



Management and Conservation

Northern Bobwhite Response to Conservation Reserve Program Habitat and Landscape Attributes

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ABSTRACT The northern bobwhite (*Colinus virginianus*; hereafter bobwhite) has experienced substantial population declines in recent decades in the United States, and especially in Maryland and Delaware. The United States Department of Agriculture's Conservation Reserve Program (CRP) could provide additional habitat for bobwhites, leading to an increase in bobwhite abundance. I investigated if bobwhite abundance was related to the percent cover of CRP land and landscape attributes in local landscapes on Maryland's Eastern Shore and Delaware. Observers conducted bobwhite point transect surveys at 113 locations during the breeding seasons of 2006–2007, and I calculated landscape metrics for 500-m radius landscapes centered on each point transect location. Most CRP land in the study landscapes was planted to herbaceous vegetation. Bobwhite abundance was strongly positively associated with percent cover of CRP land in the landscape but was not strongly related to percent cover of agriculture or forest or to landscape patch density. These results suggest that the CRP has created additional habitat for bobwhites in Maryland and Delaware and that landscapes with greater proportions of herbaceous CRP practices support more bobwhites. © 2012 The Wildlife Society.

KEY WORDS birds, Conservation Reserve Program, Delaware, landscape, Maryland, northern bobwhite, unmarked.

The northern bobwhite (*Colinus virginianus*; hereafter bobwhite) has experienced a substantial population decline over the last several decades in the United States (Brennan 1991, Burger 2001, Peterson et al. 2002, Sauer et al. 2011). In Maryland and Delaware, the bobwhite population decline has been especially steep, with over a 95% decline in the last 43 years (Sauer et al. 2011). Bobwhite declines are linked to factors including weather, harvest, disease, and land cover changes (Guthery 2000, Burger 2001, White et al. 2005). However, the primary cause of bobwhite population declines is the loss or deterioration of bobwhite habitat (Brennan 1991, Guthery 2000, Burger 2001, Lohr et al. 2011).

Bobwhites prefer relatively open, patchy habitat that includes a mix of shrubs, grasses, forbs, and bare ground (Wilkins and Swank 1992). They use a variety of areas for nesting, including grasslands, fallow fields, roadsides, pastures, and hayfields (Rosene 1969, Roseberry and Klimstra 1984, Burger 2001, Smith 2004). They often prefer heterogeneous landscapes that contain a mixture of cropland, pastureland, and early successional areas (Roseberry and Klimstra 1984, Brennan 1991, Veech 2006b). Bobwhites may also prefer landscapes with high interspersions of cover types and greater amounts of edge habitat (Leopold 1933).

The loss of bobwhite habitat is due to many factors. Clean-farming practices have reduced the number of weedy fencerows and small fields that once provided nesting and brood-rearing habitat for bobwhites across its geographic range (Brennan 1991). Habitat fragmentation has potentially reduced the amount of useable space available for bobwhites (Duren et al. 2011). Urban development and an increase in forested land due to plant succession on abandoned farms has also led to a loss of bobwhite habitat (Brennan 1991, Veech 2006b).

The United States Department of Agriculture's (USDA) Conservation Reserve Program (CRP) could provide nesting, brood-rearing, and roosting habitat for bobwhites (Burger et al. 1990, Puckett et al. 2000), leading to an increase in bobwhite abundance (Burger et al. 1990, Veech 2006b, Riffell et al. 2008, Evans et al. 2009). The CRP offers economic incentives that encourage farm owners to convert highly erodible and other environmentally sensitive agricultural land to perennial vegetation cover. The goals of the CRP are to improve water quality, reduce soil erosion, and establish wildlife habitat.

Herbaceous CRP plantings often represent the only uncultivated herbaceous areas on farmland in Maryland and Delaware and therefore may provide habitat for bobwhites (P.J. Blank, University of Maryland, personal observation). Of the roughly 35,000 ha of land enrolled in the CRP in Maryland and Delaware, the greatest percentage (44.8%) is enrolled as herbaceous filter strips (USDA Conservation Practice [CP] 21; USDA 2011a). Smaller percentages of

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CRP land are enrolled in herbaceous practices such as introduced grasses (CP1; 12.8%), native warm-season grasses (CP2; 3.2%), and existing grass (CP10; 2.7%; USDA 2011a).

