MANAGEMENT OF AGRICULTURAL LANDSCAPES FOR THE CONSERVATION OF NEOTROPICAL MIGRATORY BIRDS

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ABSTRACT.—Thirty-eight neotropical migratory birds (NTMBs) are common in the agricultural landscapes of the Midwest. Most of these species depend on herbaceous or wooded habitats, which are declining as the average size of farms in this region increases about 12 percent per decade. We recommend minimizing cultivation; encouraging moderate grazing; delaying spring mowing of hayfields, grassed waterways, and roadsides; avoiding nighttime mowing; encouraging longer intervals between mowings; avoiding fall mowing and annual mowing of grassed waterways and roadsides; retaining fencelines along roadsides; maintaining idle land that provides nesting cover; and changing the amount and configuration of idle land to enhance species richness and nesting success.

INTRODUCTION

Agriculture is the dominant land use in the Midwest. Farmland composed 66 percent of the land area in 12 midwestern states (listed in table 2) in 1993 (USDA 1993). In 1992, half of the rural, non-federal land in the Midwest was active cropland, a quarter was pasture or rangeland, 17 percent was forest or woodland, and the rest was farmsteads, shelterbelts, idle cropland, etc. (USDA 1994). Rodenhouse *et al.* (1993, 1995) reviewed the effects of agriculture on NTMBs. Here we focus on these effects in the Midwest.

NTMBs constitute the major part of midwestern, farmland avifaunas. Thirty-eight NTMB species are common in at least one farmland habitat in the Midwest, and two-thirds of the common native species are NTMBs (table 1). Thus the conversion of midwestern forest, savannah, and prairie to agriculture, mostly prior to 1920, undoubtedly changed the abundance and distribution of NTMBs. Changes in bird abundance are not well documented because there were no widespread, systematic surveys of bird populations before the mid-1960's. Extinction and local extirpation of some species have been documented (e.g., Dinsmore 1981, 1994). Grassland birds, which form a large fraction of the common farmland NTMBs (table 1), evidently did not decline much between the 1920's and 1950's, when diversified farming was common (Warner 1994). The modern era of intensive cropping coincides with population declines of grassland birds (Herkert 1991, 1995; Warner 1994). Other long-term changes, mostly of declining bird populations, have been noted in Illinois (Graber and Graber 1963) and a small study area in Iowa (Lowther 1984). These declines have continued in recent years (Graber and Graber 1983, Warner 1994). A variety of factors, acting at all stages of the annual cycle, may be contributing to these population declines.

Considering the extent of modern agriculture, the effect that agriculture has had on bird populations, and the likelihood of continuing changes, conservation biologists need to understand how future changes in agriculture are likely to affect bird populations. Will some species continue to decline even without further changes in the landscape? Which species are most vulnerable? To address these questions and others, we review how agriculture has changed recently, how agricultural land-use practices affect particular bird populations, and what can be done to conserve species likely to be negatively affected by current and future practices.

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Table 1.—*Migratory status and habitat affinities of bird species that are (1) common in at least one habitat in agricultural landscapes; (2) midwestern species of management concern due to rarity, habitat specialization, or population trend; or (3) both. Habitat affinity codes are C (common) and x (use). (Cropland includes small grains, row crops, and hayland.)*

Common species[1] and species of concern[2]	Migratory status[3]	Cropland	Herbaceous habitats	Wooded habitats	Wetland
Common loon (*Gavia immer*)[2]	W				x
American bittern (*Botaurus lentiginosus*)[2]	W				x
Least bittern (*Ixobrychus exilis*)[2]	W				x
Trumpeter swan (*Cygnus buccinator*)[2]	W				x
Mallard (*Anas platyrhynchos*)	W				C
Blue-winged teal (*Anas discors*)	W				C
Northern shoveler (*Anas clypeata*)	W				C
Gadwall (*Anas strepera*)	W				C
Northern harrier (*Circus cyaneus*)[2]	B		x		
Northern goshawk (*Accipiter gentilis*)[2]	B			x	
Red-shouldered hawk (*Buteo lineatus*)[2]	B			x	
Peregrine falcon (*Falco peregrinus*)[2]	A		x		
Gray partridge (*Perdix perdix*)[4]	R		C		
Ring-necked pheasant (*Phasianus colchicus*)[4]	R		C	C	
Northern bobwhite (*Colinus virginianus*)	R			C	
Yellow rail (*Coturnicops noveboracensis*)[2]	W				x
Black rail (*Laterallus jamaicensis*)[2]	W				x
Virginia rail (*Rallus limicola*)	W				C
American coot (*Fulica americana*)	W				C
Upland sandpiper (*Bartramia longicauda*)[2]	A		x		
Common tern (*Sterna hirundo*)[2]	W				x
Least tern (*Sterna antillarum*)[2]	W				x
Black tern (*Chlidonias niger*)[2,5]	W				C
Rock dove (*Columba livia*)[4]	R			C	
Mourning dove (*Zenaida macroura*)	B			C	
Black-billed cuckoo (*Coccyzus erythropthalmus*)	A			C	
Yellow-billed cuckoo(*Coccyzus americanus*)[2]	A			C	
Barn owl (*Tyto alba*)[2]	R			x	
Burrowing owl (*Speotyto cunicularia*)[2]	A		x		
Short-eared owl (*Asio flammeus*)[2]	B		x		
Red-headed woodpecker (*Melanerpes erythrocephalus*)[2]	S			C	
Downy woodpecker (*Picoides pubescens*)	R			C	
Northern flicker (*Colaptes auratus*)[2]	B			C	
Olive-sided flycatcher (*Contopus borealis*)[2]	A			x	
Eastern wood-pewee (*Contopus virens*)	A			C	
Eastern kingbird (*Tyrannus tyrannus*)	A		C	C	
Horned lark (*Eremophila alpestris*)	B		C		
Barn swallow (*Hirundo rustica*)	A			C	
Blue jay (*Cyanocitta cristata*)	S			C	
American crow (*Corvus brachyrhynchos*)	S			C	
Black-capped chickadee (*Parus atricapillus*)	R			C	
White-breasted nuthatch (*Sitta carolinensis*)	R			C	
Bewick's wren (*Thryomanes bewickii*)[2]	S			x	
House wren (*Troglodytes aedon*)	A			C	
Sedge wren (*Cistothorus platensis*)[2]	B		C		C
Marsh wren (*Cistothorus palustris*)	B				C
Veery (*Catharus fuscescens*)[2]	A			x	

(*table 1 continued on next page*)

(*table 1 continued*)

