Habitat Relations

Influence of Landscape Composition on Northern Bobwhite Population Response to Field Border Establishment

SHANNON A. BOWLING,[1,2] *Department of Forestry and Environmental Resources, Fisheries, Wildlife, and Conservation Biology Program, North Carolina State University, Campus Box 7646, Raleigh, NC 27695-7646, USA*

CHRISTOPHER E. MOORMAN, *Department of Forestry and Environmental Resources, Fisheries, Wildlife, and Conservation Biology Program, North Carolina State University, Campus Box 7646, Raleigh, NC 27695-7646, USA*

CHRISTOPHER S. DEPERNO, *Department of Forestry and Environmental Resources, Fisheries, Wildlife, and Conservation Biology Program, North Carolina State University, Campus Box 7646, Raleigh, NC 27695-7646, USA*

BETH GARDNER, *Department of Forestry and Environmental Resources, Fisheries, Wildlife, and Conservation Biology Program, North Carolina State University, Campus Box 7646, Raleigh, NC 27695-7646, USA*

ABSTRACT Since the 1960s, habitat loss resulting from cleaner farming, increased urbanization, and maturation of early successional cover has caused range-wide decline of northern bobwhite (*Colinus virginianus*). Although field borders increase bobwhite habitat and increase local populations, understanding how the surrounding landscape influences bobwhite response to this management practice is critical to efficient implementation. We determined the relative influence of landscape composition and field border implementation on bobwhite densities and occupancy dynamics around crop fields in North Carolina and South Carolina, USA. We used 10-minute distance point counts to estimate density, occupancy, colonization, and extinction rates of male bobwhite around 154 agriculture fields, half of which had a fallow field border. We estimated percent of cropland, forest, pasture, early successional, and urban cover within 1-km radius buffers (314 ha) surrounding all point count locations. We examined the influence of 6 predictor variables (landscape composition metrics and field border presence) on bobwhite density and occupancy dynamics. Bobwhite density increased with the presence of field borders. Conversely, bobwhite density decreased as the percentage of urban, pasture, and forest lands increased. The presence of a field border did not influence occupancy, colonization, or extinction rates. However, as the percentage of cropland increased within the landscape, bobwhite occupancy increased and as the percentage of pasture increased, bobwhite colonization decreased. As the percentage of forest and urban increased and cropland decreased, bobwhite extinction rate increased. Our results indicated that local establishment of field borders does not increase bobwhite occupancy rates, but field borders can increase densities in suitable landscapes where bobwhite are present. Habitat restoration for bobwhite will most effectively increase population densities if focused in landscapes dominated by suitable cover types, where bobwhite occurrence is high. © 2013 The Wildlife Society.

KEY WORDS agriculture, *Colinus virginianus*, colonization, extinction, field border, landscape, northern bobwhite, occupancy.

Since the 1960s, northern bobwhite (*Colinus virginianus*; hereafter bobwhite) have declined range-wide but most dramatically in the southeastern United States (Church et al. 1993, Sauer et al. 2002, Terhune et al. 2006). The decline has been attributed to the degradation and loss of habitat (Best et al. 1997, Brady et al. 1998, Burger 2002, Okay 2008). Large-scale farming and intensive pine silviculture reduced habitat quality and landscape heteroge-

neity (Brennan 1991, Fies et al. 1992, Burger 2002, Pociak 2007, Jones et al. 2010). Fire suppression facilitated forest maturation and degradation of herbaceous ground cover, and urbanization eliminated bobwhite habitat and fragmented residual habitat patches (Best et al. 1997, Burger 2002, Terhune et al. 2006, Okay 2008, Jones et al. 2009).

Field borders create a herbaceous buffer between cropland and adjacent cover types, and have been suggested as a means to restore bobwhite populations in agricultural landscapes (Puckett et al. 1995, Greenfield et al. 2002, Stamps et al. 2008, Doxon and Carroll 2010, Blank et al. 2011). Bobwhite densities may be greater on farms with field borders than on those without field borders (Palmer

et al. 2005, Blank et al. 2011), and initial increases of 45% in bobwhite abundance after field border establishment have been observed (Riddle et al. 2008). Conversely, Smith and Burger (2006) showed breeding season bobwhite density was similar in bordered and unbordered fields.

