MANAGEMENT OF MIDWESTERN GRASSLAND LANDSCAPES FOR THE CONSERVATION OF MIGRATORY BIRDS

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ABSTRACT.—Declines of Midwestern grassland birds and habitats point to the need for heightened conservation attention for grassland habitats and their associated breeding bird species. We review the conservation and management of migratory birds in Midwestern grasslands to develop management recommendations for the conservation of breeding birds in these landscapes. We used a priority ranking system to identify species of greatest management concern in the region. The Henslow's sparrow was identified as the species of highest management concern. Highly ranked bird species were associated with a variety of grassland habitats and habitat structures, including dry prairies, pastures, old fields, hayfields, wet prairies, sedge meadows and grasslands with interspersed shrubs. The diverse habitat associations of bird species with high regional management concern suggests that the problems facing Midwestern grassland birds are widespread and involved a wide variety of the region's grassland habitats. One common feature among many of the highly ranked grassland bird species was a sensitivity to habitat fragmentation, suggesting that this may be a general problem facing grassland birds in the region.

Declines in Midwestern grassland bird numbers were significantly correlated with declines in the regional acreage of pastures and hay fields. Other major landscape scale phenomenon likely impacting grassland birds in the region include habitat fragmentation and ill-timed cutting of hay fields. At a local scale, grassland birds have a variable response to management with some species being most common on grasslands recently disturbed with prescribed burning or grazing while others are most common in undisturbed areas. Grassland bird nest success can also be significantly influenced by grassland management, with nest success tending to be highest in the 2-3 years following prescribed fire. As a result of the of the variable response of grassland birds to prescribed fire, a mid-length (3-5 year) rotational burn program appears to be optimum under most circumstances. In grazed systems, a rotational system is also most desirable with a majority of areas being light to moderately grazed.

There is evidence that declines in the availability of grassland habitat in the region may be significantly influencing regional grassland bird declines. There is also some evidence that grassland bird nest success in many areas is below levels believed necessary for population maintenance. Limited winter habitat and/or winter resources have also been implicated in the declines of some grassland bird species. Efforts to identify which factors are most important in limiting grassland bird populations are hampered by limited data on many aspects of their ecology. More data on grassland bird demographics are needed in order to identify and differentiate habitats that are sources from those that are sinks, and a greater understanding of the winter ecology for most grassland bird species is also needed.

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INTRODUCTION

Populations of many species of grassland birds have declined significantly over the last 30 years (Peterjohn *et al.* 1994). Analyses of Midwestern breeding bird population trends show that grassland birds have declined more extensively than have birds associated with other habitats in the region (Herkert 1995). In fact, four of the five fastest declining species in the region (grasshopper sparrow, western meadowlark, bobolink, and loggerhead shrike) are associated with grassland habitats. Recent analyses of continental breeding bird population trends have also shown that the declines exhibited by grassland birds have been in general steeper, more consistent, and more widespread than declines in other groups of North American birds (Knopf 1994). Native grasslands throughout North America have also suffered substantial declines, with these declines being particularly severe in the Midwestern United States (Noss *et al.* 1995). Mesic tallgrass prairie, sedge meadow, and Lakeplain wet prairie are three Midwestern grassland ecosystems that have recently been identified as critically endangered in the United States (Noss *et al.* 1995). These declines point to the need for heightened conservation attention for grassland habitats and their associated breeding birds.

We review issues relevant to the conservation and management of migratory non-game grassland birds and their habitats in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin. Both short- and long-distance migrants are included, but we do not consider resident species. Short-distance migrants deserve management attention because many have experienced long-term population declines as great as or greater than many neotropical migrants (Peterjohn *et al.* 1994, Herkert 1995). We focus on two major grassland habitats: those habitats that are typically undisturbed during the breeding season, both native and non-native, including prairies, sedge meadows, prairie restorations, oldfields, fallow fields, and cool- and warm-season grass fields planted for wildlife cover; and agricultural habitats that form perennial sods but which are disturbed during the breeding season, such as hayfields and pastures. Other agricultural and grassland habitats are considered elsewhere (see Koford and Best 1996, Johnson 1996).

OVERVIEW OF GRASSLAND HABITATS IMPORTANT FOR GRASSLAND BIRD CONSERVATION IN THE MIDWEST

Native Prairies

Approximately 162 million ha of prairie occurred in North America before extensive European settlement; native prairie was the largest vegetation province in North America (Samson and Knopf 1994). Traditionally, prairies in North America have been divided into three subcategories; an eastern tallgrass section, a central mixedgrass section, and a western shortgrass component. Of the original 68 million ha of tallgrass prairie in North America, approximately 57 percent (38 million ha) occurred in the Midwestern states considered here. Declines in acreage of tallgrass prairie exceeds those reported for any other major ecosystem in North America (Samson and Knopf 1994). In the Midwest <1 percent of the region's native prairie remains intact (Samson and Knopf 1994). In many Midwestern areas, all that remains of once vast stretches of prairie are small, isolated remnants (e.g., Smith 1981, Schwegman 1983). For example in Illinois, <20 percent of the state's 245 native prairie remnants are >10 ha, and <4 percent are larger than 40 ha (Herkert 1994a). Currently, most native prairie in the region occurs in Minnesota and Missouri; both have more than 30,000 ha despite declines of >95 percent (Samson and Knopf 1994).

Large native prairies in the Midwest can support relatively diverse bird species assemblages (e.g., Sample 1989, Herkert 1991a). However, the small size of most Midwestern prairie remnants limits their attractiveness for many grassland birds (e.g., Herkert 1994a). Breeding bird communities on Midwestern prairies are dependent not only on tract size, but also on soil moisture, habitat structure, degree of woody invasion and plant species composition (e.g., Hoffman and Sample 1988, Sample and Hoffman 1989, Mossman and Sample 1990). For example, grasshopper, lark, and vesper sparrows are most common in dry prairies in the Midwest and are either uncommon or absent on wet or wet-mesic prairies, whereas sedge wrens and bobolinks are much more common on wet prairie sites than on dry prairies (Hoffman and Sample 1988, Sample and Hoffman 1989).

Other native communities related to prairies also provide valuable habitats for some grassland birds. For example, in Wisconsin sand prairies and barrens are important for lark and vesper sparrows, and large expanses of open barrens are important for upland sandpipers (Mossman *et al.* 1991).

Conservation of native grassland communities on unplowed prairie sod has the important additional conservation benefit of preserving a broader spectrum of the overall biotic diversity of grassland ecosystems—including plant species, insect populations, and soil microfauna and microflora—than do exotic grasslands on plowed soil (Henderson and Sample 1995).

Sedge Meadows

Sedge meadows are wet "grassy" meadows that are dominated by sedges (*Carex* spp.), often containing a significant grass component (Mossman and Sample 1990). Estimates of the original or current acreage of sedge meadows in the Midwest are uncertain, but states such as Wisconsin, Minnesota, Iowa and Illinois probably had the most. Like the tallgrass prairie, sedge meadows have been much reduced in the Midwest and most are highly fragmented. For example, of an estimated 500,000 original ha of sedge meadows in Wisconsin, only about 12,500 ha of high-quality meadow remains (Mossman and Sample 1990). Due to their unique hydrology, structure, and flora, sedge meadows provide the primary habitat for some distinctive grassland birds including sedge wrens and LeConte's sparrow even though overall sedge meadows do not support highly diverse bird communities. In Wisconsin, LeConte's sparrow and several other wetland specialist species occur in almost no other grassland habitat than sedge meadow (Mossman and Sample 1990). Many other wetland habitats also are used by grassland birds; in Wisconsin these include shrub-swamps and open bogs (Mossman and Sample 1990).

Restored Prairies

Restored prairies are grassland areas with diverse histories that have been planted with native grasses and forbs in an attempt to recreate prairie in areas where native prairie habitats have been lost. Restored prairies in the Midwest tend to be small and are frequently dominated by dense growths of prairie grasses, but some restorations possess a diverse forb component. The small size of many Midwestern grassland restorations may limit their conservation benefit, since most lack several grassland bird species of greatest conservation concern in the region (e.g., Herkert 1991b). Prairie restorations that are heterogenous and fairly large in size can be effective in attracting sizable populations of grassland birds (e.g., Sample 1989, Volkert 1992). Related to prairie restorations are planted stands of native, warm-season grasses, which often occur on public lands (wildlife areas, Waterfowl Production Areas, etc.) managed for gamebird production. These fields tend to be grass-dominated and have few native forbs, but weed forbs and grasses are often present on poorly established fields. Grassland bird use of these fields is variable. Relatively few species use fields with monotypic grass cover. Some of these birds, however, are specialists that only occur in other tall dense habitats such as sedge meadows. Fields that are weedy and less dense usually harbor a greater diversity of species (Sample 1989).

Hayfields and Pastures

Hayfields and pastures currently have extensive acreage. These habitats have been important in sustaining populations of some Midwestern grassland bird species as native prairies were lost. In addition, expansion of pastures and hayfields into portions of the Midwest that had previously been mostly forested allowed some grassland bird populations to greatly expand their range in some areas of the Midwest (e.g., Mayfield 1988, Brewer *et al.* 1991). This range expansion helped partially offset the tremendous loss of native prairie habitat in the prairie sections of the region and probably helped stabilize regional populations for those species that were successful in colonizing these new grassland habitats.