I conducted a study in response to the needs of land managers and conservation planners seeking to create habitat for bobwhites in the mid-Atlantic region. I assessed how landscape features may affect bobwhite populations because landscape attributes influence bobwhite abundance (Roseberry and Klimstra 1984, Brennan 1991, White et al. 2005, Veech 2006b). A few landscape-scale studies of bobwhite habitat relationships have been conducted in the Mid-Atlantic region (e.g., Duren et al. 2011, Lohr et al. 2011), but these have not evaluated the influence of the CRP. Because bird-CRP relations vary between ecological regions and conservation decisions should be based on region-specific information when possible (Whittingham et al. 2007, Riffell et al. 2008), I focused on the influence of the CRP and landscape attributes on bobwhite abundance in states within the mid-Atlantic region. My objectives were: 1) to determine if bobwhite abundance is related to the percent of CRP land in local landscapes in Maryland and Delaware, and 2) to assess the influence of landscape attributes on bobwhite abundance.

STUDY AREA

I selected bobwhite survey locations in 3 counties on Maryland's Eastern Shore (Caroline, Queen Anne's, and Talbot) and 1 county in Delaware (Kent; Fig. 1). These 4 counties were composed of approximately 44% farmland (USDA 2009) and contained about 10,000 ha of CRP land, which is 28% of the CRP land across the 2 states (USDA 2011c). At least 81% of the CRP land in these counties was planted to herbaceous conservation practices (USDA, unpublished data). Most farms contained row-crop agriculture interspersed by upland forest blocks or forested wetlands. Most herbaceous CRP land was planted with native warm-season grasses or introduced cool-season

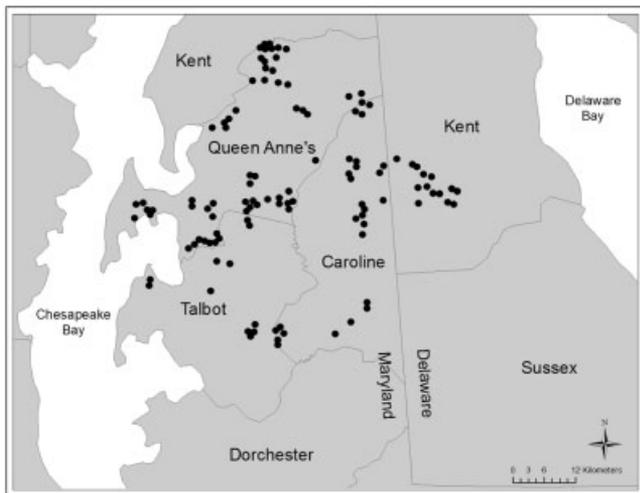


Figure 1. Location of bobwhite survey locations (dark circles) in Caroline, Queen Anne's, and Talbot counties in Maryland and in Kent county in Delaware, USA, 2006–2007. County boundaries are from the United States Census Bureau (2012).

grasses, and native wildflowers or introduced legumes were usually included in the planting mix (USDA 2011b). Common warm-season grasses included big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and indiagrass (*Sorghastrum nutans*). The most common cool-season grass in herbaceous CRP plantings in Maryland was orchardgrass (*Dactylis glomerata*; S. V. Strano, Natural Resources Conservation Service [NRCS], Maryland, personal communication), but other cool-season grasses such as red fescue (*Festuca rubra*) and sheep fescue (*F. ovina*) were also planted.

Methods

Point Transects

In 2006 and 2007, we (P.J.B. and 2 trained field assistants) surveyed calling male bobwhites twice during the breeding season at 113 locations. The bobwhite survey protocol followed a modified version of the CP33, habitat buffers for upland birds monitoring protocol (Burger et al. 2006). We conducted bobwhite surveys on fields with CRP land and on some fields without CRP land. I identified fields with and without CRP land with the assistance of NRCS staff in Maryland and Delaware. I established point transect (Buckland et al. 2001) locations on 1 corner of each field and adjacent to secondary roads. All point transect locations were ≥ 1 km apart and survey points on fields without CRP land were < 3 km from survey points on fields with CRP land (Burger et al. 2006).

We surveyed bobwhites once in late-May–mid-June and a second time in late-June–mid-July. We surveyed 40 sites in 2006 and 73 sites in 2007. No site was surveyed in both years. We conducted surveys between sunrise and 2 hours after sunrise. We did not conduct surveys during $> 75\%$ cloud cover, > 16 km/hr wind, rain, fog, or a dramatic drop in barometric pressure (> 0.13 cm/Hg). We tallied all distinct calling bobwhites during 5-minute point transects. We recorded the number of calling bobwhites in 5 distance intervals from the observer (0–50 m, 50–100 m, 100–250 m, 250–500 m, and > 500 m).

