Anderson (1974), Medina (1988), and Brown (1989). We used information on land use preference of scaled quail by Saiwana et al. (1998). Brown (1970) provided information on the specific association of precipitation patterns and scaled quail in Arizona (table 1).

The area within potential scaled quail habitat in southeastern Arizona encompassed 13,304 km^2. There was a 67.2% overlap of potential scaled quail habitat with Brown's (1970) estimate of scaled quail distribution (figure 1). We found scaled quail coveys on only 36.5% of surveys conducted inside of potential scaled quail habitat, and failed to find scaled quail on 89.6% of surveys conducted outside of potential scaled quail habitat. Comparatively we found scaled quail coveys on 64.5% of surveys conducted inside Brown's (1970) scaled quail range estimate, and failed to find scaled quail on 91.8% of surveys conducted outside of Brown's (1970) scaled quail range estimate. Of the scaled quail coveys found during random surveys, 80% occurred within the potential scaled quail habitat map, and 84% occurred within Brown's (1970) scaled quail range estimates.

The most parsimonious model (model 1) describing landscape scale habitat selection of scaled quail included all 5 habitat variables, and correctly classified 70.4% of used and unused sites (table 2). When applied to the area within potential scaled quail habitat, this model identified major concentrations of good and excellent quality habitat in the San Simon, San Bernadino, Sulphur Springs, and San Pedro Valleys (figure 2). A jackknifed classification of model 1 correctly classified only 44 of 93 used sites and 66 of 93 unused sites for an overall misclassification rate of 40.9%.

Discussion

We were able to develop a GIS-based map of potential scaled quail habitat in Arizona that correctly classified 80% of scaled quail coveys found during random surveys. Previous range estimates by Brown (1970), based on intensive field surveys and interviews, performed only slightly better. We also developed a habitat selection model that correctly classified 70% of scaled quail use. However, our ability to verify the presence of scaled quail inside potential habitat and the high misclassification rate of the jackknifed habitat selection model would suggest caution in the application of these models.

Numerous factors likely contribute to the apparent inaccuracies of our maps. First, our verification method was less than perfect, simply because we were unable to locate scaled quail during surveys does not mean that the area in question would

Table 1—Variables and Geographic Information Systems coverages used to predict potential scaled quail habitat in southeastern Arizona, 2001.

Variable	GIS coverage source	Range/class included in potential habitat
Slope	U.S.G.S. Digital Elevation Model	Less than 30%
Elevation	U.S.G.S. Digital Elevation Model	Between 1,067 and 1,400 m
Precipitation	N.O.A.A. Arizona climatological data 1987-1997	Average April-August >14.5 cm.
Vegetation type	GAP vegetation type (Graham 1995)	Semidesert grassland, Grassland, Sonoran scrub, Chihuahuan scrub, Mixed oak, Playa, and Agricultural
Land use	Arizona State Lands Department	Shrub and brush rangeland, Herbaceous rangeland, Mixed rangeland, Evergreen forest, and Cropland and pasture

