Herbicide and Prescribed Fire as Habitat Management Tools for Northern Bobwhite in Conservation Reserve Program Fields

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Abstract: Kentucky-31 tall fescue *(Festuca arundicacea)* was a common planting established on Conservation Reserve Program (CRP) fields throughout the southeastern United States during the late 1980s and 1990s. Fescue-dominated grassland communities on CRP fields offer poor quality nesting, brood-rearing, and foraging habitat for northern bobwhite *(Colinus virginianus)* because of dense vegetation, high litter cover, low bare ground, and low plant diversity. Herbicide applications have been shown to reduce fescue and release early successional plant communities, and therefore may enhance bobwhite habitat quality. However, the relative efficacy of herbicide used in conjunction with fire has not been investigated. We tested singular and joint effects of herbicide (glyphosate) application and burning on vegetation in fescue CRP fields in east Mississippi. We tested the following 4 treatments: spring glyphosate application, spring burn, spring burn and glyphosate application, and control. All manipulations modified plant communities and enhanced bobwhite brood-rearing habitat to varying degrees. Spring burn increased bare ground and decreased litter cover ($P \leq 0.05$). Spring herbicide application increased forbs, legumes, and annual weeds, but decreased grass and fescue canopy ($P \leq 0.05$). Spring burn/herbicide application increased forbs, legumes, annual weeds, and bare ground but decreased grass canopy, fescue canopy, and litter cover ($P \leq 0.05$). Canopy coverage of bobwhite food plants was greatest in spring burn/herbicide ($P \leq 0.05$). Herbicide applied alone and in conjunction with burning enhanced bobwhite brood-rearing habitat in fescue CRP fields in east Mississippi by promoting early successional plant communities. This information has implications for implementation of wildlife management in federal agricultural multiple-year land retirement programs and other cool season grasslands not enrolled in federal programs.

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The Conservation Reserve Program (CRP) provision of the 1985 Food Security Act was designed to remove highly erodible cropland (HEL) from production. Wildlife habitat enhancement has been promoted as a secondary benefit of CRP. Under CRP, landowners receive an annual payment to remove HEL from production for 10 years and plant a permanent cover crop (i.e., grasses, legumes, and/or trees) (Berner 1998 and ref. therein). Nationally, as of August 1999, approximately 12.1 million hectares were enrolled in CRP (U.S. Dep. Agric. 1999).

Northern bobwhite *(Colinus virginianus)* could benefit from CRP (Burger et al. 1990, 1993; Best et al. 1997; Ryan et al. 1998). Both Ryan et al. (1998) and Best et al. (1997) concluded that overall benefits of CRP were positive for grassland bird species, but Roseberry and David (1994) reported no consistent relationships among amounts of CRP land and northern bobwhite population indices in Illinois. However, in Missouri, bobwhite frequently used CRP fields for nesting, brood rearing, and roosting, and nest success and survival of bobwhite did not differ between 2 landscapes with and without CRP (Burger et al. 1995).

The value of CRP fields for northern bobwhite varies in relation to planted cover and time since last habitat manipulation (Burger et al. 1990). Roseberry and Klimstra (1984) suggested that establishment of coarse-stemmed, sod-forming grasses like fescue on cropland diversion program lands would produce low-quality habitat for bobwhite. Barnes et al. (1995) reported that fescue fields in Kentucky, characterized by dense vegetation, little bare ground, and low plant species diversity, lacked the proper vegetation structure, floristic compositions and food quality to provide bobwhite habitat. Vegetarian structure and composition in CRP fields are not static over the life of the contract, but vary in relation to time since establishment (Ryan et al. 1995). As plantings age, vegetation composition changes from a diverse annual community with an abundance of bare ground to a perennial grass and forb community with dense litter accumulation and little bare ground (Ryan et al. 1995). Some type of disturbance (e.g., fire, mechanical, herbicide,) is required to maintain CRP fields in early succession plant communities that meet roosting, foraging, and brood-rearing needs of bobwhite (Burger et al. 1995, Barnes et al. 1995, Ryan et al. 1998). Madison et al. (1995) reported that prescribed fire alone did not substantially enhance bobwhite brood habitat in fescue fields, and benefits derived from fall disking were short-lived. Herbicidal conversion of fescue-dominated CRP fields might improve bobwhite habitat quality by promoting more desirable native early successional plants (Madison et al. 1995, Ryan et al. 1995). However, no study has investigated synergistic effects of both fire and herbicide on bobwhite brood habitat of fescue-dominated CRP fields. Therefore, in 1996, we evaluated effects of herbicide and prescribed fire, both singly and in conjunction, on vegetation structure, floristics, and invertebrates in CRP fields dominated by tall fescue *(Festuca arunicacea)* in Mississippi. We used vegetation structure and floristics as indices of bobwhite brood-rearing habitat quality. Our objectives were to quantify short-term effects of prescribed fire and herbicide application on indices of bobwhite habitat quality in fescue-dominated CRP fields in Mississippi.

