Assessing the Potential Impact of Conservation Reserve Program Lands on Bobwhite Habitat Using Remote Sensing, GIS, and Habitat Modeling

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Abstract
*A classified Landsat 5 Thematic Mapper image of Hamilton County, Illinois was edited to include the actual location of all Conservation Reserve Program (CRP) fields as of 1990. We investigated the spatial relationship of CRP fields to other land-use types using geographic information system (GIS) software. We used computer simulation and habitat modeling to evaluate northern bobwhite (*Colinus virginianus*) habitat quality with and without CRP land. Contribution of CRP fields to habitat quality depended on (1) the amount of CRP land present, (2) its suitability for bobwhite use, (3) the suitability of replaced and remaining cropland for bobwhite use, (4) the juxtaposition of CRP fields with other habitat components, and (5) the composition and quality of existing bobwhite habitat, in particular, the limiting factors.*

Introduction
Over the past three decades, northern bobwhite populations have declined significantly in at least 24 of the 31 states comprising their primary range (Brennan, 1991). Intensified land use, primarily agricultural, is commonly blamed for this trend. In the Midwest, monocultural cropping patterns, removal of brushy fencerows and woody hedgerows to accommodate larger fields, and reduced amounts of grassy/herbaceous vegetation are thought to contribute to the widespread loss and deterioration of habitat for bobwhite and other upland species (Farris and Cole, 1981; Kenney, 1985).

The Conservation Reserve Program (CRP) was a provision of the 1985 Food Securities Act (Farm Bill) that encouraged landowners to retire highly erodible cropland for a minimum of 10 years. Several optional cover types (Conservation Practices or CPs) were available, including various grass/legume mixtures, shrubs, and trees. Positive benefits to wildlife were widely anticipated, especially where nesting and brood rearing cover were generally lacking (Isaacs and Howell, 1988; Schenck and Williamson, 1991). It was recognized, however, that these benefits would depend on characteristics of the CRP vegetation and the spatial relationship of CRP fields with other habitat components (Burger *et al.*, 1990; Langner, 1989; Stauffer *et al.*, 1990).

Our objective was to assess the potential contribution of CRP to bobwhite habitat using computer modeling in combination with knowledge of the actual composition and spatial distribution of land-cover types, including CRP fields. We used remote sensing and ground referencing to classify land cover in Hamilton County, Illinois. Spatial relationships of CRP fields to other habitat components were investigated using geographic information system (GIS) computer software. We employed habitat modeling and simulation to evaluate the potential contribution of CRP to bobwhite habitat under various scenarios relating to the composition and management of CRP and cropfields.

Study Area
Hamilton County occupies 112,700 ha in the southeastern part of Illinois. Topography varies from gently rolling Pennsylvanian-age bedrock formations to large areas of nearly level soils formed from Illinoisan glacial till and lake-bed sediments. Approximately 55 percent of the county is cropland (corn, soybeans, winter wheat), 21 percent is grasslands (pasture, hay, CRP), 19 percent is forested or brushy oldfields, and 5 percent is miscellaneous (water, developed, farmsteads, etc.).

Study Methods
A digitized land-cover image and data file of the study area were created using a combination of field mapping (30 percent of the county), visual interpretation of high altitude color infrared (CIR) photography (4 April 1988; scale 1:21,120), and supervised classification of a Landsat 5 Thematic Mapper (TM) scene (17 June 1989). The following land-use classes were identified at 30- by 30-m (0.09-ha) ground resolution for Hamilton County, Illinois inclusive of a 0.8-km buffer zone: row crops (corn, soybeans, milo), small grains (winter wheat), grasslands (pasture, hay, CRP), deciduous forest, coniferous forest, hedgerow, oldfield, water, developed, barren, and farmstead. All woodlands, oldfields, hedgerows, developed areas, and farmsteads were identified on the CIR aerial photos and manually edited (digitized) into the scene using a modified PC version of Earth Resources Laboratory Applications Software (ELAS) (Graham *et al.*, 1965; Koeln *et*

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TABLE 1. LAND-USE COMPOSITION* IN SECTIONS WITH VARYING AMOUNTS OF CRP LAND, HAMILTON COUNTY, ILLINOIS.