Early hayfields in the prairie sections of the region tended to be comprised primarily of native grasses (e.g., Warner 1994) and therefore presumably supported a grassland bird fauna that was largely similar to the native prairies although some species adapted to relatively short grass structure and periodic

disturbance may have increased in abundance in these fields. Early in this century, these native grasses were replaced by non-native grasses (Warner 1994), and more recently the non-native grasses have been largely replaced with varieties of alfalfa hay. In 1992, alfalfa hay accounted for 53 percent of the 6.2 million ha of hay in the region (U.S. Department of Commerce 1994). In the 1950's hayfields continued to provide an important habitat for Midwestern birds. Graber and Graber (1963) estimated that even though hayfields comprised only 7 percent of Illinois landscape in the late 1950's, as much as 20 percent of the entire breeding bird fauna in the state may have resided in this habitat.

Pastures are currently the region's most abundant grassland habitat, accounting for 8.7 million ha in the Midwest (roughly 7.5 percent of the region's land area, U.S. Department of Commerce 1994). Pastures also were important refuges for grassland birds as prairies were converted for agriculture (e.g., Ridgway 1895, Forbes 1908, Graber and Graber 1963). Pastures are still important grassland bird habitats because, when not overgrazed, they can support diverse assemblages of grassland bird species including many species with declining populations (e.g., Sample 1989).

Pastures and hayfields reached their peak abundance in the Midwest in the early 1900's and have declined in acreage almost continuously ever since (fig. 1). Over the last 50 years, combined pasture and hayfield acreage has declined by more than 50 percent (~17.0 million ha) in the Midwest and is now at its lowest level in more than 100 years (fig. 1).

Old Fields, Introduced Cool-season Grasses, and Other Non-prairie Grasslands

There are several other types of grassland habitats in the Midwest that are important for grassland birds. Old fields are attractive to many Midwestern grassland birds including many species of high conservation concern (Sample 1989). Without periodic disturbance, old fields can quickly succeed to brushy shrublands that are generally of minimal conservation value to grassland bird species. Fallow fields (fields plowed but not planted in the current or previous year) also provide some habitat for grassland birds in the Midwest. Grassland bird use of fallow fields is generally lower than old fields and most other types of grassland habitats (see Sample 1989). Estimates of the area of the various types of miscellaneous grasslands in the Midwest are scant. In 1992 more than four million ha of cropland was idle, fallow, or in cover crops, legumes, or soil improvement grasses in the Midwest (U.S. Department of Commerce 1994), suggesting that these miscellaneous grasslands may provide significant habitat for grassland bird populations in the region.

Fields of introduced, cool-season grasses, both monotypic and grass-legume mixtures, such as state wildlife areas and Waterfowl Production Areas are locally common in parts of the Midwest region. These habitats are important to some non-game grassland bird species; in Wisconsin these are often species that commonly nest in hay, such as bobolinks (Petersen *et al.* 1982, Sample 1989).

Other miscellaneous grassland bird habitats are young conifer plantations (field, vesper, and clay-colored sparrows), orchards (loggerhead shrikes), and retired pasture; these habitats may be of local conservation importance. Grassed roadsides and waterways, long-term farmland set-aside fields, and other crop fields are other examples of grassland habitats in the Midwest. Koford and Best (1996) discuss the value of these habitats for migratory birds.

STATUS OF MIGRATORY GRASSLAND BIRDS IN THE MIDWEST

Of the 26 species of grassland birds that breed in the Midwest region, 8 are neotropical migrants (spend their nonbreeding period primarily south of the United States), 14 are short-distance migrants (winter extensively in North America, although some populations winter south of the United States) and 4 are non-migratory, resident species. Only the 22 long- and short-distance grassland migrant species are considered here. In addition to the migratory grassland bird species, we have also included five species of migratory "shrubland" birds that require an open shrub/grass matrix and are of conservation concern in the Midwest in our assessment (loggerhead shrike, Bell's vireo, clay-colored sparrow, lark sparrow, field sparrow).

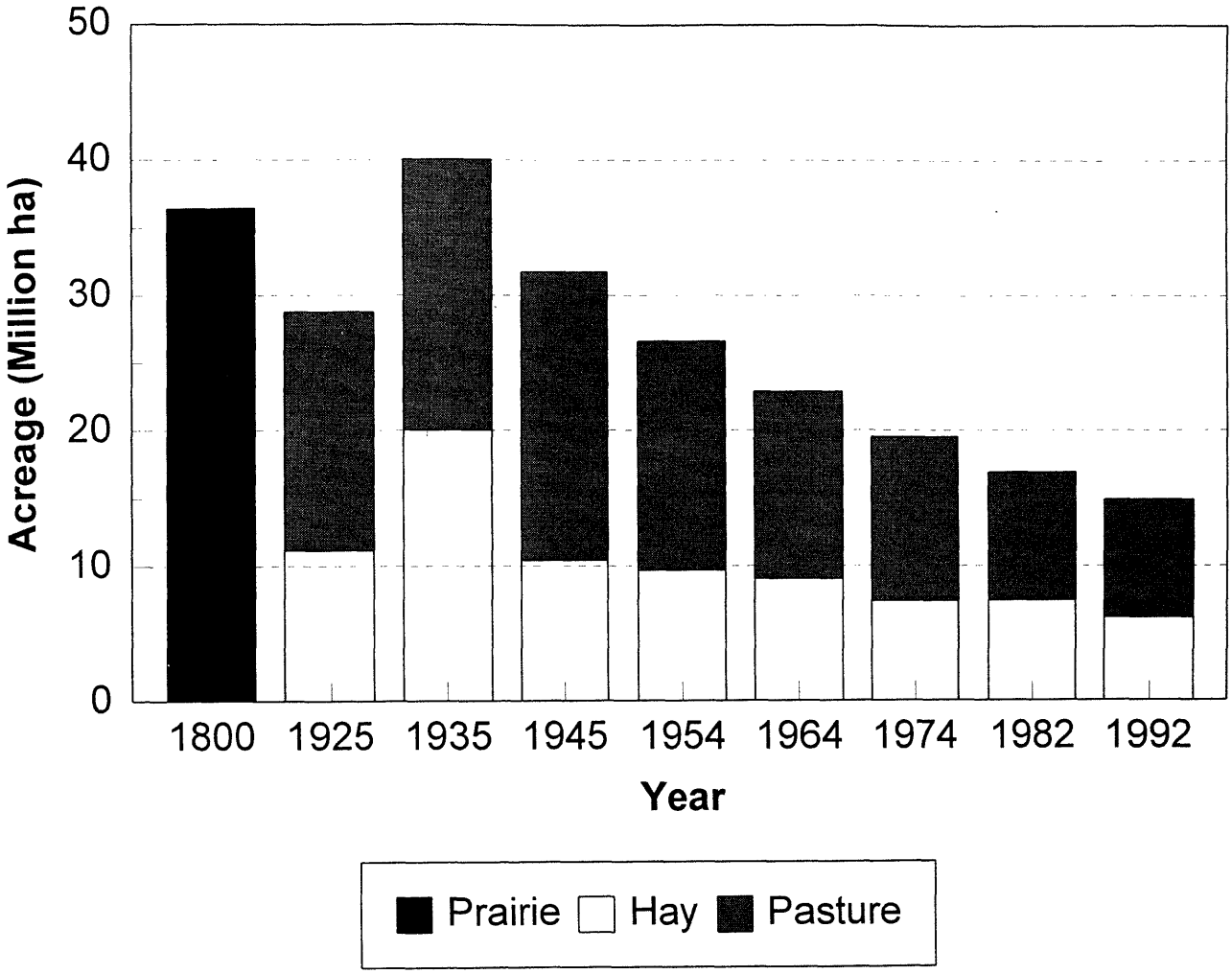

Figure 1.—*Acreage of major grassland habitats in the Midwestern United States 1800-1992. Figures for prairie were obtained from Samson and Knopf 1994, figures for hay and pasture were obtained from the U.S. Census of Agriculture (e.g., U.S. Department of Commerce 1994).*

Population Status and Trends of Migratory Grassland Birds

Populations of 10 species of Midwestern grassland birds have shown significant regional population declines over the last quarter century based on federal Breeding Bird Survey data (table 1). Only one migratory grassland bird species (killdeer) has shown a significant regional population increase over this same period. Many of these grassland birds are also undergoing significant population declines at the national level (table 1). Additionally, many migratory grassland bird species have very small populations in some portions of the region and as a result are considered to be either threatened or endangered in some of the Midwestern states in which they occur. Nearly half (48 percent) of the 27 grassland-associated species we examined are considered to be endangered or threatened in at least one Midwestern state (table 2).