Spatial Analysis and Selection of Landscape Metrics

I projected the 113 point transect locations onto a 2006 national land cover dataset (Homer et al. 2004) raster image in a Geographic Information System. I reclassified the land cover classes into open water and emergent wetlands, developed and barren land, forest, or agricultural land (including cropland and pastureland). I merged the reclassified land cover layer with a layer containing CRP contracts in Maryland and Delaware obtained from the NRCS.

I selected 5 landscape metrics that I predicted would be related to bobwhite abundance. The landscape metrics were percent cover of agriculture, CRP land, and forest; length of total edge; and landscape patch density. I chose CRP cover because I predicted that landscapes with greater proportions of CRP land would have more bobwhites. I predicted that bobwhite abundance would be positively associated with agriculture cover and negatively associated with forest cover (Veech 2006b, Riddle et al. 2008, Riffell et al. 2008). I

predicted that bobwhite abundance would be positively associated with total edge and patch density because bobwhites may prefer habitats with greater amounts of edge (Leopold 1933) and because bobwhite nesting locations have been associated with landscapes that contain many cover patches (White et al. 2005). I calculated all landscape metrics in FRAGSTATS 3.3 (<http://www.umass.edu/landeco/research/fragstats/fragstats.html>, accessed 01 May 2011) and derived them from 500-m radius (78.5 ha) landscapes centered on each point transect location. I chose this radius because it approximates the audible range at which an observer is likely to detect a calling bobwhite (Burger et al. 2006).

Statistical Analyses

I used the `gdistsamp` function in the UNMARKED (Fiske and Chandler 2011) package of R (R Development Core Team 2011) to model the abundance of male bobwhites. The `gdistsamp` function fits the generalized distance sampling model of Royle et al. (2004) and allows for modeling abundance and detection parameters as functions of covariates. I used the negative binomial distribution to model abundance due to overdispersion in the data. I right truncated the observations at 500 m so the spatial scale of the bobwhite observations matched the spatial scale of the landscape metrics; this avoided problems associated with drawing inferences from data collected at different scales (Turner et al. 2001) and minimized the probability that bobwhites observed from 2 different locations were double-counted. I used the number of repeated visits at each survey location ($n = 2$) as an offset in the abundance component of the model.

I considered models with all possible combinations of covariates, and a model with no covariates, generating 16 candidate models of bobwhite abundance. I evaluated the models by using Akaike's Information Criterion adjusted for small sample sizes (AIC_c), ΔAIC_c values, and Akaike weights (Burnham and Anderson 2002). The global (full) model included agriculture cover, CRP cover, forest cover, and patch density. Because total edge and patch density were highly correlated ($r = 0.80$), I chose to remove 1 of these variables from the analysis. I retained patch density because I predicted that the presence of more land cover patches (i.e., greater patch density) in the study landscapes would have a greater influence on bobwhite abundance than the total amount of edge in the landscapes. I centered and standardized all predictor variables to facilitate model convergence and to improve the interpretability of the model parameters (Schielzeth 2010). I hypothesized that forest cover could influence detection probability, therefore I tested the influence of forest cover on detection in the global model. I considered models with smaller ΔAIC_c values (e.g., <10) to have some support and estimated the relative importance of predictor variables (which can range from 0 to 1) by summing the Akaike weights across all models in which the variable occurred (Burnham and Anderson 2002). I calculated model-averaged parameter estimates and 95% confidence intervals of the estimates for each predictor

variable based on the entire set of the candidate models (Burnham and Anderson 2002).

I evaluated the goodness of fit of the global model by calculating the Freeman–Tukey fit statistic (Brooks et al. 2000) for the observed data and comparing it to expected values generated from 500 bootstrap simulations (Kéry et al. 2005). I calculated the bootstrap P -value as the proportion of expected values greater than the observed value. I calculated predicted bobwhite abundances by using the predict function in UNMARKED. I calculated the abundance of male bobwhites across all landscapes by summing the predicted abundances for each landscape from the most supported model (i.e., the model with the smallest AIC_c value), and generated a 95% confidence interval of abundance by calculating the 2.5% and 97.5% quantiles of 500 parametric bootstrap simulations. I also generated model-averaged predicted estimates of bobwhite abundance as a function of CRP cover while holding agriculture cover, forest cover, and patch density constant at their means (Fig. 2).

