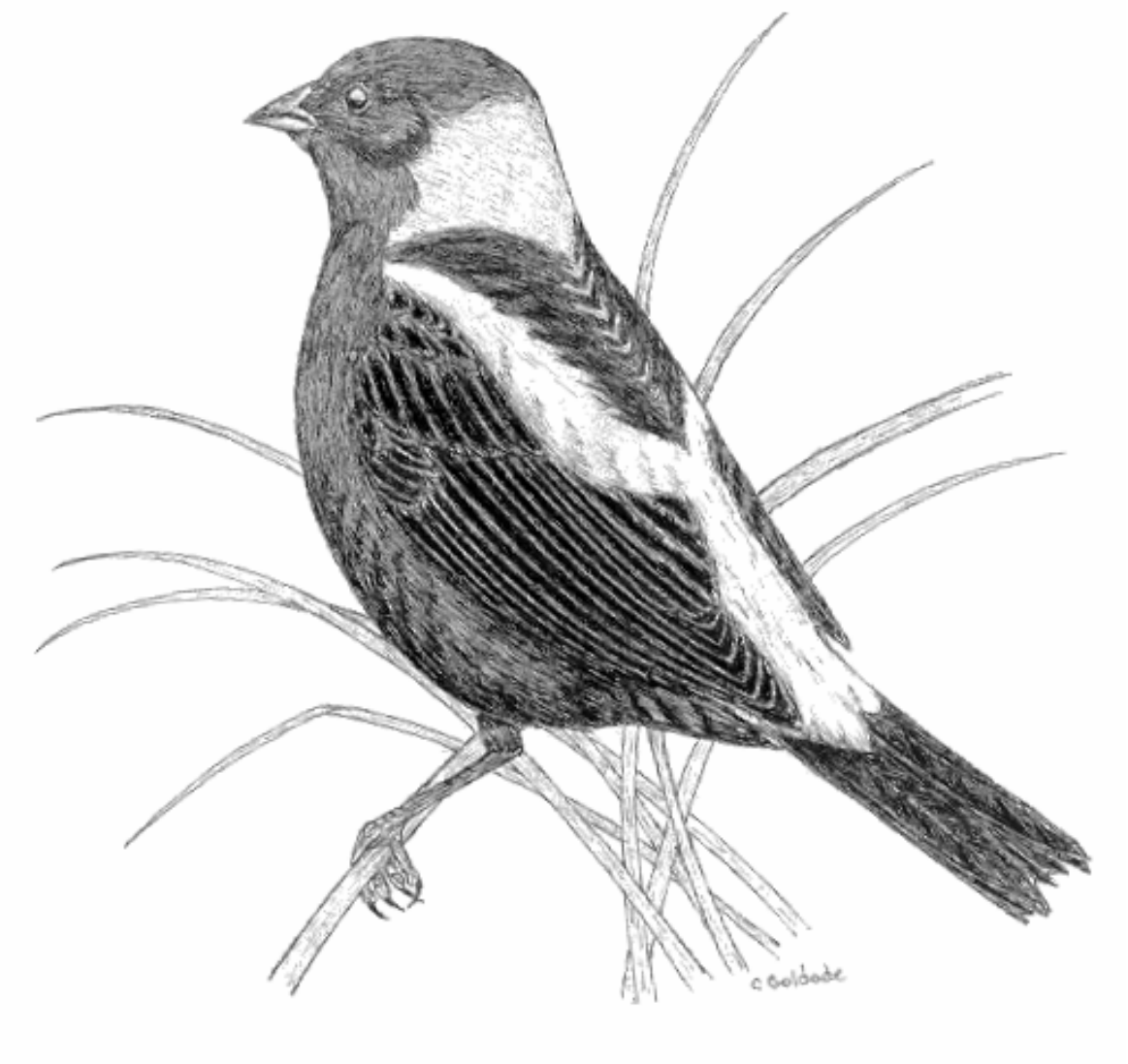
EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

BOBOLINK



Grasslands Ecosystem Initiative
Northern Prairie Wildlife Research Center
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Jamestown, North Dakota 58401

This report is one in a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV recently adopted a new goal, to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

American Bittern
Mountain Plover
Marbled Godwit
Long-billed Curlew
Willet
Wilson's Phalarope
Upland Sandpiper
Greater Prairie-Chicken
Lesser Prairie-Chicken
Northern Harrier
Swainson's Hawk
Ferruginous Hawk
Short-eared Owl
Burrowing Owl
Horned Lark
Sedge Wren
Loggerhead Shrike
Sprague's Pipit
Grasshopper Sparrow
Baird's Sparrow
Henslow's Sparrow
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow
Vesper Sparrow
Savannah Sparrow
Lark Sparrow
Field Sparrow
Clay-colored Sparrow
Chestnut-collared Longspur
McCown's Longspur
Dickcissel
Lark Bunting
Bobolink
Eastern Meadowlark
Western Meadowlark
Brown-headed Cowbird

EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

BOBOLINK

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

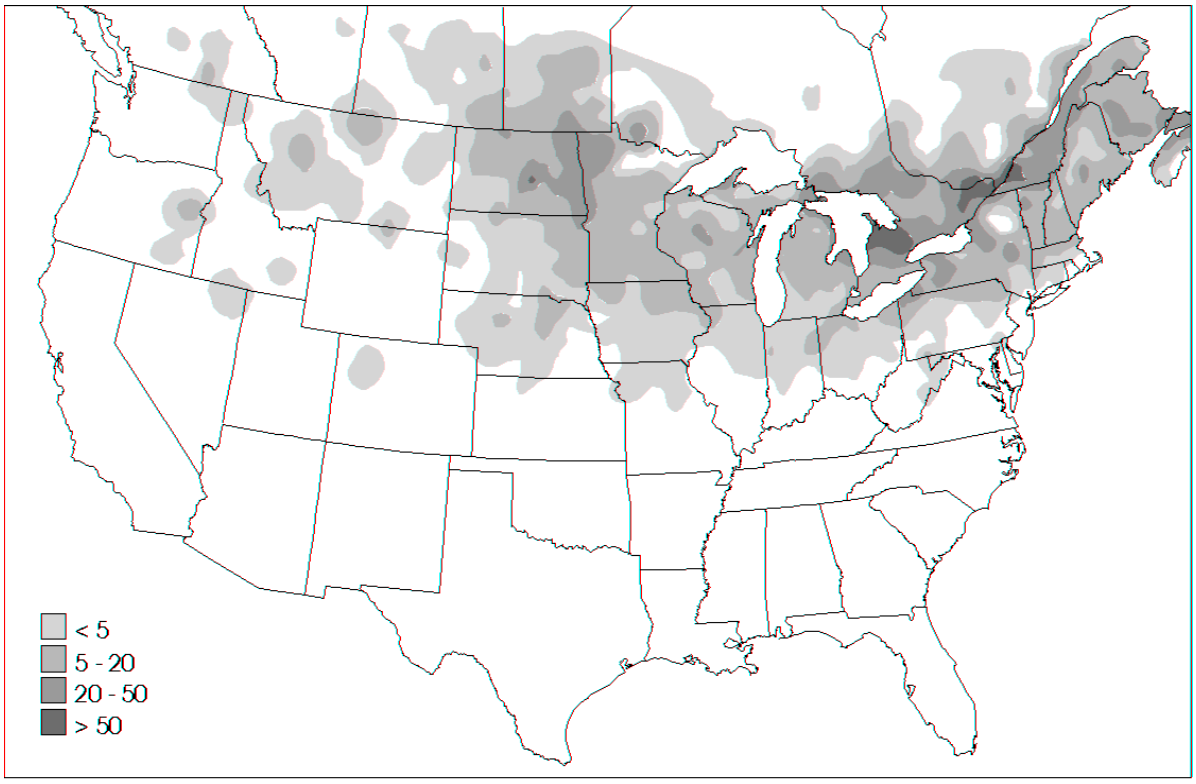
Information on the habitat requirements and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers. A ***range map*** is provided to indicate the relative densities of the species in North America, based on Breeding Bird Survey (BBS) data. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief ***capsule statement***, which provides the fundamental components or keys to management for the species. A section on ***breeding range*** outlines the current breeding distribution of the species in North America, including areas that could not be mapped using BBS data. The ***suitable habitat*** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A ***table*** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. A special section on ***prey habitat*** is included for those predatory species that have more specific prey requirements. The ***area requirements*** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The Brown-headed Cowbird (*Molothrus ater*) is an obligate brood parasite of many grassland birds. The section on ***cowbird brood parasitism*** summarizes rates of cowbird parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on ***breeding-season phenology and site fidelity*** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. ***Species' response to management*** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on ***management recommendations*** complements the previous section and summarizes specific recommendations for habitat management provided in the literature. If management recommendations differ in different portions of the species' breeding range, recommendations are given separately by region. The ***literature cited*** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

 Please direct comments and suggestions to Douglas H. Johnson, Northern Prairie Wildlife Research Center, U.S. Geological Survey, 8711 37th Street SE, Jamestown, North Dakota 58401; telephone: 701-253-5539; fax: 701-253-5553; e-mail: Douglas_H_Johnson@usgs.gov.

BOBOLINK

(*Dolichonyx oryzivorus*)

Figure. Breeding distribution of the Bobolink in the United States and southern Canada, based on Breeding Bird



Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, London, England. 364 pages.

Keys to management are providing large areas of suitable habitat (native and tame grasslands of moderate height and density, with adequate litter), controlling succession, and protecting nesting habitat from disturbance during the breeding season.

Breeding range:

Bobolinks breed from southern British Columbia across southern Canada to Nova Scotia, and south to eastern Oregon, central Colorado, central Illinois, western Virginia, and western North Carolina (National Geographic Society 1987). (See figure for the relative densities of Bobolinks in the United States and southern Canada, based on Breeding Bird Survey data.)

Suitable habitat:

Bobolinks prefer habitat with moderate to tall vegetation, moderate to dense vegetation, and moderately deep litter (Tester and Marshall 1961, Bent 1965, Harrison 1974, Bollinger 1995), and without the presence of woody vegetation (Sample 1989, Bollinger and Gavin 1992). Bobolinks are found in native and tame grasslands, haylands, lightly to moderately grazed pastures, no-till cropland, small-grain fields, oldfields, wet meadows, and planted cover (e.g., Conservation Reserve Program [CRP] fields, Permanent Cover Program [PCP] fields, and dense