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Methods

Study Areas

Our study was conducted in 1996 on 3 privately owned CRP fields in Lowndes County of east-central Mississippi (centered at 332030N, 883330W. The sites were selected based on landowner interest and cooperation, CRP contract expiration date, cover crop type and quality, site size, and uniformity of slope. The sites had been enrolled in the CRP program in 1987 with contracts expiring in 1997 and were within 800 m of each other. They were enrolled under Conservation Practice-1 (CP-1) and had been planted to tall fescue in 1987. Other dominant vegetation in 1996 included broomsedge *(Andropogon virginicus)* and goldenrod (*Solidago* spp.; Greenfield 1997).

Sites were located within the Blackland Prairie physiographic region of Mississippi (Pettry 1977). Elevation in this area ranged from 62–92 m with nearly level to strongly sloping, rolling hills. Soils were chalks, calcareous clays, and acid clays with sediments overlying calcareous materials. Soils were alkaline with low magnesium levels (Pettry 1977). Although these soils have high water holding capacities, they require special management, being unusually expansive and sticky when moist (Pettry 1977). The Blackland Prairie region had 200–230 frost-free days and an annual precipitation of 127–140 cm (Pettry 1977). Mean winter and summer temperatures in Lowndes County were 27 and 8 C, respectively (U.S. Dep. Agric. 1979).

Soil tests indicated an average pH of 7.26 across sites. Average organic matter was 2.12%, and average levels of phosphorus and potassium (kg of extractable nutrient per ha) across sites were 10 and 219, respectively (Greenfield 1997). Prior to enrollment in the CRP in 1987, the sites had been row cropped with soybeans, corn, cotton, or forage or used for livestock production for a minimum of 60–70 years.

Study Site Establishment

We designed an experiment to evaluate effects of 4 treatments (i.e., spring burn, spring herbicide application, spring burn followed by herbicide application, and control) on vegetation structure and floristics in the 3 fescue CRP sites. Study sites were established in a split-plot arrangement of treatments in a randomized complete block design. Each study site (blocking factor) contained 5 hillslope positions (whole plot effect) with 4 10×20 m split-plots/position. We randomly assigned treatments to split-plots within each hillslope position. Each treatment was replicated in 5 split-plots (1 in each whole-plot) in each of 3 study sites for a total of 15 split-plots/treatment. Whole plots (hillslope position) and split plots (treatment plots) were separated by a 5-m mowed strip. We included site as a blocking factor to control for anticipated variation among the sites.

Treatment of Application

Study sites were mowed prior to burning. Spring burn treatments were applied during March 1996. Burning conditions followed Mississippi Forestry Commission recommendations (U.S. Dep. Agric.). All burns were conducted on the same day under consistent fire weather conditions. Plots were burned with a backing fire until an approximate 1-m backline was created along the downwind side, then finished with a head fire. For maximum herbicide efficacy on burn-herbicide treatments, fescue was allowed to recover following the burn to a height of 15–20 cm, at which stage an inflorescence bearing stem emerges. Fescue met these guidelines 3 weeks following spring burns. In April 1996, we applied herbicide treatments to those plots assigned a burn/herbicide or herbicide only treatment. Both herbicide treatments consisted of an application of glyphosate at a rate of 4.7 liters/ha with a flow volume of 45.4 liters/ha. Spraying was conducted with a boom sprayer (i.e., 2.6 m boom width) mounted on an all-terrain vehicle. Effects of herbicide application (i.e., dead fescue plants) were apparent within 7 days of herbicide application.

