Continuous Conservation Reserve Program: Factors Influencing the Value of Agricultural Buffers to Wildlife Conservation

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Abstract

The Continuous Conservation Reserve Program (CCRP) principally consists of linear buffer conservation practices designed to remove highly erodible land from production and to improve water quality. The extent of projects differentiates CCRP from the general signup CRP, which focuses on whole-field enrollments. Small sizes and high edge to area ratios have the potential to limit the usefulness of these practices for wildlife. Careful planning and management are keys to gaining the desired wildlife benefits from these plantings, particularly with regard to the role of buffers in the landscape. Evidence that the practices enrolled in the CCRP are used by wildlife is mounting, although studies are still most heavily focused on the avian community. Further study on reproductive success and survival is needed on all species of wildlife using these plantings to determine how the CCRP can best serve wildlife habitat functions.

Introduction

The Continuous Conservation Reserve Program (CCRP), authorized by the 1996 Farm Bill, made certain high-priority agricultural conservation practices eligible for enrollment in the Conservation Reserve Program (CRP) on a continuous basis, rather than through the general CRP signup process. Practices eligible under this program include riparian buffers, wildlife habitat buffers, wetland buffers, herbaceous filter strips, wetland restoration, grassed waterways, shelterbelts, living snow fences, contour grass strips, salt-tolerant vegetation, and shallow-water areas for wildlife (FSA 2003). Riparian buffers, herbaceous filter strips, and grassed waterways account for 61% of the acres currently enrolled in the CCRP (FSA 2004). CCRP plantings are generally small in area (often <5.0 ha [12.5 acres]), concentrated along waterways on highly erodible lands or other high-priority areas, and are generally linear because they are associated with field edges. Contracts in this program are 10–15 years in duration (FSA 2003). In this paper, we use the term "buffer" in reference to these collective CCRP practices, because the majority of them are designed to either buffer natural features such as wetlands or streams from adjacent agricultural areas or to provide a wind barrier. The objectives of the program are to improve water quality and control soil erosion, improve air quality, enhance aesthetics, and create wildlife habitat (FSA 2003)

Example of a sod waterway.
NRCS, Lynn Betts

The 2002 Farm Bill resulted in no major modifications of the CCRP, which remains available to producers. CCRP currently enrolls 1,143,892 ha (2,826,608 acres) in conservation practices (Tables 1 and 2) (including Conservation Reserve Enhancement Program acres authorized under continuous signup) (FSA 2004). The 2002 Bill also authorized implementation of the Conservation Security Program (CSP) (see Henry, *this volume*), which was designed to work in conjunction with pre-existing programs such as the CRP and CCRP, but not to replace them (CCC & NRCS 2004). Enrollment of acres in CCRP can earn producers points toward qualification for Tiers II and III CSP, providing additional incentive for conservation.

This paper updates and expands the previous review that summarized CCRP based on similar strip-cover practices (Best 2000). That review focused on avian responses. Since that time, interest in documented use of strip-cover by invertebrates, amphibians and reptiles (herpetofauna), and small mammals has emerged. Furthermore, in the intervening years there has been opportunity to study birds and other taxa directly on areas enrolled in CCRP rather than infer CCRP effects from research on similar strip-cover habitats such as roadsides or field borders. We have incorporated those newer findings as well as repeated some of the important findings of research focused on areas functionally similar to CCRP. We first review the evidence that addresses how CCRP differs as potential habitat from the annual crops that it is designed to replace. Then we review the available information that documents benefits of CCRP to wildlife, including how buffers function as edges and corridors and how predators respond to buffers. We address the state of our understanding of the importance of landscape context on the conservation value of buffers. Finally, we conclude with an assessment of information gaps that should be addressed in future monitoring or research programs. We have organized the review according to the functional aspects of CCRP practices for wildlife rather than following a taxonomic chapter organization. We focused on CCRP as applied in agricultural/grassland regions of the Midwest and Great Plains rather than the wooded riparian systems of the East and Southeast, largely because the available research has primarily addressed grassland systems. We did not address any information on CCRP benefits to fish, although our review of information on CCRP benefits revealed a paucity of information on this subject.