nesting cover [DNC]) (Bent 1965; Speirs and Orenstein 1967; Birkenholz 1973; Harrison 1974; Skinner 1974, 1975; Stewart 1975; Joyner 1978; Johnsgard 1979, 1980; Faanes 1981; Kantrud 1981; Kantrud and Kologiski 1982; Renken 1983; Huber and Steuter 1984; Basore et al. 1986; Renken and Dinsmore 1987; Bollinger 1988, 1991, 1995; Sample 1989; Bollinger et al. 1990; Messmer 1990; Herkert 1991*a*, 1994*a*,1997; Bollinger and Gavin 1992; Bock et al. 1993; Johnson and Schwartz 1993; Dhol et al. 1994; Hartley 1994; Jones 1994; King and Savidge 1995; Madden 1996; Patterson and Best 1996; Prescott and Murphy 1996; Best et al. 1997; Dale et al. 1997; Delisle and Savidge 1997; McMaster and Davis 1998; Schneider 1998; Koford 1999). Bobolinks are commonly found in areas with high percent grass cover and moderate percent forb cover (Wiens 1969, Skinner 1974, Renken 1983, Renken and Dinsmore 1987, Sample 1989, Herkert 1994*a*, Madden 1996). Bollinger (1988, 1995) found that Bobolinks preferred haylands with high grass-to-forb ratios and avoided haylands with high legume-to-grass ratios; however, a forb component was beneficial for nesting cover. In Colorado, Bock et al. (1999) compared the abundance of Bobolinks between upland (mixed-grass prairie) and lowland (tallgrass prairie or tame hayland) grasslands. Bobolinks were significantly more abundant on lowland than on upland plots. Within mixed-grass pastures in North Dakota, abundance of Bobolinks was positively associated with percent grass cover, litter depth, density of low-growing shrubs (western snowberry [*Symphoricarpos occidentalis*] and silverberry [*Elaeagnus commutata*]), vegetation density, and plant communities dominated by Kentucky bluegrass (*Poa pratensis*) and native grass (*Stipa*, *Bouteloua*, *Koeleria*, and *Schizachyrium*) (Schneider 1998). Abundance was negatively associated with percent clubmoss (*Selaginella densa*) cover, bare ground, and plant communities dominated solely by native grass. Strongest vegetational predictors of the presence of Bobolinks were decreasing bare ground, increasing litter, and increasing vegetation density. Madden (1996) found that the best predictors of Bobolink occurrence in North Dakota mixed-grass prairie were increasing amounts of forb and grass cover, decreasing amounts of shrub cover, and decreasing frequency of native grasses. In Illinois tallgrass prairie fragments, the best predictors of Bobolink occurrence were mean number of live forb contacts, mean vegetation height, and mean grass height (Herkert 1994*a*). In another Illinois study, Bobolinks occurred only in patches of Kentucky bluegrass and were absent from tallgrass prairie (Birkenholz 1973). In Nebraska, Bobolink abundance in CRP planted to cool-season grasses was significantly and positively correlated with percent litter cover and negatively correlated with vertical density of vegetation (measured using a Robel pole) (Delisle and Savidge 1997). In tame CRP grasslands in Iowa, Bobolink abundance was positively correlated with litter cover and grass canopy cover and negatively correlated with forb cover and the horizontal patchiness of vegetation (Patterson and Best 1996). Bobolink abundance in Wisconsin was highest in cool-season grasses, followed by wet pastures, bluegrass (*Poa*)/quackgrass (*Agropyron repens*) communities, and alfalfa (*Medicago sativa*)/grass hayfields (Sample 1989). In New York tame hayfields, Bobolinks increased in abundance as the hayfields aged (Bollinger 1988, 1995). Older hayfields ($\geq$3 yr old) were characterized by sparse, patchy, grass-dominated vegetation and high litter cover.

In Nebraska, Bobolinks nested in wet prairie, alfalfa, upland native prairie, domestic hayland, and wheat (Faanes and Lingle 1995). Bobolinks in Iowa nested under or near native bluestem (*Andropogon* or *Schizachyrium* not specified) or Kentucky bluegrass (Kendeigh 1941). Bobolinks in Wisconsin nested at the bases of large forbs (Martin 1971). In Montana, Bobolinks nested in a wet-meadow pasture (Silloway 1904). In Ontario, Bobolinks nested in a

weedy meadow near a wetland; nests were built in the litter layer, had a canopy of dead grasses, and were surrounded by living vegetation 33-41 cm tall (Boyer and Devitt 1961, Joyner 1978). Bobolinks have been found nesting in CRP fields in Iowa and Michigan (Best et al. 1997).

Bobolinks occasionally nest in cropland. In Iowa, Bobolinks nested at low densities in untilled fields of corn that were idle in the fall and spring and contained year-round crop residue, rather than in tilled fields or strip cover (Basore et al. 1986). In Wisconsin, a few Bobolinks were found in small-grain fields, but none were found in rowcrops (Sample 1989). The species was absent from cropland in Saskatchewan and Manitoba (Hartley 1994, Jones 1994). A table near the end of the account lists the specific habitat characteristics for Bobolinks by study.

Area requirements:

Territories include both foraging and nesting areas (Martin 1967). Average territory size ranged from 0.45 to 0.69 ha in a mixed hayland on a floodplain in Wisconsin (Martin 1967, 1971), 0.49 ha at six tame hayfields in New York (Bollinger 1988), 1.4 ha in a tame hayfield in Michigan (Raim 1975), and 2.5 ha in a dry, sparsely vegetated pasture in Wisconsin (Wiens 1969). Bobolinks appear to be area sensitive, preferring large grassland areas over small (Herkert et al. 1993, O'Leary and Nyberg 2000). Herkert (1991*b*) reported that the minimum area on which Bobolinks were found was 10-30 ha in Illinois tallgrass prairie fragments. The minimum patch size requirement for Bobolinks in wet meadows in Nebraska was 46 ha, with a perimeter-area ratio of about 0.010 (Helzer 1996, Helzer and Jelinski 1999). Occurrence of Bobolinks was positively correlated with patch area and inversely correlated with perimeter-area ratio (Helzer and Jelinski 1999). Bobolink abundance in tallgrass prairie fragments was positively related to area (Herkert 1994*b*). Bobolink abundance was positively correlated with fragment size in New York and Maine (Bollinger and Gavin 1992, Vickery et al. 1994).