Results

Land cover among the 113,500-m radius landscapes was dominated by agriculture ($\bar{x} = 56.0\%$, $SD = 17.7\%$, $\text{min.} = 6.0\%$, $\text{max.} = 91.6\%$), followed by forest ($\bar{x} = 20.9\%$, $SD = 14.6\%$, $\text{min.} = 0.0$, $\text{max.} = 80.3\%$) and CRP land ($\bar{x} = 10.7\%$, $SD = 11.6\%$, $\text{min.} = 0.0$, $\text{max.} = 58.4\%$). Mean landscape patch density was 35.6 patches/100 ha ($SD = 11.3$ patches/100 ha, $\text{min.} = 11.5$ patches/100 ha, $\text{max.} = 60.0$ patches/100 ha). Ninety-five of the landscapes contained CRP land, represented by 14 different CRP practices. The majority of CRP land was CP21 filter strips

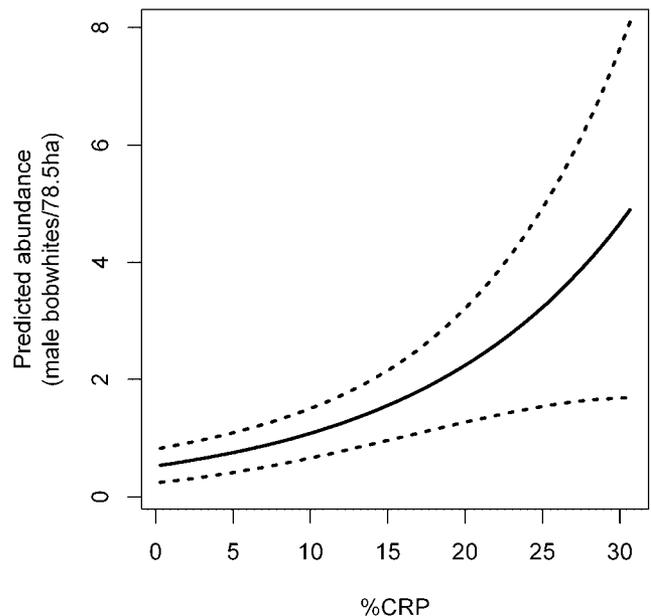


Figure 2. Predicted male bobwhite abundance as a function of the percent cover of CRP land in the landscape (%CRP). The predictions were derived from model-averaging bobwhite abundance estimates from 16 candidate models. The data for the models were from point transects conducted in 113,500-m radius landscapes in Maryland and Delaware, USA, from 2006–2007. The solid line indicates predicted abundance; dotted lines indicate 95% confidence intervals.

Table 1. Top models of bobwhite abundance on Maryland's Eastern Shore and Delaware, USA, from 2006–2007. Only models considered to have some support are shown.

Variables in model ^a	K ^b	AIC _c ^c	ΔAIC _c ^d	w _i ^e
%CRP, %Forest	5	378.52	0.00	0.23
%CRP, %Ag	5	378.79	0.27	0.20
%CRP	4	379.03	0.51	0.18
%CRP, %Forest, %Ag	6	380.26	1.74	0.10
%CRP, %Forest, PD	6	380.30	1.78	0.10
%CRP, %Ag, PD	6	380.63	2.11	0.08
%CRP, PD	5	381.22	2.70	0.06
%CRP, %Forest, %Ag, PD	7	381.81	3.29	0.05

^a Variable definitions: percent cover of agriculture (%Ag), CRP land (%CRP), and forest (%Forest), and patch density (PD).

^b K = the number of estimated parameters in the model.

^c AIC_c = Akaike's Information Criterion adjusted for small sample sizes.

^d ΔAIC_c = difference in AIC_c relative to the top model.

^e w_i = Akaike weight.

(51.1%). Other herbaceous CRP practices included wetland restoration (CP23; 8.7%), CP2 native grasses (8.7%), CP10 existing grasses (5.0%), and CP1 introduced grasses (4.7%). At least 81% of all CRP land in the study landscapes was planted to herbaceous practices.

We detected male bobwhites in 50 of the 113 study landscapes and detected 143 male bobwhites during all 226 surveys. Estimated abundance across all landscapes was 207 male bobwhites (CI = 121–289 bobwhites), or 0.023 male bobwhites/ha (CI = 0.014–0.033 bobwhites/ha).