Wildlife Abundance and Species Composition in CCRP Buffers

In the Midwest and Great Plains, the major benefit of CCRP, like that of CRP and other farm conservation programs, is that they replace annual row crops with perennial vegetation cover, thus providing substantial improvement for wildlife (Best 2000, Johnson 2000, Reynolds 2000, Ryan 2000). Even though some bird species such as vesper sparrows (*Pooecetes gramineus*), dickcissels (*Spiza americana*), and red-winged blackbirds (*Agelaius phoeniceus*) are known to nest in row-crop fields, abundances in vegetation buffers are an order of magnitude greater than in row crops (Best 2000). All recent studies confirmed that generalist species comprise the largest part of the abundance of birds using buffers. For example, red-winged blackbirds accounted for 54% of total bird abundance sampled in Iowa filter strips (Henningsen 2003) and 50% of the total bird abundance in Iowa grassed waterways (Knoot 2004).

Game birds such as ring-necked pheasants (*Phasianus colchicus*), gray partridge (*Perdix perdix*), and mallards (*Anas platyrhynchos*) have been documented using strip cover (Best 2000). Ring-necked pheasants and, more rarely, mallards have nested in CCRP plantings (Henningsen 2003, Kammin 2003, Knoot 2004), although these species exhibit a preference for large blocks of cover (Clark et al. 1999, Reynolds 2000). CCRP may provide winter cover for resident game birds, but unfortunately little data have been collected on winter use of CCRP by wildlife. Kammin (2003) documented 11 species of birds, including ring-necked pheasants, present in filter strips in winter in Illinois, but abundance was low for all species. When snow is deep, buffers often act as drift fences that catch snow, thereby reducing their value as winter habitat. Presence of shrubs and trees provides additional structure and may ameliorate this effect somewhat. Some resource managers recommend seeding plans for buffers based upon winter cover considerations, choosing switchgrass (*Panicum*

Table 1. Conservation practices on continuous signup CRP acres as of December 2004 (excludes general signup acres). Adapted from NRCS (2004).

		Continuous (CREP)		Continuous (non-CREP)		Total	
Code	Practice	Acres	%	Acres	%	Acres	%
CP1	New introduced grasses and legumes	100,065	16	72,303	3	172,368	6
CP2	New native grasses	60,392	10	19,361	1	79,753	3
CP3	New softwood trees (not longleaf)	375	0	320	0	695	0
CP3A	New hardwood trees	8,092	1	877	0	8,969	0
CP4	Permanent wildlife habitat	38,314	6	3,053	0	41,367	1
CP5	Field windbreaks	2,633	0	68,750	3	71,383	2
CP7	Erosion control structures	1	0	0	0	1	0
CP8	Grass waterways	559	0	105,025	5	105,584	4
CP9	Shallow water areas for wildlife	2,282	0	45,732	2	48,014	2
CP10	Existing grasses and legumes	11,033	2	37,385	2	48,418	2
CP11	Existing trees	357	0	0	0	357	0
CP12	Wildlife food plots	1,662	0	0	0	1,662	0
CP15	Contour grass strips	111	0	76,620	3	76,731	3
CP16	Shelterbelts	385	0	28,147	1	28,532	1
CP17	Living snow fences	0	0	3,968	0	3,968	0
CP18	Salinity reducing vegetation	9	0	292,964	13	292,973	10
CP21	Filter strips (grass)	126,244	20	835,773	37	962,017	34
CP22	Riparian buffers	142,204	23	552,562	25	694,766	24
CP23	Wetland restoration	91,216	15	0	0	91,216	3
CP23	Wetland restoration (floodplain)	0	0	62,630	3	62,630	2
CP23A	Wetland restoration (non-floodplain)	0	0	1,670	0	1,670	0
CP24	Cross wind trap strips	38	0	643	0	681	0
CP25	Rare and declining habitat	38,165	6	0	0	38,165	1
CP26	Sediment retention	6	0	0	0	6	0
CP29	Wildlife habitat buffer (marginal pasture)	1,520	0	13,694	1	15,214	1
CP30	Wetland buffer (marginal pasture)	188	0	9,939	0	10,127	0
CP31	Bottomland hardwood	55	0	7,198	0	7,253	0
CP33	Upland bird habitat buffers	0	0	3,697	0	3,697	0
	Unknown	410	0	904	0	1,314	0
Total		626,315	100	2,243,217	100	2,869,532	100

Table 2. Continuous CRP enrollment as of December 2004, not including CREP. Adapted from NRCS (2004).