In Minnesota tallgrass prairie, nest depredation and Brown-headed Cowbird (*Molothrus ater*) brood parasitism decreased farther from woody edges, and nest depredation rates were lower on large (130-486 ha) than on small (16-32 ha) grasslands (Johnson and Temple 1990). Nest productivity in Minnesota was highest for nests in habitats far (>45 m) from a forest edge (Johnson and Temple 1986). In Nebraska, Bobolink abundance was lower near woody edges (<100 m) than far (>100 m) from woody edges (Helzer 1996). In Colorado, Bock et al. (1999) compared the abundance of Bobolinks between interior and edge locations. Edge was defined as the interface between suburban development and upland or lowland habitat, and interior locations were 200 m from edge. Bobolinks were significantly more abundant on interior plots than on edge plots.

Brown-headed Cowbird brood parasitism:

Bobolinks generally are considered an uncommon (Hicks 1934, Friedmann 1963, Friedmann et al. 1977, Davis 1994, Martin and Gavin 1995) or rare (Martin 1967, Strausberger and Ashley 1997) host of the Brown-headed Cowbird. However, parasitism rates vary from 0% of 20 nests (Martin 1967) to 34% of 47 nests (Johnson and Temple 1990). Refer to Table 1 in Shaffer et al. (2003) for rates of cowbird brood parasitism. Bobolinks may be multiply-parasitized (Silloway 1917, Roberts 1932, Friedmann 1963, Davis and Sealy 2000).

Breeding-season phenology and site fidelity:

In Iowa, Michigan, Minnesota, Nebraska, and Wisconsin, Bobolinks arrive on the breeding grounds from late April to mid-May and depart from July to September (George 1952; Bent 1965; Martin 1967, 1971; Harrison 1974; Johnsgard 1980; Faanes 1981; Kent and Dinsmore 1996). In Alberta and Saskatchewan, Bobolinks arrive in early June and depart around early September (Maher 1974, Salt and Salt 1976). The peak of the breeding season in North Dakota occurs from early June to mid-July (Stewart 1975). Females typically renest if the first nest is destroyed, and will occasionally attempt to renest a third time (Martin 1971, Gavin 1984, Martin and Gavin 1995). Bobolinks are usually single-brooded (Johnsgard 1979), but double-brooding has been recorded (Martin 1971, Gavin 1984, Martin and Gavin 1995). Both sexes exhibit high breeding-site fidelity (Martin 1971, Bollinger 1988). In Michigan, male Bobolinks exhibited breeding-site fidelity (George 1952). In tame hayfields in New York, 44% of 59 males and 25% of 71 females returned to previous breeding sites in subsequent years (Bollinger 1988).

Species' response to management:

If habitat is not maintained, use by Bobolinks declines significantly, possibly due to the accumulation of litter and encroachment of woody vegetation (Johnson 1997). Bobolinks respond positively to properly timed burning or mowing treatments (Herkert 1991*a*, 1994*b*; Bollinger and Gavin 1992; Madden 1996; Johnson 1997; Madden et al. 1999). In 2 yr, a Wisconsin field that was burned in April each year was occupied by Bobolinks in early June; the year it was not burned, the field was occupied by mid-May (Martin 1971). In Minnesota, Bobolinks were absent from tallgrass prairie 1 yr postburn but established territories 2 yr postburn (Tester and Marshall 1961). Nest productivity in Minnesota was highest 1 yr postburn, and the probability of encountering Bobolinks was highest on areas 1 yr postburn (Johnson and Temple 1986). In Illinois tallgrass prairie fragments, Bobolinks preferred recently burned or mowed (burned or mowed 1-4 mo prior to the breeding season) sites over areas burned >1 yr previous or to unmowed areas (Herkert 1991*a*, 1994*b*). In North Dakota, Bobolink abundance peaked 1-3 yr postburn (Madden 1996, Johnson 1997), but declined 5 yr postburn (Johnson 1997). Abundance was highest in grasslands that had been burned four times in the previous 15 yr, compared to unburned areas and areas burned one to two times in the previous 15 yr (Madden et al. 1999). In South Dakota, Bobolinks preferred lightly grazed (grazed by American bison [*Bison bison*]) areas over spring-burned areas (Huber and Steuter 1984). Bobolink abundance in Maine declined in the burn year, but peaked 1-2 yr postburn (Vickery 1993).

In Nebraska, Bobolinks occurred more frequently in tallgrass hayland than tallgrass pasture (Helzer 1996). In North Dakota, Kantrud (1981) found the highest Bobolink densities in hayland mowed the previous year, with lightly grazed areas containing the second highest densities. In another North Dakota study, there was no difference in abundance in the year following haying between hayed and idled portions of CRP fields (Horn and Koford 2000). In Michigan and Wisconsin, Bobolinks were common in hayfields before mowing, but deserted these fields after the fields were mowed (Harrison 1974, Sample 1989). In Missouri, however, Skinner (1974) found that Bobolinks were present in hayfields before and after mowing. In Illinois, a decline in Bobolink abundance was significantly correlated with declines in the number of hectares of alfalfa, oats, and pasture in the northern one-third of the state from 1952 to 1992 (Herkert 1997). In Saskatchewan, Bobolinks were more abundant in emergency-mowed

(mowed during drought years) tame hayfields than in native grassland, tame grassland, or annually mowed tame haylands (Dale 1992). Dale et al. (1997) found that Bobolink abundance in Saskatchewan was higher in annually or periodically (idle for 4-8 yr) mowed tame hayland than in idle native grassland. However, mowing during the breeding season can cause high rates of nest failure for Bobolinks; mowing accounted for 51% of Bobolink nest losses in a New York hayfield (Bollinger et al. 1990).