Evaluation of Vegetation Structure

Vegetation sampling coincided with the bobwhite brood-rearing season. Vegetation structure was evaluated using 2 techniques. We used a 0.1-m^2 Daubenmire frame to ocularly estimate vegetation structural characteristics (Daubenmire 1959). Canopy cover of various plant life forms was estimated in 5.0% cover classes within the frame. Characteristics measured included total canopy, perennial grass canopy, fescue grass canopy, forb canopy, legume canopy, annual weed canopy, woody canopy, bare ground, litter cover, and litter depth. We also used a Robel pole to obtain visual obstruction readings (VOR), thereby indexing vegetation height and density (Robel et al. 1970). We measured maximum and average canopy height at each Robel pole location.

We conducted vegetation sampling systematically and divided each split-plot into 4 quadrants. A vegetation sampling point was established at the midpoint of each quadrant (5.6 m from each corner along the plot diagonal). We used the established pint to place 4 0.1-m^2 Daubenmire frames within each split-plot quadrant. Each frame was oriented relative to hill slope position. The first frame was placed directly up slope from the point, the second across the slope directly to the left of the point, the third directly down slope from the point, and the fourth across the slope directly to the right of the point. Four VOR were taken in the same directions at each quadrant midpoint 4 m from the point at a height of 1 m. Sixteen Daubenmire frames and VOR readings were taken within each split-plot. We measured vegetation in the first growing season post-treatment during June 1996.

Evaluation of Floristics

We used a 10-m line intercept to estimate canopy cover of plant species (Canfield 1941). The line intercept was established along the plot diagonal (from up slope left corner to down slope right corner) with the 5-m point of the line centered at the midpoint of the plot. We identified plants that intercepted ≥1 cm of the line to genus and species, when possible. However, stage of plant growth hindered the ability to identify plants to species in some instances. Plant identification and taxonomy followed Radford et al. (1968).

We used 3 methods to analyze floristic data. First, cover of each species was reported and treatment effects evaluated. Secondly, we evaluated cover of bobwhite food plants. Bobwhite foodplants were defined as plants producing seed that were reported by Brazil (1993) to comprise on average ≥1 cm of the line to genus and species, when possible. However, stage of plant growth hindered the ability to identify plants to species in some instances. Plant identification and taxonomy followed Radford et al. (1968)

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Statistical Analysis

We used analysis of variance (ANOVA) in a split-plot, randomized complete block design to evaluate vegetation and floristic response to treatments. We used a split-plot design with hillslope position as a whole plot effect because we apriori anticipated variation in vegetation response along the hydrological gradient associated with hillslope position. We controlled for variation among fields by blocking on site. For each vegetation structural characteristic and plant taxonomic grouping, we tested the null hypothesis of no difference among treatments. We blocked on study site, treated hillslope position as whole-plot effects, and treatments as split-plot effects (Milliken and Johnson 1992). When no interactions were observed between hillslope position and treatment effects, treatment main effects were discussed. Following a significant F-test ($P \leq 0.05$) for treatment main effects, we used Tukey's Multiple Comparison (HSD) to compare among treatments (Milliken and Johnson 1992).

Results

Vegetation Structure

We observed a hillslope position by treatment interaction ($P \leq 0.05$) in litter depth ($F_{12,8}=4.06$, $P=0.0009$); therefore, this variable was discarded. Hillslope position by treatment interactions were not detected in any of the 12 remaining vegetation variables ($P>0.05$). Therefore, we investigated treatment main effects for each of the remaining 12 vegetation structural characteristics. We detected treatment effects ($P<0.003$) for VOR, maximum vegetation height, average canopy height, percentage total canopy, percentage grass canopy, percentage planted grass canopy, percentage forb canopy, percentage legume canopy, percentage annual weed canopy, percentage bare ground, and percentage litter cover (Table 1).

VOR was greatest in spring burn/herbicide treatments ($P\leq0.05$) and spring burn/herbicide had the greatest maximum vegetation and average canopy height ($P\leq0.05$). Relative to control plots, herbicide and burn/herbicide treatments reduced percentage grass and planted grass canopy the most of the 4 treatments ($P\leq0.05$). Percentage forb, legume, and annual weed canopy were greatest in burn/herbicide ($P\leq0.05$). Spring burn and burn/herbicide increased bare ground the most ($P\leq0.05$), whereas litter cover was the least in spring burn ($P\leq0.05$; Table 1.).