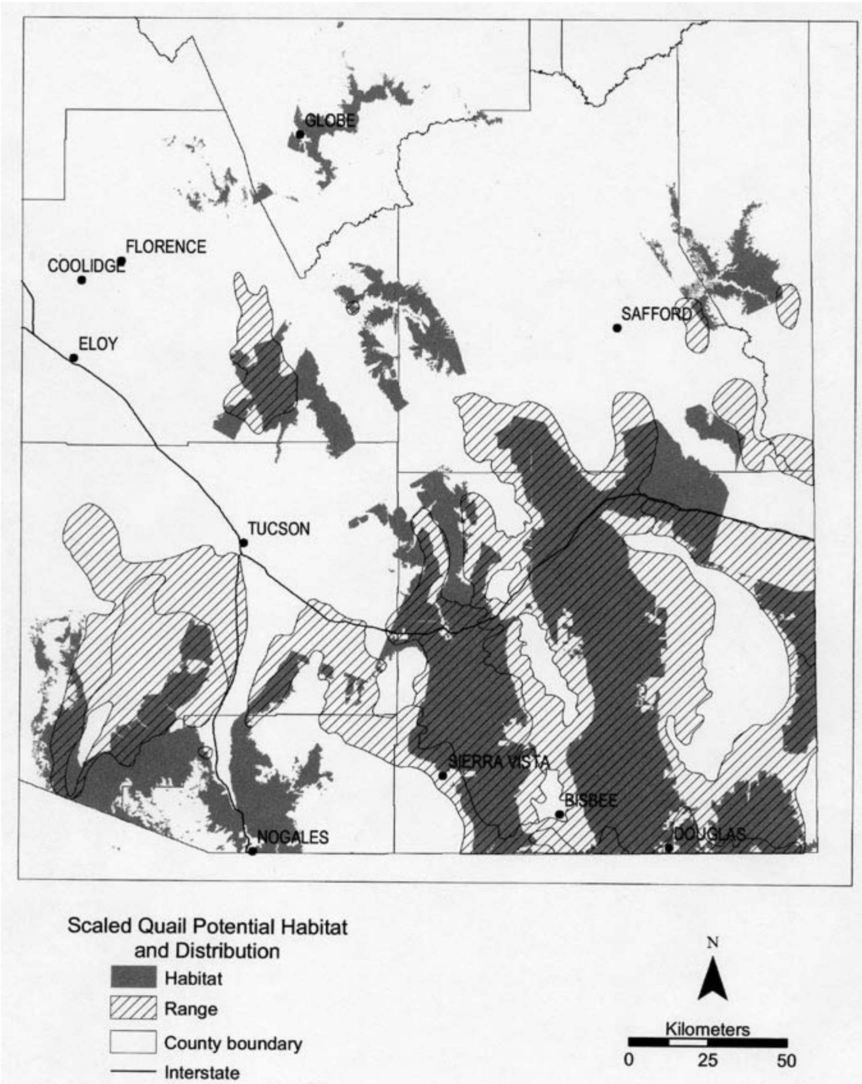

Figure 1—Potential scaled quail habitat and scaled quail range (Brown 1970) in southeastern Arizona.

Table 2—Logistic regression models[a] differentiating scaled quail use sites (n = 93) and random unused sites (n = 93) at a landscape scale, in southeastern Arizona, 2001-2003.

Model	-2 log likelihood	% used sites correctly classified	% unused sites correctly classified	AIC_c	Delta AIC_c
1[b]	198.097	63.4	77.4	226.213	0.000
2	229.347	66.7	69.9	243.816	17.603
3	229.051	65.6	65.6	245.865	19.652
4	233.964	68.8	69.9	246.433	20.220
5	233.940	67.7	69.9	248.569	22.356
6	238.349	59.1	64.5	250.818	24.605

1 Vegetation[c], slope[d], elevation[e], land use[f], and precipitation[g]
2 Vegetation, elevation, and precipitation.
3 Vegetation, slope, elevation, and precipitation.
4 Vegetation, slope, and precipitation.
5 Vegetation, and elevation.

[a] P –values for all models were <0.01 and degrees of freedom were equal to number of variables in the model.
[b] Z = 38.259 –21.968 Sonoran scrub –21.613 semidesert grassland –41.632 mixed oak –20.642 Chihuahuan scrub + 0.0 cropland and pasture –0.016 slope +.002 elevation –21.230 shrub and brush rangeland –19.948 mixed rangeland –42.056 evergreen forest + 0.105 herbaceous rangeland + 0.0 agriculture + 0.218 precipitation.
[c] Vegetation class.
[d] Average percent slope.
[e] Average elevation (m).
[f] Land use class.
[g] Average precipitation (cm) recorded between April and August.