In the Great Plains, measures of abundance indicated that Bobolinks responded positively to moderate grazing in tallgrass, but negatively to heavy grazing in shortgrass (Bock et al. 1993). In southeastern North Dakota, Bobolinks occurred in grazed areas that had few shrubs and moderate to deep litter (Messmer 1990). Higher densities of Bobolinks were found in areas under a short-duration grazing treatment (involved a system of pastures rotated through a grazing schedule of about 1 wk grazed and 1 mo ungrazed) than in idle areas. In southwestern Wisconsin, Bobolinks were nearly equally abundant in rotationally grazed pastures, continuously grazed pastures, and ungrazed pastures (Temple et al. 1999). Ungrazed grasslands were neither mowed or grazed from 15 May to 1 July. Continuously grazed sites were grazed throughout the summer at levels of 2.5-4 animals/ha. Rotationally grazed pastures, stocked with 40-60 animals/ha, were grazed for 1-2 d and then left undisturbed for 10-15 d before being grazed again; pastures averaged 5 ha. All sites were composed of 50-75% cool-season grasses, 7-27% legumes, and 8-23% forbs. In southeastern South Dakota, Bobolinks preferred lightly grazed areas on typic ustoll soils (Kantrud and Kologiski 1982). In Missouri, Bobolinks were most abundant in lightly to moderately grazed tallgrass prairie and were not present in idle prairie (Skinner 1974, 1975). In Alberta, Bobolinks were found in tame pastures but not in native pastures (Prescott and Murphy 1996).

Bobolinks nested or were found in CRP fields in Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, and South Dakota (Johnson and Schwartz 1993, Patterson and Best 1996, Best et al. 1997, Delisle and Savidge 1997). In North Dakota, higher densities of Bobolinks were found in DNC planted to alfalfa and wheatgrass (*Agropyron* spp.) than in idle mixed-grass prairie (Renken 1983, Renken and Dinsmore 1987). In CRP fields in Nebraska, Bobolink abundance was significantly higher in cool-season grasses than in warm-season grasses, possibly because of shorter vegetation in cool-season grasses (Delisle and Savidge 1997). King and Savidge (1995) found Bobolinks in tallgrass prairie and CRP planted to cool-season grasses but did not find them in CRP planted to warm-season grasses. In Minnesota and North Dakota, Koford (1999) reported that Bobolink abundance was equal or nearly equal between CRP fields and Waterfowl Production Areas (tracts of grassland and wetland managed by the U. S. Fish and Wildlife Service to provide nesting and brood-rearing habitat for waterfowl). In Manitoba and Saskatchewan, Bobolinks were found in native and tame DNC and in idle native grassland (Dhol et al. 1994, Hartley 1994); wheat fields were avoided (Hartley 1994). Bobolinks also were found in Permanent Cover Program lands in Canada (McMaster and Davis 1998). PCP was a Canadian program that paid farmers to seed highly erodible land to perennial grassland cover; it differed from CRP in the United States in that haying and grazing were allowed annually in PCP. In Canadian aspen parkland, Bobolinks occurred more frequently in PCP than in cropland (McMaster and Davis 1998). However, their frequency of occurrence did not differ between hay and pasture sites within the parkland PCP sites. In North Dakota, Bobolinks were present in areas seeded to native grasses 1 yr after seeding occurred

(Higgins et al. 1984). In Wisconsin, Bobolinks occurred in a restored native tallgrass prairie site 3 yr following seeding (Volkert 1992).

In Maine, territory density of Bobolinks decreased for 2-5 yr following the application of the herbicide hexazinone at a rate of 4 kg/ha on lowbush blueberries (*Vaccinium angustifolium*) (Vickery 1993).

Management Recommendations:

Regardless of geographic location, avoid disturbing (e.g., haying, burning, moderately or heavily grazing) nesting habitat during the breeding season, approximately early May to mid-July (Bollinger 1991). Treatments can be done in early spring (several weeks prior to the arrival of adults on the breeding grounds) or in the fall after the breeding season (Martin and Gavin 1995). Recommendations follow for the Great Plains and for the East and Midwest.

Great Plains (based on studies from Nebraska, North Dakota, South Dakota, and Saskatchewan):

Create large patches of habitat and minimize woody edges whenever possible to increase Bobolink densities (Johnson and Temple 1990, Helzer 1996, O'Leary and Nyberg 2000). In Nebraska, minimum patch size requirement for wet meadows was >40 ha, and Bobolink abundance was lower near woody edges (<100 m) than far (>100 m) from woody edges (Helzer 1996). Shape, as well as area, of management units must be taken into consideration; perimeter-area ratio strongly influenced occurrence of Bobolinks in Nebraska (Helzer and Jelinski 1999).

Reduce amount of grassland edge near suburban interfaces (Bock et al. 1999).

Burn habitat once every 2-4 yr to prevent encroachment of woody vegetation and remove deep litter (Johnson and Temple 1990, Madden 1996, Johnson 1997, Madden et al. 1999).

Conduct controlled burns on CRP fields every 3-5 yr to reduce dense vegetation (King and Savidge 1995). In Nebraska, Bobolink abundance was negatively correlated with vertical density of vegetation (Delisle and Savidge 1997).

Burn large areas on a rotational basis, burning portions of the total area each year (Johnson 1997). Burn small areas periodically. Ensure that adjacent areas are burned in different years to create a variety of successional stages.

Provide hayland areas, and mow as late as possible. In Nebraska, Bobolinks occurred more frequently in native hayland than pastures (Helzer 1996). Kantrud (1981) found Bobolink densities to be highest in hayland mowed the previous year, with lightly grazed areas containing the second highest density. Dale et al. (1997) found that Bobolink abundance in Saskatchewan was higher in annually or periodically mowed tame hayland than in native grassland.