Land-Use Type	CRP Land Per Section (ha)			
	0	1-16	>16	Total
Cropland	77%	59%	57%	64%
Grassland	9%	11%	15%	12%
Woods	10%	15%	21%	16%
Oldfield	1%	5%	3%	3%
Other	3%	9%	4%	5%

*Prior to CRP.

al., 1986). Row crops, small grains, and grasslands were resolved using a combination of unsupervised and supervised classification of the satellite image. Spectral bands 1 to 6 were reduced dimensionally to a single channel digital matrix consisting of 228 spectral classes using principle components and maximum-likelihood classification techniques. Digital spectral classes were then grouped into land-cover categories (training classes) based on ground reference data from 30 percent of the county and extrapolated to the remainder of the study area.

Location of all CRP fields in the county was obtained from maps on file with the Hamilton County Agricultural Stabilization and Conservation Service (ASCS) office and transferred to acetate overlays of the CIR photographs. Individual CRP fields were then identified on a graphic display of the classified satellite image and the corresponding digital data file changed to the CRP category using Map and Image Processing System (MIPS) software (Miller *et al.*, 1989).

We evaluated the effects of CRP fields on local bobwhite habitat with a model designed to assess bobwhite habitat suitability on a landscape scale based upon amount and spatial distribution of land-cover types discernable from remotely sensed data. A complete description of the model is presented elsewhere (Roseberry and Richards, 1992). General assumptions and functional relationships relevant to the present application are outlined below:

- Optimal proportions of woods, cropland, grassland, and oldfields for northern bobwhite were assumed to be 15, 30, 20, and 25 percent of the total area, respectively.
- Overall habitat suitability for northern bobwhite was a function of amount and quality of food, cover, and breeding habitat and the spatial interspersion of land-cover types contributing to these life requisites. Winter food and cover were weighted 1.5 times more heavily than breeding habitat.
- The winter food component was primarily a function of relative amount and quality of cropland and early oldfields, with mid- and late-successional oldfields, woods, and grasslands contributing proportionately less.
- The nesting component was primarily a function of relative amount and quality of grasslands and mid-successional oldfields.
- Quality of grasslands was a function of the predominant vegetative type and relative amount of disturbance (e.g., haying, grazing). Mixed warm season grasses and forbs were considered most valuable and monoculture fescue least valuable for bobwhite. Value also varied inversely with disturbance.
- Quality of croplands was a function of crop type and overwinter management. Corn, soybeans, and milo were considered superior to winter wheat. Fall-plowed cropfields were of lesser value than spring plowed or minimum tillage fields.

We used a moving window approach to systematically produce a bobwhite habitat suitability index (HSI) for each of the County's 432 Public Land Survey sections (259 ha). A square mile of prime midwestern habitat could contain more than 20 winter coveys and 50 breeding pairs (Roseberry and Klimstra, 1984). Therefore, we consider this spatial unit to be sufficiently large to assess northern bobwhite habitat on a local scale. Simulations were run in two modes: with CRP fields extant and with CRP fields reverted to their original cropland status. Various sets of conditions reflecting composition, structure, and management of CRP fields and type and overwinter management of croplands were simulated by altering the value of coefficients representing "quality" or suitability of CRP and cropland as bobwhite habitat from 0.1 (minimum) to 1.0 (optimum). Comparable runs under various sets of conditions were made with and without CRP, and the resulting HSIs were compared on a section by section basis.

Results

Characteristics of CRP Fields

At the time of our study (through signup 9), approximately 10,163 ha (9.0 percent) of Hamilton County were enrolled in the CRP, ranking it first and third in the State in terms of relative and total amounts of CRP land, respectively. Thirteen Illinois counties (with greater than 38 percent of the total CRP acreage) now contain comparable relative amounts of CRP (5.4 percent to 12.7 percent) following signup 12. Almost all (98.5 percent) of the Hamilton county CRP acreage was committed to CP-1 contracts (introduced grasses and legumes), with tall fescue (*Festuca arundinaceae*) planted on approximately 78 percent. Within the 26-county southcentral quail management region of Illinois that includes Hamilton County, 2.7 percent of the land was in CRP, 92.2 percent was in CP-1 vegetation, and about 24 percent contained fescue.