Mixed responses by bobwhite to field border establishment may be related to the surrounding landscape composition and the associated influence on bobwhite ability to disperse and gain access to field borders (Puckett et al. 1995, Guthery et al. 2001, Smith and Burger 2006, Pociak 2007, Seckinger et al. 2008). Bobwhite abundance has been shown to be greater in landscapes with greater percentages of useable cover types, so bobwhite may be more likely to colonize new habitat patches in these landscapes (Roseberry and Sudkamp 1998, Schairer et al. 1999, Lusk et al. 2002). Additionally, certain cover types (e.g., row crop and recent timber harvests) are more permeable to dispersing bobwhite and may facilitate colonization or decrease local extinction when present on the landscape (Brady et al. 1993, Guthery 1997, Roseberry and Sudkamp 1998). Conversely, urban areas, pasture, and closed canopy forest lack food and cover for bobwhite, reduce landscape permeability, and fragment patches of habitat (Guthery 1999, Veech 2006). The lack of useable cover in landscapes with high percentages of urban or forest cover types may decrease bobwhite occupancy and colonization, and increase bobwhite extinction rates (Guthery 1999, Riddle et al. 2008). Landscapes with low percentages of useable cover types may elevate extinction rates and reduce colonization rates, which may be the mechanisms explaining bobwhite decline in these landscapes.

Field borders established in landscapes with more suitable cover types may be more successful at increasing bobwhite abundance than borders created in unsuitable landscapes because bobwhite are better able to disperse through continuous areas of useable cover (Roseberry and Sudkamp 1998, Williams et al. 2004, Riddle et al. 2008). Field borders located in landscapes with sparse habitat may not be used because the borders are isolated from other habitat patches and dispersing bobwhite are more susceptible to predation (Fies et al. 1992, Guthery 1999, Riddle et al. 2008).

Most studies investigating landscape influence on bobwhite populations have focused on bobwhite abundance (Palmer et al. 2005, Riddle et al. 2008, Blank et al. 2011), but the mechanisms underlying the bobwhite-landscape relationship are less studied. Riddle et al. (2008) noted a difference in bobwhite response to field borders related to the composition of the surrounding landscape, but only compared landscapes dominated by croplands or forests. A more extensive analysis of the influence of landscape composition (i.e., cropland, early successional, forest, urban, pasture) on border efficacy is needed to better guide bobwhite conservation through habitat creation. Although distance sampling allows for the estimation of individual detection probabilities to improve density estimates, the sampling technique does not identify unique individuals. Thus, modeling dynamics of change across years such as survival and recruitment is not possible. However, by reducing the distance sampling observations to binary observations of detection or non-detection, we can use occupancy models to examine the dynamics of the system. Estimates of colonization and extinction rates may help identify mechanisms of local population change and can be quantified using occupancy analysis. The combination of these 2 modeling approaches (i.e., density and occupancy dynamics) allows us to evaluate the impacts of field borders on bobwhite dispersal to new locations and on the density at sites already occupied. Therefore, we determined the relative influence of landscape composition and field border presence on bobwhite density and occupancy, colonization, and extinction rates over 6 years (i.e., 2006–2011) and across 2 states. Understanding the influence the landscape has on habitat restoration efforts will aid managers in targeting resources in the most suitable landscapes and in the most cost efficient manner (Williams et al. 2004, White et al. 2005, Winter et al. 2006).

STUDY AREA

We surveyed bobwhite around 154 agriculture fields located in North Carolina and South Carolina (Fig. 1). Fields were located in the Piedmont and Coastal Plain physiographic regions in 21 counties in North Carolina and 15 counties in South Carolina. We selected fields randomly from all established Conservation Practice 33 (CP33) fields in each state. Conservation Practice 33 is a field border practice created under the Conservation Reserve Program (CRP-479: United States Department of Agriculture) and was designed in response to bobwhite and early successional species declines across the United States (Burger et al. 2006, Stamps et al. 2008). The CP33 borders are linear strips of fallow vegetation between cropland and the adjacent cover types (Burger et al. 2006, Stamps et al. 2008, Doxon and Carroll 2010). A third of the border typically is disturbed each year to maintain early successional cover. For survey purposes, we paired each field with a CP33 border with a nearby field without a border (40 pairs in North Carolina and 37 pairs in South Carolina). Fields without a border were
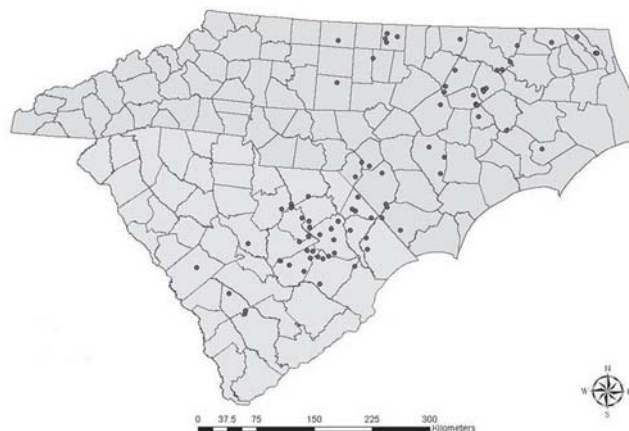