Species Priority Ranking

We ranked our grassland-associated species according to regional management priority using a modification of the Partners in Flight priority ranking scheme (Hunter *et al.* 1993, Thompson *et al.* 1993). To identify grassland birds of greatest management concern in the

Table 1.—*Breeding distribution and population trends for migratory bird species associated with Midwestern grassland habitats.*

Species	# Midwestern states in which species breeds	Breeding Bird Survey population trend - 1966-1994	
		Midwest[1]	U.S.[1]
Northern harrier	8	-2.0	-1.2*
Killdeer	8	2.2***	0.1
Upland sandpiper	8	-0.6	2.0***
Common barn owl	8	*a*	*a*
Burrowing owl	3	*a*	*a*
Short-eared owl	8	*a*	1.9
Common nighthawk	8	0.3	-0.9
Horned lark	8	-0.4	-0.8**
Sedge wren	8	1.7	1.7*
Sprague's pipit	1	*a*	-0.1
Loggerhead shrike	8	-8.2***	-3.5***
Bell's vireo	8	4.3	-3.0**
Dickcissel	8	-3.6***	-1.6***
Clay-colored sparrow	5	-0.6	-1.3
Field sparrow	8	-3.0***	-3.4***
Vesper sparrow	8	-1.7***	-0.9**
Lark sparrow	7	-2.7	-3.4***
Lark bunting	2	*a*	-0.7
Savannah sparrow	7	-1.1**	-1.2***
Baird's sparrow	1	*a*	-0.9
Grasshopper sparrow	8	-5.5***	-3.7***
Henslow's sparrow	8	-7.6***	-8.2***
Le Conte's sparrow	3	1.3	-0.7
Chestnut-collared longspur	1	*a*	-0.3
Bobolink	8	-3.3***	-1.8***
Eastern meadowlark	8	-2.9***	-2.6***
Western meadowlark	8	-4.0***	-0.6*

[1] * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$; *a* = too rare for BBS trend estimation.

region, we used estimates of species' global abundance, winter and breeding distributions, threats on the breeding and wintering grounds, and population trends, as well as an estimate of the importance of the Midwest to each species' North American breeding population (table 3). Ranks for species' global abundance, winter and breeding distributions, and threats on the breeding and wintering grounds for neotropical migrants were scored initially by Thompson *et al.* (1993) and Carter and Barker (1993); we added scores for some short-distance migrants. Ranks for the importance of the Midwest region for each species were estimated using field guide range maps (National Geographic Society 1983; Peterson 1980, 1990) and data from the BBS (VU-BBS computer program, Hines *et al.* 1994). Ranks for species' population trends (1966-1994) were based primarily on data from the Breeding Bird Survey. If BBS data were unavailable and we were unable to form an opinion regarding population trend for a species, we assigned a score of three for the population trend. In tabulating overall scores, we doubled the value for each species' importance of area score because we believed this was an important variable in our ranking system. We derived each species' overall score by calculating the geometric mean of each species' individual scores.

Most of the species we analyzed (55 percent) had mean management concern scores between two and three (table 3). Only three species had scores below two (common nighthawk, horned lark, and killdeer). Nine species

Table 2.—*Endangered and threatened birds associated with Midwestern grasslands*

Species	State Status[1]
Northern harrier	IL[E] IN[E] IA[E] OH[E] MO[E] WI[SC]
Upland sandpiper	IL[E] IN[E] MN[SC] OH[T] WI[SC]
Common barn owl	IA[E] IL[E] IN[E] MI[E] OH[E] WI[E]
Burrowing owl	IA[E] MN[E]
Short-eared owl	IA[E] IL[E] IN[E] MI[E] MO[E] MN[SC] OH[SC] WI[SC]
Sedge wren	OH[E] IN[T] WI[SC]
Sprague's pipit	MN[E]
Loggerhead shrike[2]	IL[T] IN[E] WI[E] MN[T] MI[E] OH[E]
Bell's vireo[2]	WI[T]
Baird's sparrow	MN[E]
Henslow's sparrow	IL[E] IA[T] IN[T] MN[SC] OH[SC] WI[SC]
Lark sparrow[2]	OH[E] WI[SC]
Chestnut-collared longspur	MN[E]

[1] E=endangered, T = Threatened, SC = special concern

[2] Associated with grasslands with scattered shrubs

had scores above three. The Henslow's sparrow was ranked as the grassland species of the highest management concern in the region, and was clearly separate from other highly ranked species. Interestingly, four of the five "shrubland" species were included among the region's ten highest-ranking grassland-associated species (table 3).

An important result of the ranking process was the observation that the ten highest ranking grassland-associated species were associated with a variety of grassland habitats and habitat structures. For example, grasshopper sparrows prefer habitats with relatively short-stature vegetation and diverse structure, including dry prairies, pastures, and old fields (Sample 1989); upland sandpipers also typically prefer areas that have relatively short cover (e.g., Skinner 1975, Ailes 1980, White 1983, Buhnerkempe and Westemeier 1988, Sample 1989), but in some areas they may also preferentially utilize large tracts of native grasslands such as open sandy barrens (e.g., Mossman *et al.* 1991); bobolinks prefer areas with lush grassy vegetation including hayfields, idle cool-season grasses, and low pastures and prairies (Sample 1989, Brewer *et al.* 1991); dickcissels prefer old fields, hayfields, and other idle grasslands with moderately tall herbaceous vegetation (Taber 1947, Gross 1921, Emlen and Wiens 1965, Zimmerman 1971, Brewer *et al.* 1991); Henslow's sparrows prefer undisturbed grasslands (native and non-native) that have tall, dense cover (Wiens 1969, Skinner *et al.* 1984, Zimmerman 1988, Sample 1989, Herkert 1994b); LeConte's sparrows and sedge wrens prefer very tall and dense vegetation, sometimes on upland sites but most often in wet prairies and sedge meadows (Mossman and Sample 1990); Bell's vireos, field sparrows and loggerhead shrikes require grasslands with interspersed shrubs (Walkinshaw 1968, Brooks and Temple 1990, Prescott and Collister 1993, Hands *et al.* 1989); and clay colored sparrows also prefer grasslands with interspersed shrubs, including cut-over forest lands and young pine plantations (Roberts 1936, Brewer *et al.* 1991, Mossman *et al.* 1991).

An examination of the diverse habitat associations of species with high regional management concern scores suggests that the problems facing Midwestern grassland birds are widespread and involve a wide variety of the region's grassland habitats. Many of the highest-ranking species, however, are also known to be sensitive to habitat fragmentation (e.g., Herkert 1994a, Vickery *et al.* 1994) suggesting that grassland fragmentation may be a common problem facing many of the region's grassland bird species of high management concern.

Table 3.—*Scores used to rank management concern for Midwestern migratory grassland bird species. A score of 5 indicates high management concern, 1 indicates low management concern. See Carter and Barker(1993), Hunter* et al. *(1993), and Thompson* et al. *(1993) for more details regarding the Partners In Flight ranking system.*

Species	GA[1]	WD[2]	WT[3]	BD[4]	BT[5]	IA[6]	PT[7]	TOTAL
Henslow's sparrow	4	3	3	4	4	5	5	4.05
Dickcissel	2	4	4	3	3	4	5	3.51
Bobolink	2	4	3	3	3	4	5	3.39
Sedge wren	4	4	3	3	4	5	1	3.31
Bell's vireo	3	4	3	3	3	3	4	3.22
Grasshopper sparrow	2	3	3	2	4	4	5	3.22
Upland sandpiper	3	3	3	3	4	3	3	3.11
Field sparrow	2	3	2	3	3	4	5	3.11
Clay-colored sparrow	3	4	2	4	2	3	4	3.02
Loggerhead shrike	3	3	4	2	3	2	5	2.85
Le Conte's sparrow	4	3	3	3	3	2	3	2.81
Common barn owl	4	2	3	3	3	2	3	2.67
Lark sparrow	3	3	3	2	3	2	4	2.67
Baird's sparrow	4	4	4	4	3	1	3	2.63
Chestnut-collared longspur	3	4	4	4	4	1	3	2.63
Vesper sparrow	3	2	2	2	2	3	5	2.61
Northern harrier	4	1	4	1	4	2	4	2.38
Sprague's pipit	3	3	3	4	3	1	3	2.36
Burrowing owl	4	3	3	3	3	1	3	2.36
Eastern meadowlark	1	1	3	3	3	3	5	2.35
Lark bunting	2	3	3	4	4	1	3	2.33
Savannah sparrow	2	2	3	1	3	2	5	2.28
Western meadowlark	1	2	3	2	3	2	5	2.28
Short-eared owl	4	1	4	1	4	2	2	2.18
Common nighthawk	2	2	2	1	2	2	3	1.93
Horned lark	1	1	1	1	1	2	5	1.45
Killdeer	1	1	1	1	1	2	1	1.19

[1]GA - Global Abundance, abundant or demonstrably secure = 1; common or apparently secure = 2; uncommon to fairly common, including locally common = 3; rare to uncommon = 4; very rare to rare = 5.

[2]WD - Winter Distribution, Very widespread = 1; widespread = 2; intermediate = 3; local = 4; very local = 5.

[3]WT - Severity of Threats on the Winter Grounds, no known threats = 1; minor threats = 2, moderate threats = 3; severe threats = 4; extirpation or extinction likely = 5.

[4]BD - Breeding Distribution, the area of the breeding range in North America. ≥76% of temperate North America = 1; 51-75% = 2; 26-50% = 3; 11-25% = 4; ≤ 10% = 5.

[5]BT - Severity of Threats of Breeding Grounds in Midwest Region (habitat loss and fragmentation, low nesting success, contaminants, human disturbance, etc.). No known threats = 1; Minor threats = 2; Moderate threats = 3; Severe threats = 4; extirpation or extinction likely = 5.