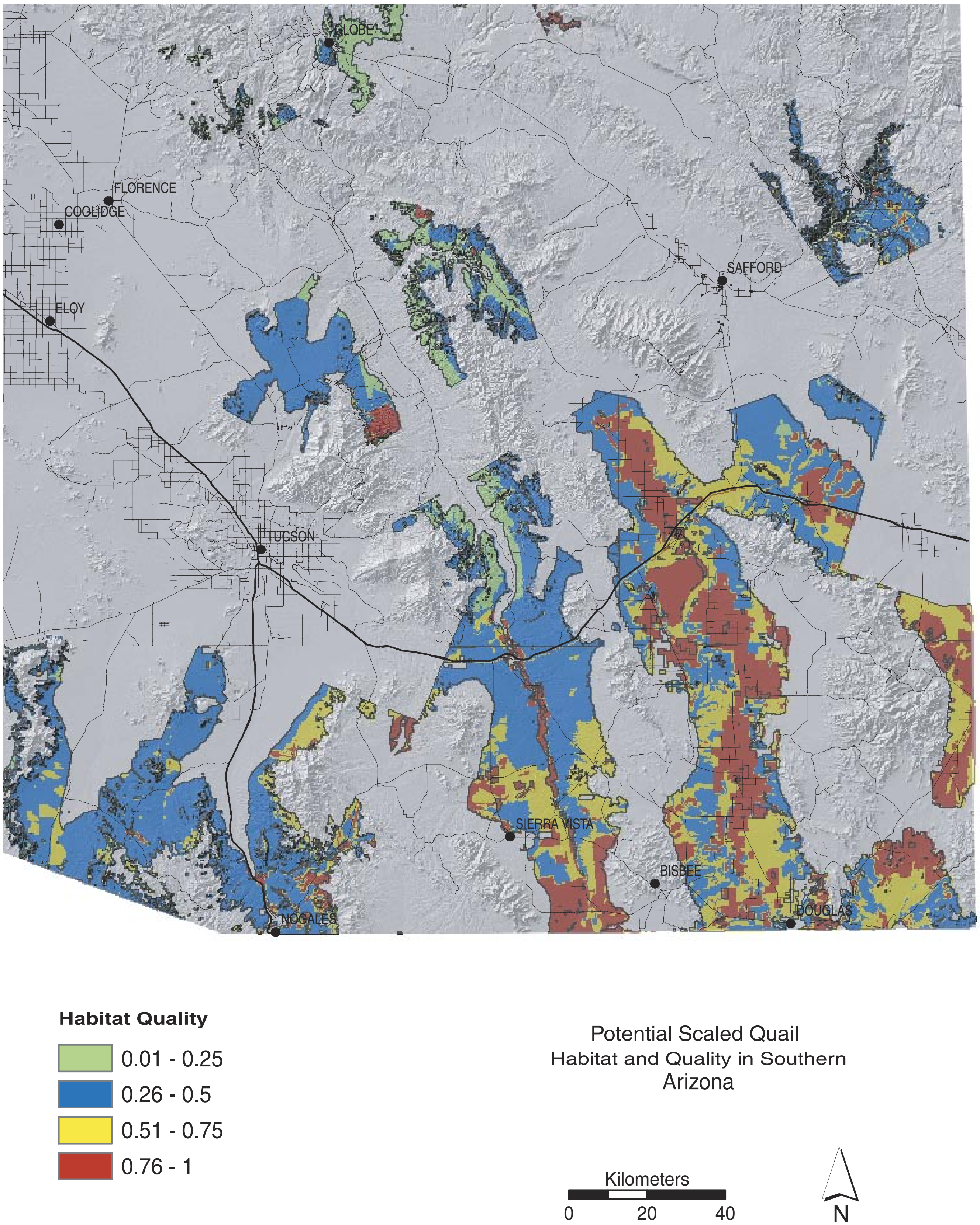

Figure 2—Relative quality of scaled quail habitat within potential scaled quail habitat in southeastern Arizona.

not support scaled quail. Studies using marked quail have found that pointing dog surveys can miss as much as 50% of the coveys in an area (Sisson et al. 2000). Moreover, quail populations in the Southwest are volatile, expanding and contracting in number and distribution each year with changing annual rainfall (Rollins 2000). Our survey efforts were conducted during a drought year when rainfall amounts and presumably scaled quail populations were lower than average.

Another likely explanation for model inaccuracies is that scaled quail are selecting habitat at a finer scale than is available for many of the landscape habitat covers. Habitat factors such as grass and forb coverage and diversity (Anderson 1974; Brown 1978), range condition (Saiwana et al.1998), shrub density (Rollins 2000), and exotic grass invasion (Medina 1988) can affect scaled quail habitat use, yet cannot be differentiated with currently available landscape scale GIS covers.