Figure 1. Locations of distance sampling point counts ($n = 154$) for northern bobwhite on fields with Conservation Practice 33 (CP33) field borders in 21 counties in North Carolina and 15 counties in South Carolina, USA (2006–2011).

located greater than 1 km away but within 3 km of the corresponding CP33 field (Burger et al. 2006). Fields with and without borders were in active crop management rotation, but could be fallow if part of the normal rotation (Burger et al. 2006).

Agricultural crops grown on fields included tobacco, soybean, cotton, peanuts, potatoes, and corn. Fallow borders consisted of various species of forbs (old field aster [*Aster* spp.], common ragweed [*Ambrosia artemisiifolia*], horseweed [*Conzya canadensis*], dogfennel [*Eupatorium capillifolium*], morning glory [*Ipomoea* spp.], prickly lettuce [*Lactuca serriola*], Chinese lespedeza [*Lespedeza cuneata*], bicolor lespedeza [*Lespedeza bicolor*], American pokeweed [*Phytolacca americana*], pigweed [*Portulaca oleracea*], java-bean [*Senna obtusifolia*], goldenrod [*Solidago* spp.], and clover [*Trifolium* spp.]), grasses (broomsedge [*Andropogon virginicus*], common oat [*Avena* spp.], bermudagrass [*Cynodon dactylon*], and tall fescue [*Schedonorus arundinaceus*]), shrubs (baccharis [*Baccharis halimifolia*], and blackberry [*Rubus argutus*]), and seedling trees (red maple [*Acer rubrum*], sweetgum [*Liquidambar styraciflua*], loblolly pine [*Pinus taeda*], longleaf pine [*Pinus palustris*], black cherry [*Prunus serotina*], and oak [*Quercus* spp.]).

METHODS

Northern Bobwhite Surveys

We surveyed paired fields simultaneously between sunrise and 1000 hours. We randomly assigned an observer to 1 of the paired fields during each round of counts. Using distance sampling point counts, we recorded male bobwhite seen or heard during a 10-minute time interval (Burger et al. 2006). We estimated the distance to each singing male using distance intervals (e.g., 0–25 m, 25–50 m, 50–100 m, 100–250 m, 250–500 m, and >500 m). To aid in distance estimation, we referred to pre-measured distance rings marked on aerial photography maps created in ArcMap 9.3 (Environmental Systems Research Institute, Redlands, CA). We referenced local weather data and visually estimated measures of cloud cover, fog level, and wind speed for each survey.

We conducted point counts from mid-May until mid-July to coincide with the bobwhite breeding season in North Carolina and South Carolina. From 2006 to 2008, the South Carolina Department of Natural Resources conducted surveys at South Carolina sites once per field season. From 2007 to 2008, the North Carolina Wildlife Resources Commission conducted surveys at North Carolina sites 3 times per field season. From 2009 to 2011, North Carolina State University conducted surveys in South Carolina and North Carolina twice per field season.

Landscape Composition Analysis

We described landscape composition using a 1-km buffer around each survey location, which reduced the overlap among buffers while maximizing our scale of analysis. We quantified landscape composition using Southeast Gap Analysis Program data (hereafter SE-GAP) in ArcMap 9.3. The SE-GAP data and classification schemes were based on the National Land Cover Data (NLCD). We combined the landcover categories used in the SE-GAP into 8 categories (cropland, urban, forest, open water, pasture, early successional, wetland, and other). The early successional category was comprised of shrub/scrub and herbaceous vegetative classes. We calculated estimates of landscape composition using Patch Analyst for ArcMap 9.3. Although SE-GAP data was combined into 8 landscape classes, we chose only the 5 landscape classes believed to be the most influential to bobwhite: percent cropland, forest, pasture, early successional, and urban cover (Roseberry and Sudkamp 1998; Table 1).