[6]IA - Importance of Midwest Region to Species. Less than 1% of population in region = 1; 1-10% = 2; 11-25% = 3; 26-50% = 4; > 50% = 5.

[7]PT - Population Trend in Midwest Region (based on Breeding Bird Survey data). Ranking is based on both regional and national population trends. Trends are shown as regional and national trends with + indicating a positive trend and - indicating a negative trend, an * indicates statistical significance ($p<.10$) for the trend estimate. Trends which were unknown at both the national and regional level were assigned a rank of 3.

		Regional Population Trend (1966-94)				
		+*	+	unk	-	-*
National	+*	1	1	2	3	3
Population	+	1	2	2	3	4
Trend	-	3	3	3	4	5
(1966-94)	-*	3	4	4	5	5

We agree with Millsap *et al.* (1990) and Hunter *et al.* (1993) who have stressed that priority ranking systems should not replace human judgement in the allocation of conservation resources, rather these systems should be used as one tool in determining where to direct resource conservation efforts. Moreover, Thompson *et al.* (1993) caution against using ranking systems to focus management on a limited number of highly ranked species and recommend landscape-level management aimed at addressing the needs of suites of highly ranked species. In light of the diverse habitat associations of our highly ranked species, our ranking exercise suggests that large scale, diverse grassland management is needed to meet the habitat needs of the migratory grassland bird species of the greatest conservation concern in the region. Regional variation both in the distribution and quality of grassland habitat and in the distribution and abundance of grassland birds means that bird species and habitats of highest management concern will vary from one part of the region to another.

Conservation issues for grassland birds of management concern

Close attention needs to be paid to the distribution and extent of grassland habitats and birds in the region to properly focus and maximize use of scarce management resources. Grassland habitats are not evenly distributed across the region (fig. 2), and tract size and quality vary regionally. The most efficient way to manage for particular habitats (e.g., pastures or sedge meadows) is to focus on areas where the most acreage currently is and where the best opportunities for management of large tracts or landscapes lie (Sample and Mossman, in press). For example, certain states and areas will be best-suited for maintenance of sedge meadows and sedge meadow birds (such as portions of Minnesota, Wisconsin, Michigan and Northern Illinois), while others will lend themselves to managing relatively large-scale native prairie sites (parts of Missouri and Minnesota) or large pasture systems (Iowa, Missouri, Wisconsin). Some areas may contain unique complexes or concentrations of a variety of grassland habitats, and some Midwestern landscapes will require large-scale grassland restorations. Additionally, relatively widespread bird species such as eastern meadowlarks and vesper sparrows may benefit from management actions applied broadly across the region, whereas species with more localized distributions in the region such as sedge wrens and LeConte's and Henslow's sparrows will require much more targeted efforts.

States in the region should begin to identify large grassland areas and landscapes that contain significant grassland bird populations using existing land cover maps (including statewide GIS land use maps) and information such as bird data from the BBS and state Breeding Bird Atlas projects. To identify the type and location of habitats and landscapes important to the conservation of migratory grassland birds, some states may need to conduct additional surveys of bird distribution, abundance, and habitat preferences.

The question of how much habitat we need in the region to maintain or improve population sizes of grassland birds is unresolved. Also unsettled are questions regarding the spatial arrangement of conservation lands so as to maximize the benefits to grassland birds. Although there is little doubt that regional populations of many grassland bird species are declining, the underlying causes of these declines remain poorly known. For example, we do not know if population declines are due to the loss of breeding habitat or if they are the result of reproductive failure in existing habitats due to habitat degradation, mowing and other land-use changes or some combination of these factors. Additionally, potential problems on the wintering grounds and migratory routes must be considered as possible sources of population declines. Therefore, it is unclear if we should recommend to managers the creation of new grassland habitats for these species or if we should recommend management actions that seek to improve reproductive success in existing grassland areas. For most grassland birds we have too little information regarding their winter ecology to adequately assess the severity of threats on their winter grounds. For these reasons we recommend that conservation activities on the breeding grounds include both efforts directed toward enhancing habitat availability as well as actions directed toward improving grassland bird reproductive success in existing grassland areas in the region until more comprehensive data on other limiting factors become available and help focus management on specific problem areas.

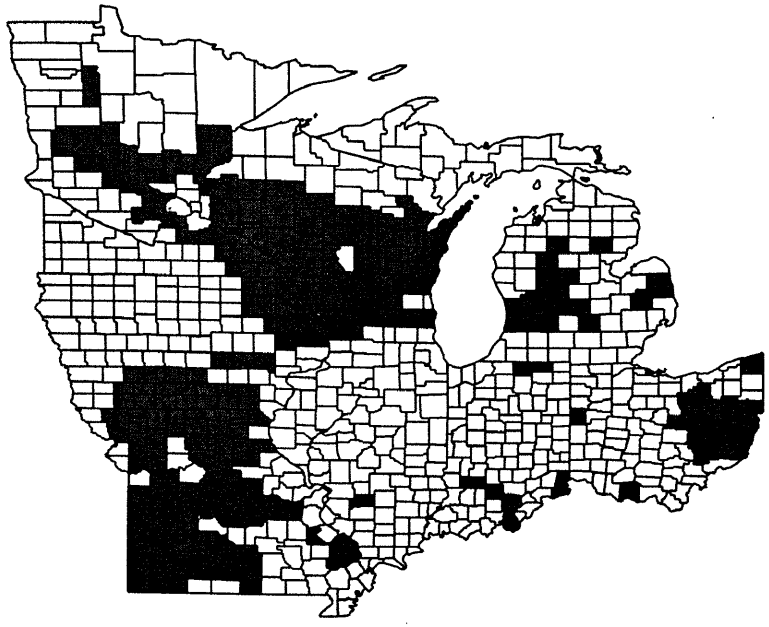

Fig 2a. Percent Hay (>6%)

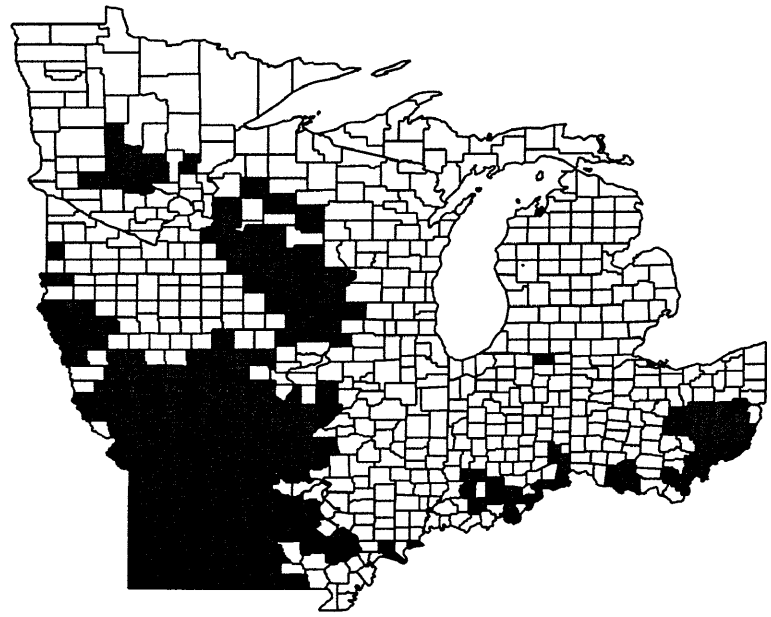

Fig. 2b. Percent Pasture (>8%)

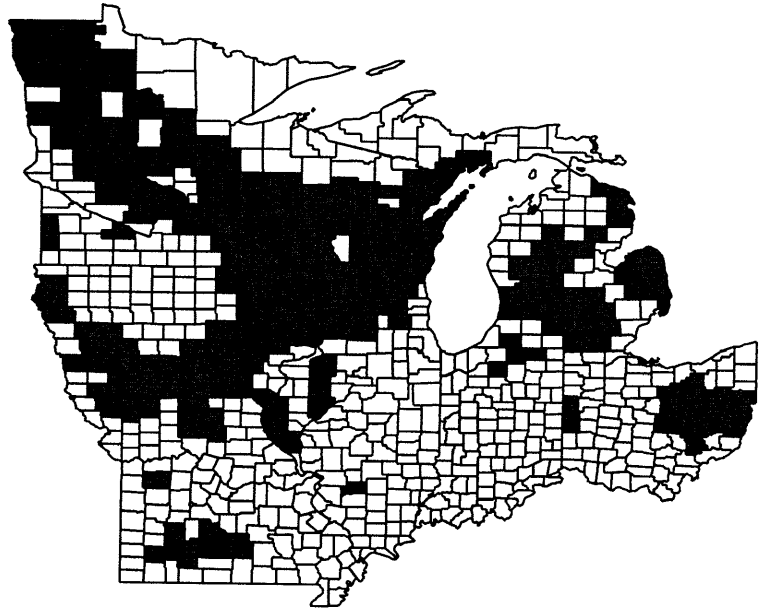

Fig. 2c. Alfalfa Acreage (>4,000 ha)

Figure 2.—*Distribution of counties in the Midwestern United States with significant amounts of grassland habitats, 1992. Data were compiled from the 1992 Census of Agriculture (U.S. Department of Commerce 1994).*

IMPACTS OF MAJOR MIDWESTERN LAND USE PRACTICES ON GRASSLAND BIRDS

Impacts of Hayfield and Pasture Acreage Loss on Midwestern Grassland Bird Populations

We used data from the North American Breeding Bird Survey (BBS) and the U.S. Census of Agriculture to examine the potential influence that regional changes in pasture and hayfield acreage may have had on Midwestern grassland birds over the last quarter century. The BBS consists of randomly located permanent survey routes established along secondary roads throughout the continental U.S. and southern Canada (Peterjohn and Sauer 1993). Survey routes are 39.4 km. long and consist of 50 stops at 0.8-km intervals. Each route is surveyed once annually, and all birds seen or heard within 0.4 km of each survey point during a 3-min census are recorded. In the Midwestern U.S. (Iowa, Illinois, Indiana, Michigan, Minnesota, Missouri, Ohio, and Wisconsin) there are 431 BBS routes that have been run since the late 1960s. Annual population indices for each species were extracted from the VU-BBS computer program (Hines *et al.* 1994) which were calculated using the residual method of Sauer and Geissler (1990).