Delay mowing until after 15 July, by which time at least 70% of nestlings will have fledged in years of normal breeding phenology (Dale et al. 1997). To maintain dense cover in idle

haylands, mow some fields in alternate years while leaving others idle for at least 3 yr. Divide large fields in half, with each half being mowed in alternate years, thus ensuring productivity of hay and of birds.

Lightly graze areas where Bobolinks have exhibited positive responses to this treatment; heavy or moderate grazing may negatively affect Bobolink populations (Kantrud 1981).

East and Midwest (based on studies from Illinois, Iowa, Michigan, Minnesota, Missouri, New York, and Wisconsin):

Delay treatments until late July or August to protect fledglings and late-nesting females (Bollinger 1991). Mowing accounted for 51% of Bobolink nest losses in a New York hayfield (Bollinger et al. 1990).

Create large habitat patches (>10-30 ha) and minimize woody edges whenever possible to decrease Brown-headed Cowbird brood parasitism (Bollinger and Gavin 1992).

Use a rotating treatment schedule on several nearby prairie fragments to make a variety of successional stages available (Herkert 1994*b*). Adjacent patches of alternative habitat provide refuge for fledglings to escape from mowed areas and for late-nesting females (Bollinger et al. 1990).

Create or maintain patches of relatively sparse, grass-dominated vegetation resembling old (>8 yr since planted) hayfields (Bollinger and Gavin 1992). Scattered forbs (e.g., clover [*Trifolium* spp.]) should be encouraged for nest-site cover. Bollinger (1988, 1995) found that a minimal forb component for nesting cover was beneficial, but Bobolinks preferred haylands with high grass-to-forb ratios and avoided haylands with high legume-to-grass ratios.

Burn large areas (>80 ha) using a rotational system. Subunits of ≥30 ha in area, or about 20-30% of the total area, should be treated in a year (Herkert 1994*b*). Johnson and Temple (1990) found lower rates of nest depredation on Bobolink nests in recently burned (≤3yr) areas in Minnesota.

In small, isolated prairie fragments, burn ≤50-60% of the total area at a time (Herkert 1994*b*).

Mow or burn patches every 2-3 yr to prevent excessive encroachment of woody vegetation (Bollinger and Gavin 1992, Herkert 1994*a*). In most years, delaying mowing until the end of June may allow young Bobolinks time to fledge (Harrison 1974).

Graze at moderate levels to provide diverse grass heights and densities in areas where the average height of vegetation is 20-30 cm (Skinner 1974, 1975). Graze using a rotational system of two or more grazing units (Skinner 1974). This will increase the variation in grass heights and densities within and between units. To maintain plant vigor, do not graze warm-season grasses in tallgrass prairie to a height of <25 cm during the growing season (Skinner 1975).

Table. Bobolink habitat characteristics.

Author(s)	**Location(s)**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Basore et al. 1986	Iowa	Cropland, idle	Nested at low densities in corn planted into sod residue
Bent 1965	Rangewide	Cropland, idle, pasture, tame hayland, wet meadow	Preferred thick, tall vegetation of alfalfa (*Medicago sativa*) hayfields, wet meadows, and dense stands of weeds; were common in small-grain fields
Birkenholz 1973	Illinois	Idle, idle tallgrass, idle tame, wetland, wet meadow	Occurred in stands of Kentucky bluegrass (*Poa pratensis*); were absent from native prairie with dense vegetation and litter
Bock et al. 1999	Colorado	Idle mixed-grass, idle tallgrass, mixed-grass pasture, tallgrass pasture, tame hayland	Were more abundant on interior plots than on edge plots and in lowland habitat than in upland habitat; edge was defined as the interface between suburban development and upland or lowland habitat, and interior locations were 200 m from edge; upland grasslands were mixed-grass prairie and lowland grasslands were tallgrass prairie or tame hayland
Bollinger 1988	New York	Tame hayland	Preferred larger, older, grass-dominated (rather than legume-dominated) hayfields with mean vegetation values of 65% total cover, 3.5% trefoil (*Lotus*) cover, 28% grass cover, 9% alfalfa cover, 8% clover (*Trifolium* spp.) cover, 5-25% litter cover, and 18 cm vegetation height
Bollinger 1995	New York	Tame hayland	Preferred short, sparse, patchy, grass-dominated vegetation and high percent litter cover
Dale 1992	Saskatchewan	Idle native, idle native/tame, tame hayland	Were most abundant in a tame hayfield mowed only during drought (mowed once in $\geq$3 yr)

Dale et al. 1997	Saskatchewan	Idle mixed-grass, idle tame, tame hayland	Abundance was higher in annually or periodically (idle for 4-8 yr) mowed tame hayland than in native grassland
Delisle and Savidge 1997	Nebraska	Conservation Reserve Program (CRP; burned seeded-native, idle seeded-native, idle tame, seeded-native hayland, tame hayland)	Abundance was significantly higher in cool-season grasses than warm-season grasses, possibly because of shorter vegetation; abundance was significantly and positively correlated with percent litter cover and negatively correlated with vertical density
Dhol et al. 1994	Manitoba	Dense nesting cover (DNC; idle seeded-native, idle tame), idle mixed-grass	No difference in abundance or productivity was found between habitats; were found in tall and dense DNC plots
Faanes 1981	Minnesota, Wisconsin	Cropland, idle, idle tallgrass/tame, shrub carr, tame hayland, tame pasture, wetland, wet meadow, woodland	Observed in cropland, alfalfa fields, tame pasture, and prairie fragments
Faanes and Lingle 1995	Nebraska	Cropland, idle mixed-grass, idle shortgrass, idle tallgrass, pasture, sand-sage grassland, tame hayland, wetland, wet meadow, woodland	In order of decreasing density, nested in wet prairie, alfalfa, upland native prairie, tame hayland, and wheat
George 1952	Michigan	Cropland, hayland, pasture, woodland edge	Nested in hayfields and avoided cropland
Harrison 1974	Michigan	Tame hayland	Occupied areas of high plant diversity (14 plant species), relatively heavy litter, and dense vegetation at