State	Acres	Annual Rental (× $1000)	Payments ($/acre)
Alabama	29,059	1,460	50.25
Alaska	482	28	57.12
Arkansas	43,759	2,842	64.95
California	5,973	405	67.78
Colorado	8,073	326	40.62
Connecticut	83	7	82.32
Delaware	858	68	78.95
Florida	68	3	39.88
Georgia	1,983	99	50.12
Idaho	9,024	488	54.05
Illinois	251,599	33,354	132.57
Indiana	78,897	9,941	126.00
Iowa	409,688	58,054	141.70
Kansas	52,672	3,335	63.31
Kentucky	47,646	4,681	98.24
Louisiana	20,607	1,247	60.52
Maine	368	24	65.09
Maryland	3,157	268	84.83
Massachusetts	27	3	105.06
Michigan	20,384	2,006	98.41
Minnesota	229,925	18,923	82.30
Mississippi	139,820	8,403	60.10
Missouri	75,389	6,690	88.75
Montana	152,578	5,732	37.56
Nebraska	58,392	4,593	78.66
New Hampshire	185	10	52.75
New Jersey	182	14	75.50
New Mexico	6,662	292	43.77
New York	8,423	447	53.08
North Carolina	12,579	914	72.67
North Dakota	138,600	5,635	40.65
Ohio	42,900	4,692	109.37
Oklahoma	12,973	567	43.71
Oregon	12,191	724	59.42
Pennsylvania	1,075	55	50.77
Puerto Rico	436	28	65.00
South Carolina	34,392	1,837	53.42
South Dakota	148,342	9,162	61.76
Tennessee	15,630	1,536	87.88
Texas	39,599	10	38.78
Utah	216	19	46.39
Vermont	358	78	53.96
Virginia	1,603	6,555	48.68
Washington	93,024	12	70.46
West Virginia	266	2,663	46.43
Wisconsin	27,865	232	95.56
Wyoming	5,199	1,536	44.71
Total U.S.	2,243,217	199,837	89.08

RIng-necked pheasants.
NRCS, Roger Hill

virgatum) because it maintains more vertical structure than the most commonly planted species, smooth brome (*Bromus inermis*). However, we could find no research on what types of factors influence wildlife use of CCRP in winter.

Grassland specialist bird species use buffer strips in comparatively small numbers. Knoot (2004) observed grasshopper sparrows (*Ammodramus savannarum*), Savannah sparrows (*Passerculus sandwichensis*), and vesper sparrows in fewer than 5 of 33 grassed waterways surveyed. Kammin (2003) reported that grassland species such as grasshopper sparrows, Henslow's sparrows (*Ammodramus henslowii*), and vesper sparrows were absent from filter strips surveyed in Illinois. Buffers with shrubs and small trees have greater species richness than herbaceous buffers due to the increased heterogeneity of vegetation structure, but such plantings also chiefly host generalist species such as red-winged blackbirds, song sparrows (*Melospiza melodia*), and brown-headed cowbirds (*Molothrus ater*) (Kammin 2003).

Small mammals, including mice (*Peromyscus* spp.), voles (*Microtus* spp.), shrews (*Sorex* spp. and *Blarina* spp.), and ground squirrels (*Spermophilus* spp.) are common residents in perennial vegetation that comprises buffers (Snyder and Best 1988, Wiewel 2003). Voles are restricted to areas with substantial vegetation and litter cover (Getz 1961, Birney et al. 1976) and would be rare in row-crop fields. In contrast, deer mice densities of 15–50/ha (Clark and Young 1986, Wiewel 2003) have been observed in both perennial vegetation and row-crop fields. Specialist mammals like meadow jumping mice (*Zapus hudsonius*) and least weasels (*Mustela nivalis*) would be uncommon in buffers.

Buffers with their perennial vegetation provide habitat for invertebrates to aggregate. In soybean fields in Ohio, researchers found that above-ground arthropod predator numbers were higher in grassy corridors than in adjacent soybean fields; the corridors may have even drawn in predators from the planted fields (Kemp and Barrett 1989). Uncultivated land adjacent to crop fields harbors natural enemies that annually colonize fields to exploit pests (Price 1976). The practice of strip intercropping was developed as a method of managing insect crop pests because uncut strips in alfalfa fields attract pest populations into small areas and provide refuge for parasites and predators of insect pests (Weiser et al. 2003).

