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Effects of Management Practices on Grassland Birds: Grasshopper Sparrow

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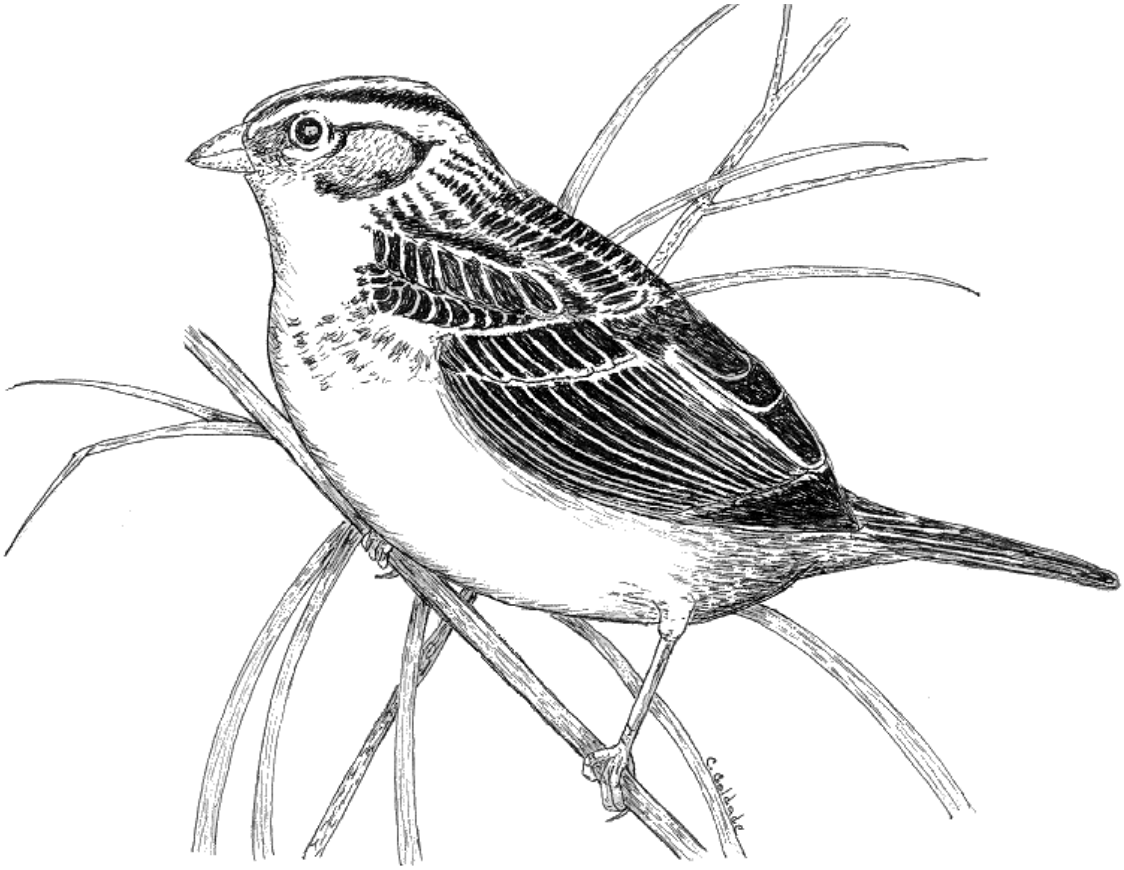

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This report is one in a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV recently 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:

GRASSHOPPER SPARROW

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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and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers.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.

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GRASSHOPPER SPARROW
(*Ammodramus savannarum*)