			heights of 5 cm; breeding activities were terminated due to mowing; foraged in mowed fields; mean vegetation measurements were 75% litter cover, 56 cm vegetation height, and 12.3 vertical density (number of contacts along a metal rod placed vertically in the vegetation)
Hartley 1994	Saskatchewan	Cropland, DNC (idle seeded-native, idle seeded-native/tame, idle tame, idle tame hayland), idle mixed-grass	Were found in both DNC and idle native grassland; wheat fields were not used
Herkert 1991*a*	Illinois	Burned seeded-native, burned tallgrass, cropland, idle seeded-native, idle tallgrass, idle tame, tame hayland	Preferred recently burned and mowed sites (burned or mowed 1-4 mo prior to breeding season) over sites burned >1 yr previous or unmowed areas
Herkert 1994*a*	Illinois	Idle seeded-native, idle tallgrass, idle tame	Predictors of occurrence were high mean number of live forb contacts, tall mean vegetation height, and tall mean grass height
Horn and Koford 2000	North Dakota	CRP (idle tame, tame hayland)	Abundance in the year following haying did not differ between hayed and idled portions of fields
Huber and Steuter 1984	South Dakota	Burned mixed-grass pasture, mixed-grass pasture	Preferred lightly grazed areas over spring-burned areas
Johnsgard 1979, 1980	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota,	Cropland, idle, idle mixed-grass, idle shortgrass, idle tallgrass, mixed-grass pasture, tallgrass pasture, tame	Occurred in tallgrass prairie, idle to lightly grazed mixed-grass prairie, wet meadows, hayfields, retired cropland, and occasionally in small-grain fields

	South Dakota	hayland, wet meadow	
Johnson 1997	North Dakota	Burned mixed-grass, burned tame, idle mixed-grass	Densities were low immediately after burn, peaked 1-3 yr postburn, and declined 5 yr postburn
Johnson and Schwartz 1993	Minnesota, Montana, North Dakota, South Dakota	Cropland, CRP (idle mixed-grass, idle tame)	Density was positively associated with percent grass cover
Johnson and Temple 1990	Minnesota	Burned tallgrass, idle tallgrass, woodland edge	Nest success was higher on large fragments (130-486 ha) than on small fragments (16-32 ha) and higher for nests located far (>45 m) from a wooded edge; nest success decreased with increased number of growing seasons since vegetation was last burned
Jones 1994	Manitoba	Cropland, DNC (idle seeded-native, idle tame), idle mixed-grass, idle tame, tame hayland, woodland	Were present in native grasslands and tame hayland; were not found in DNC or cropland
Joyner 1978	Ontario	Idle, wetland	Nested in a weedy oldfield next to a wetland; nests were built in the litter layer, overlayed by dead grasses, and surrounded by living vegetation 33-41 cm in height
Kantrud 1981	North Dakota	Mixed-grass hayland, mixed-grass pasture	In order of preference, occurred in native hayfields, lightly grazed mixed-grass pasture, and heavily grazed mixed-grass pasture
Kantrud and Kologiski 1982	Colorado, Montana, Nebraska,	Mixed-grass pasture, shortgrass pasture, shrubsteppe	Preferred lightly grazed areas with typic ustoll soils

	North Dakota, South Dakota, Wyoming		
Kendeigh 1941	Iowa	Idle tallgrass (restored)	Nested under or near clumps of native bluestem (*Andropogon* or *Schizachyrium* not specified) and Kentucky bluegrass
King and Savidge 1995	Nebraska	Burned tallgrass, cropland, CRP (burned seeded-native, idle seeded-native, idle tame, tame hayland), idle tallgrass, tallgrass hayland	Occurred in CRP planted to cool-season grasses and native tallgrass species; were not found in CRP planted to warm-season grasses
Koford 1999	Minnesota, North Dakota	CRP (idle tame), Waterfowl Production Area (WPA; burned, hayland, idle native, idle native/tame, idle seeded-native, idle tame)	Were nearly or as abundant in WPA as in CRP fields
Madden 1996	North Dakota	Burned mixed-grass, burned tame, idle mixed-grass, idle tame	Occupied areas were characterized by (means in parentheses) greater forb cover (26%), grass cover (41%), live vegetation (45%), and frequency of broad-leaved exotic grasses than unoccupied areas; occupied areas also had lower shrub cover (22%), visual obstruction (17 cm), litter depth (3.4 cm), vegetation density (17.5 total contacts), and shrub frequency than unoccupied areas; were absent from unburned areas; reached highest abundances 1-3 yr postburn
Martin 1971	Wisconsin	Burned tallgrass, idle tame, tallgrass/sedge	Preferred building nests at the bases of large forbs and where vegetation structure was characterized as