The presence of invertebrate, bird, and small mammal prey within the perennial vegetation in buffers has been shown to attract larger predators. In a radiotelemetry study of striped skunks (*Mephitis mephitis*) and red foxes (*Vulpes vulpes*) in North Dakota, Phillips et al. (2003) found that skunks selected perennial cover along wetland edges over other habitat types, probably because of abundant food resources (Greenwood et al. 1999). Red foxes selected planted perennial cover over cropland, especially where perennial vegetation was <20% of the landscape. Such selection of agricultural–wetland edges indicates the potential for enhanced predator–prey interactions within buffers (see sections below).

Vegetation Structure

In general, diverse vegetation structure and composition benefits a greater variety of wildlife, but for CCRP there is not a nationwide planting mixture that is required. The CCRP filter strip practice standard says “species selected shall have stiff stems and a high stem density near the ground surface…[and] be such that the stem spacing does not exceed 1 inch.” The standard further states that if the goal is to create wildlife habitat, then “plant species selected for this purpose shall be for permanent vegetation adapted to the wildlife or beneficial insect population(s) targeted” (NRCS 2003). Brome and brome-alfalfa (*Medicago sativa*) is still commonly planted in CCRP buffers, although individual resource managers may recommend mixtures of native species as are effectively required for general enrollment CRP.

CCRP buffers. NRCS, Lynn Betts

Diverse buffers may provide habitat for beneficial (and detrimental) arthropods that have importance to agriculture, are prey for wildlife, and have intrinsic esthetic value. Integrated pest managers and ecologists have suggested that integration of uncultivated corridors in agricultural fields could have positive economic impacts with regards to pest management (Kemp and Barrett 1989). In a study of filter strips in Minnesota, butterfly abundance and diversity were associated with the quantity of broad-leaved forbs within the strips that provide nectar sources and host plants for larvae (Reeder 2004).

McIntyre and Thompson (2003) studied prey items of breeding grassland birds and reported that arthropod abundance and diversity were highest at sites with highest vegetative diversity. Benson (2003) found similar patterns in his study of riparian floodplain restoration in Iowa. Pheasant chicks depend on adequate populations of arthropods for normal growth and development (Woodward et al. 1977, Nelson et al. 1990) and landscapes dominated by row crops have insufficient arthropod biomass to support pheasant broods (Whitmore 1982). In fact in Europe, conservation headlands with diverse plantings of wildflowers are often incorporated into small grain production specifically to the benefit of game birds (Potts 1986).

Plant species diversity and associated structural heterogeneity provides a variety of perching and nesting sites for birds, and leads to a greater variety of microhabitats for invertebrates and small mammals. Grassland birds are influenced by structural diversity of native and restored plant communities (Johnson and Schwartz 1993). Within grassed waterways in Iowa, vegetation vertical density was positively associated with the presence of dickcissels, common yellowthroats (*Geothlypis trichas*), and red-winged blackbirds (Knoot 2004). Population density of small mammals varied greatly with habitat characteristics, but was generally greater in denser vegetation (Birney et al. 1976). Most explanations of the effects of plant cover on wildlife emphasize food availability and protection from predation (Birney et al. 1976, Grant et al. 1977). Prairie voles (*Microtus ochrogaster*) actually have lower density in habitat with the greatest cover such as tallgrass prairie but which have less diverse availability of high-quality forbs for food (Cole and Batzli 1979), whereas meadow voles (*Microtus pennsylvanicus*) are abundant in areas with dense grass and litter.

There is very little information on responses of herpetofauna to vegetation structure within CCRP buffers, but like other taxa the individual species' habitat requirements would dictate the expected response. For example, Knoot (2004) found that occurrences of smooth green snakes (*Lioclonorophis vernalis*) in grassed waterways in Iowa were positively associated with litter cover, but eastern garter snake (*Thamnophis sirtalis*) occurrence was negatively correlated with litter.