Two-hundred ninety-two (67.6 percent) of the county's 432 political sections contained CRP land: 110 (25.5 percent) had from 1 to 16 ha, 63 (14.6 percent) from 17 to 32 ha, 74 (17.1 percent) from 33 to 65 ha, and 45 (10.4 percent) over 65 ha. In general, sections with no CRP land were more intensively cultivated and less forested than those with CRP (Table 1). Consequently, CRP fields tended to be located in closer proximity to protective cover than did the remaining cropfields. Almost 44 percent of all CRP land was within 90 m of a woods or a woody hedgerow, compared to only 31 percent for the remaining cropland. In contrast, 45 percent of remaining cropland was greater than 240 m from protective cover, compared to 33 percent for CRP land (Figure 1).

As the above would suggest, CRP land tended to be situated in better bobwhite habitat than did land not enrolled or not eligible for the program. Over 70 percent of the sections with no CRP were judged poor to fair bobwhite habitat while only 13 percent were rated good to excellent. In contrast, 46 percent of the sections with greater than 16 ha of CRP had previously been excellent quail habitat, whereas only 19 percent had been poor to fair.

Simulations

The ratio of sections in which bobwhite habitat suitability increased or declined with the addition of CRP land varied with quality and amount of CRP and quality of replaced and remaining cropland (Table 2, Figure 2). When suitability of CRP land for bobwhite was assumed to be good, overall habitat conditions were improved in 56 to 70 percent of the sections and reduced in only 1 to 7 percent, depending on quality of replaced and remaining cropland. When CRP suitability was assumed average, bobwhite habitat improved in 37 to 52 percent of the sections and declined in 3 to 15 percent,

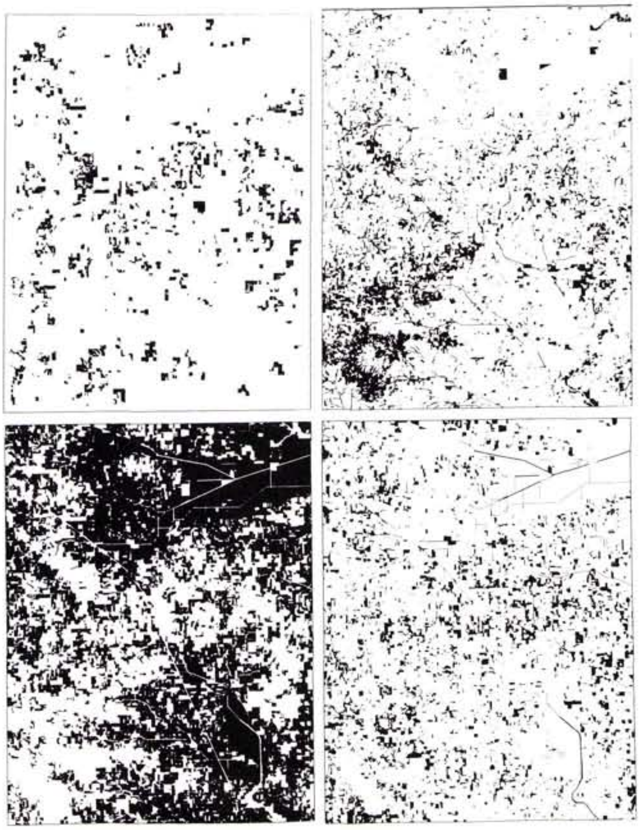

Figure 1. Spatial distribution of CRP fields (upper left), woodlands (upper right), cropfields (lower left), and non-CRP grasslands (lower right), Hamilton County, Illinois, 1989.

again depending on the cropland quality coefficient. Poor quality CRP improved bobwhite habitat in 12 to 19 percent of the sections while reducing it in 10 to 26 percent.

When CRP vegetation was assumed to be primarily grass or a grass/legume mix, its addition generally lowered the model's food component value, the exception being when average-good quality CRP replaced poor quality cropland. In most cases, however, the slight reduction in food value was more than compensated by a large increase in nesting value. When CRP fields were assumed to represent early oldfields rather than grassland, both the food and nesting component often increased and overall habitat quality was improved in 91 percent of the sections.