Common species[1] and species of concern[2]	Migratory status[3]	Crop-land	Herbaceous habitats	Wooded habitats	Wet-land
Wood thrush (*Hylocichla mustelina*)[2]	A			x	
American robin (*Turdus migratorius*)	B		C	C	
Gray catbird (*Dumetella carolinensis*)	A			C	
Brown thrasher (*Toxostoma rufum*)	S			C	
Loggerhead shrike (*Lanius ludovicianus*)[2]	B			C	
European starling (*Sturnus vulgaris*)[4]	R			C	
Bell's vireo (*Vireo bellii*)	A			x	
Blue-winged warbler (*Vermivora pinus*)	A			x	
Golden-winged warbler (*Vermivora chrysoptera*)	A			x	
Yellow warbler (*Dendroica petechia*)[5]	A			C	
Blue-winged warbler (*Vermivora pinus*)	A			x	
Golden-winged warbler (*Vermivora chrysoptera*)	A			x	
Common yellowthroat (*Geothlypis trichas*)	A		C	C	C
Northern cardinal (*Cardinalis cardinalis*)	R			C	
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	A			C	
Indigo bunting (*Passerina cyanea*)	A			C	
Dickcissel (*Spiza americana*)[2]	A	C	C	C	
Rufous-sided towhee (*Pipilo erythrophthalmus*)[5]	B			C	
Bachman's sparrow (*Aimophila aestivalis*)[2]	S			x	
Chipping sparrow (*Spizella passerina*)	A			C	
Clay-colored sparrow (*Spizella pallida*)[5]	A		C		
Field sparrow (*Spizella pusilla*)[2]	S			C	
Vesper sparrow (*Pooecetes gramineus*)	B		C	C	
Lark bunting (*Calamospiza melanocorys*)[5]	A		C		
Savannah sparrow (*Passerculus sandwichensis*)	B		C		
Baird's sparrow (*Ammodramus bairdii*)[2,5]	A		C		
Grasshopper sparrow (*Ammodramus savannarum*)[2]	A	C	C	C	
Henslow's sparrow (*Ammodramus henslowii*)[2]	S		x		
Song sparrow (*Melospiza melodia*)	B		C	C	
Swamp sparrow (*Melospiza georgiana*)	B				C
Chestnut-collared longspur (*Calcarius ornatus*)[5]	B		C		
Bobolink (*Dolichonyx oryzivorus*)[2]	A	C	C		
Red-winged blackbird (*Agelaius phoeniceus*)	B	C	C	C	C
Eastern meadowlark (*Sturnella magna*)[2]	B		C	C	
Western meadowlark (*Sturnella neglecta*)	B		C	C	
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	A				C
Common grackle (*Quiscalus quiscula*)	S		C	C	C
Brown-headed cowbird (*Molothrus ater*)	B		C	C	
Northern oriole (*Icterus galbula*)	A			C	
American goldfinch (*Carduelis tristis*)	B			C	
House sparrow (*Passer domesticus*)[4]	R		C	C	

[1] The list of common species is from Best et al. (1995) unless otherwise indicated. Common species were those in which densities have exceeded 25 birds per 100 ha.

[2] USFWS (1995).

[3] A: breed in U.S. or Canada, winter south of U.S.
B: breed in U.S. or Canada, winter in U.S. and south of U.S.
S: short-distance migrants; not neotropical migrants (Gauthreaux 1992).
R: year-round resident species.
W: wetland bird, therefore not on the preliminary list of neotropical migratory landbirds (Gauthreaux 1992).

[4] Exotic species.

[5] Common according to Stewart and Kantrud (1972).

RECENT CHANGES IN AGRICULTURAL HABITATS AND LANDSCAPE STRUCTURE

The changes in agricultural landscapes that most concern conservation biologists are those that have occurred on a large spatial scale. We focus on changes in agricultural habitats in the last three decades, when bird population trends in the Midwest were well documented (Herkert 1995). The major habitats in the Midwest are crops, including small grains (wheat, oats, etc.), corn, soybeans, sunflowers, and forage (hay). Other habitats are pastureland and rangeland, wetlands, woodlands, and strip cover (e.g., fencerows, roadsides, waterways, terraces). Idle cropland is not explicitly considered a habitat in this section but is covered below under land-use practices. The amounts and relative proportions of cropland, pastureland and rangeland, woodland, and other rural land vary across the Midwest (table 2).

The total area of cropland in the Midwest in the early 1980's was similar to that in the late 1940's (Frey and Hexem 1985). There was a steady decline in cropland area, associated with surplus production, from the late 1940's to the mid-1970's. The area then increased until the early 1980's, as exports expanded. The pattern of change varied geographically. The area used for crops in the Northern Plains (Kansas, Nebraska, North Dakota, South Dakota) in the early 1980's was similar to that in the late 1940's. In the Corn Belt (Illinois, Indiana, Iowa, Missouri, Ohio), there was a dip in the mid-1970's but an increase of 9.5 percent between the late 1940's and early 1980's. In the Lake States (Michigan, Minnesota, Wisconsin), there was an increase of 2.1 percent over the same period. The area of active cropland in the Midwest declined again from 1982 to 1992, mostly due to enrollment of cropland in the Conservation Reserve Program (CRP; USDA 1994).

Analysis of data from the National Resources Inventory (NRI), which has been conducted since 1967, also demonstrates declines in cropland area in the Midwest between 1967 and 1977 and between 1982 and 1992 (fig. 1). Analysis procedures changed between 1977 and 1982, so inventory data before 1977 cannot be directly compared with data after 1982 (USDA 1990).

Table 2.—*Estimated land use (thousands of hectares) of non-federal, rural land in the 12 midwestern states in 1992 (USDA 1994). Pastureland includes rangeland and excludes grazed forested land. Land enrolled in the Conservation Reserve Program is included with other rural land.*

Region State	Cropland	Pastureland	Woodland	Other
Corn Belt				
Illinois	9,761	1,119	1,385	563
Indiana	5,473	756	1,469	481
Iowa	10,120	1,503	782	1,196
Missouri	5,406	4,875	4,721	944
Ohio	4,831	919	2,683	516
Total	35,590	9,173	11,039	3,701
Lake States				
Michigan	3,639	953	6,321	975
Minnesota	8,649	1,329	5,595	2,520
Wisconsin	4,379	1,196	5,431	1,301
Total	16,667	3,479	17,347	4,796
Northern Plains				
Kansas	10,759	7,302	539	1,444
Nebraska	7,792	10,017	315	865
North Dakota	10,021	4,655	173	1,693
South Dakota	6,657	9,757	219	1,319
Total	35,228	31,731	1,245	5,321