Wildlife Reproduction in Buffers

Best (2000) provided a very comprehensive review of the factors contributing to low nest success in strip buffers in agricultural landscapes. Recent studies of nesting birds in CCRP confirm that success is far lower than in block habitat, but comparable to success in other types of strip-cover. Nest success reported in 3 recent studies in filter strips in Iowa, in filter strips in Illinois, and in grassed waterways in Iowa was 27%, 13%, and 27%, respectively (Henningsen 2003, Kammin 2003, Knoot 2004). The dominant cause of nest failure was predation. Best et al. (1997) reported nest success in CRP fields to be 40%, and Patterson and Best (1996) reported a 38% nest success rate in CRP. Similarly, duck nests have exhibited higher survival in large blocks than in strip-cover (Pasitschniak-Arts and Messier 1996). Pheasant nest success is highest in areas consisting of several grassland blocks of at least 16 ha (40 acres) (Clark et al. 1999). Data on mammals and herpetofauna have not been organized in such a way that we can draw any conclusions about reproductive performance in buffers.

Patch Area

Most CCRP projects would be only minimally sufficient in size for some area-sensitive bird species and are insufficient for others. For example, consider a buffer 0.8 km (0.5 mile) long and 61 m (200 feet) wide, which would be 4.9 ha (12 acres) in area—a representative CCRP planting. Such a patch would be adequate for species with a small home range like that of many small mammals (Gaines et al. 1992), invertebrates, and many snakes, but for more mobile taxa such as birds, such small patches are often insufficient. Several species of grassland birds have minimum area requirements (Herkert 1994, Vickery et al. 1994, Walk and Warner 1999, Winter and Faaborg 1999). These requirements are manifested on a distributional level (reduced density or absence in smaller patches) and on a demographic level (reduced reproductive success in smaller patches) (Winter and Faaborg 1999). Herkert (1994) found minimal area requirements for 5 grassland bird species ranging from 5 to 55 ha (12.4–136 acres), and Walk and Warner (1999) reported similar area requirements ranging from 12 to 75 ha (29.7–185.3 acres).

Patterns of area sensitivity can differ depending on the surrounding landscape (Donovan et al. 1997), suggesting that the effectiveness of small CCRP patches might vary regionally. However, Johnson and Igl (2001) studied density and occurrence of grassland bird species in relation to patch size across the northern Great Plains and found fairly consistent area sensitivity across this geographical region, including bird species ranging from northern harriers (*Circus cyaneus*) to sedge wrens (*Cistothorus platensis*).

Buffer Width

The linear characteristic of buffers potentially makes width more relevant to wildlife habitat value than patch area per se, but researchers are just beginning to collect data on the effects of width. With regard to birds, the results of recent studies are quite mixed. For example, Knoot (2004) found a predictive relationship of grassed waterway width in Iowa for only 2 of 7 species of songbirds, and the direction of the relationship contrasted. In filter strips, Kammin (2003) found no relationship, and Henningsen (2003) found that only the abundance of the eastern meadowlark (*Sturnella magna*) was associated with width. Henningsen (2003) found nest success of only 1 species, the red-winged blackbird, was positively associated with width of the filter strip. Perhaps these results reflect the fact that the strips studied in these cases ranged only between 8 and 40 m (26–131 feet), making it difficult to detect an effect on vagile species like birds.

Studies conducted in wider strips and with less vagile species than birds provide more consistent support for the positive effects of width. Knoot (2004) also reported that presence of plains garter (*Thamnophis radix*), eastern garter, and brown (*Storeria dekayi*) snakes was positively correlated with width of grassed waterways. Reeder (2004) found that the diversity of butterflies, and also the abundance of certain larger or habitat-sensitive butterflies was positively correlated with widths ranging between 18 and 167 m (59–548 feet) in Minnesota buffers. Semlitsch and Brodie (2003) integrated biological criteria of both amphibians and reptiles when they considered guidelines for buffers around wetlands and riparian habitats.

Disturbance

A large part of the value of CCRP and other set-aside programs is that the habitat created is undisturbed relative to the surrounding agricultural lands. Although vegetation management is required periodically for maintenance of healthy plantings, substantial or frequent disturbance often negatively affects wildlife communities. Different CCRP practices have different management scenarios; filter strips are supposed to be mowed or sprayed for noxious weed control as needed, whereas grassed waterways are supposed to be mowed yearly to facilitate water flow. Grassed waterways embedded in crop fields are routinely driven across with tractors. For example, farm equipment caused 9% of nest failures in grassed waterways in Iowa (Knoot 2004), and Kammin (2003) reported that 3.6% of nest failures in filter strips in Illinois were caused by human disturbance. But the anthropogenically caused nest failure rates above are small in comparison to the 80% and 88% of failures caused by predation in those studies, respectively (Kammin 2003, Knoot 2004).