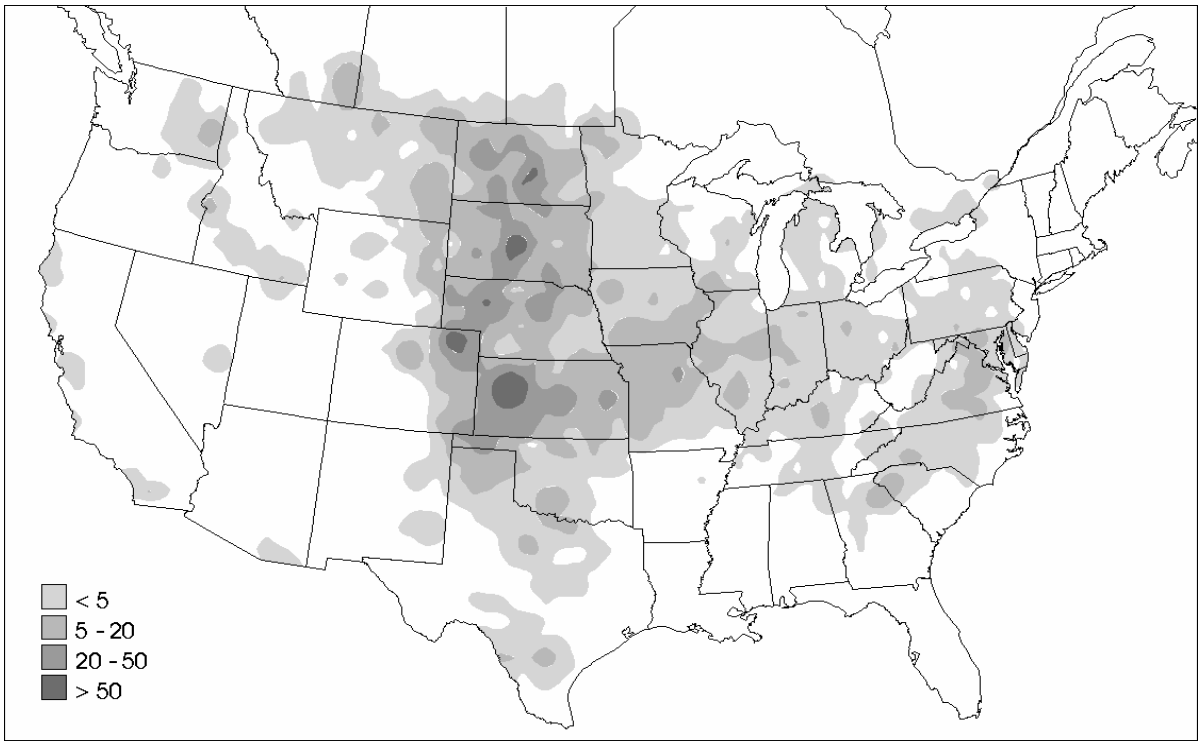

Figure. Breeding distribution of the Grasshopper Sparrow in the United States and southern Canada, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, London, England. 364 pages.

Keys to management are providing large areas of contiguous grassland of intermediate height with moderately deep litter cover and low shrub density.

Breeding range:

Grasshopper Sparrows breed from southern British Columbia and southern Alberta to southern Maine, south to southern California, southcentral Texas, and central Georgia, and east to North Carolina, Maryland, and New Hampshire. The main population is in the Great Plains, from North Dakota south to northern Texas, and east to Illinois (National Geographic Society 1987). (See figure for the relative densities of American Bitterns in the United States and southern Canada, based on Breeding Bird Survey data.)

Suitable habitat:

Grasshopper Sparrows prefer grasslands of intermediate height and are often associated with clumped vegetation interspersed with patches of bare ground (Bent 1968, Blankespoor 1980, Vickery 1996). Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation (Smith 1963; Bent 1968; Wiens 1969, 1970; Kahl et al. 1985; Arnold and Higgins 1986). Grasshopper Sparrows breed in both native and tame grassland vegetation (Kendeigh 1941, Birkenholz 1973, Whitmore 1979, Sample 1989, Wilson and

Belcher 1989, Madden 1996), including native prairie, Conservation Reserve Program (CRP) fields, pasture, hayland, airports, and reclaimed surface mines (Wiens 1970, 1973; Harrison 1974; Ducey and Miller 1980; Whitmore 1980; Kantrud 1981; Renken 1983; Laubach 1984; Renken and Dinsmore 1987; Bollinger 1988; Frawley and Best 1991; Johnson and Schwartz 1993; Klute 1994; Berthelsen and Smith 1995; Hull et al. 1996; Patterson and Best 1996; Delisle and Savidge 1997; Prescott 1997; Koford 1999; Jensen 1999; Horn and Koford 2000). Grasshopper Sparrows occasionally inhabit cropland, such as corn and oats, but at a fraction of the densities found in grassland habitats (Smith 1963, Smith 1968, Ducey and Miller 1980, Basore et al. 1986, Faanes and Lingle 1995, Best et al. 1997). In Alberta, Manitoba, and Saskatchewan, Grasshopper Sparrows were more common in grasslands enrolled in the Permanent Cover Program (PCP) than in cropland (McMaster and Davis 1998). PCP was a Canadian program that paid farmers to seed highly erodible land to perennial cover; it differed from CRP in that haying and grazing were allowed annually in PCP.