Density Analysis

We used Program Distance 6.0 (Thomas et al. 2009, hereafter Distance) to estimate male bobwhite densities and used the multi-covariate sampling engine to estimate the influence of observational covariates (cloud cover, fog level, and wind speed) on detection probability (Buckland et al. 1993, Thomas et al. 2009). To remove outliers and improve the precision of the analysis, we truncated detections to the 500-m distance surrounding survey locations (Somershoe et al. 2006). Individual site-level detection probability was not possible because of the low number of observations per site (<30); however, we suspected that forest cover would directly affect detection rates because of a decreased ability to detect bobwhite as forest density increased. Thus, we estimated a detection function for each of 3 categories of forest cover in a 500-m buffer around survey locations (0–25% = 1, 25–50% = 2, >50% = 3; Somershoe et al. 2006). We applied the detection function that was calculated for each percent forest category to each site within that particular forest category.

Within Distance, we analyzed models with every combination of distribution functions (key functions: half-normal

Table 1. Mean, minimum, maximum, linear regression coefficients, standard errors (SE), and 95% confidence intervals (CI) for landscape metrics used to investigate the influence of the surrounding landscape on northern bobwhite densities in North Carolina and South Carolina, USA (2006–2011).

Landscape metrics[a]	Mean	Minimum	Maximum	Coefficients	SE	95% CI
Border				0.30	0.15	−0.01, 0.60
Forest	30.11	1.36	79.20	−0.43	0.26	−0.93, 0.07
Crop	45.01	6.28	79.76	−0.22	0.23	−0.67, 0.22
Early	9.23	0.18	47.65	0.08	0.14	−0.19, 0.35
Pasture	7.48	0.41	22.75	−0.22	0.11	−0.44. 0.01
Urban	4.76	0.00	23.43	−0.12	0.04	−0.20, −0.05

[a] Border, presence or absence of Conservation Practice 33 (CP33) border at the study site. All other metrics indicate the percentage of specified cover within a 1-km buffer. Early indicates early successional land cover.

and hazard-rate), series expansions (simple, cosine, and hermite), and observation-level covariates (cloud cover, fog score, and wind speed). From this model set, we selected the model that best estimated male bobwhite densities according to Akaike's Information Criterion adjusted for small sample size (AIC_c; Buckland et al. 1993, Burnham and Anderson 1998, Thomas et al. 2009).

To determine landscape and field border influence on bobwhite density, we conducted a linear regression analysis with bobwhite density as the dependent variable and 5 landscape metrics and presence or absence of a CP33 border as predictor variables (PROC REG; SAS Institute, Cary, NC). We standardized landscape metrics using a z-score transformation (Osborne and Waters 2002). We determined significance of covariates present in the top models by examining the coefficient values and 95% confidence intervals (Nakagawa and Cuthill 2007). We considered coefficients significant if their confidence interval did not overlap zero or only slightly overlapped (Shake et al. 2011). We considered coefficients with confidence intervals centered over zero to have no significance.

Occupancy Dynamics Analysis

To calculate occupancy (ψ), colonization (γ), and extinction (ε) rates, we used the multi-season analysis within Program Presence (Hines 2008). We considered a site (or field) occupied when at least 1 bobwhite was present. Colonization was the probability that a site not occupied during 1 sampling occasion became occupied at the next sampling period, and extinction was the probability the site became unoccupied after being occupied at the previous sampling occasion.

The multi-season analysis allowed us to infer the latent occupancy state for years with missing observations because of varying survey effort (MacKenzie et al. 2003). We only used data from 2007 to 2011 in occupancy dynamic analysis because of limited surveys in 2006. Within the multi-season analysis, we used the default parameterization model in which occupancy in the first field season (year), local colonization, and seasonal extinction were directly calculated, and occupancy in the subsequent seasons were derived from the first season's estimates (Hines 2008).

To establish the best model for estimating occupancy parameters, we first determined the model that best captured the component of detection variability in our study (Kéry et al. 2010). While holding the state variables (occupancy, extinction, and colonization) constant, we examined all possible combinations of sampling-occasion covariates (wind speed, cloud cover, and fog score) and the effect of year in the detection probability. We used AIC model selection (Burnham and Anderson 1998) to determine the best model for describing detection variability. We then used this model as a base for modeling the occupancy, extinction, and colonization parameters.