While many studies of wildlife habitat selection focus on a microhabitat scale, information on landscape scale relationships can provide useful insights into range-wide trends that may relate to population trends. However, to be useful the landscape scale data must be current and specific enough to explain the dynamic nature of wildlife habitat selection. While our models could be useful for identifying areas where habitat improvements may benefit scaled quail, more specific information on scaled quail habitat selection in Arizona is necessary to design effective mitigations and treatments. Without verification, we would advise similar caution in the application and use of other GIS-based landscape scale habitat suitability models.

References

Anderson, W. L. 1974. Scaled quail: social organization and movements. M.S. Thesis, University of Arizona, Tucson. 132 p.

Arthur, S. M.; B. F .J. Manly; L. L. McDonald; G. W. Gardner. 1996. Assessing habitat selection when availability changes. Ecology 77:215-227.

Boyce, M. S.; J. S. Waller. 2003. Grizzly bears for the Bitterroot: predicting potential abundance and distribution. Wildlife Society Bulletin 31:670-683.

Brennen, L. A. 1994. Broad-scale population declines in four species of North American quail: An examination of possible causes. In: Sustainable ecological systems: Implementing an ecological approach to land management. Gen. Tech. Rep. RM-247. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO: 44-50

Bristow, K. D.; R. A. Ockenfels. 2000. Effects of human activities and habitat conditions on Mearns' quail populations. Arizona Game and Fish Department Research Branch Technical Guidance Bulletin No. 4, Phoenix. 27 p.

Brown, D. E. 1970. Arizona Game and Fish Department scaled quail habitat evaluation. Arizona Game and Fish Department, Phoenix. 6 p.

Brown, D. E. 1978. Grazing, grassland cover and gamebirds. North American Wildlife Conference 43:477-485.

Brown, D. E. 1989. Scaled quail. In: Arizona game birds. University of Arizona Press and Arizona Game and Fish Department, Tucson: 145-161.

Brown, D. E. 1994. Grasslands. In: D. E. Brown, ed. Biotic communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City, UT: 107-142.

Brown, D. E.; C. L. Cochran; T. E. Waddell. 1978. Using call-counts to predict hunting success for scaled quail. Journal of Wildlife Management 4:281-287.

Burnham, K. P.; D. R. Anderson. 1992. Data-based selection of an appropriate biological model: the key to modern data analysis. In: McCullough, D .R.; R. H. Barret, eds. Wildlife 2001: Populations. Elsevier Science Publishers, London: 16-30.

Graham, L. A. 1995. Arizona natural vegetation, as mapped for the Arizona GAP Analysis program. Digital GIS File. School of renewable Natural Resources, University of Arizona, Tucson, AZ.

Hosmer, D. W., Jr.; S. Lemeshow. 1989. Applied logistic regression. John Wiley and Sons, Inc., New York, N.Y. 307 p.

Medina, A. L. 1988. Diets of scaled quail in southern Arizona. Journal of Wildlife Management 52: 753-757.

National Oceanic and Atmospheric Administration. 2003. Arizona climatological data. Vol. 107.

Rollins, D. 2000. Status, ecology and management of scaled quail in West Texas. Quail IV: Proceedings of the Fourth National Quail Symposium. 5:165-172.

Roseberry, J. L.; S. D. Sudkamp. 1998. Assessing the suitability of landscapes for northern bobwhite. Journal of Wildlife Management 62:895-902.

Rosenstock, S. S.; V. M. Dickenson; B. F. Wakeling. 1996. Status and management of Arizona quail: a technical review. Arizona Game and Fish Department, Phoenix. 47 p.

Saiwana, L.; J. L. Holechek; A. Tembo; R. Valdez; M. Cardenas. 1998. Scaled quail use of different seral stages in the Chihuahuan Desert. Journal of Wildlife Management 62:550-556.

Sisson, D. C.; H. L. Stribling; D. W. Speake. 2000. Efficiency of pointing dogs in locating northern bobwhite coveys. Quail IV: Proceedings of the Fourth National Quail Symposium. 4:109.

Stormer, F. A. 1984. Night roosting habitat of scaled quail. Journal of Wildlife Management 48:191-197.

Verbyla, D. L.; J. A. Litvaitis. 1989. Resampling methods for evaluating classification accuracy of wildlife habitat models. Environmental Management 13:783-787.