Floristics

We detected no hillslope position by treatment interactions in canopy cover of the 39 plant taxa observed ($P\leq0.05$). Therefore, only treatment main effects on each variable were addressed. We observed treatment effects in canopy cover of Illinois bundleflower (*Desmanthus illionensis;* $F_{3,30}$=9.97, $P<0.001$), tall fescue ($F_{3,30}$= 59.29, $P<0.001$), goldenrod (*Solidago* spp.; $F_{3,30}$=6.62, P=0.001), and Johnsongrass (*Sorghum halepense;* $F_{3,30}$=28.44, $P\leq0.001$).The ANOVA indicated treatment differences in canopy cover of *Croton* spp. And *Euphorbia* spp.; however, Tukey's multiple comparisons procedure did not indicate treatment differences ($P>0.05$). Spring burn/herbicide produced greatest canopy cover of Illinois bundleflower and Johnsongrass and least canopy cover of tall fescue and goldenrod ($P\leq0.05$). Spring herbicide did not differ from spring burn/herbicide in canopy cover of Illinois bundleflower and tall fescue ($P>0.05$). Plant species richness differed among treatments ($F_{3,30}$=3.73, P=0.022; Table 1).

Treatments differed in canopy cover of bobwhite food plants ($F_{3,30}$=30.99, $P<0.001$; Table 1) with greatest canopy cover of bobwhite food plants in spring burn/herbicide ($P\leq0.05$). Bobwhite food plants observed during the first growing season post-treatment included *Panicum* spp., *Setaria* spp. and Johnsongrass, and *Vicia* spp.

Discussion

On the fescue-dominated CRP sites in this study, the spring burn reduced litter accumulation, increased bare ground, and enhanced plant species richness, but did not affect fescue, legume, or quail food plant canopy cover. The spring herbicide a burn/herbicide effectively eliminated 90% and 95% of the fescue cover, respectively. Herbicide and burn/herbicide reduced perennial grass cover, and increased forb cover, legume cover and bobwhite food plant cover. The burn/herbicide combination

Table 1. Mean vegetation structural characteristics, plant species richness, and mean percentage of bobwhite food plants during the first growing season post treatment in tall fescue *(Festuca arundinacea)* Conservation Reserve Program (CRP) fields managed for northern bobwhite *(Colinus virginianus)* in Lowndes County, Mississippi. Spring burns and herbicide applications (i.e., herbicide alone and burn/herbicide) conducted in March and April 1996, respectively. Vegetation structure was measured in June 1996.

	Treatments								
	Control		Spring burn		Spring herbicide		Spring burn/herbicide		
Variable	*x*	SE	*x*	SE	*x*	SE	*x*	SE	Pr >*F*
VOR (cm)	27.33BC[2]	1.41	21.81C	2.18	38.83AB	4.99	46.31A	5.05	0.0002
Maximum vegetation									
Height (cm)	91.10B	1.84	88.79B	2.89	83.25B	6.89	113.65A	9.55	0.0006
Average canopy height	31.32BC	0.91	28.80C	1.55	37.50AB	2.51	41.81A	3.05	0.0004
Total canopy (%)	57.17AB	1.95	59.67AB	2.25	50.98B	4.48	66.24A	3.38	0.0027
Grass canopy(%)	45.13A	2.53	43.42A	2.79	20.60B	3.42	27.16B	3.40	0.0001
Fescue canopy (%)	43.57A	2.57	40.27A	2.86	4.53B	2.69	2.76B	1.35	0.0001
Forb canopy (%)	21.73C	2.81	27.92BC	4.27	37.28B	6.26	53.80A	4.43	0.0001
Legume canopy (%)	15.43C	2.70	21.19BC	3.76	30.65B	5.75	47.45A	4.86	0.0001
Annual weed canopy (%)	0.46B	0.21	0.57B	0.28	0.84B	0.30	2.56A	0.85	0.0029
Woody canopy (%)	0.43A	0.30	0.32A	0.30	0.31A	0.15	0.00A	0.00	0.5931
Bare ground(%)	2.28B	0.65	33.16A	4.19	1.59B	0.63	37.17A	5.27	0.0001
Litter cover (%)	37.67B	1.53	15.16D	2.11	67.96A	2.64	26.15C	3.09	0.0001
Litter depth (%)[b]	1.51	0.04	0.93	0.05	1.68	0.09	0.94	0.04	interaction
Plant species richness	4.53B	0.38	6.73A	0.45	5.07B	0.37	61.3B	0.74	0.0217
Canopy cover of bobwhite —food plants	2.31C	0.72	5.37C	1.80	28.83B	6.50	54.95	7.28	0.0001

a. Numbers within rows followed by identical letters are not different, Tukey's HSD ($P>0.05$).

b. An interaction ($P<0.05$) occurred between hillslope position and treatment; therefore, disregard results.

was more efficacious than herbicide alone insofar as forb, legume, annual weed, and bare ground cover were greater and litter cover less than the herbicide alone.