Within Presence, we compared models with combinations of the landscape covariates and field border presence, but limited models to 3 covariates to prevent overparameterization. We hypothesized occupancy and colonization rates would increase and extinction rates would decrease as the percentage of crop and early successional cover increased. Also, we hypothesized that occupancy and colonization would decrease and extinction would increase as the percentage of forest, urban, and pasture increased.

Because of the large number of possible models (6 variables and all possible combinations for 3 variables), we followed a procedure to identify the best model. We chose 1 of the 3 state variables (occupancy, colonization, or extinction) and determined the top models describing landscape influence on that state variable (using the same standardized landscape metrics as the density analysis), while holding the other 2 constant. To limit total number of models in the final model set, we selected the top 2 models using AIC_c (Burnham and Anderson 1998, Thomas et al. 2009). We used those top models for the selected state variable, and examined all possible models for the second state variable, while continuing to hold the third state variable constant. After determining the top 2 models from the model set examining 2 state variables, we examined all combinations of covariates for the third state variable.

We repeated the process 6 times, changing the order to include all combinations of the 3 state variables, ensuring a robust process to examine all covariates and the parameters. The process resulted in 6 separate model sets examining field

Table 2. Model set including the difference in corrected Akaike's Information Criterion (ΔAIC_c), model weight (w_i), likelihood, and number of model parameters (K) for determining the influence of field border establishment and landscape composition on northern bobwhite occupancy (ψ), colonization (γ), and extinction rates (ε) around agriculture fields in North Carolina and South Carolina, USA (2007–2011). The year and wind speed (wind) detection variability parameters (p) were held constant for all models.

Model[a]	ΔAIC_c	w_i	Likelihood	K
ψ (crop), γ (pasture), ε (forest, crop, urban), p(year, wind)[b]	0	0.31	1.00	14
ψ (crop), γ (·), ε (forest, crop, urban), p(year, wind)	0.53	0.24	0.77	13
ψ (crop, urban), γ (pasture), ε (forest, crop, urban), p(year, wind)	1.55	0.14	0.46	15
ψ (crop, urban), γ (·), ε (forest, crop, urban), p(year, wind)	1.92	0.12	0.38	14
ψ (crop), γ (crop), ε (forest, crop, urban), p(year, wind)	2.6	0.08	0.27	14
ψ (crop), γ (crop, urban), ε (forest, crop, urban), p(year, wind)	3.92	0.04	0.14	15
ψ (crop), γ (crop, early, urban), ε (forest, crop, urban), p(year, wind)	5.26	0.02	0.07	16
ψ (all), γ (all), ε (all), p(year, wind)	24.74	0.00	0.00	27
ψ (·), γ (·), ε (·), p(year, wind)	50.49	0.00	0.00	9

[a] Land cover metrics indicate the percentage of specified cover within a 1-km buffer. Early indicates early successional land cover. All indicates crop, pasture, forest, urban, and early were included in the model.
[b] Top model AIC_c, 1,898.8.

border presence and landscape composition influence on occupancy, colonization, and extinction. The final combined model set consisted of the null and full models and the top 2 models from each of the 6 iterations (duplicate models removed; Table 2). We selected top overall models as those with $\Delta AIC_c < 2$ (Burnham and Anderson 1998, Thomas et al. 2009). We determined significance of covariates present in the top models by examining the coefficient values and 95% confidence intervals (Nakagawa and Cuthill 2007). We considered confidence intervals significant if their confidence interval did not overlap zero or only slightly overlapped (Shake et al. 2011). We considered coefficients with confidence intervals centered over zero to have no significance.

RESULTS

Density Analysis
We detected 2,332 male bobwhite during the 6-year study, with 877 detections in the 0–25% forest cover category, 1,182 detections in the 25–50% category, and 273 detections in the >50% category. The averaged detection probability of bobwhite in distance sampling decreased as the percentage of forest cover increased (0–25% forest cover: 0.1823, 25–50% forest cover: 0.1326, and >50% forest cover: 0.1042). The model containing the hazard-rate key functions with cosine series expansion parameters and all 3 observational covariates (wind speed, cloud cover, and fog score) best modeled male bobwhite detection probabilities at the site-level.

Bobwhite densities were 29% greater around fields that contained field borders than those without. The 95% confidence interval around the parameter estimate for border presence slightly overlapped zero (Table 1). Bobwhite densities decreased as percent forest, urban, and pasture cover increased (Table 1).