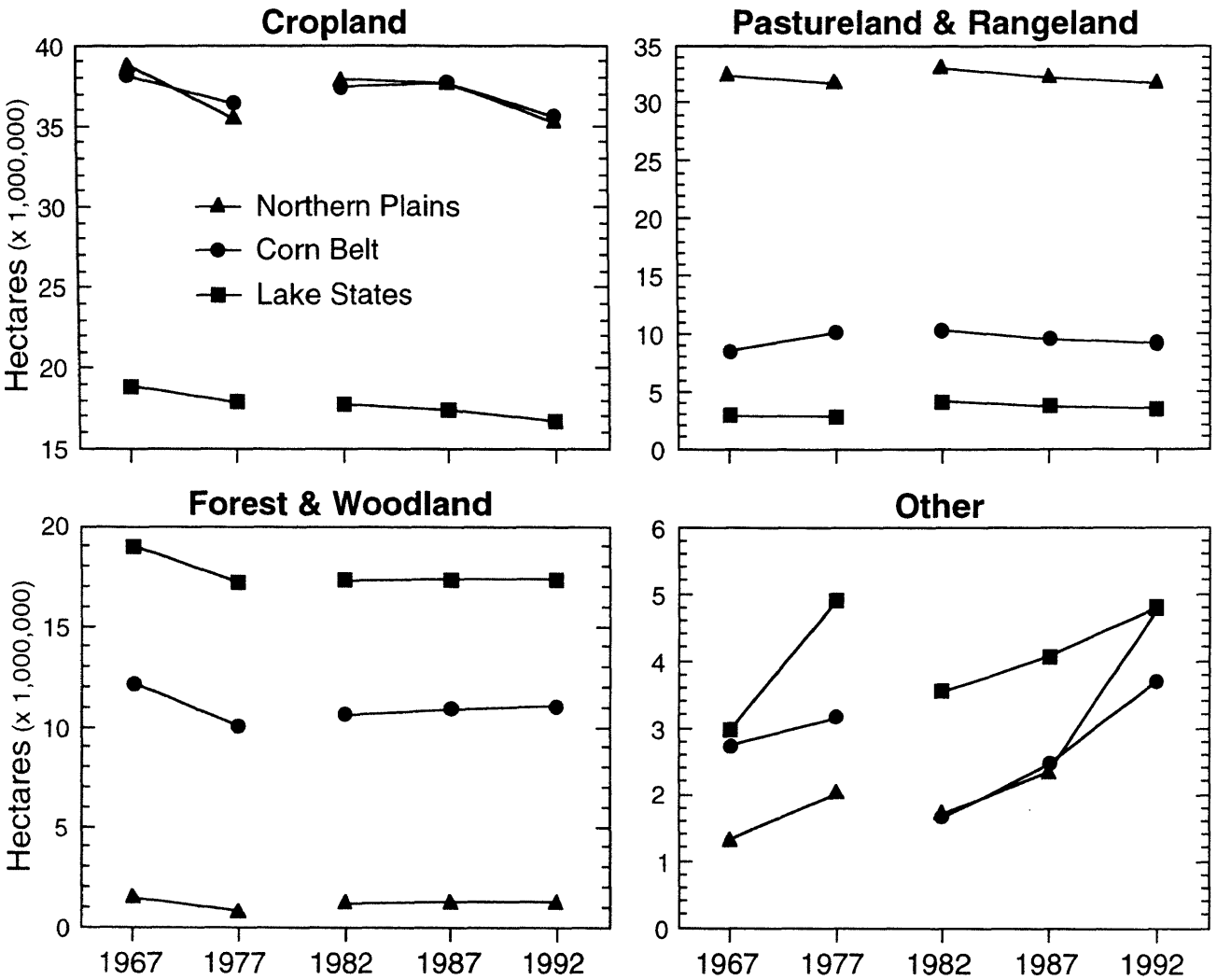

Figure 1.—*Recent changes in estimated land use of non-federal, rural land in three midwestern regions (USDA 1971b, 1982a, 1994). "Pastureland & Rangeland" excludes grazed forested land. Analysis procedures changed between 1977 and 1982, so inventory data before 1977 cannot be directly compared with data after 1982 (USDA 1990).*

With the exception of the CRP, changes in the total area of midwestern cropland have been relatively small, particularly during the last three decades, when the best bird survey data have been available. We focus on these decades in our presentation of changes at the level of major habitats.

Cropland Habitats

Small grains.—Wheat and other small grains are grown mostly in the Northern Plains. Wheat area increased in the 1970's and has remained relatively stable since then (fig. 2). The area planted to oats has declined by two thirds over the past three decades.

Corn and soybeans.—The area planted to corn in the Midwest declined in the 1960's, increased in the 1970's, then declined in the late 1980's (fig. 2). Soybean area increased steadily from the 1960's until the 1980's, then remained fairly stable. Corn and soybean area in Illinois reflected this pattern and increased from 4.9 million ha in 1945 to 8.4 million ha in the 1980's (Warner 1992). Corn and soybeans are usually grown in alternate-year rotation.

Sunflowers.—Sunflowers are grown mostly in North Dakota, South Dakota, and Minnesota (USDA 1993). Sunflowers are a relatively new crop in these states (fig. 2). The rapid increase

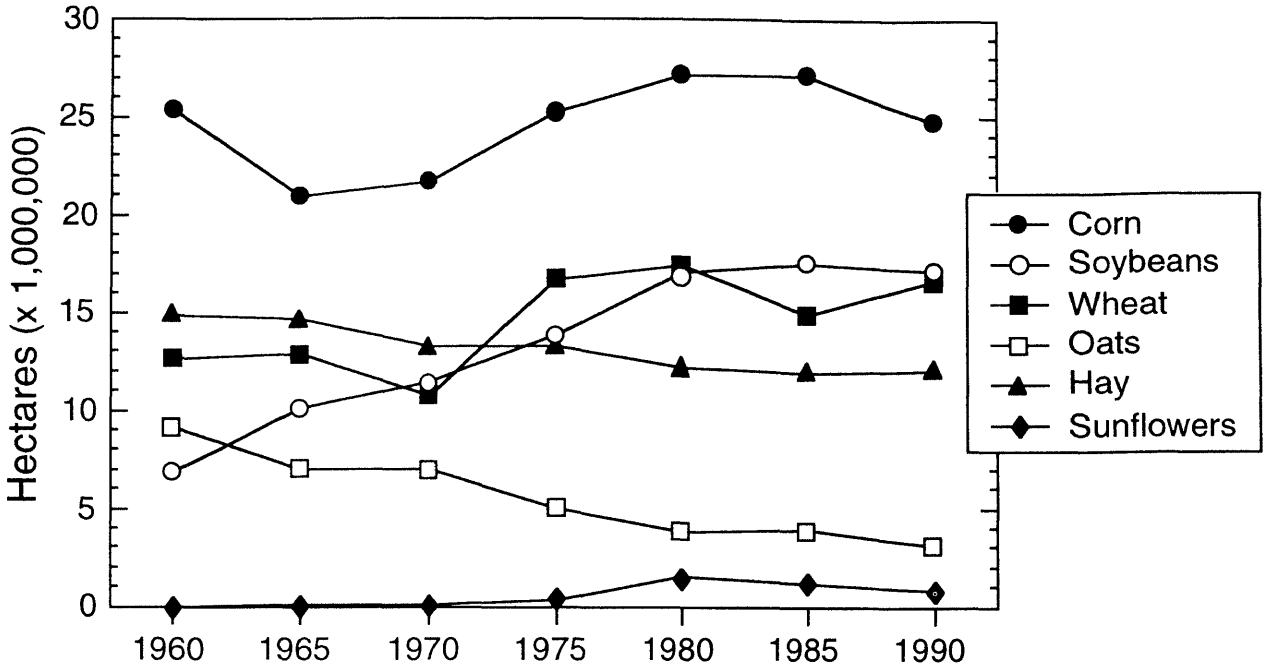

Figure 2.—*Recent changes in planted area of selected crops and harvested area of hay in the Midwest (USDA 1962, 1967, 1972, 1975, 1977, 1982b, 1987, 1991).*

in sunflower area was followed by a decline associated with increased worldwide production (McCormick *et al.* 1992).

Hayland.—After a decline in the late 1960's, the area of harvested hay in the Midwest has remained stable (fig. 2). Traditionally, livestock provided agricultural diversity for farmers who also raised crops, and hay was harvested from untilled prairie which was sometimes seeded with grasses. On tilled land, alfalfa is the primary hay crop. Herkert *et al.* (1996) discuss hayland further.

Non-cropland Habitats

Pastureland and Rangeland.—The general trend in the Midwest between 1982 and 1992 was toward less pastureland and rangeland; between 1967 and 1977 the trend varied geographically (fig. 1). Herkert (1995) reported a 53 percent decline in pastureland from 1964 to 1992 in Illinois, Iowa, Ohio, and Wisconsin. Pastureland is used primarily for production of forage plants for livestock and is typically managed by fertilization and reseeding, according to the instructions for reporting NRI data. Rangeland is land on which the climax or potential vegetation is grasses, forbs, and shrubs suitable for grazing; management does not usually include application of chemicals. Pastureland is more common in the eastern part of the Midwest and rangeland is more common in the western part. In Iowa, the amount of pastureland declined by 23 percent between 1958 and 1967 (Iowa Soil and Water Conservation Needs Inventory Committee 1970). Most of this converted Iowa land was classified as forest or cropland in 1967. At a national scale, too, much of the conversion to cropland prior to the 1980's was from rangeland and pastureland (Heimlich 1985).