Burger et al. (1994) described structural characteristics of plant communities used by radio-marked northern bobwhites to meet seasonal habitat requirements in northern Missouri. They reported that plant communities used for brood-rearing were characterized by 51% grass canopy cover, 47% forb canopy cover, 25% bare ground, and 63% litter cover. They contrasted these values to 74% grass canopy cover, 26% forb canopy cover, 6% bare ground, and 71% litter cover in plant communities used by bobwhites for nesting. Similarly, Taylor and Burger (2000) reported 33% grass canopy cover 40% forb canopy cover, 19% bare ground, and 67% litter cover at brood sties and 36% grass canopy cover, 33% forb canopy cover, 25% bare ground, and 61% litter cover at bobwhite nest sites in Mississippi. During 1997–2001, Smith (2001) and Szukatis (2001) characterized vegetation structure at brood foraging locations during normal rainfall years of 1997 and 1998 and reported that broods used locations with a mean 40.9% (SE=3.21) grass canopy, 40.1% (SE=2.78) forb canopy, 36.6% (SE=3.47) bare ground, 63.4% (SE=3.46) litter cover, and 41.7 cm (SE=2.73) VOR. Szukatis (2001) described vegetation at brood sites during the drought of 1999–2000 and reported mean vegetation of 22.4% (SE=2.21) grass canopy, 48.5% (SE=2.3) forb canopy, 58.8% (SE=2.77) bare ground, 26.6% (SE=2.65) litter cover, and 70.8 cm (SE=3.72) VOR. These studies collectively characterize brood habitat as 20%–50% bare ground, 25%–65% litter cover, 22%–50% grass canopy, and 36%–50% forb canopy. Only the burn and the burn/herbicide treatment of our study achieved levels of bare ground similar to that reported by these authors. All of our treatments exhibited grass canopy within the range reported by these authors, but in control and burn treatments most of the grass canopy was fescue. Barnes et al. (1995) characterized fescue stands as providing low quality habitat for bobwhite broods. Canopy coverage of broad-leaved forbs is a consistent and important characteristic of brood habitat (Taylor and Burger 2000). Only the herbicide and burn/herbicide treatments in our study produced forb canopies within the range of those reported to be used by bobwhite broods.

Abundant and accessible arthropod food resources are a critical component of brood-rearing habitat and may limit bobwhite populations in agricultural ecosystems (Burger et al. 1990, 1993). If managed properly, plant communities that meet brood-rearing needs of bobwhite can be encouraged on CRP lands (Burger et al. 1990, 1995). Management practices that promote early succession plant communities (i.e., burning and strip disking) have been shown to increase invertebrate abundance, diversity, and biomass (Hurst 1970, 1972; Manley et al. 1994; Madison et al. 1995). Burger et al. (1993) reported that CRP fields with a substantial legume component supported greater arthropod populations than those planted to a grass monoculture. During our study, herbicide and especially burn/herbicide treatments substantially enhanced legume canopy cover in fescue dominated fields. Plant community composition has been shown to influence invertebrate abundance; however, vegetation structure likely influences availability of invertebrates to foraging chicks. Burning modified the structure of plant communities by decreasing litter cover and increasing bare ground. These changes in structural characteristics may have enhanced brood-rearing habitat by improving accessibility of existing invertebrates (Madison et al. 1995, Barnes et al. 1995).