Discussion

Our modeling exercise suggested that the potential of the CRP to enhance local bobwhite habitat would depend on (1) the amount of CRP land present, (2) its suitability for bobwhite use, (3) the suitability of replaced and remaining cropland for bobwhite use, (4) the juxtaposition of CRP fields with other habitat components, and (5) the composition and quality of existing bobwhite habitat, in particular, which components were limiting (e.g., winter food, protective cover, nesting/brood rearing areas).

The simulated effect of low-quality CRP on bobwhite habitat was slightly to moderately negative, and intensified as the amount of CRP land increased. When CRP quality was good, bobwhite habitat was positively affected, regardless of quality of replaced or remaining cropland, and the positive effect increased as the amount of CRP land increased. Average-quality CRP produced only minor positive effects for sections with less than 6 percent CRP. Beneficial effects increased as the amount of CRP increased and occurred, regardless of the quality of replaced or remaining cropland.

Our model represented quality or suitability of CRP fields for bobwhite as a single coefficient value (range 0.1 to 1.0), an obvious oversimplification. In reality, the potential of CRP fields to meet various seasonal needs of bobwhite would depend on such things as composition and structure of growing and residual vegetation, which in turn would vary with type, rate, and success of initial plantings, site conditions, and years since establishment (age of field). Burger *et al.* (1990) found that newly established CRP fields (less than 3 years old) in northern Missouri were generally characterized by more bare ground and a larger annual weed component than older fields, thus making them more suitable as summer brood rearing and winter roosting habitat. As fields matured (greater than 3 years old), they become more rank and the grass component increased, thereby improving their value as nesting cover. Burger *et al.* (1990) also considered CP-2 (warm-season grasses) and CP-4 (wildlife habitat) fields to be superior to CP-1 (cool-season grasses/legume) fields for bobwhite nesting and possibly brood rearing habitat. As noted earlier, almost all Illinois CRP land (greater than 98 percent) through signup 9 was in CP-1.

The timing and intensity of disturbance (e.g., mowing, grazing, burning, herbicide applications) can also influence suitability of CRP fields for bobwhite. Burger *et al.* (1990) noted that: "... disturbance [mowing] is a major factor limiting habitat quality on CRP lands ... ." Except for the allowance of emergency haying during the drought year of 1988, mowing of CRP fields is technically permitted only for "weed control" and as part of the initial establishment of permanent cover (Hays *et al.*, 1989). Annual mowing is not required by law; nevertheless, it appears to be a common practice in many areas (Burger *et al.*, 1990; Hays *et al.*, 1989). As much as 40 percent of Illinois CRP land may be seasonally mowed (Roseberry and David, 1994); field observations suggested the incidence of mowing in Hamilton County was much higher.

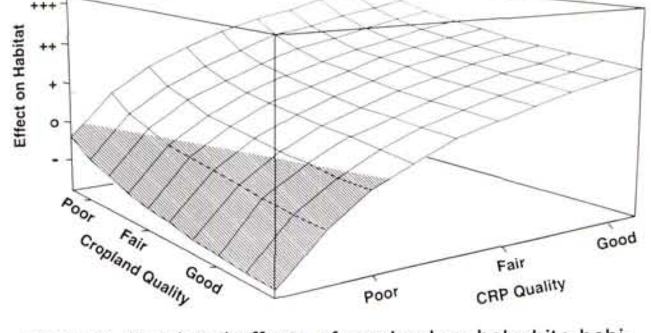

Figure 2. Simulated effects of CRP land on bobwhite habitat at various levels of CRP and cropland suitability.

TABLE 2. PERCENTAGE OF SECTIONS IN WHICH BOBWHITE HABITAT QUALITY INCREASED:DECREASED WITH ADDITION OF CRP LAND, HAMILTON COUNTY, ILLINOIS.

Quality of CRP Cropland*		CRP Land Per Section (ha)				
		1-16	17-32	33-65	>65	Total
good	good	36:3	68:3	66:10	73:13	56:7
good	fair	39:2	70:6	76:7	80:9	61:5
good	poor	39:1	84:0	91:30	93:2	70:1
fair	good	16:6	49:16	51:26	47:22	37:15
fair	fair	18:3	56:8	60:12	56:20	42:9
fair	poor	17:2	60:6	74:4	84:2	52:3
poor	good	4:7	14:19	23:38	11:64	12:26
poor	fair	5:7	16:19	30:35	16:51	16:24
poor	poor	3:4	19:8	35:12	33:24	19:10

*Replaced and remaining.