Wetlands.—Wetlands are a prominent part of the natural landscape in the Prairie Pothole Region of North Dakota, South Dakota, Minnesota, and northern Iowa. Many wetlands have been connected to ditches or underground pipes (tile lines) to facilitate rapid drainage of cropland in the spring. Loss of original wetland area in the Midwest ranged from 164,211 ha in Kansas to 2,816,802 ha in Illinois (Dahl 1990). The percentage of wetland area lost ranges from 35-48 percent in the Northern Plains states, 42-50 percent in the Great Lakes states, and 85-90 percent in the Corn Belt. Wetlands are discussed further by Johnson (1996).

Woodlands.—Woodlands on midwestern farms are mostly riparian areas, woodlots, and shelterbelts. They are more abundant in the east (table 2). In Iowa, the amount of land classified as forest or woodland increased between 1958 and 1967 (Iowa Soil and Water Conservation Needs Inventory Committee 1970). Most of this land had previously been classified as pasture. Woodland habitat decreased in the Midwest from 1967 to 1977 but has been relatively stable since then (fig. 1). Below, we discuss shelterbelts as a form of strip cover under land-use practices. We do not consider riparian areas and woodlots further in this paper. Wooded, non-strip-cover habitats may be the only nesting habitats used by some woodland species, such as cerulean warblers (see other chapters, this volume).

Strip cover.—Some strip-cover habitats (e.g., fencerows) have declined in recent decades as the average size of crop fields has increased. Rodenhouse *et al.* (1993) reviewed information on loss of fencerows in midwestern agricultural regions and found that 30-80 percent of fencerows had been removed since the 1930's.

Landscape structure.—The habitats discussed here (small grains, corn, soybeans, sunflowers, hay, pastureland and rangeland, wetlands, woodlands, and strip cover) are arranged in landscapes that affect NTMBs (Freemark *et al.* 1995). Interspersion of habitat types, habitat-patch size, and other aspects of landscape structure can affect species composition, abundance, pairing and reproductive success, and population dynamics. Species richness and abundance of birds in farmland are greatest in grasslands, pasture, early-successional habitats, strip cover, and shelterbelts (Freemark *et al.* 1995). Recent declines in the areal extent of these habitats have led to a simplification, or reduction in diversity, of farmland landscapes in general (Warner 1994). In Ohio, for example, the percentage of farmland that was harvested increased from 45 to 67 percent between 1940 and 1982 (Barrett *et al.* 1990). The declines in these habitats also have been accompanied by a trend toward larger crop fields. As an indication of this trend, the average size of farms in the Midwest in 1970, 1980, and 1990 was 164, 183, and 206 ha, respectively (USDA 1971a, 1981, 1991).

EFFECTS OF LAND-USE PRACTICES ON NTMBs

The agricultural habitats that appear to have declined the most are pastureland and strip cover. These declines may have contributed to population declines of grassland and shrubland birds (Herkert 1995). Population declines also may be related to agricultural land-use practices. Land-use practices create, modify, and destroy habitat for various species. These practices include cultivation, chemical application, grazing, haying, idling cropland, and maintaining strip cover. Some of these practices have changed in recent years, but it is important to realize that a practice may be contributing to population declines (e.g., by providing poor nesting habitat) even if the extent of the practice has not changed. Here we consider each practice individually. The effects of such practices in combination (i.e., farmland structure) is covered elsewhere (Freemark *et al.* 1995, Rodenhouse *et al.* 1995).

Cultivation

Cultivation, or tillage, of soil is integral to the process of raising most crops. The amount of cultivation varies with the tillage system. Conventional tillage consists of tilling fields up to several times per year to prepare fields for planting and to control weeds after the crop has emerged. Little crop plant residue remains on the surface of the soil during the growing season. Tillage is often the main method of weed control in organic farming. Conservation tillage, defined by the Conservation Technology Information Center (CTIC), is any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water or, where wind erosion is the primary concern, maintains at least 1,000 pounds/acre of residue throughout the critical wind-erosion period (CTIC 1994). The types of conservation tillage are no-till, ridge-till, and mulch-till. Reduced tillage, which leaves 15-30 percent crop residue or 500-1000 pounds/acre of residue, is a form of crop residue management but is not currently considered conservation tillage (CTIC 1994).

Cultivation affects birds in several ways (Best 1985, Rodenhouse *et al.* 1993). The amount of cultivation of rowcrop fields influences bird use by affecting the amount of crop residue on the surface of the soil (Rodenhouse and Best 1983, Basore *et al.* 1986). An immediate effect of cultivation may be to expose arthropods and other prey to foraging birds, etc. A more lasting effect, however, is a reduction in abundance of the litter-dwelling arthropods that are prey items for many birds. Conventionally tilled fields have lower arthropod abundance than no-till fields or idle areas except during pest outbreaks in the crop (Hendrix *et al.* 1986). Early summer cultivation also can disrupt nesting activity, destroying nests or causing nest abandonment (e.g., Rodenhouse and Best 1983).

The extent of conservation tillage has increased in recent years. Using a slightly different definition of conservation tillage from that in CTIC (1994), CTIC (1983) reported that conservation tillage was used on 10 percent of U.S. cropland in 1982 and reduced tillage on another 14 percent. Conservation tillage increased from 28 to 40 percent of the planted area in the Midwest between 1990 and 1994 (CTIC 1994). This increase occurred throughout the Midwest (fig. 3). Reduced tillage was used on another 24 percent of the planted area in the Midwest in 1994 (CTIC 1994). This increase in conservation tillage is an important contribution to sustainable agriculture (Barrett *et al.* 1990). Other contributions are organic farming, alternative crops, and strip intercropping.

Castrale (1985) compared conventionally tilled fields (corn and soybeans) with no-till fields in Indiana and found one third more bird species on the no-till fields during the summer. No-till fields had greater total bird abundance, and the eight most common species were more abundant on no-till fields. Killdeer and horned larks were more abundant on conventionally tilled fields. No-till fields are also more attractive than tilled fields to most NTMBs in Iowa (Basore *et al.* 1986) and Illinois (Warburton and Klimstra 1984).

Chemical Application

Application of herbicides can affect birds by reducing the availability of seeds. Herbicides and insecticides reduce the abundance and diversity of litter- and foliage-dwelling arthropods (Rodenhouse *et al.* 1993). Pesticides also can cause acute or sublethal effects on birds. Gard and Hooper (1995) reviewed