Occupancy Dynamics Analysis
The model that best estimated the probability of detecting at least 1 male bobwhite included year and the wind speed (wind) sample-occasion covariate. The final combined model set describing the influence of landscape composition on bobwhite occupancy, colonization, and extinction rates, contained 4 models with $\Delta AIC_c < 2$ (Table 2). We obtained parameter estimates by using the model-averaged values from these top 4 models, which included percent cropland and percent urban as predictors of initial occupancy, percent pasture for colonization, and percent forest cover, cropland, and urban for extinction (Fig. 2).

Percent cropland was a significant predictor of bobwhite occupancy and extinction based on the model-averaged estimates; as the percent cropland in the landscape increased, bobwhite occupancy increased and extinction decreased (Fig. 2). Although percent urban was included in 2 of the top models according to the AIC_c, the 95% confidence interval overlapped zero when predicting initial occupancy (Fig. 2) suggesting percent urban may be less of a significant predictor than percent cropland cover. Percent pasture cover was included in 2 of the top 4 models as a predictor of bobwhite colonization, suggesting that as pasture cover
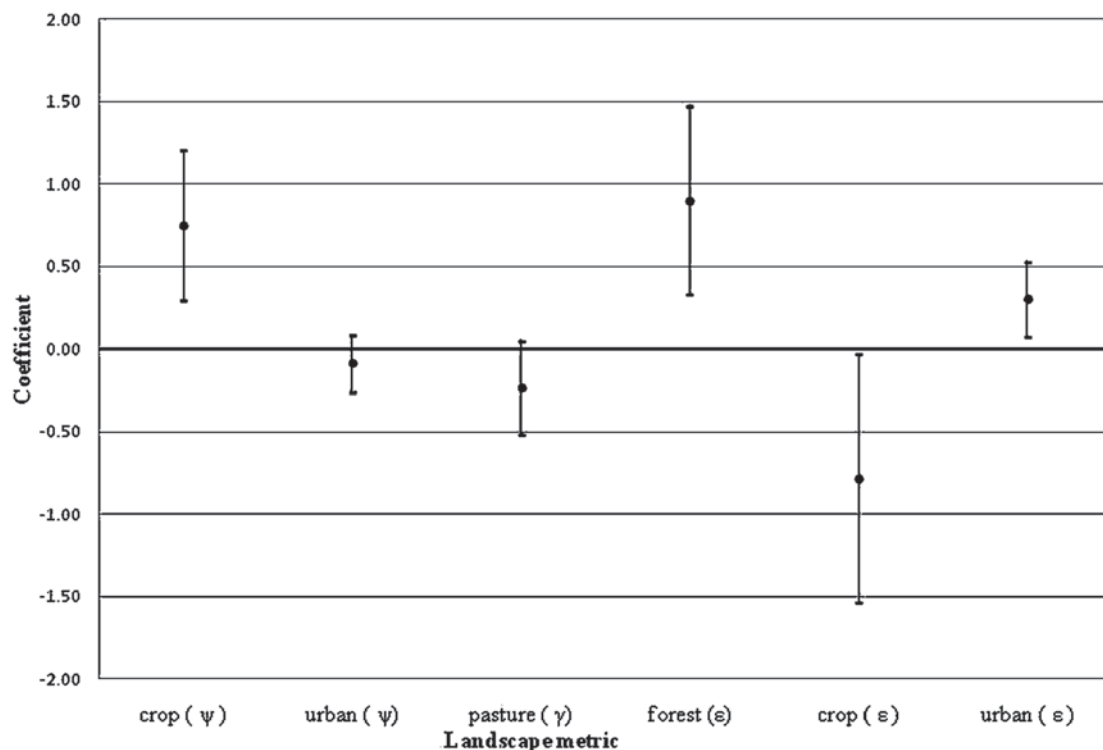

Figure 2. Model-averaged coefficient estimates and 95% confidence intervals for landscape metrics (percentage of crop, urban, pasture, and forest within 1-km buffers around survey sites) in the top models for estimating landscape composition influence on northern bobwhite occupancy (ψ), colonization (γ), and extinction rates (ε) around crop fields in North Carolina and South Carolina, USA (2007–2011).

increased, bobwhite colonization decreased; however, the model-averaged 95% confidence interval slightly overlapped zero (Fig. 2). Percent forest and urban cover were significant predictors of bobwhite extinction (Fig. 2), indicating that as percent forest and urban cover increased bobwhite extinction increased. The field border covariate was not present in any of the top models for occupancy dynamics.