The change in vegetation structure after mowing or burning is reflected in the wildlife community. Mowing or burning that is done before the nesting cycle of birds has been completed caused nest failure and adult mortality (Bryan and Best 1991, Delisle and Savidge 1997, Johnson 2000, Horn and Koford 2000, Murray 2002). Mowing and burning can also impact less mobile species or immature, sedentary life stages of species such as flying insects (Swengel 1996). However, these negative effects are usually short-lived (Panzer 2002, Benson 2003). The habitat improvement gained through prudent use of mowing and burning confers long-term benefits to most species (Panzer 2002).

The CCRP does not generally allow grazing except under certain situations such as drought, although there has been discussion of liberalizing the regulations. The effect of grazing on wildlife has received considerable attention in the literature, reflecting primarily negative effects among ground-nesting birds, especially waterfowl (Kirsch 1969, Hertel and Barker 1987, Kruse and Bowen 1996). This is particularly true when grazing is focused on small patches, as opposed to extensive rangelands. In buffer habitats the results are highly variable and some studies suggest that intermediate disturbance may be beneficial. For example, Walk and Warner (2000) found that light grazing favored abundances of 5 grassland bird species. Chapman and Ribic (2002) compared the small mammal community in buffer strips to that found in intensively managed rotationally grazed plots and continuously grazed plots. They found 6–7 times more species and 3–5 times more individual small mammals in the buffer sites than in the pastures, and speculated that this was likely due to the fact that the buffer sites receive relatively little disturbance from haying, grazing, or herbicide application.

Linear Habitats as Movement Corridors

The potential for linear landscape features to connect otherwise isolated habitat fragments is often cited as a possible conservation strategy (Bunce and Hallam 1993, Rosenberg et al. 1997, Beier and Noss 1998, Haddad et al. 2000, Tewksbury et al. 2002). If CCRP projects served this function, they could mitigate some of the negative consequences of habitat fragmentation by increasing the effective population sizes of plants and wildlife occupying isolated fragments of grassland.

Experimental evidence confirming the benefits of corridors like those of a typical CCRP project is lacking, although some studies provide guidance with regard to important issues like width, structure, and landscape context (Rosenberg et al. 1997, Haddad et al. 2000). Corridors can potentially serve 3 beneficial roles: they can simply provide additional habitat; they can connect otherwise isolated habitat patches; and they can act as drift fences, intercepting animals moving across the landscape and directing them into the patches that they connect (Rosenberg et al. 1997). Corridors may have population and ecosystem function effects because they enhance movement of organisms in the landscape (Tewksbury et al. 2002). Although it is tempting to view CCRP as wildlife corridors, buffers do not necessarily connect larger patches of habitat, and there is very little information on whether CCRP plantings increase movement of organisms between patches.

Edge Effects

Another important factor related to CCRP practices is that they are essentially all edge habitats, so that the potential for edge effects must be considered. Edges have both positive and negative effects on wildlife depending on the species (Lidicker and Koenig 1996). With regard to more vagile species like birds, the small extent of CCRP projects makes it likely that area is probably more relevant than edge effect per se. Nonetheless, bird ecologists have frequently studied edge effects in buffers, particularly in forested systems, but also to determine effects on grassland songbirds. Fletcher and Koford (2003) reported that bobolink (*Dolichonyx oryzivorus*; a declining, area-sensitive grassland songbird) territory densities in grassland habitat were lower near edges of all types (forest, road, and agriculture). Winter et al. (2000) studied the effect of forested, shrubby, road, and agricultural field edges on artificial nests, and on real nests of dickcissels and Henslow's sparrows. The forested edges were associated with the most pronounced effects on artificial nests, artificial nest survival was depressed within 30 m (98 feet) of woodland edges, and real nests suffered greater predation within 50 m (164 feet) of shrubby edges.