Most of our simulations were based on the premise that CRP vegetation consisted primarily of grasses, or grass/legume mixes. However, CRP fields in the Midwest (especially new fields) often contain a considerable annual weed component (Burger *et al.*, 1990; Hays *et al.*, 1989). In addition to age, the amount and composition of weedy vegetation in CRP fields would depend on such factors as relative success of initial plantings, season of initial tillage, and the proximity and composition of seed banks. Quail biologists have long recognized the importance of early successional vegetation to bobwhite (Roseberry and Klimstra, 1984; Rosene, 1969; Stoddard, 1931). Such areas provide important year-round food sources as well as roosting sites and brood-rearing cover. Indeed, in our simulations, conversion of retired cropland to early oldfields improved bobwhite habitat in almost every instance. However, no CP specifically provides this type of cover, and accepted management practices often discourage the establishment of such vegetation. Burger *et al.* (1990) recommended that one-third of each CRP field be lightly disced on a 3-year rotation as a means of maintaining early successional vegetation and increasing field-level diversity.

In addition to vegetative composition and structure, juxtaposition of CRP fields with other land-use types is also a major determinant to their potential value as wildlife habitat (Langner, 1989). Under most sets of simulated conditions, we recorded both positive and negative CRP effects at the sectional level. This was mainly due to the fact that habitat conditions (and limiting factors) varied spatially; thus, CRP fields contributed previously limiting components or life requisites in some sections while detracting from them in others.

In Hamilton County, CRP fields tended to be located in closer proximity to protective cover (woods, hedgerows) than did cropfields not enrolled in the program. This spatial relationship would be most beneficial for CRP fields that provided food. Immediate proximity to heavy cover would not be as critical if only nesting and/or brood rearing habitat were provided (Roseberry and Klimstra, 1984). In areas lacking sufficient cover, a shrub component in CRP fields would increase their contribution to bobwhite habitat. However, shrub cover is usually lacking in recently established CRP fields, but would likely increase with age unless suppressed by mowing or herbicide applications (Hays *et al.*, 1989).

Based on the extensive use of fescue and mowing, we judged the actual suitability of most CRP fields in Hamilton County for northern bobwhite as poor. Data were not available to reliably assess annual bobwhite population trends in the county. However, a concurrent study that examined temporal trends in bobwhite harvest and call-count data from 1983 through 1991 (Roseberry and David, 1994) concluded that the CRP did not measurably impact regional quail abundance in southcentral Illinois (including Hamilton County).

Conclusions

The CRP offered considerable potential for enhancing northern bobwhite habitat (Howell and Isaacs, 1988), but this potential has not been fully realized (Brennan, 1991; Roseberry and David, 1994). In fact, local effects may have even been negative in situations where (1) the composition and/or structure of CRP vegetation was unsuitable for bobwhite, (2) untimely disturbance resulted in large-scale nest destruction or brood mortality, or (3) life requisites contributed by CRP were not limiting, but replaced those that were.

Warner and Etter (1985) suggested that wildlife habitat initiatives on agricultural lands be addressed at three spatial scales — field (site), farm (landscape), and regional. This approach seems appropriate for CRP or similar land retirement programs if positive benefits to wildlife are to be maximized. Initially, regional conditions should be appraised before decisions are made to promote individual species or groups of species. Next, attention should be directed toward the spatial relationship of existing and proposed CRP fields to other habitat components (farm/landscape considerations), and a careful evaluation should be made of existing habitat conditions, especially those components or life requisites that appear to be limiting. Only then can intelligent recommendations be made regarding which Conservation Practice would be most beneficial to a particular species. Finally, efforts must be directed toward promoting the establishment and maintenance of favorable vegetative composition and structure on retired acres (field/site considerations). The latter will necessitate action at both the national level, where contract provisions are established (Cook 1989), and the local level, where individual land owners are advised and directed (Miller and Bromley, 1989).

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