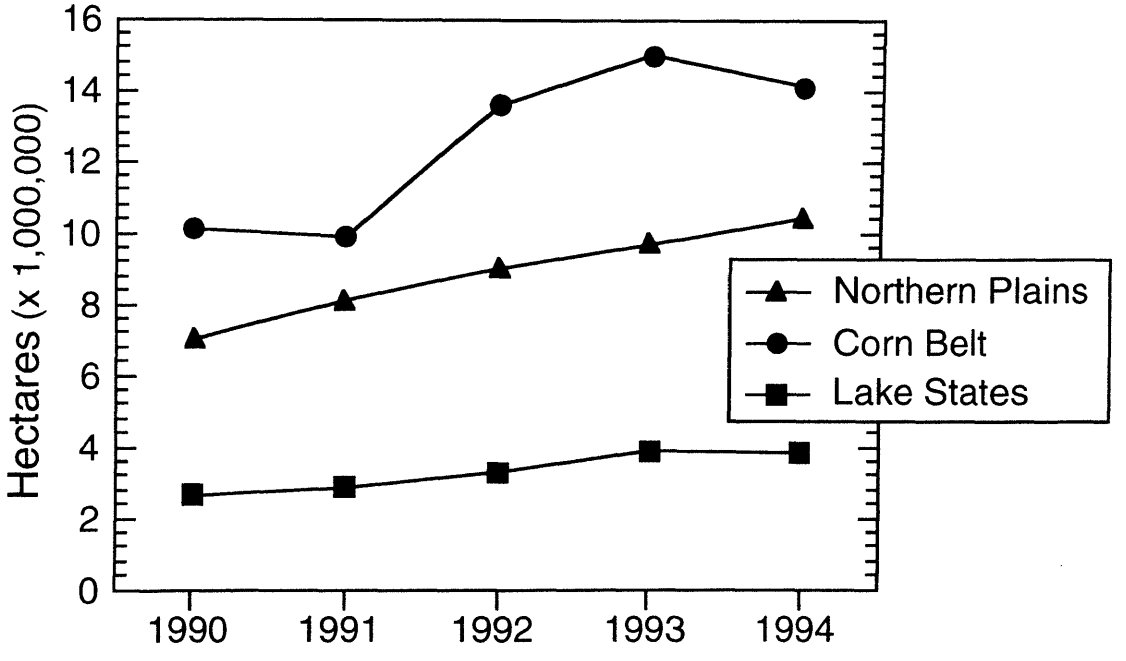

Figure 3.—*Recent changes in estimated extent of conservation tillage in three midwestern regions (CTIC 1994).*

the effect of pesticides and contaminants on NTMBs and pointed out that the effects on populations are poorly understood. Insecticides and contact herbicides are the main methods of weed and insect control in no-till fields (Castrale 1985, Wooley *et al.* 1985).

Grazing

Grazing by livestock can have direct and indirect effects on NTMBs. Nests can be lost from trampling if stocking rates are high (Jensen *et al.* 1990). Grazing also can affect the avifauna composition by altering vegetation structure (Skinner *et al.* 1984). Grazing effects are discussed further by Herkert *et al.* (1996).

Haying

Mowing hay drastically alters the structure of the vegetation, which affects species differently depending on their habitat preferences (Frawley and Best 1991). Mowing hay also can cause nest losses as well as mortality of fledglings and adults (Frawley 1989, Rodenhouse *et al.* 1993). If mowing is frequent, many birds may not be able to complete their nesting cycles. Haying is discussed further by Rodenhouse *et al.* (1993, 1995) and Herkert *et al.* (1996).

Idling Cropland

Little farmland in the Midwest is idled unintentionally because the land is generally very productive. In 1987, 11 percent of the farmland in the midwestern states was idle cropland (USDA 1993). Most of this land was idled by federal cropland-retirement programs. Annual set-asides are used to adjust the planted area in an attempt to influence the supply of various crops. Also, there have been multiple-year retirement programs, such as Soil Bank and the CRP (Harmon and Nelson 1973, Berner 1988).

Few NTMBs are likely to benefit from annual set-asides. On annual set-asides in Illinois (R. Warner, Univ. of Illinois, Urbana, pers. comm.) and Iowa (L. B. Best, pers. observ.), the most commonly planted vegetation is oats (*Avena sativa*), in which few bird species nest (Best *et al.* 1995). Furthermore, the value of this vegetation as nesting habitat is limited if it is planted late in the nesting season because nesting cover is not established when breeding begins. For example, Warner (pers. comm.) found that, in the 1980's, very little hay and oats persisted over the winter; therefore, very little of this vegetation was well established in the spring. In contrast, half or more of this vegetation persisted over the winter in the 1960's and early 1970's. An additional limitation in this habitat is that mowing destroys some of the nests that are initiated. Finally, the great spatial and temporal variability of this habitat means that philopatric birds may not find suitable nesting habitat in the same place from year to year.

Land enrolled in multiple-year retirement programs, on the other hand, generally has significant value for wildlife species (Harmon and Nelson 1973). Recent work has documented use of CRP fields by NTMBs. Surveyed CRP fields in western Minnesota, North Dakota, South Dakota, and eastern Montana had high species richness and high abundance of some NTMBs compared with cropland (Johnson and Schwartz 1993a). Many of the species that were more abundant in CRP fields had declined in the central U.S. in the quarter century before the CRP era (Johnson and Schwartz 1993b). Lark buntings and grasshopper sparrows, for example, were the most abundant species in CRP fields, and their populations declined substantially during this period. In contrast, species that were more abundant in cropland than in CRP fields had been relatively stable before the CRP era. These findings suggest that the CRP may have benefited many NTMBs that nest in grassland, assuming that the CRP boosted reproduction.

Nest success in CRP fields is comparable or higher than that in some other habitats. Bird use of CRP fields (exotic, cool-season grasses) differed from use of reduced-tillage, rowcrop fields (Patterson and Best 1996). The most abundant species in CRP fields were red-winged blackbirds, dickcissels, grasshopper sparrows, and bobolinks. Horned larks and vesper sparrows were the only species found nesting in rowcrop fields. In CRP fields, nest success (Mayfield estimate) was 34 percent for ring-necked pheasants, 14 percent for dickcissels, 16 percent for vesper sparrows, 30 percent for grasshopper sparrows, and 15 percent for red-winged blackbirds (based on at least 27 active nests for each of these five species). These estimates were higher, in general, than estimates from alfalfa fields and strip-cover habitats, indicating that CRP fields are better nesting habitat than many of the alternative habitats (Patterson and Best 1996).

Nest success in CRP fields also may be comparable to that in pastureland, although some CRP fields attract fewer species and individuals than some pastureland. Nest success did not differ significantly between CRP fields (native grasses) and grazed, native-vegetation pastures in Kansas (Granfors 1992, Klute 1994). Nest success (Mayfield estimate) was 11 to 25 percent in eastern meadowlarks and 6 to 12 percent in dickcissels. Avian abundance in native-grass CRP fields was lower than that in moderately grazed, native-vegetation pastures (Klute 1994). Other CRP fields in the same area, however, had greater grass cover and greater bird abundances than those used in the pasture comparison (Hull 1993).

It is important to recognize that the habitat structure of CRP fields changes over time. Older CRP fields in Michigan tended to have lower avian abundance and diversity (Millenbah 1993). The cover on older fields was more dense and these fields had less bare ground than younger fields.

Maintaining Strip Cover

Strip cover provides habitat for most of the NTMBs of agricultural landscapes because it is used by birds requiring either herbaceous or woody vegetation (table 1). These areas, which include grassed waterways, terraces, fencerows, roadsides, and windbreaks/shelterbelts, usually provide habitat that is more long term than that provided by areas enrolled in cropland-retirement programs. Food (e.g., arthropods, weed seeds) is often more abundant in strip cover than in crop fields, and complex vegetation structure provides nesting sites, song perches, and cover (Rodenhouse *et al.* 1993). Many of these habitats are associated with conservation practices used to control soil erosion, such as crop rotation, terraces, contour planting, strip intercropping, grassed waterways, and windbreaks. Some kinds of strip cover are subject to disturbances such as mowing. During the past few decades, the average size of cropped fields has increased, reducing the amount of strip-cover habitat (Rodenhouse *et al.* 1995).