Within grazed mixed-grass areas in North Dakota, abundance of Grasshopper Sparrows was positively associated with percent grass cover, litter depth, visual obstruction (vegetation height/density), density of low-growing shrubs (western snowberry [*Symphoricarpos occidentalis*] and silverberry [*Elaeagnus commutata*]), vegetation density, plant communities dominated by shrubs and introduced grass (smooth brome [*Bromus inermis*], Kentucky bluegrass [*Poa pratensis*], and quackgrass [*Agropyron repens*]), and plant communities dominated by Kentucky bluegrass and native grass (*Stipa*, *Bouteloua*, *Koeleria*, and *Schizachyrium*) (Schneider 1998). Abundance was negatively associated with percent clubmoss (*Selaginella densa*) cover and with plant communities dominated solely by native grass. The strongest vegetational predictors of the presence of Grasshopper Sparrows were decreasing clubmoss cover, decreasing bare ground, and increasing litter. In Missouri tallgrass, density of Grasshopper Sparrows decreased with increasing vegetation height and amount of woody cover (Winter 1998). In Colorado, Bock et al. (1999) compared the abundance of Grasshopper Sparrows between upland (mixed-grass prairie) and lowland (tallgrass prairie or tame hayland) grasslands. Abundance was not significantly different between upland and lowland plots. In portions of Colorado, Kansas, Montana, Nebraska, Oklahoma, South Dakota, Texas, Wisconsin, and Wyoming, abundance of Grasshopper Sparrows was positively correlated with percent grass cover, percent litter cover, total number of vertical vegetation hits, effective vegetation height, and litter depth; abundance was negatively correlated with percent bare ground, amount of variation in litter depth, amount of variation in forb or shrub height, and the amount of variation in forb and shrub heights (Rotenberry and Wiens 1980). A table near the end of the account lists the specific habitat characteristics for Grasshopper Sparrows by study.

Area requirements:

Although average territory size for Grasshopper Sparrows is small (<2 ha) (George 1952; Wiens 1969, 1970; Ducey and Miller 1980; Laubach 1984; Delisle 1995; O'Leary and Nyberg 2000), Grasshopper Sparrows are area sensitive, preferring large grassland areas over small areas (Herkert 1994*a*,*b*; Vickery et al. 1994; Bollinger 1995; Helzer 1996; O'Leary and Nyberg 2000). In Illinois, the minimum area on which Grasshopper Sparrows were found was 10-30 ha (Herkert 1991), and the minimum area needed to support a breeding population may be $\geq$30 ha (Herkert 1994*b*). In Nebraska, the minimum area in which Grasshopper Sparrows were found was 8-12 ha, with a perimeter-area ratio of 0.018 (Helzer 1996, Helzer and Jelinski 1999).

Occurrence of Grasshopper Sparrows was positively correlated with patch area and inversely correlated with perimeter-area ratio (Helzer and Jelinski 1999). However, in southwestern Missouri tallgrass prairie fragments, vegetation structure more strongly influenced the density of Grasshopper Sparrows than did fragment size (Winter 1998, Winter and Faaborg 1999).

In Kansas tallgrass prairie, rates of Brown-headed Cowbird (*Molothrus ater*) brood parasitism were not statistically different for nests placed ≤100 m from woodland edges compared to nests placed >100 m from woodland edges; parasitism rates also were not different for nests placed ≤100 m from agricultural edges versus nests placed >100 m from agricultural edges (Jensen 1999). In Minnesota tallgrass prairie, nest depredation and 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). The probability of encountering Grasshopper Sparrows was highest on large fragments far from a forest edge and ≥4 yr postburn; however, nest productivity was highest for nests far from a forest edge and 1 yr postburn (Johnson and Temple 1986). Delisle (1995) found that only one of 31 territories in Nebraska CRP fields had ≥50% of its area within 50 m of an edge. However, 14 territories were classified as interior territories and 17 as edge territories when 100 m instead of 50 m was used as the criterion for interior versus edge territories. Of 10 nests, none were placed ≤50 m from an edge and nest distance from an edge averaged 119 m. Edges included roadsides, wooded draws, and fencelines that separated CRP fields from crop fields. In Colorado, Bock et al. (1999) compared the abundance of Grasshopper Sparrows 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. Grasshopper Sparrows were significantly more abundant on interior plots than on edge plots.