Agricultural field borders, a CCRP practice. NRCS, Lynn Betts

The effects of proximity to multiple edges are particularly relevant to CCRP because they are specifically designed as buffers along edges of other vegetation types and they are often in a dendritic pattern. Henningsen (2003) noted that some birds, including common yellowthroats and song sparrows, showed an aversion to placing nests near both the wooded edges and the crop field edges. Fletcher (2003) showed that nesting grassland passerines avoided corners of fields where there were 2 edges until they were at least 100 m from either edge. Edge avoidance and nesting success data for game birds including ducks and pheasants have come primarily from studies conducted in large blocks of cover. It is difficult to generalize from the literature because an edge effect on nest success has been found in some studies (Horn et al., in press) but not in others (Pasitschniak-Arts et al. 1998). It is also hard to establish that there is edge-averse nest-placement behavior that is related to avoidance of predation because relatively few studies quantify use of edges by nest predators. Kuehl and Clark (2002) showed that raccoon (*Procyon lotor*), skunk, and red fox preferred vegetation edges near large blocks of grassland cover and that these predators more frequently entered patches at corners than along sides. Edges along streams and wetlands are particularly preferred by these generalist predators (Phillips et al. 2003).

CCRP buffers are described by wildlife ecologists as "hard" edges, in contrast to more natural edges that are gradual or "feathered" to which wildlife species are better adapted (Ratti and Reese 1988). Studies of butterflies illustrate how many animals respond to these hard edges. Ries and Debinski (2001) found that 2 species of butterflies, a habitat specialist (*Speyeria idalia*) and a habitat generalist (*Danaus plexippus*) both avoided or turned back from tree-line boundaries of prairie patches. The specialist butterfly exhibited the same behavior with regard to edges with roads and crop fields. Such behavior might serve to hold butterflies in CCRP plantings once they have entered them, when a particular project provides diverse, quality habitat for butterflies.

Landscape Context

Landscape context influences local distribution patterns, and, on a larger scale, the long-term population dynamics of wildlife. Landscape variables, such as the amount of cover in the landscape or the proximity of a habitat patch to other landscape features, affect avian abundance and reproductive success (Clark et al. 1999, Bergin et al. 2000, Ribic and Sample 2001), carabid beetle assemblages (Jeanneret et al. 2003), butterfly diversity and abundance (Jeanneret et al. 2003, Luoto et al. 2001), and anuran abundance and richness (Knutson et al. 1999, Pope et al. 2000). Knoot (2004) observed that the characteristics of the surrounding landscape explained variation in occurrence of 6 of 8 bird species and 3 out of 5 snake species studied in grassed waterways in Iowa. In the case of aquatic species, the cumulative effects of watershed-level conservation efforts and disturbance patterns often have more influence on habitat suitability than amount of buffers in the immediate area (Willson and Dorcas 2003).

These effects can be visualized easily when the perspective is at a township extent rather than the level of an individual buffer project. Understanding the value of buffers created by CCRP depends importantly on distinguishing the effects on local distribution (i.e., much of the wildlife count data cited above) from the influence that buffers might have on long-term, large-scale changes in population dynamics. Observing large numbers of individuals in buffers may be misleading because such observations reveal little about the reproduction and survival in these strip covers (Pulliam and Danielson 1991). Given the effects of small patch size, linear shape, and large edge ratio, buffers often could be ecological traps (Gates and Gysel 1978, Anderson and Danielson 1997).

There is evidence that sometimes success of ground-nesting birds is actually as high in small, isolated strips of habitat as it is in large blocks (Clark et al. 1999, Horn et al. in press). In fact, Horn et al. (in press) observed that nest success of waterfowl was lowest in intermediate-sized patches of CRP. Evidence from studies of pheasants suggests that success is especially low where intermediate-sized patches are clustered so that there is a relatively large amount of edge per unit of landscape area (Clark et al. 1999). The mechanism influencing these patterns is that generalist predators like skunks, raccoons, and foxes spend a disproportionately large part of their activity in intermediate-sized patches and along edges (Kuehl and Clark 2002, Phillips et al. 2003, Phillips et al. 2004).