Grassed waterways are heavily used by birds. These waterways are natural drainage systems or channels constructed to transport water off crop fields at a non-erosive velocity. Various grass species are planted in these waterways to slow the flow of water. In Iowa, 48 bird species used grassed waterways, compared with only 14 in surrounding rowcrop fields (Bryan and Best 1991). The most abundant bird species using waterways were red-winged blackbirds, dickcissels, barn swallows, grasshopper sparrows, brown-headed cowbirds, song sparrows, and western meadowlarks. Total bird abundance in waterways averaged 2,198 birds/census count/100 ha, compared with 682 for crop fields. Eleven bird species nested in the grassed waterways; red-winged blackbird and dickcissel nests were most common (Bryan and Best 1994). Considering nests of all species, more than twice as many nests were found in forbs as in grass. Sweetclover (*Melilotus* spp.) and curly dock (*Rumex crispus*) were predominant nest substrates. Orientation of crop rows relative to the waterway influenced agriculture-related disturbance. Nest densities were greater when the rows paralleled the waterways. Nest success (Mayfield estimate) of red-winged blackbirds and dickcissels in waterways was 8.4 and 22.0 percent, respectively. Predation was the most common cause of nest loss (57 percent of all nest losses), followed by mowing (16 percent).

The practice of planting and maintaining grassed waterways clearly provides habitat for a variety of NTMBs. Mowing, however, affects the quality of this habitat. Mowing alters the structure of the vegetation, which in turn may affect the bird community. Dickcissels, common yellowthroats, and red-winged blackbirds preferred to nest in waterways with tall (>60 cm) grass cover, whereas nest densities of vesper sparrows were greater in mowed waterways (Bryan and Best 1994). Grasshopper sparrows nested only in waterways that had been mowed the previous year; sedge wrens nested only in waterways that had not been mowed the previous year. The timing of mowing also may affect populations. Birds that have been displaced from mowed hayfields may move into grassed waterways with suitable vegetation structure. Mowing waterways at the peak or late in the nesting season may interfere with some birds' last nesting attempt of the season.

Terraces are another kind of strip cover that results from conservation-oriented land use in cropland. Wildlife use of terraces is poorly known but has been examined by D.W. Beck (USDA Soil Conservation Service, Des Moines,

Iowa, unpubl. data). Beck observed 13 bird species using grassed backslope terraces and found evidence of nesting by mallards, dickcissels, vesper sparrows, red-winged blackbirds, and ring-necked pheasants.

Fencerows are linear habitats that separate agricultural fields with a fenceline and associated vegetation. Best (1983) examined bird use of fencerows with only herbaceous vegetation, herbaceous vegetation with scattered woody plants, and continuous woody vegetation. The number of species was greatest in the continuous woody type and least in the herbaceous type, regardless of season.

In Michigan, 16 species nested in herbaceous and woody fencerows; nest density in fencerows was 43.5 nests/ha (Shalaway 1985). Fencerow width, adjacent field type, and area of open shrubs (i.e., <50 percent shrub cover 1.5-2.0 m above the ground) most influenced nest density. Wider fencerows, which were more heterogeneous and had greater shrub coverage than narrow fencerows, supported greater nest densities. Fencerows bordered by old fields had more nests than those bordered by crop fields. Nest density and abundance increased with shrub abundance. Song sparrows, American robins, northern cardinals, red-winged blackbirds, gray catbirds, brown thrashers, northern flickers, and ring-necked pheasants were the most frequent nesters in fencerows. Apparent nest success (successful nests/active nests) in fencerows was 58 percent overall. Raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), and long-tailed weasels (*Mustela frenata*) were responsible for most nest losses. Nest success was lower for larger, ground-nesting game birds than for passerines nesting on or above the ground.

Herbaceous cover along roadsides is used by many species. In Iowa, 35 bird species were observed in roadsides compared with 26 species in adjacent rowcrop fields (Camp and Best 1993). Grass was the dominant vegetation in roadsides and forbs were uncommon. Increased diversity of roadside vegetation can increase bird species richness (Paruk 1990, Warner 1992). Abundance of some bird species in roadsides was related to vegetation height and vertical density (Camp and Best 1993). Both of these vegetation characteristics are influenced by burning and the composition of grasses (exotic vs. native). The number of bird species observed was inversely related to grass coverage and directly related to the amount of bare ground (Camp and Best 1993). Red-winged blackbird nests were the most common, and nest success (Mayfield estimate) was 26 percent. Predation was the main cause of nest failure, accounting for the fate of 52 percent of all active nests. Mowing appeared to benefit some species; vesper sparrows and meadowlarks nested on mowed roadside shoulders.

In Illinois roadsides, 92 percent of all passerine nests were of red-winged blackbirds; other nesting species included dickcissels, brown thrashers, eastern meadowlarks, grasshopper sparrows, vesper sparrows, song sparrows, and sedge wrens (Warner 1992). Nest densities in roadsides were affected by the kind of habitat in the vicinity of the roadside. The number of passerine nests in roadsides was higher in years in which a smaller proportion of the study area was planted to small grains, presumably because less of the non-roadside habitat was suitable for nesting. Within years, the 4-mi^2 study plot with the most grassland area had the highest density of passerine nests in linear, grassland habitats. Similarly, roadside study plots with the highest density of pheasant nests were near other prime nesting habitats such as hay (Warner and Joselyn 1986, Warner *et al.* 1987). In Iowa, the highest densities of red-winged blackbirds were found in roadsides adjacent to idle grasslands and hayfields (M. K. Koob and L. B. Best, Iowa State Univ., Ames, unpubl. data).

Densities of passerine nests in Illinois roadsides also were affected by characteristics of the roadsides (Warner 1992). Nest densities were greater in interstate roadsides than in secondary roadsides and increased with width of the roadside. Nest densities were four to five times greater in interstate roadsides dominated by brome-alfalfa (*Bromus inermis-Medicago sativa*) than in those dominated by fescue (*Festuca* spp.). There were over six times more passerine nests on managed (mowing deferred until 1 August) than on unmanaged (frequently mowed) secondary roadsides. In this Illinois study, as in the Iowa study (Camp and Best 1993), mowing was confined to the roadside shoulders; the sloped sections were left unmowed.

Higher nest densities in a particular landscape do not necessarily indicate that a species is doing better there; high densities could lead to lower nest success. Ring-necked pheasants in Illinois had low annual nest success in linear habitats (farmland corridors and managed roadsides) in years with low amounts of grassland (strip-cover habitats, forage crops, small grains) per hen in the spring (Warner 1994). Also, nest success in roadsides was lower in years with high nest densities than in years with low densities (Warner *et al.* 1987). Similar findings have not been reported for passerines.

Shelterbelts are a common feature of midwestern landscapes (Johnson and Beck 1988). For many decades, federal agencies have encouraged farmers to plant shelterbelts or windbreaks to decrease wind erosion and to protect crops, livestock, and farmsteads. Establishment of shelterbelts can provide positive economic returns (Brandle *et al.* 1992). Shelterbelts usually consist of one to five rows of trees and shrubs (Capel 1988) but can be much wider, especially around farmsteads. Because shelterbelts usually contain trees, they provide habitat for forest and forest-edge species.

In North Dakota, at least 64 species of birds are known to have bred in shelterbelts or tree claims (trees planted by homesteaders) (Cassel and Wiehe 1980). The most common species were the brown thrasher, mourning dove, vesper sparrow, least flycatcher, eastern kingbird, black-billed cuckoo, yellow warbler, American goldfinch, gray catbird, clay-colored sparrow, and American robin. The vesper sparrows and American goldfinches were presumably not nesting in the shelterbelts (see Yahner 1982). Yahner (1982, 1983a) recorded 87 bird species using farmstead shelterbelts in Minnesota and documented nesting in 17 of these. In South Dakota, the number of bird species increased with shelterbelt area both during spring migration and during the breeding season (Martin 1980, 1981). The density and diversity of breeding birds was significantly correlated with both the age and size of shelterbelts in North Dakota (Cassel and Wiehe 1980).