Brown-headed Cowbird brood parasitism:

Rates of brood parasitism by Brown-headed Cowbirds on Grasshopper Sparrows vary from 0% of 23 nests (Winter 1998) to 58% of 12 nests (Klute 1994, Klute et al. 1997). Refer to Table 1 in Shaffer et al. (2003) for rates of cowbird brood parasitism. Grasshopper Sparrows may be multiply-parasitized (Elliott 1976, 1978; Davis and Sealy 2000). In Kansas, cowbird parasitism cost Grasshopper Sparrows about 2 young/parasitized nest, and there was a low likelihood of nest abandonment occurring due to cowbird parasitism (Elliott 1976, 1978). In Manitoba, mean number of host young fledged from successful, unparasitized nests was significantly higher than from successful, parasitized nests; cowbird parasitism cost Grasshopper Sparrows about 1.3 young/successful nest (Davis and Sealy 2000).

Breeding-season phenology and site fidelity:

Grasshopper Sparrows arrive on the breeding grounds in mid-April and depart for the wintering grounds in mid-September (George 1952, Bent 1968, Smith 1968, Harrison 1974, Stewart 1975, Laubach 1984, Vickery 1996). In Saskatchewan and Manitoba, they arrive later (mid-May) and leave earlier (August) (Knapton 1979). Throughout most of their range, Grasshopper Sparrows can produce two broods, one in late May and a second in early July (George 1952, Smith 1968, Vickery 1996). However, in the northern part of its range, one brood is probably most common; in Maine, no territories showed evidence of successfully fledging two broods and double-broodedness in Wisconsin is uncommon (Vickery et al. 1992, Wiens 1969). Conversely, in Michigan, double broods have been recorded (Harrison 1974). Grasshopper

Sparrows frequently renest after nest failure, and if unsuccessful in previous attempts, may renest 3-4 times during the breeding season (Vickery 1996).

Grasshopper Sparrows may be site faithful; two banded adult males were recaptured in the year following banding in the same breeding area in Maryland (Skipper 1998). In Nebraska, a banded bird was recaptured 3 yr later at the site where it was banded (Klimkiewicz and Futcher 1987).

Species' response to management:

Regardless of management treatment, avoid disturbing (e.g., burning, haying, heavy grazing) nesting habitat during the breeding season, approximately mid-April to late August (Stewart 1975, Whitmore 1981, Frawley 1989, Rodenhouse et al. 1995, Vickery 1996). Treatments can be done in early spring (several weeks prior to the arrival of adults on the breeding grounds) or possibly in the fall after the breeding season, as suggested for Bobolinks (*Dolichonyx oryzivorus*) (Renken 1983, Martin and Gavin 1995). Bollinger (1988) suggested leaving adjacent, untreated areas to provide refuge for fledglings and late or re-nesting Bobolinks, a technique that could also be applied to Grasshopper Sparrows.

In general, Grasshopper Sparrows avoid spring-burned areas in the summer immediately following the burn (Huber and Steuter 1984, Johnson 1997). Grasshopper Sparrows exhibited variable responses to burning across their range. In North Dakota, Grasshopper Sparrows responded positively to prescribed burning, becoming most abundant 2-4 yr postfire (Madden 1996, 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). Density of Grasshopper Sparrows decreased immediately after burning in South Dakota, due to loss of nesting cover (litter and live vegetation) and loss of food source, but increased 2-3 yr postburn (Forde et al. 1984). A similar pattern occurred on a burned tallgrass prairie in Wisconsin (Volkert 1992). However, density decreased after the prairie was burned a second time. In Illinois tallgrass, Grasshopper Sparrows were significantly more abundant 1-2 yr postfire (Herkert 1994*a*), and in Montana shrubsteppe, densities were depressed for $\geq$3 yr postfire (Bock and Bock 1987). In Kansas, relative abundances were not affected by burning in moist years, but may be reduced in drought years (Zimmerman 1992); relative abundances between annually burned and unburned grasslands did not differ (Zimmerman 1993). No differences in mean number of young/attempted nest were detected between areas that were burned but not grazed and areas that were neither burned or grazed (Zimmerman 1997). Jensen (1999) found Grasshopper Sparrow nests in heavily grazed and recently burned (burned every 1-2 yr) tallgrass pastures. Grasshopper Sparrows were more abundant in moderately grazed, annually burned tallgrass prairie than in native, annually burned CRP, possibly because invertebrate prey was higher in the grazed areas (Klute 1994, Klute et al. 1997). In a Kansas study of spring-burned and unburned native CRP fields, abundance of Grasshopper Sparrows was nonsignificantly higher on spring-burned than unburned fields (Robel et al. 1998). In Oklahoma, number of nests, clutch size, number of young fledged from successful nests, and nest success did not differ significantly between idle tallgrass plots and plots that were burned and/or grazed (Rohrbaugh et al. 1999). Fewer nests were found on undisturbed plots in the second and third year of the study than in the first year, possibly due to increased vegetation density caused by lack of fire or grazing. Densities of Grasshopper Sparrows in southwestern Missouri were not affected by burning (Winter 1998). Johnson and