On Black Prairie sites, the plant community released by herbicidal control of the fescue was dominated by Illinois Bundleflower and Johnsongrass. This plant community provides better brood-rearing habitat than a fescue dominated community because of abundant bare ground, decreased litter cover, a higher availability of seed resources, and potentially higher invertebrate resources. The structural characteristics (i.e., abundant bare ground and reduced litter component) allow chicks and adult bobwhites to access available food resources more easily than in a fescue-dominated community. However, Illinois bundle flower and Johnsongrass are not the most desirable plants from a bobwhite management perspective. Johnsongrass meets the previously mentioned criteria for a bobwhite food plant (Brazil 1993), but is an aggressive exotic that can easily dominate plant communities and severely limit native plant diversity. Additionally, because Johnsongrass is an agronomic weed it would be considered undesirable by many landowners. Glyphosate is a foliar active herbicide, thus it only controls individual plants that receive foliar contact. Therefore, our spring (April) herbicide application had no efficacy in suppressing the later emerging warm-season Johnsongrass. In fact, control of fescue likely released Johnsongrass. On sites where Johnsongrass is present in the seedbank, an alternative herbicide such as imazapyr with some soil residual action might be more effective in controlling emergence of Johnsongrass, thereby releasing more desirable species. Although Illinois (bundleflower is a legume and prolific seed producer, it is infrequently consumed by bobwhite (Brazil 1993). However, it is a native legume and may offer benefits to other wildlife species (Radford et al. 1968).

One goal of this study was to evaluate plant response in the absence of fescue competition. We effectively eliminated fescue competition, but observed only a limited plant response. One plausible explanation may stem from an impoverished seed bank, attributable to the area's cropping history followed by the establishment of a fescue community. On lands where a depleted seed bank may limit plant response, seeding of desirable forbs (i.e., partridge pea *[Cassia fasciculate],* kobe lespedeza *[Lespedeza striata],* Korean lespedeza *[L. stipulacea],* beggar-ticks [*Desmodium* spp.]) and native prairie grasses in conjunction with these treatments may produce more desirable results.

Although duration of this study precludes any certain knowledge of plant responses 2–3 growing seasons post-treatment, maintenance of early successional communities on CRP fields will require some regular disturbance over the life of the contract in order to improve bobwhite habitat. In fescue-dominated fields, initial herbicidal control of fescue will be required, after which prescribed fire or disking may be sufficient to maintain desired communities (Manley et al. 1994, Madison et al. 1995). Because of the erosion controlling objectives of the CRP, state and county Farm Services Agency (FSA) and Natural Resources Conservation Service (NRCS) personnel are often hesitant to permit disturbance on CRP fields. However, during our study all treatments exhibited 20%–45% perennial grass cover and 50%–60%

total canopy cover by the middle of the growing season, thus erosion should be minimal.

Habitat enhancement of fescue-dominated fields is difficult and, as can be observed from this study, even extreme measures do not always produce the most desirable results. This emphasizes the importance of initial cover crop selection on CRP land. Cover crop selection is critical to the long-term habitat potential of CRP fields and will influence cost of renovation or management later in the contract life. Acceptance of CRP contracts during enrollment 1–9 were based primarily on erodibility and rental rate. Since signup 10, an environmental benefit index (EBI) has been used to prioritize and rank CRP offerings. The current (signup 20) national EBI includes 6 environmental ranking factors (wildlife habitat cover benefits, water quality benefits, on-farm benefits of reduced erosion, enduring benefits, air quality benefits, and benefits of enrollment in conservation priority areas [CPA]) and 1 cost factor. The wildlife habitat cover benefit factor is a function of the specific cover crop planted and additional subfactors that relate to endangered species benefits, proximity to permanent water, adjacency to protected areas, other wildlife enhancements, and wetland restoration. In general, native grasses and forbs receive higher scoring on the wildlife habitat cover benefits factor than exotics, and mixtures score higher than monocultures.

Literature Cited

Barnes, T. G., L. A. Madison, J. D. Sole, and M. J. Lacki. 1995. An assessment of habitat quality for northern bobwhite in tall fescue-dominated fields. Wildl. Soc. Bull. 23:231–237.

Berner, A. H. 1988. The 1985 farm act and its implication for wildlife. Pages 437–466 *in* W. J. Chandler, ed. Audubon Wildl. Rep., 1988/1989. Natl. Audubon Soc. and Acad. Press, San Diego, Calif.

Best, L. B., H, Campa, K. E. Kemp, R. J Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, Jr., and S. R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the Midwest: a regional approach. Wildl. Soc. Bull. 25:864–877.

Brazil, D. C. 1993. Winter diet of hunter harvested northern bobwhites in Mississippi. M. S. Thesis, Miss. State Univ., Mississippi State. 153 pp.