DISCUSSION

The presence of a field border was a significant positive predictor of bobwhite density but did not predict occupancy dynamics. Although individual field borders provide food and cover for bobwhite (Burger et al. 2006, Smith and Burger 2006, Riddle et al. 2008, Blank et al. 2011), we speculate these and other small-scale efforts to establish habitat do not significantly influence landscape-scale processes (e.g., dispersal). Our results showed that bobwhite densities were 29% greater in fields with borders than those without, and other studies have shown similar increases in density estimates when field borders were present (Palmer et al. 2005, Riddle et al. 2008, Blank et al. 2011). However, the presence of field borders in our study did not affect occupancy, colonization, or extinction rates. By combining the 2 modeling techniques, we demonstrated that field borders can increase bobwhite abundance locally, but the field borders had less influence on occurrence than landscape composition. Therefore, field borders likely will be most effective if implemented in landscapes that promote bobwhite presence and facilitate dispersal.

Landscapes dominated by cropland are permeable to dispersing bobwhite and may yield greater occupancy and less extinction in local habitat patches (e.g., field borders; Brady et al. 1993, Schairer et al. 1999). Similar to this study, previous studies showed greater bobwhite abundance was correlated with increased cropland within the landscape (Brady et al. 1993, Schairer et al. 1999, Lusk et al. 2002, Peterson et al. 2002, Riddle et al. 2008). Cropland especially is critical to bobwhite populations during the growing season because of the habitat provided, including foraging and escape cover (Brady et al. 1993).

Cover types that lack appropriate ground cover (e.g., closed-canopy forest, urban, and pasture) are barriers to dispersal, so prevalence of these cover types likely affects colonization and extinction of bobwhite in local habitat patches (Barnes et al. 1995, Guthery 1999, Dimmick et al. 2002, Veech 2006). Because dispersal from surrounding areas (i.e., >2 km) may alleviate local population decline, the reduced ability of bobwhite to disperse through landscapes dominated by unsuitable cover types may increase extinction rates in isolated patches such as field borders (Fies et al. 2002, Townsend et al. 2003, Riddle et al. 2008). Mature closed canopy forests shade ground cover and reduce seed bearing plants that produce commonly eaten bobwhite foods (Lohr et al. 2011). Though bobwhite may disperse through closed canopy forest, reduced ground cover increases bobwhite vulnerability to predation, causing decreased colonization and increased extinction (Rollins and Carroll 2001, Riddle et al. 2008). Pastures in the eastern United States are comprised primarily of non-native grass species that restrict movement and provide limited overhead cover for bobwhite, possibly restricting bobwhite survival and ability to colonize new areas, including areas with field borders (Fies et al. 1992, Dimmick et al. 2002). Similarly, urban landscapes lack appropriate cover, are fragmented, and increase the risk of predation for bobwhite (Brady et al. 1998, Lohr et al. 2011). Bobwhite have been noted to go locally extinct as the percent of urban cover in the landscape approaches 30% (Veech 2006). Although the scale of our analysis (314 ha) was much smaller than the 20,000-ha landscapes studied by Veech (2006), we observed decreases in bobwhite densities with small percentages of urban cover in the landscape, indicating urbanization negatively influences bobwhite demography at multiple scales.

MANAGEMENT IMPLICATIONS

The CP33 field border program successfully increased local bobwhite populations within North Carolina and South Carolina, which is further evidence of the value of field borders to bobwhite conservation in agricultural settings. However, individual field borders did not influence bobwhite occurrence within the landscape, which suggests future conservation efforts should consider the surrounding landscape when implementing localized habitat improvement practices for northern bobwhite; in fact, the Northern Bobwhite Conservation Initiative recommends the use of focal areas in targeting habitat management efforts (Palmer et al. 2011). Accordingly, establishing habitat in focal areas that contain a high probability of bobwhite occurrence (i.e., greater percentages of crop cover and minimized percentages of urban, non-native pastures, and closed canopy forest) will maximize the efficiency of conservation efforts. Additionally, increasing useable cover on the landscape by thinning and burning forests to open the canopy and promote ground cover could aid in creating landscapes that promote bobwhite occurrence.

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