We obtained data on changes in the acreage of Midwestern pastures and hayfields from the periodic U.S. Census of Agriculture conducted in 1964, 1969, 1974, 1978, 1982, 1987, and 1992 and published by the U.S. Department of Commerce. Estimates of pasture and hayfield acreage in intervening years were obtained by interpolating between known years assuming a constant rate of change within intervals. Comparisons of Illinois hayfield acreage estimates using this averaging method, with known annual acreage figures were highly correlated ($r = >0.90$, $n=30$), suggesting that these periodic data and this method may provide reliable annual acreage estimates for agricultural habitats.

Declines in the combined regional acreage of hayfields and pastures were significantly associated with declines in Midwestern grassland bird populations (fig. 3). The relationships between hayfield and pasture declines and concurrent grassland bird declines were strong; the correlation coefficients for the six species examined ranged from 0.76 to 0.94 (fig 3). More detailed analyses of these data suggested that population declines for these six Midwestern grassland bird species were more strongly associated with changes in pasture acreage than with changes in hayfield acreage (table 4).

Although we cannot discount the possible effects of other factors, our analyses (fig. 3) showed that population declines for several of the Midwest's most common grassland bird species are strongly correlated with regional declines in pasture and hayfield acreage, providing support to the idea that recent declines in these habitats have significantly influenced regional grassland bird populations.

Grassland Fragmentation

Several species of grassland birds avoid small grassland fragments and have populations in the Midwest that tend to be restricted to large grassland areas (Herkert 1994a). Migratory grassland bird species that appear to be influenced most by habitat fragmentation include northern harrier, short-eared owl, upland sandpiper, grasshopper sparrow, Henslow's sparrow, and bobolink, (Bollinger 1988, 1991; Herkert 1991c, 1992, 1994a; Herkert *et al.* 1993; Vickery *et al.* 1994). The estimates above are for minimal areas for species to occur at a site with some probability (generally >50 percent), not minimal areas required for self-sustaining populations. Both theoretical and empirical studies have shown that larger populations have a significantly greater probability of persistence, and that small populations are much more susceptible to local extinctions (e.g., Pimm *et al.* 1988, Berger 1990, Tracy and George 1992, Mangel and Tier 1994). Therefore, simply attracting small numbers of area-sensitive species to particular areas should not be the ultimate goal of grassland management. Rather, managers should strive toward providing habitat for large populations of area-sensitive species to increase the likelihood of long-term persistence for these populations. However, our knowledge of what constitutes a viable population size (and sources and sinks) for most all grassland species is very scarce. For this reason, areas that are much larger than a particular species' minimum area of occurrence will likely be required to adequately ensure the long-term persistence of area-sensitive grassland bird species. For some of the more area-sensitive grassland species

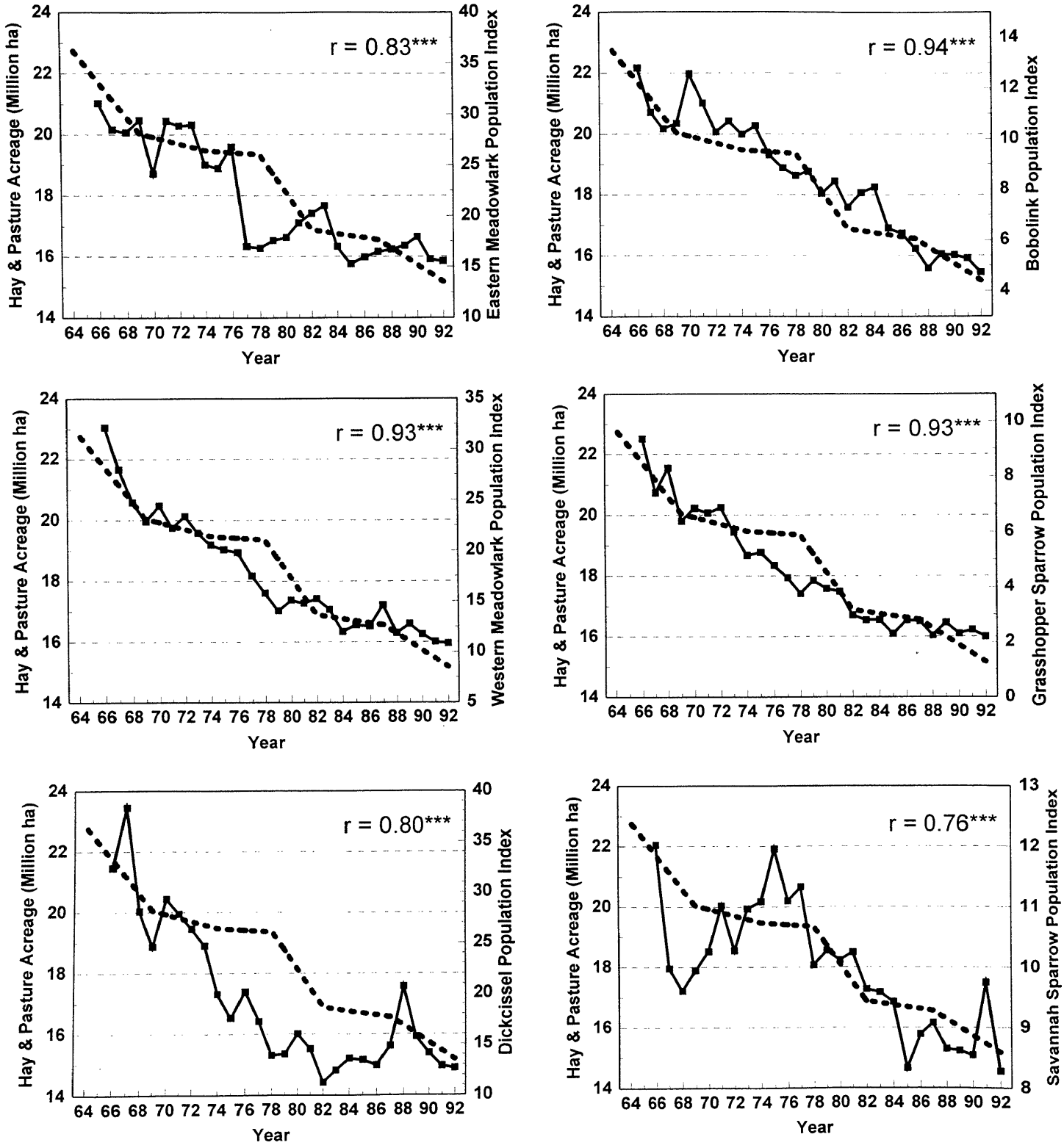

Figure 3.—*Correlations between combined Midwestern hay and pasture area and grassland bird population changes. Solid lines and squares represent grassland bird population indices. Pasture and hay area are shown with dashed lines. Grassland bird population changes were estimated from data from the Breeding Bird Survey. (*** = P<0.001.) See text for additional details.*

Table 4.—*Partial correlations between yearly estimates of regional grassland bird abundance and pasture and hayfield area. Pasture correlations are between annual grassland bird population indices and regional pasture area with the regional area of hayfields partialled out. Hayfields correlations are between bird indices and hayfield area with pasture area partialled out. Breeding bird indices were obtained from data from the Breeding Bird Survey. See text for additional details.*

Species	Pasture	Hayfields
Bobolink	0.94 ***	0.17
Dickcissel	0.85 ***	-0.26
Savannah sparrow	0.67 ***	0.35
Grasshopper sparrow	0.95 ***	-0.11
Eastern meadowlark	0.90 ***	-0.43 *
Western meadowlark	0.93 ***	-0.02

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

these areas may be on the order of hundreds or possibly even thousands of hectares. For example, Temple (1992) determined in a modeling exercise that a population of sharp-tailed grouse, a non-migratory grassland species, would require 280 individuals and about 4,000 ha to be considered a viable population. Actual acreage required at a specific location will ultimately depend on the regional land use context of that particular area. In landscapes with minimal grassland cover in the surrounding landscape matrix, larger areas may be necessary, whereas small areas may suffice in landscapes with high proportions of grassland cover (see Sample and Mossman, in press).