To a very large degree the landscape composition, that is the amount of perennial habitat in the landscape, has a much larger effect on the persistence of populations than the configuration and fragmentation of that habitats (Fahrig 1997). Nonetheless Clark et al. (2001) demonstrated that predicted response of pheasant abundance in typical Iowa townships could differ between conditions where CRP was allocated in general

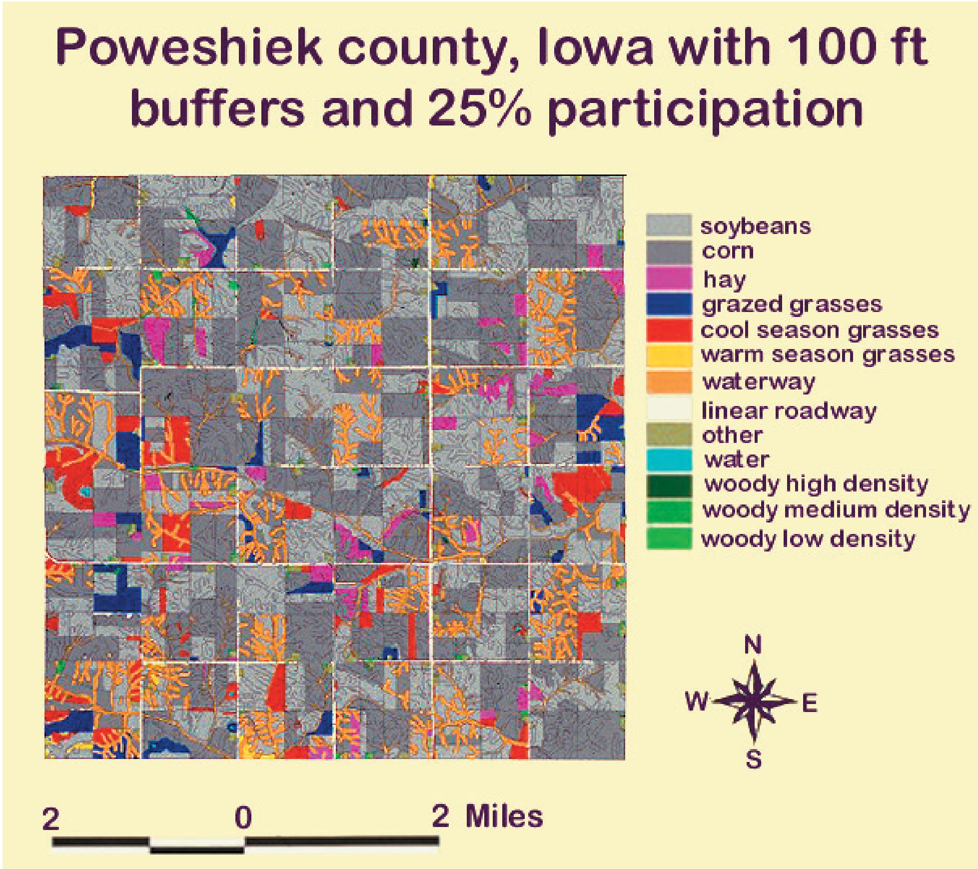

Figure. 1. A township in Poweshiek County, Iowa, with hypothetical CCRP projects, assuming that 25% of all landowners participated and were able to enroll all eligible areas into 100-foot riparian filter strips planted to grasses.
William Clark

enrollment of fields in blocks versus buffers (Figure 1). They estimated that if 10–15% of the landscape was configured in grassland conservation buffers, pheasant populations would be predicted to be only about one-third of the density predicted when the same area of grassland is configured in blocks. Under either scenario, pheasant abundance would be expected to increase most rapidly over the range of 10–20% increase in perennial grassland and would not be expected to reach peak abundance until nearly 50% of the landscape was in perennial grassland.

Conclusions and Directions for Future Research

In the Midwest and Great Plains, the major benefit of buffers, like that of CCRP and other farm conservation programs, is that they replace annual row crops with perennial wildlife habitat. Most of the major limitations of buffers are related to the small area of individual projects and the associated edge and width effects. Many of the assessments of wildlife using buffers are based only on counts of animals, and information on the functional effects of these buffers on reproduction and survival is lacking for a broad array of taxa. Further study is needed on the arrangement of buffers and their potential to act as drift fences and migratory corridors. It would be particularly useful to better understand the landscape-level influence of buffers on wildlife population dynamics. Modeling outcomes under an array of landscape configuration scenarios could help managers to understand the tradeoffs between an allocation of CRP into blocks or into buffers, or to suggest goals for establishing buffers that could be translated into farm policy. Long-term research on a large (multi-state) level is necessary to provide an assessment of how CCRP is affecting regional wildlife populations. Furthermore, a comparative approach across watersheds would identify what factors drive large-scale patterns of wildlife use of CCRP.

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