The configuration of shelterbelts can affect the species composition of the avifauna. Shelterbelts with only a few rows of woody plants attracted more birds associated with open habitats, whereas those with many rows attracted more birds associated with forested habitats (Cassel and Wiehe 1980). Yahner (1983a), however, provided correlations between variables describing vegetation structure and avian community or population variables in shelterbelts and found that the perimeter and length of shelterbelts were associated more often with measures of community structure than were area and width of shelterbelts.

The avian species composition of shelterbelts also can be affected by vegetation structure and landscape context. Martin and Vohs (1978) found the highest bird species diversity in South Dakota shelterbelts with developed tree canopies and lush grass layers; dense shrub growth under the trees was not preferred. In Minnesota, vegetation structure was a major factor determining bird community structure in shelterbelts, with older belts having lower densities of shrubs, higher densities of trees, and greater bird species richness (Yahner 1983a). Distance to wooded and old-field habitats, and the amount of cropland and pastureland surrounding shelterbelts, influenced which birds were found in shelterbelts. A concentration effect occurred in isolated shelterbelts, which were more likely to have certain species, probably because of the paucity of similar habitat in the vicinity. In addition to species occurrence, it is important to examine nest success (Yahner 1982, 1983b). Apparent nest success (successful nests/active nests) of mourning doves and American robins in shelterbelts was 32 and 56 percent, respectively.

Additional perspectives on shelterbelts can be found in several papers. Johnson and Beck (1988) reviewed shelterbelt management and wildlife. They classified bird species on the basis of how much they benefit from shelterbelts and discussed characteristics of shelterbelts that relate to wildlife use. Schroeder (1986) presented a Habitat Suitability Index model for wildlife species richness in shelterbelts which reliably predicts species richness over much of the Great Plains (Schroeder *et al.* 1992). Podoll (1979) distinguished between shelterbelts as a habitat that is essential for some species but merely used by other species. Johnson (1996) points out that trees may have detrimental effects on prairie birds.

CONSERVATION STRATEGIES

This review suggests that current agricultural practices are contributing to population declines of farmland birds, although not necessarily to the exclusion of factors acting during migration and on the wintering grounds. Other investigators have reached similar conclusions (e.g., Rodenhouse *et al.* 1993, 1995; Herkert 1994, 1995; Warner 1994). Recent population declines could be due mainly to loss of habitat (Rodenhouse *et al.* 1995) or to a combination of loss of habitat and degradation of habitat (e.g., low nest success or survival rates in attractive habitats and landscapes). Conservation measures to deal with these declines will depend on the relative importance of habitat loss and degradation, the objectives of a conservation strategy, the costs of implementing a strategy, and the feasibility of the strategy.

Owners and operators of farms can implement agricultural practices that will benefit NTMBs on midwestern farmland. Many farmers appreciate having non-pest bird species on their farms and nearby. If farmers are forced to choose, however, between economic survival and having wildlife to observe and hunt, they will choose survival. Even in situations in which economic survival is not at stake, farmers will consider costs. It is in these situations where information and education (e.g., university extension) may make the difference in favor of wildlife generally and NTMBs specifically. Here we take the practical approach of recognizing that recommendations for farmland must be aimed at a broad audience that includes private landowners as well as professional wildlife managers. We offer three objectives that we believe will have broad support, review a general framework that likewise should have broad support, and summarize specific recommended modifications to current agricultural practices.

Objectives

A primary objective of a conservation strategy for NTMBs in midwestern agricultural landscapes should be to conserve the remnants of prairie and savannah that still exist. Most of the prairie has been lost (Samson and Knopf 1994), increasing the value of the remnants. Although restoration of midwestern prairie and savannah ecosystems on a large scale is impractical, the remnants can be used for biological investigations, ecological education, and core areas for additional restoration. Although the persistence of grassland and open-woodland birds in the Midwest may not depend on these remnants, it is important for the conservation of biodiversity in general to save or restore representative natural ecosystems with a large proportion of their native flora and fauna. Of similar importance are the remnant woodlands, riparian areas, and wetlands required by a variety of bird species (Best *et al.* 1995, table 1).

A second objective of a conservation strategy should be to ensure the population viability of species that are (1) listed under the Endangered Species Act (ESA), (2) listed by individual states, or (3) are of special concern to managers because their populations are declining or vulnerable (USFWS 1995). Forty-one of these species occur in midwestern farmland (table 1). Investments that could prevent listing of additional species under the ESA may be economical in the long run, given the costs of listing, preparing recovery plans, etc. Beyond this practical reason, drastic population declines of rare species will result in loss of these species from some ecosystems, which may affect ecosystem functioning and be undesirable for other reasons (Wiens and Dyer 1975, Ehrlich and Mooney 1983, Saunders *et al.* 1991, Chapin *et al.* 1992, Baskin 1994).

A third objective should be to identify priority species or groups of species beyond those identified under the second objective. A different conservation strategy for these NTMBs might be called for, depending on whether the primary concern is for reversing population declines or for promoting biodiversity. Some species may require large blocks of grassland habitat (Herkert 1994); others may benefit from increased availability of edge habitat in the form of strip cover. Ideally, management can benefit all groups (Tome *et al.* 1994).

General Framework

Identification of sources and sinks (Wiens and Rotenberry 1981, Pulliam 1988) is an important step in implementing a conservation strategy for NTMBs in farmland (Rodenhouse *et al.* 1993). This step has been taken for forested habitats in the Midwest (Donovan *et al.* 1995). Many managers now understand that creating attractive habitat may not necessarily benefit target species if that new habitat is a sink for

those species. The review by Rodenhouse *et al.* (1993) of nest success in farmland indicates that few species are known to be reproducing at levels sufficient to balance estimated mortality. Even the nest success estimates in CRP fields and moderately grazed pastures, reviewed in the "Idling cropland" section, are not encouraging.

After sources and sinks have been identified, habitat, land-use, and landscape features that distinguish them can be examined to determine which features contribute to differences in vital rates. Such analyses can lead to recommended practices that will change the attractiveness of sources and sinks or increase individual fitness in them. Simulation modeling can be useful in evaluating potential actions (e.g., Cowardin *et al.* 1983). Finally, after actions have been taken, the status and trends of target species or guilds should be monitored to evaluate the results. All of this can be done in the context of a comprehensive framework for conservation and management planning (Freemark *et al.* 1993, 1995). A major limitation of this process is our incomplete understanding of factors affecting population dynamics and ecosystem functions in agricultural ecosystems.

Specific Recommendations

Rodenhouse *et al.* (1993) made the insightful observation that farming might develop along two tracks. Small, owner-operated farms would predominate close to urban centers where farm families could obtain supplemental income. These farms would provide habitat for many NTMBs because expensive inputs (large machinery, fuel, inorganic fertilizer, and pesticides) would be minimized and farming would be diversified. Large, externally owned farms would exist in rural areas with the most productive soil. These would be intensively managed and provide little non-crop habitat. These tracks certainly seem reasonable, considering current economic conditions in the Midwest.

Agricultural practices on larger farms may best be influenced by modifying agricultural programs and policies. These farms can be expected to attract species nesting in cultivated fields: horned larks, vesper sparrows, and killdeer. Although these species are not common in cropland (table 1), their cropland habitat is very extensive. Populations of these species are large. Monitoring of population trends of these species should continue. As long as their populations are relatively stable (Johnson and Schwartz 1993b), these species should not receive high conservation priority. Vesper sparrow populations have declined recently in parts of the Midwest, according to data from the North American Breeding Bird Survey, and have low nest success in Iowa (Perritt and Best 1989).