Efforts to derive estimates of minimum habitat areas for grassland birds have suffered from a lack of consistent methods. Nevertheless, most estimates for minimum area requirements for grassland birds range from 10 to 100 ha, with some indication that a few of the larger, wide-ranging species may possibly require as much as 200 ha (Herkert 1994a, Vickery *et al.* 1994). Individual species' actual habitat area requirements, however, vary from location to location and may be greater for species near the edges of their range or where populations are very small and/or declining (O'Conner 1981, Smith and Smith 1992, Vickery *et al.* 1994).

Many grassland birds also appear to be influenced by regional landscape composition. For example, several grassland bird species may be more numerous in Midwestern landscapes that have a relatively high proportion of grassland cover such as pastures and idle grasslands (e.g., Rolley and Sample 1993). The distribution and abundance of these landscape features likely plays a strong role in determining regional grassland bird distribution and abundance patterns and also may influence species utilization of different size grassland fragments. For example, grassland birds may use smaller-sized fragments in landscapes with a higher proportion of grassland cover than in landscapes with minimal regional grassland cover. Such a relationship has been demonstrated for forest birds (Freemark and Collins 1992), but has yet to be shown for grassland bird species. In Wisconsin, however, grassland bird abundance has been shown to be influenced by factors in the landscape surrounding a site, such as mean patch size and amount of nearby idle grasslands (Sample and Mossman, in press).

Grassland fragmentation also influences grassland bird nest success. Nelson and Duebbert (1974) found that waterfowl nesting success was higher on large blocks of grassland habitat (32-48 ha) than on small blocks ($\leq$ 16 ha), due to high rates of nest predation in the smaller blocks. Johnson and Temple (1986, 1990) also found nest success to be lower on small prairie fragments (16-32 ha), than on large prairie fragments (130-486 ha) in Minnesota due to high rates of nest predation on their small prairie fragments. More recently, Greenwood *et al.* (1994) have suggested that bird nests in small blocks of grassland habitat are at higher risk of predation than are nests in large contiguous blocks of habitat that have not been fragmented. Davis (1994) also found nest success to be lower on his small site (22 ha) than it was on either of his two large (64 ha) sites. However, Davis' lower nest success was due to higher rates of nest parasitism on his smaller fragment. Nest predation rates were not significantly higher on his small site.

Grassland Management: Prescribed Burning, Grazing, and Mowing

Grasslands are disturbance-adapted systems. Historically, prairie fires occurred frequently and presently are recognized as one of the

most important types of disturbance essential for the maintenance of grassland ecosystems (Anderson 1970, Bragg 1982). Some form of regular disturbance appears to be important not just for grassland maintenance, but also for maintaining breeding bird diversity. Several studies have shown that grassland areas not subjected to periodic disturbances, such as fire or grazing, generally support both few grassland bird species and individuals (e.g., Kirsch and Kruse 1972, Skinner 1975, Whitmore 1981, Westemeier and Buhnerkempe 1983). In the absence of disturbance, grassland vegetative productivity declines and extensive invasion of woody plant species can occur (Risser *et al.* 1981, Hulbert 1986). Encroachment of woody vegetation onto grassland areas can occur rapidly, especially on small patches (Anderson 1970) and where residual forest cover (e.g., woodlots) or invading woody vegetation (e.g., from farmsteads, hedgerows, railroad lines, etc.) provide abundant seed sources of woody species.

Many grassland birds are negatively impacted by increases in woody vegetation or proximity to woody edges. Eastern meadowlarks, grasshopper sparrows, Henslow's sparrows, savannah sparrows, and Baird's sparrows all tend to avoid grassland areas that are being invaded by too much woody vegetation (e.g., Kahl *et al.* 1985, Arnold and Higgins 1986, Peterson 1983, Zimmerman 1988). Additionally, woody encroachment has been implicated as a factor in local grassland bird declines in studies in Iowa (Bernstein *et al.* 1990) and Massachusetts (Melvin 1994). Encroachment of grassland areas by woody vegetation has also been identified as a management and conservation problem in the southern United States (Hunter 1990, Telfer 1992), where many species of Midwestern migratory grassland bird species overwinter (American Ornithologists' Union 1983). In addition to the propensity for many grassland birds to avoid areas being invaded by woody vegetation, proximity to woody vegetation also has been shown to influence nest success. Grassland bird nests located close to woody vegetation experience higher rates of nest predation than do nests located far from woody vegetation (e.g., Johnson and Temple 1986, 1990; Burger *et al.* 1994; With 1994). Additionally, grassland bird nests located close to woody vegetation experienced higher rates of nest parasitism by brown headed cowbirds than nests located far from woody vegetation (Berger 1951, Best 1978, Johnson and Temple 1990).

As a result of the problems associated with encroachment of woody vegetation, managers now widely recognize the importance of regular management in maintaining grassland areas. However, grassland birds prefer a wide range of grass heights and densities; some species prefer short sparse vegetation whereas others prefer tall dense vegetation (e.g., Wiens 1969, Skinner *et al.* 1984, Sample 1989, Herkert 1991a, Herkert *et al.* 1993). As a result of these different habitat preferences, individual bird responses to various forms of grassland management are variable. Some species of grassland birds are more abundant in grasslands recently managed by fire, grazing or mowing, whereas others are more abundant in undisturbed areas.

Prescribed burning

Prescribed burning is the most commonly employed grassland management tool in the Midwest. Prescribed burning is an effective tool for suppressing woody encroachment, decreasing litter cover, and improving grass and forb production (reviewed by Ryan 1986).

Grassland birds whose abundance tends to be consistently lower immediately following a prescribed burn include sedge wren, Baird's sparrow, Henslow's sparrow, clay-colored sparrow, field sparrow, and dickcissel (Best 1979; Halvorsen and Anderson 1980; Huber and Steuter 1984; Zimmerman 1988, 1992; Pylypec 1991; Reinking and Hendricks 1993; Herkert 1994b, 1994c). Eastern meadowlarks, western meadowlarks, savannah sparrows and grasshopper sparrows show a variable, and possibly regionally dependent, short-term response to burning. Some studies have shown a positive short-term response to burning for these species while others have shown a negative short-term response (Tester and Marshall 1961, Huber and Steuter 1984, Pylypec 1991, Herkert 1994c). Grassland bird species that tend to be consistently more abundant on recently burned grasslands include upland sandpipers, killdeer, horned larks, chestnut-collard longspurs, vesper sparrows and lark sparrows (Renwald 1977, White 1983, Huber and Steuter 1984, Buhnerkempe and Westemeier 1988, Pylypec 1991, Zimmerman 1992). Some grassland bird species, such as bobolinks, have densities that are initially lowered by burning, but are usually higher in the 2 to 3 years following fire than they are in unburned areas (e.g., Cody 1985, Vickery 1993).

Burning also significantly effects grassland bird nest success. Nest success for a variety of ground nesting grassland birds is generally higher in recently burned grasslands than it is in unburned grasslands (e.g., Kirsch and Kruse 1972; Fritzell 1975; Johnson and Temple 1986, 1990). However, Toland (1986) found that nesting success for northern harriers in Missouri prairies was higher in unburned areas than in recently burned areas; and Reinking and Hendricks (1993) recently found nest success in burned tallgrass prairie areas to be variable from year-to-year and not consistently higher than unburned areas. Additionally, Best (1979) found that burning lowered cowbird parasitism rates on Illinois field sparrows. However, Johnson and Temple (1990) did not find a significant effect of burning on rates of cowbird parasitism in their study of breeding birds in Minnesota prairie fragments.

Few studies have attempted to assess the relative importance of other factors in determining grassland bird relative abundances within grassland areas subjected to prescribed burning. Herkert (1994c) found that habitat area had, in general, a stronger influence on grassland bird communities than did burn status for prairie fragments in Illinois. Precipitation patterns also may influence grassland bird response to burning, with individual species response to burning varying in relation to fluctuations in yearly precipitation (Zimmerman 1992). Factors such as the intensity and completeness of the burn and availability of adjacent refuge habitats also may influence grassland bird response to burning (Ryan 1986) but have received little attention to date. Additionally, timing of the burn (spring vs. fall) also may affect grassland bird response to fire. Higgins (1986) suggested that rates of nest success may be greater in grassland areas burned in the fall than in spring burned areas. Therefore, burning appears to be only one of a variety of factors that influence grassland bird distribution and abundance patterns within grasslands managed by prescribed fire. Further research is needed to more fully understand the relationship between burning and these other factors.

Grazing

Grazing is a versatile grassland management technique that can benefit many grassland bird species, particularly species which prefer short to medium vegetation heights (Skinner *et al.* 1984, Sample 1989). Grazing limits vegetation height, reduces litter accumulation, and also helps reduce woody encroachment (Sample 1989). In the Midwest, grazed grasslands tend to have more breeding grassland bird species and individuals than hayfields and even some idle grasslands (Skinner 1975, Sample 1989). Some species of migratory grassland bird species that are of high regional conservation concern, such as the grasshopper sparrow and bobolink, attain some of their highest regional densities in grazed grasslands (Sample 1989).