The global model of bobwhite abundance adequately fit the data ($P = 0.40$). Forest cover was not a significant detection covariate in the global model ($Z = 1.0$, $P = 0.32$) and did not improve the AIC_c; therefore, I did not include it as a detection covariate in the suite of candidate models. Eight candidate models of bobwhite abundance had some support (Table 1). The remaining 8 candidate models had essentially no support ($18 < \Delta AIC_c < 33$ for each model). I found strong support that bobwhite abundance was positively related to CRP cover; it was included in all 8 of the top models (Table 2), the parameter estimates for CRP cover were positive in all of the top models and the confidence intervals of the estimates did not include 0.0, and the relative importance of CRP cover was 1.0. The model-averaged parameter estimate for CRP cover was positive (estimate = 0.84, CI = 0.49–1.19) and bobwhite abundance was predicted

to increase as CRP cover increased (Fig. 2). I found little support that agriculture cover, forest cover, and patch density influenced bobwhite abundance; the confidence intervals of their parameter estimates in each of the top models overlapped 0.0 and their relative importance was low (agriculture cover = 0.41, forest cover = 0.44, patch density = 0.28). The confidence intervals of the model-averaged parameter estimates for agriculture cover, forest cover, and patch density also overlapped 0.0 (agriculture cover: estimate = 0.10, CI = -0.20 to 0.39; forest cover: estimate = -0.13, CI = -0.48 to 0.23; patch density: estimate = 0.02, CI = -0.11 to 0.16).

Discussion

I found a strong positive association between CRP cover and bobwhite abundance, suggesting a significant population-level response of bobwhites to the CRP in Maryland and Delaware. My results also suggest that landscapes with greater proportions of CRP practices support more bobwhites. Based on model-averaged predictions of bobwhite abundance, an increase from 0% to 30% of CRP land in a 500-m radius landscape could produce approximately 5 additional male bobwhites (i.e., an increase of 0.06 male bobwhite/ha).

Because most of the CRP land in the study landscapes was planted to herbaceous vegetation, I infer that herbaceous CRP land has provided additional habitat for bobwhites. Herbaceous CRP plantings can provide roosting, brood-rearing, and nesting habitat for bobwhites (Burger et al. 1990, Puckett et al. 2000), and can provide habitat for many grassland and scrub-shrub bird species (e.g., Best et al. 1997, Gill et al. 2006, Veech 2006a, Riffell et al. 2008, Blank et al. 2011). Greater bobwhite abundance in CRP habitats could be due to relatively high food availability (e.g., greater invertebrate densities) and therefore higher quality brood cover (Burger et al. 1990).

This study is one of the few landscape analyses to document a bobwhite population-level response to the CRP, or to detect such a response at a relatively small landscape scale (500-m radius). Riffell et al. (2008) reported that bobwhite abundance in 25-km radius landscapes was positively related to grass-based CRP practices in the southwest part of their range, and positively related to total CRP in the central hardwoods and piedmont ecological regions. Evans et al.

Table 2. Parameter estimates with 95% confidence intervals for the top models of bobwhite abundance on Maryland's Eastern Shore and Delaware, USA, from 2006–2007.

Variables in model ^a	%Ag		%CRP		%Forest		PD	
	Estimate	CI	Estimate	CI	Estimate	CI	Estimate	CI
%CRP, %Forest			0.77	0.49–1.05	-0.28	-0.61 to 0.06		
%CRP, %Ag	0.24	-0.06 to 0.55	0.95	0.61–1.28				
%CRP			0.82	0.53–1.10				
%CRP, %Forest, %Ag	0.14	-0.25 to 0.53	0.86	0.48–1.24	-0.19	-0.61 to 0.23		
%CRP, %Forest, PD			0.73	0.44–1.03	-0.33	-0.71 to 0.04	0.11	-0.21 to 0.42
%CRP, %Ag, PD	0.29	-0.05 to 0.62	0.95	0.61–1.29			0.10	-0.21 to 0.41
%CRP, PD			0.82	0.53–1.11			-0.01	-0.29 to 0.28
%CRP, %Forest, %Ag, PD	0.18	-0.22 to 0.46	0.84	0.45–1.23	-0.23	-0.67 to 0.20	0.14	-0.18 to 0.46

^a Variable definitions: percent cover of agriculture (%Ag), CRP land (%CRP), and forest (%Forest), and patch density (PD).