		hayland (floodplain)	follows: 83% forb cover, 90% sedge (*Carex*) cover, 30% grass cover, <1% woody cover, 15% open sky at ground level, 0.9 cm litter depth, 77 cm mean height of nearest forb (meadow rue [*Thalictrum*] or golden alexander [*Zizia*]), 2.0 m mean distance to nearest forb (meadow rue or golden alexander), and heavy concealing cover around nests (11.0 mean number of total vertical contacts at nest site compared to 9.0 at random point)
Messmer 1990	North Dakota	Idle mixed-grass/tame, mixed-grass/tame hayland, mixed-grass/tame pasture, wet-meadow pasture	Used grazed and idle areas; were most common in silty range areas characterized by loamy soils, 1-15% slope, mean grass coverages ranging from 17 to 65%, low shrub cover, moderate to high litter cover, maximum vegetation height of 70 cm, and moderate to deep litter (3.9-9.1 cm)
Patterson and Best 1996	Iowa	CRP (idle tame, tame hayland), cropland	Abundance was positively correlated with litter cover and grass canopy cover; abundance was negatively correlated with forb cover and horizontal patchiness of vegetation; nested in CRP
Prescott and Murphy 1996	Alberta	Mixed-grass pasture, tame pasture	Were found in tame pastures but not in native pastures
Renken 1983, Renken and Dinsmore 1987	North Dakota	DNC (idle tame), idle mixed-grass, mixed-grass pasture	Territories were in areas with greater grass and forb cover than unused areas; abundance was correlated positively with effective height of vegetation; mean vegetation values for used areas were: 75% grass cover, 34% forb cover, 99% litter cover, 2% shrub cover, 0.1% bare ground, 22 cm effective height, and 3.2 cm litter depth
		Burned tallgrass,	Occupied areas with an average of 2% woody cover,

Sample 1989	Wisconsin	cropland, DNC (idle seeded-native, idle tame), idle, idle seeded-native, idle tallgrass, idle tallgrass/tame, idle tame, tame hayland, tame pasture, tame savanna pasture, wet meadow, wet-meadow pasture	78% herbaceous cover, 15% litter cover, 5% bare ground, 63 cm maximum vegetation height, and 22 cm height/density (Robel pole); density was positively correlated with plant species richness and negatively correlated with percent woody cover 1-3 m and 3-6 m above the ground, total number of dead stems per m^2, maximum vegetation height, height/density, and proportion of plots burned
Schneider 1998	North Dakota	Mixed-grass pasture, tame pasture, wet- meadow pasture	Abundance was positively associated with percent grass cover, litter depth, density of low-growing shrubs (western snowberry [*Symphoricarpos occidentalis*] and silverberry [*Elaeagnus commutata*]), vegetation density, and plant communities dominated by Kentucky bluegrass and native grass (*Stipa*, *Bouteloua*, *Koeleria*, and *Schizachyrium*); abundance was negatively associated with percent clubmoss (*Selaginella densa*) cover, bare ground, and plant communities dominated solely by native grass; strongest vegetational predictors of the presence of Bobolinks were decreasing bare ground, increasing litter, and increasing vegetation density
Skinner 1974, 1975	Missouri	Idle tallgrass, idle tame, tallgrass hayland, tallgrass pasture, tame hayland, tame pasture	Preferred lightly to moderately grazed grasslands; were found in hayland before and after mowing; highest densities occurred when grass heights were 10-30 cm; were not found in idle grasslands
Speirs and Orenstein 1967	Ontario	Cropland, idle, pasture, tame hayland	Preferred oldfields and hayfields; were uncommon in pastures
Stewart 1975	North Dakota	Cropland, idle, idle	Breeding habitat included ungrazed and lightly grazed

		mixed-grass, idle tallgrass, mixed-grass pasture, tallgrass pasture, tame hayland, wetland	mixed-grass prairie, tallgrass prairie, wet-meadow zones of wetlands, domestic haylands, retired cropland, and small-grain fields
Tester and Marshall 1961	Minnesota	Burned tallgrass, idle tallgrass, tallgrass hayland, tallgrass pasture	Abundance was significantly and positively correlated with litter depth, although areas with very high amounts of litter seemed to be avoided; no territories were located on areas the first growing season postburn; territories occurred the second growing season postburn
Vickery et al. 1994	Maine	Eastern grassland (barren burned), eastern grassland hayland	Abundance was correlated positively with high grass cover, high forb cover, high patchiness, and area of habitat patch
Wiens 1969	Wisconsin	Idle pasture, tame pasture	Preferred high percent grass cover, tall forbs, high vegetation density, and high forb density; territories had 96% grass cover, 28% forb cover, 3% bare ground, and 35% vegetation cover with an effective height (measure of height/density) of <5 cm tall; heavy-stemmed forbs were an important substrate for singing, and medium-stemmed forbs appeared to be important as lookout perches; nests were built at bases of dense grasses or clumps of forbs; of 8 territories, mean distance from territory boundary to woods was 100 m, to fence line was 0 m, and to cultivated field was 59.4 m; all territories included posts and fence lines, 25% contained wire bales or tangles, and 50% contained trees

*In an effort to standardize terminology among studies, various descriptors were used to denote the management or type of habitat. "Idle" used as a modifier (e.g., idle tallgrass) denotes undisturbed or unmanaged (e.g., not burned, mowed, or grazed) areas. "Idle" by itself denotes unmanaged areas in which the plant species were not mentioned. Examples of "idle" habitats include weedy or fallow areas (e.g., oldfields), fencerows, grassed waterways, terraces, ditches, and road rights-of-way. "Tame" denotes introduced plant species (e.g., smooth brome [*Bromus inermis*]) that are not native to North American prairies. "Hayland" refers to any habitat that was mowed, regardless of whether the resulting cut vegetation was removed. "Burned" includes habitats that were burned intentionally

or accidentally or those burned by natural forces (e.g., lightning). In situations where there are two or more descriptors (e.g., idle tame hayland), the first descriptor modifies the following descriptors. For example, idle tame hayland is habitat that is usually mowed annually but happened to be undisturbed during the year of the study.

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