Grassland bird response to grazing varies regionally (Kantrud and Kologiski 1982). In the Midwest, shortgrass species such as the horned lark and killdeer favor heavily grazed areas, whereas upland sandpipers, grasshopper sparrows and eastern and western meadowlarks favor moderate grazing (Skinner 1975, Skinner *et al.* 1984). Many species tolerate light grazing, however moderate to heavy grazing greatly reduces and may even eliminate species such as northern harriers, short-eared owls, sedge wrens and Henslow's sparrows from grassland areas (Skinner 1975, Skinner *et al.* 1984, Kantrud and Higgins 1992, Lingle and Bedell 1989). Many factors can influence bird species response to grazing including soil types, soil moisture, plant species composition, weather, and stocking density and duration.

The effects of grazing on grassland bird nest success are not well known. Some studies have suggested that grazing during the breeding season may lower grassland bird nest success (e.g., Bowen and Kruse 1993, Kantrud and Higgins 1992, Kirsch and Higgins 1976). Other results show nest success varying regionally and according to grazing management practice. For example, Barker *et al.* (1990) found average nesting success for waterfowl in North Dakota was greater on all but one of five specialized pasture systems with low stocking rates than on idle grasslands; and with few exceptions it was greater than that believed necessary to sustain duck populations. Bientema and Muskens (1987) reported that trampling accounted for between 23 and 52 percent of total nest losses for four bird species in Dutch pastures and predicted that nesting success can be drastically reduced by high cattle densities. In Texas pastures with very low stocking rates, 84 to

100 percent of artificial bobwhite and turkey nests were lost, most to predation (Bariess *et al.* 1986). Using clay targets to simulate nests in Oklahoma pastures, Jensen *et al.* (1990) found that significant nest losses can result from trampling alone, especially with cattle densities above 10 head/hectare (similar to cattle densities in pastures in some parts of the Midwest).

Little work has been done on nest success in pastures in the Midwest. In Iowa warm season grass fields, pheasants and passerines hatched or fledged more young in idle fields than in fields grazed annually in July and August (George *et al.* 1979). Initial results from recent research in Wisconsin indicate that grassland bird nest success in continuously grazed pastures averaged 26 percent over 2 years (Stanley Temple, pers. comm.). Also in Wisconsin, an average of 73 percent of simulated pheasant nests were lost in pastures with a low-intensity rotation (9 head/ha) commonly used in dairy farming (Paine *et al.*, 1996). In general, pastures that are not managed to maximize variables such as forage, meat, or milk production are likely to have higher nest success (or at least fewer losses due to trampling), primarily due to lower stocking rates than when those variables are maximized. Further work on nest productivity in pastures under a variety of management regimes is needed.

Intensive rotational grazing (Undersander *et al.* 1991) is gaining popularity and acceptance in parts of the Midwest. Research in Wisconsin has shown that nest success in pastures that are under intensive rotational grazing is similar to or lower than that of conventionally grazed pastures (Paine *et al.*, in press; Stanley Temple, pers. comm.).

Mowing

Mowing, like grazing and burning, also can be used to lower vegetation height, reduce litter build up (if cuttings are harvested), and control woody vegetation (Sample 1989). Grassland bird response to mowing, when used as a management tool, is usually similar to their response to prescribed burning. Species whose abundance tends to be significantly reduced by burning, such as sedge wrens and Henslow's sparrows, also tend to be adversely affected by mowing (e.g., Herkert 1994c). The cutting and harvesting of hay during the nesting season, however, has serious consequences for breeding birds significantly reducing both breeding bird densities (Frawley and Best 1991) and reproductive success (Frawley 1989, Bollinger *et al.* 1990). Additionally, the harvesting of hay also may result in a loss of nutrients from the system and could result in altered grass and forb production (Ryan 1986). Overall, hayed grasslands support fewer bird species and individuals than grazed grasslands (Skinner *et al.* 1984). Several studies have shown that many grassland bird species abandon hayfields after their first cutting (Harrison 1974, Sample 1989, Frawley and Best 1991, Igl 1991). Some species, however, return to these hayfields after their first cutting and attempt to renest (Frawley 1989). Unfortunately, in many Midwestern hayfields there is generally not enough time between first and second cuttings for most species of grassland birds to raise young successfully (Frawley 1989; Herkert, in press). Cutting also has significant demographic consequences for grassland birds. In Iowa alfalfa fields, Frawley (1989) found that all above ground nests active at the time of cutting and 50 percent of all active ground nests were destroyed by hay mowing. In New York alfalfa hayfields, Bollinger *et al.* (1990) reported that mowing resulted in the failure of 94 percent of all bobolink nests active at the time of cutting. These losses to hay cutting can be a significant drain on grassland bird populations.

Although most attention of the effects of midseason cutting has been focused on agricultural hayfields, several other grassland habitats, such as public refuge lands and farm set-aside fields, are occasionally mowed during the nesting season (e.g., Strassman 1987, Hays and Farmer 1990) and also significantly reduce bird nesting success in these habitats. Several studies in the Midwest have reported an influx of birds into remaining uncut grasslands around the time that hayfields and roadsides are generally cut (e.g., Igl 1991, Bryan and Best 1991) pointing to the critical need for an increase in the acreage of uncut grasslands in the region. However, these secondary grassland areas also are occasionally cut creating a double jeopardy situation for breeding birds that may be attracted to them (Lou Best, pers. comm.).

If mowing is used as a management alternative, mowing must be timed to reduce the effects of cutting on breeding bird nest success. Ideally, mowing in areas that are being managed for grassland birds would not be conducted before 20 July. For each week that they are cut prior to this date, grassland bird potential reproductive success is reduced by approximately 5-10 percent (see fig. 2 in Frawley 1989:79). In agricultural hayfields, either delaying the first cutting of hayfields or an increase in the interval between successive cuttings would have obvious benefits for breeding birds. However, such recommendations are not realistic because they conflict with the objectives of farm operators to maximize their yields and to cut the forage crop when it has its peak value for livestock. This may be an example of an unreconcilable conflict, and we may have to accept the fact that some types of hayfields will always be ecological traps for breeding birds (Lou Best, pers. comm.).

Management implications: burning, grazing, and mowing

Due to the differing responses of grassland birds to the various forms of habitat management, managers are usually encouraged to provide a mosaic of burned and unburned, mowed and unmowed, or grazed and ungrazed grasslands to provide for the full range of grassland bird habitat preferences (e.g., Skinner *et al.* 1984, Ryan 1986, Renken and Dinsmore 1987, Herkert *et al.* 1993, Herkert 1994c). In such a plan, grassland areas are subdivided and managed in some type of rotational system in which some areas are burned, mowed, or grazed and other areas are left undisturbed. How frequently these subareas are disturbed is dependent on the management technique. Grasslands managed with prescribed burning or mowing should be burned or mowed often enough to prevent woody encroachment and possibly enhance nest success, but not so often as to negatively affect species, such as the Henslow's sparrow and sedge wren, which require areas that have not been recently disturbed. These vague recommendations do not translate easily into specific management prescriptions. This is due in part to the fact that there are still not enough data regarding individual species' responses to management to make robust predictions about the way that various species will respond to different management strategies under varying conditions. Moreover, most studies of the effects of burning on grassland birds have emphasized species short-term response to fire, and there is very little information available by which to predict how these short-term responses might be chained together to produce long-term patterns under different management scenarios. Based on the data at hand, however, it appears that burning or mowing 20-30 percent of a given grassland area every 3-5 years would sufficiently balance both the positive and negative impacts of burning or mowing in a way that would be most beneficial to migratory grassland birds. Just how large these subunits need to be is also not clear. However, it appears that subunits that are at least 30 ha or more in size stand the best chance of providing benefits to grassland bird species (Zimmerman 1988, Herkert 1994c). In bird conservation areas where grazing is the main management tool, some type of a rotational system is also usually recommended with a majority of areas being light to moderately grazed and with some closely grazed areas also provided in each season (Skinner *et al.* 1984).

With respect to woody encroachment there are currently few data regarding "threshold" levels of woody vegetation for grassland areas. Most grassland bird species tolerate some woody vegetation, and a few grassland bird species such as eastern meadowlarks, dickcissels, and vesper sparrows frequently use tall trees as song perches (Sample 1989). Research in Wisconsin has shown that grassland habitats with >4 percent total cover of woody vegetation >1 m begin to benefit woody or edge species over true grassland species (Sample 1989). In Missouri, grasshopper sparrows and Henslow's sparrows avoid areas with woody invasion >1 m tall (Kahl *et al.* 1985). Johnson and Odum (1956) reported grasshopper sparrows from early successional areas characterized by <10 percent coverage by shrubs. Based on these data, we recommend that managers strive to keep total cover of woody vegetation to <5 percent in areas being managed for grassland birds of open areas (see Sample and Mossman, in press). This recommendation also highlights the differing needs of grassland-associated bird species identified as of high regional concern in our prioritization scheme. Several high-ranking grassland-associated species, such as Bell's vireo and loggerhead shrike, are dependent on the presence of woody vegetation

in a grassland context for habitat suitability (Sample and Mossman 1994). Reducing woody vegetation too much on grassland areas will negatively influence these species. Therefore, there is also a need for the creation and maintenance of "shrub grassland" areas that focus on providing for the specific habitat requirements of these species in addition to providing grasslands areas that are open and free of woody vegetation for the "true" grassland birds. Providing habitat for shrub-prairie and open-grassland birds will require large areas if both habitats are to be included in the same area. An alternative is to manage specific areas as either open grassland or shrub prairie. In this situation, regional coordination would be needed to ensure that adequate amounts of both habitat types are available in the regional landscape in appropriate locations (see Ryan 1990).