(2009) found substantially greater breeding season bobwhite densities on fields with upland bird habitat buffers (CP33) than on control fields without buffers in 500-m radius landscapes in the mid-west and the southern United States. My results suggest that herbaceous CRP practices in the Mid-Atlantic region can provide suitable bobwhite habitat, and that the proportion of herbaceous CRP in relatively small landscapes can increase the amount of available habitat for bobwhites.

The vegetation planted and maintained in CRP plantings will affect their usefulness for bobwhites. Warm-season grasses are known to provide nesting, foraging, and brood-rearing habitat for bobwhites (Burger et al. 1990, Guthery 2000) and other ground-nesting birds (e.g., Whitmore 1981, Harper et al. 2007), whereas cool-season grass plantings may not provide proper vegetation structure and composition necessary for bobwhites (Guthery 2000). For example, tall fescue (*Festuca arundinacea*) is a common cool-season grass planted in CRP fields but provides inferior cover for bobwhites because it grows too dense and lacks sufficient food quality (Barnes et al. 1995). Collins et al. (2009) found that bobwhite broods in southern New Jersey tended to avoid sites with cool season grasses and select sites with greater forb cover. Including perennial forbs in planting mixtures can provide seeds for bobwhites and may increase the abundance of insects available for bobwhite chicks (Guthery 2000).

Occasional disturbance of CRP habitat is required to reduce litter and vegetation density and to maintain areas of annual weeds and bare ground that are essential for bobwhites (Burger et al. 1990, Brennan 1991, Greenfield et al. 2003). Controlled burning maintains more open habitat and often stimulates the growth of bobwhite food plants (Brennan 1991). Light disking can improve habitat for bobwhites by encouraging more bare ground and forbs and decreasing litter and grass cover (Greenfield et al. 2002). However, opening vegetation on CRP land must be balanced with the CRP goals of improving water quality and reducing soil erosion.

This study did not address the response of bobwhites to the spatial distribution or shape of CRP habitat, or to specific CRP practices. Bobwhites may respond differently to CRP habitat depending on whether it is more or less aggregated or if it is planted in certain shapes (Riddle et al. 2008, Riffell et al. 2010). Bobwhites could have difficulty colonizing suitable habitat patches if the distance between patches exceeds normal bobwhite dispersal distances (Fies et al. 2002, Duren et al. 2011). Therefore, increasing cohesion of bobwhite breeding habitat could increase occupancy of habitat patches (Duren et al. 2011). Treating all CRP land as a single habitat type may obscure the influence of specific CRP practices (Riffell et al. 2010). Because the specific planting mixture of each CRP field in my study landscapes was not indicated in the land cover file I obtained from the NRCS and could not be determined remotely, I was unable to determine if some practices were actually different in the field. For example, both CP1 introduced grasses and CP2 native grasses were in the study landscapes, but I could not

differentiate the vegetation in these plantings from the CP21 filter strips that could have been either introduced or native grasses. Because a bobwhite response to specific CRP practices may not have been biologically meaningful, I chose to combine CRP practices into a single habitat type.

I found that the proportion of agriculture and forest in the landscape, and landscape patch density, were not strongly related to bobwhite abundance in local landscapes in Maryland and Delaware. This contrasts with several studies that have found relationships between these variables and bobwhite abundance. For example, Riddle et al. (2008) found that summer bobwhite abundance was greater in agriculture-dominated landscapes compared to forest-dominated landscapes in North Carolina. Lohr et al. (2011) found that bobwhites used forest habitats less than in proportion to their availability in southern New Jersey. White et al. (2005) found that patch density was positively related to the occurrence of bobwhite nests at several spatial scales in Georgia and recommended that patch density be increased by interspersing agricultural areas with fallow areas. Differences between my results and other studies may be due to differences in land cover types between study areas, size of the study landscapes, or different responses of bobwhites to land cover patterns across their range (Whittingham et al. 2007).

MANAGEMENT IMPLICATIONS

The CRP offers many environmental benefits, such as reduced erosion, increased wildlife habitat, and improved water quality (USDA 2011b). However, CRP acreage has declined nationally over the last few years, in part because of reductions in the maximum allowable acreage in the program (USDA 2010). In Maryland and Delaware, CRP acreage decreased more than 3,000 ha from 2007 to 2012 (USDA 2012). The results of this study suggest that increasing the acreage of CRP land in Maryland and Delaware would create additional habitat for bobwhites and that landscapes with greater proportions of CRP practices support more bobwhites. If bobwhite conservation is a priority, conservation agencies should continue to encourage land owners to enroll land in the CRP, particularly in herbaceous practices.

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