Smaller farms should be encouraged to enhance the attractiveness of their land to NTMBs, especially grassland birds that have declined in recent decades, such as grasshopper sparrows and bobolinks. Long-term set-aside, such as the CRP, provide much of the grassland habitat in the Midwest today and should be encouraged. A wide variety of other species, including woodland species, also can benefit from farmland (table 1). The following recommendations are organized by agricultural practice, as covered above.

Cultivation.—Tillage should be minimized. Rodenhouse *et al.* (1993) recommended that crop residue be retained on the soil surface, which could be done by reducing the number of times a field is cultivated annually and by using subsurface tillage where appropriate. A greater variety of NTMBs may be attracted by increasing the diversity of crops grown, especially if the structure of the vegetation is quite different. Crop diversity also will contribute to sustainable agriculture (Barrett *et al.* 1990).

Grazing.—Grazing is not incompatible with a diverse avifauna. Moderate grazing of pastures may enhance local habitat diversity. It has been suggested, however, that public grasslands managed for wildlife should benefit species that prefer habitat that is in relatively short supply; that is, grassland that is not frequently grazed or hayed (Kirsch *et al.* 1978). This recommendation could be extended to private land in the Midwest. Each grassland species has a particular kind of preferred vegetation for nesting (Owens and Myres 1973, Skinner *et al.* 1984), facilitating management for particular groups of species. Further grazing recommendations are in Herkert *et al.* (1996).

Haying.—Haying appears to be a major problem for NTMBs because hayfields have low nest success (Frawley 1989, Bollinger *et al.* 1990). They are highly attractive to certain

species, but the cutting interval is usually too short to allow complete nesting cycles. Rodenhouse *et al.* (1993) recommended that spring mowing be delayed as long as possible, nighttime mowing be avoided, and the intervals between mowings be as long as possible. Additionally, hayfields with warm-season grasses should be encouraged because they would be cut later in the year than alfalfa. Further recommendations are in Herkert *et al.* (1996).

Idling cropland.—Idled cropland would seem to require relatively little management because it already attracts a variety of species. Practices such as mowing or burning, however, could modify many areas and change the composition of the avifauna. Mowing during the nesting season can lower nest success substantially. It may be possible to enhance bird reproduction and survival by changing the amount and configuration of idle land; nest success may be higher in block habitats than in linear ones with proportionately more edge habitat. In a Minnesota study, nest success in tall-grass-prairie remnants was lower near woody edges than it was farther from such edges (Johnson and Temple 1990). Finally, if certain kinds or configurations of idled cropland are found to be source habitats, they should be strongly encouraged to counteract the many apparent sinks in agricultural landscapes.

Patterson and Best (1996) examined bird use of CRP fields that differed in structure and composition of vegetation and made recommendations aimed at benefiting grassland birds. The species composition of the vegetation should be based in part on vegetational attributes that attract birds. A wider variety of planted species than has been used in the past would enhance bird use. Mowing of weeds should be done after the peak of the nesting season. Some large tracts of habitat should be maintained for the benefit of area-sensitive species. Other recommendations could be added to their list. Grazing may enhance species richness if the structural diversity of the habitat is increased. Prescribed burning, every few years, is often recommended for other grassland habitats to maintain attractive nesting cover and presumably would benefit birds using CRP fields. Multiple-year programs, such as the CRP, appear to offer many more benefits to NTMBs than annual set-aside programs. Grassland cover that is at least a year old is established well enough in the spring, when migratory birds arrive, to attract breeding pairs. After a few years, vegetative and sexual reproduction by plants fills in gaps from the initial seeding, increasing the height and density of vegetative cover.

Maintaining strip cover.—Recommendations for strip cover depend on whether management is intended to favor grassland species or edge species. Management for the former should favor herbaceous cover. The benefits to NTMBs of permanent herbaceous cover can be enhanced by changing common practices. Timing of mowing of grassed waterways should be considered. Because peak nesting in grassed waterways occurred in July in Iowa, Bryan and Best (1991) recommended that mowing in waterways be deferred until the end of August or early September. Fall mowing is not recommended because residual cover would be reduced in the subsequent winter and spring, and annual mowing is discouraged (Bryan and Best 1994).

Beck (unpubl. data) found several factors that decreased wildlife use of grassed-backslope terraces, such as steeper backslopes, poor grass stands, narrow width, grazing, and herbicide drift. He suggested that improved management might involve flattening backslopes, improving grass stands, improving grazing management, and planting alternative vegetation.

If herbaceous vegetation on roadsides is mowed, it should be mowed in mid-to-late August (Camp and Best 1993). Also recommended is prescribed burning in the spring every 3 to 5 years. Both mowing and burning should be conducted in blocks to ensure that some portions of roadsides are undisturbed at any time. Fencelines should be retained along roadsides because roadsides with fencelines are less susceptible to agricultural encroachment and fencelines provide singing perches for birds. Mowing roadside shoulders provides nesting habitat for some species, but mowing should be restricted to early spring and late summer to reduce nest losses.

An adoption model for roadside (and other) habitat management involves farm operator attitudes and perceptions (Warner 1983). Warner (1992) made the following roadside management recommendations for grassland

birds: (1) fescue and bluegrass (*Poa*) sods should be seeded to brome-alfalfa and/or native grasses and forbs, (2) mowing should be delayed until after 1 August, (3) widths of roadside tracts should be maximized where possible, and (4) the establishment and protection of woody plants should be encouraged. In areas where brown-headed cowbirds are abundant, the effect of woody plants on frequency of brood parasitism will have to be considered carefully. The prescribed burning recommended by Camp and Best (1993), which would slow the establishment of woody plants, could be used in areas where woody plants were not desired. They also noted that bird use of roadsides with well-established native vegetation has not been evaluated. Such roadsides may become more prevalent in the future as the agencies charged with managing roadside vegetation seek methods that will benefit wildlife and minimize invasion of weeds.

Managing for breeding, edge species should be focused on providing diverse habitat in which nest success can potentially be high. Fencerows should be >3m wide, according to the recommendation of Shalaway (1985), who worked in Michigan. This would allow for greater shrub/tree growth and potentially reduce the likelihood of nest predation. Farther west, where brown-headed cowbirds are more abundant, the possible enhancement of habitat for this species would have to be considered. Shalaway (1985) also suggested that selective mowing and woodcutting in fencerows can create a mosaic of vegetation types attractive to a variety of birds. He also recommended retaining or creating at least 1 to 2 large snags per km of fencerow. Artificial nest-boxes may attract eastern bluebirds and tree swallows (Robertson *et al.* 1992), both NTMBs.

Management recommendations for shelterbelts, given by Yahner (1983a), include: establish shelterbelts at least 0.6 ha in area and 8 rows in width, consider proper spacing within and between rows, use a diversity of plantings, discourage livestock grazing, discontinue mowing and cultivation after the shelterbelt becomes established, and retain snags as nesting and foraging sites.

General.—Our final recommendation is that biologists and managers strive to improve their working relationships with private landowners and the organizations that represent them. The concept of benefiting NTMBs in agricultural landscapes is different from much of traditional wildlife management, which has focused on managing land controlled by state and federal governments. Those seeking to benefit NTMBs can learn from those who have sought to benefit ducks and upland game species, most of which occur on private land. Many game managers have learned the value of education, outreach, and attention to landowner concerns. Progress may require compromise and consideration of large-scale solutions, such as influencing agricultural policy. The recent efforts to renew the CRP brought together many wildlife and farming organizations that shared a common interest. Serious consideration has been given to the major effects of agricultural policies on wildlife in agricultural landscapes (Risley *et al.* 1995). With enhanced communication, sound science, and a common conservation strategy, we are confident that farmers and wildlife can continue to coexist in the Midwest.

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