Burger, L. W., Jr., E. W. Kurzejeski, T. V. Dailey, and M. R. Ryan. 1990. Structural characteristics of vegetation in CRP fields in northern Missouri and their suitability as bobwhite habitat. Trans. North Am. Wildl. Nat. Resour. Conf. 55:72–83.

———, ———, ———, and ———. 1993. Relative inverebrate abundance and biomass in conservation reserve program plantings in northern Missouri. Quail III: 102–108.

———, M. R. Ryan, E. W. Kurzejeski, and T. V. Dailey. 1994. Factors affecting the habitat value of conservation reserve program lands for northern bobwhite in northern Missouri. Pages 142–156 *in* M. Dicks and M. Monsoon, eds. Proceedings NC-163 post CRP land use conference. U.S. Dep. Agric., CSRS. Proj. 92110381.

———, ———,———, and R. E. Musnson. 1995. Evaluation of wildlife habitat quality on CRP lands following management practices designed to imporove forage quality. Final Rep. Mo. Dep. Conserv., Agric. Res. Prog., Columbia, Mo. 11pp.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. For. 39:388–394.

Daubenmire, R. K. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 43:43–64.

Greenfield, K. C. 1997. Effects of disking, burning, and herbicide application on vegetation, invertebrates, and soil erosion in Conservation Reserve Program fields managed for northern bobwhite. M. S. Thesis, Miss. State Univ., Mississippi State. 223pp.

Hurst, G. A. 1970. The effects of controlled burning on arthropod density and biomass in relation to bobwhite quail brood habitat on a right-of-way. Pages 173–183 *in* Proceedings of the Tall Timbers Conference on the Ecology of Animal Control by Habitat and Man. Tallahassee, Fla.

———. 1972. Insects and bobwhite quail brood habitat management. Quail I:65–82.

Madison, L. A., T. G. Barnes, and J. D. Sole. 1995. Improving northern bobwhite brood rearing habitat in tall fescue dominated fields. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 49:525–536.

Manley, S. W., R. S. Fuller, J. M. Lee, and L. A. Brennan. 1994. Arthropod response to strip disking in old fields managed for northern bobwhite. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:227–235.

Milliken, G. A. and D. E. Johnson. 1992. Analysis of messy data. Chapman and Hall, N. Y. 473 pp.

Pettry, D. E. 1977. Soil resource areas of Mississippi. Information sheet 1278. Miss. Agric. For. Exp. Stat., Miss. State Univ., Mississippi State. 4pp.

Radford, A.E., H.E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. N. C. Press, Chapel Hill, N. C. 1183pp.

Robel, R. J., J. N. Briggs, A. D. Dayton, and L.C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23:295–297.

Roseberry, J. L. and L. M. David. 1994. The Conservation Reserve Program and northern bobwhite population trends in Illinois. Trans. Ill. State Acad. Sci. 87:61–70.

——— and W. D. Klimstra. 1984. Population ecology of the bobwhite. Sourhtern Ill. Univ. Press. Carbondale, Ill. 259 pp.

Ryan, M. R., L. W. Burger, Jr., and E. W. Kurzejeski. 1998. The impact of CRP on avian wildlife: a review. J. Prod. Agric. 11:61–66.

———, ———, ———, and T. D. McCoy. 1995. The relationships of forage quality and land capability class with vegetation on CRP lands in northern Missouri. Compl. Rep., Mo. Dep. Nat. Resour., Jefferson City. 46pp.

Smith, M. D. 2001. Northern bobwhite population response to intensive habitat development on a prairie site in Mississippi. M. S. Thesis, Miss. State Univ., Mississippi State. 118pp.

Szukatis, S. Habitat and population ecology of northern bobwhite in northern Mississippi. M. S. Thesis, Miss. State Univ., Mississippi State. 119pp.

Taylor, J. D. and L. W. Burger., Jr. 2000. Habitat use of breeding bobwhite in managed oldfield habitats in Mississippi. Quail IV:7–15.

United States Department of Agriculture (USDA). 1979. Soil resource inventory of Lowndes County, Mississippi. USDA Soil Conserv. Serv., Washington, D.C. 137pp.

———. 1989. A guide for prescribed fire in southern forests. Natl. Wildfire Coordinating Group, U.S. For. Serv., For. Serv. South. Reg. Tech. Publ. R8-TP11, U.S. Govt. Printing, Washington, D.C. 56pp.

———. 1999. News release No. 0391.99. USDA Off. Commun. 4 Oct. 1999. 1pp.