Water-level Manipulation

Moist-soil habitats such as wet prairies, wet oldfields, and sedge meadows are affected not only by conventional grassland management activities but also by water level manipulations. For example, in Wisconsin ditching and draining sedge meadows lowers the local water table and can result (without other disturbances) in succession to shrub and tree-dominated communities, while flooding wet grasslands or sedge meadows to create impoundments or cranberry bogs can lower habitat quality for grassland birds (Mossman and Sample 1990). Thus, water-level manipulations must be carefully managed to maintain wet grassland and sedge communities.

LIMITING FACTORS

Temple (1988) identified three categories of factors that influence breeding bird populations and have the potential to influence long-term population trends; availability of breeding habitat, reproductive failure, and overwinter mortality. Loss and degradation of habitat are generally considered the most serious conservation problem facing species in North America (Noss and Murphy 1995). Many authors have implied that a decline in the acreage of native prairie and more recently agricultural grassland habitats has contributed to Midwestern grassland bird declines (e.g., Mayfield 1989, Sample 1989, Herkert 1991c, Warner 1994).

Our analysis of regional grassland bird population trends (fig. 3) suggests that loss of agricultural grassland habitats may be significantly influencing population declines for some species of Midwestern grassland birds. A few studies, however, have suggested that there is structurally suitable habitat that is unoccupied by some Midwestern grassland bird species (e.g., Brooks and Temple 1990, Basili and Temple 1995) suggesting that other factors besides habitat loss are also creating problems for migratory grassland birds in the Midwest.

Nest success for grassland birds is generally low, reports of nest success are frequently $\leq$ 30 percent (e.g., Roseberry and Klimstra 1970, Best 1978, Steigman 1990, Bryan and Best 1994, Camp and Best 1994). Several studies have suggested that nest success for grassland bird populations were so low that it was unlikely that adults were replacing themselves, and that these populations seemed dependent on immigration from other areas for population maintenance (e.g., Best 1978, Wray *et al.* 1982, Johnson and Temple 1986, Frawley 1989). Predation is generally considered the major cause of nest failure for grassland birds (Johnson and Temple 1986, Greer and Anderson 1989, Kantrud and Higgins 1992, Bowen and Kruse 1993, Bryan and Best 1994). However, in some Midwestern habitats mowing/haying is the primary source of nest losses (e.g., Frawley 1989). In pastures, trampling can also be a significant source of nest loss. Research in Wisconsin suggests that nest losses from trampling range from 25 percent (natural nests; Stanley Temple, pers. comm.) to 75 percent (simulated nests; Paine *et al.*, in press). Rates of nest parasitism by brown-headed cowbirds are variable among grassland birds, in some areas parasitism rates can be high (e.g., Hergenrader 1962, Hill 1976, Elliot 1978, Camp and Best 1994), but in other areas nest parasitism rates can be low (Robinson *et al.*, in press).

Limited winter habitat and/or winter resources have also been implicated in the declines of some grassland bird species (e.g., Fretwell 1986, Bucher and Nores 1988, Lymn and Temple 1991, Basili and Temple 1995). Fretwell (1972, 1986) suggested that dickcissel numbers, at least historically, and possibly still are winter-limited by the supply of seeds on their tropical winter areas. More recently, Basili and Temple (1995) have suggested that

efforts to control dickcissel's on their South American wintering grounds, where they are perceived as crop pests, may be behind recent population declines for this species. In the southeastern United States, the amount of suitable winter grassland habitat also has decreased substantially over the last 50 years due to conversion to croplands and pine plantations, and woody encroachment (Hunter 1990, Lymn and Temple 1991). This habitat loss also may be contributing to population declines since most declining Midwestern grassland birds winter primarily or partially in the southeastern Gulf Coast region (Herkert 1994a). Similar loss and conversion of grassland habitats are also occurring in major South American wintering areas used by Midwestern migratory grassland birds such as upland sandpipers and bobolinks (e.g., Bucher and Nores 1988, White 1988).

In summary, there is evidence that declines in the availability of grassland habitat, reproductive failure (due primarily to high rates of nest predation and occasionally nest parasitism), and problems on the North and South American winter grounds are all potentially influencing Midwestern grassland bird populations. Efforts to identify which factors are most important in limiting grassland bird populations are hampered by the limited data on aspects of their ecology. More data on grassland bird demographics are needed to identify and differentiate habitats that are sources from those that are population sinks, and a greater understanding of the winter ecology for most grassland species is also needed.

CONSERVATION STRATEGIES AND HABITAT MANAGEMENT GUIDELINES

We recommend that regional conservation efforts focus on all three of the potential limiting factors discussed above (habitat availability, reproductive failure, and winter ecology) until more information identifying specific problem areas for particular species becomes available. Most of our recommendations below focus on the breeding grounds although we recognize a serious need for more detailed information regarding the winter ecology for most of these species.

Our recommendations are in two broad groups. Our "conservation strategies" section includes recommendations that pertain to large-scale conservation and regional planning efforts. Often these are actions that transcend state boundaries but would be initially carried out by states or other local working groups, and at some point would need to be compiled into a comprehensive regional conservation plan. Our second group of "management guidelines" pertains to particular actions that land managers can carry out with the goal of benefiting local populations of grassland birds.

Conservation Strategies

- Stabilize the regional acreage of declining and undisturbed grassland habitats (i.e., pasture, old fields, native prairie, etc.), which may require some efforts to influence agricultural policies which significantly influences the amount of pasture, old field, and fallow areas on the landscape. At a minimum we recommend a "no net loss" principle for acreage of these major grassland habitats in the region. However, most likely the conservation of grassland birds in the region will require additional acreage of both native and non-native grasslands, especially some of the presently more restricted habitat types such as sedge meadows, wet-prairie, dry-prairie, shrub-prairie and open barrens.

- Maintain grasslands with a broad range of structure, plant species composition, field ages, moisture regimes, and topography in the regional landscape matrix. Ensure inclusion of habitats important for all species of local management concern.

- Increase conservation attention for the preservation of existing native grassland remnants. Wherever possible native remnants should form the core of restoration efforts targeted toward increasing the acreage of prairie and other native grasslands in the regional landscape. Incorporation of native remnant vegetation in habitat planning will promote the conservation of other components of native grassland biota (Henderson and Sample 1995).

- Initiate large-scale restorations (> 600 ha) in areas of the region that presently have limited grassland habitats available in the local landscape. Grassland bird use of these restorations should be closely monitored and used to guide future grassland restorations. A few large scale restorations are already underway in the region including

the 2,000-3,000 ha Walnut Creek National Wildlife Refuge (U.S. Fish and Wildlife Service) in Iowa and the 7,500 ha Midewin National Tallgrass Prairie (U.S. Forest Service) in Illinois.

- States should identify grassland areas and landscapes that possess significant grassland bird populations or have high grassland restoration potential. These landscapes should be large (>1,000 ha) and as treeless and open in character as possible (Henderson and Sample 1995).

- Initiate studies that relate grassland bird nest success to local habitat and landscape features so that regional "source" areas (or habitats) can be identified and so that features associated with low grassland bird reproductive success can be better identified. Habitat-specific productivity estimates are needed so that restoration and management efforts can be directed toward providing the most productive habitats for the species of concern.

- Support research addressing the winter ecology of migratory grassland birds that breed in the region.

- Maintain some managed upland grassland/shrub communities in appropriate parts of the region to meet the needs of bird species requiring a grassland/shrubland landscape matrix. Many of the region's open lands wildlife management areas have high potential for this and may, with minor modifications, be able to provide abundant habitat for these species requiring shrubland (S. K. Robinson, pers. comm.).

- Develop a regional assessment of the distribution, quantity, and quality of grassland habitat and the distribution, abundance, and habitat preference of grassland birds to determine where in the region it is most appropriate to manage for bird species and communities of management concern.

Management Guidelines

- Avoid fragmentation of existing grassland areas. The preservation and proper management of existing grassland areas, especially those presently used by area-sensitive, rare, or declining species is the most effective means of providing quality habitat for grassland birds (Herkert *et al.* 1993).

- Use some form of a rotational management system to provide a mosaic of burned and unburned, mowed and unmowed, or grazed and ungrazed grasslands to provide for the full range of grassland bird habitat preferences on large sites or among nearby small sites.

- When possible, locate managed grasslands adjacent to existing grassland habitat to increase overall size of grassland habitat blocks (Herkert *et al.* 1993, Sample and Mossman, in press).

- Eliminate mid-season cutting (prior to 20 July) of grasslands on public lands and agricultural set-aside lands.

- Aggressively control, and where necessary remove, woody encroachment in grassland areas being managed for open country grassland birds. Keep overall woody cover below 5 percent.

- Recognize the special features and value of your particular grassland areas. Avoid the temptation to provide habitat for all grassland birds in the region on all sites. Some sites may be best suited for management of low diversity grassland habitats (e.g., sedge meadows) that provide important habitat for specialist species that are rare in the regional avafauna (Sample and Mossman, in press).

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