Temple (1990) found lower rates of depredation on nests in recently burned (≤3 yr) areas in Minnesota than nests in areas unburned for ≥4 yr.

Depending upon location, mowing prior to arrival in spring can improve habitat for Grasshopper Sparrows, and may be preferable to prescribed burning (Bollinger 1988, Swengel 1996). In Missouri tallgrass prairie fragments, Grasshopper Sparrow density increased one year after haying but decreased in areas that had been hayed more than one year earlier (Winter 1998). Grasshopper Sparrows nested in tallgrass prairie hay meadows in eastern Kansas (Jensen 1999). In Iowa rowcrop fields, Grasshopper Sparrows nested in grassed waterways that were mowed the previous year (Bryan and Best 1994). In Nebraska CRP seeded to native tallgrass, the only field that maintained a consistent Grasshopper Sparrow population was mowed 3 out of 4 yr (Delisle and Savidge 1997). In North Dakota CRP seeded to cool-season grasses, there was no significant difference in abundance of Grasshopper Sparrows in the year after mowing between idled and mowed portions of fields (Horn and Koford 2000). However, Grasshopper Sparrows were found only in mowed portions of five of six fields. Grasshopper Sparrows preferred older hayfields (not reseeded in more than 10 yr) in New York (Bollinger and Gavin 1992, Bollinger 1995). Fields in New York mowed at earlier dates (late May-early June) the previous year had lower Grasshopper Sparrow densities than those mowed at later dates (Bollinger 1995). Mowing-induced nest destruction appeared to be responsible for this reduction in nesting density. Grasshopper Sparrows preferred hayfields and avoided permanent pasture on a farm in Michigan (George 1952). However, Grasshopper Sparrows were more common in grazed PCP than mowed PCP fields (McMaster and Davis 1998). In southern Saskatchewan hayfields, number of pairs was not affected by amount of cropland or wetland within 1.6 km of study areas (McMaster et al. 1999). In an alfalfa (*Medicago sativa*) field in Michigan, Grasshopper Sparrows continued breeding following mowing in late June, but breeding was terminated after the second mowing in early August (Harrison 1974).

Grazing in sparse, arid grasslands can be detrimental, as vegetation may become too short and open for Grasshopper Sparrow use (Bock et al. 1984, Bock and Webb 1984, Bock et al. 1993). However, in areas where grass is too tall or dense, grazing benefits Grasshopper Sparrows by creating patchy areas, decreasing vegetation height, and thinning dense vegetation (Skinner 1974, Kantrud 1981, Whitmore 1981). Kantrud and Kologiski (1982) found significantly greater Grasshopper Sparrow densities on lightly grazed plots than on heavily grazed plots, and moderately grazed plots supported intermediate sparrow densities. In northcentral Colorado, Grasshopper Sparrows were found on prairie that was heavily grazed in the winter, but not on prairie that was heavily grazed in the summer (Wiens 1970). Grasshopper Sparrows preferred grazed over idle areas in North Dakota; density was highest on short-duration, twice-over rotation, and season-long grazing systems, but density decreased as litter increased (Messmer 1990). In Nebraska, abundance of Grasshopper Sparrows did not differ between cattle-grazed areas and areas both grazed by American bison (*Bison bison*) and burned (Griebel et al. 1998). In southwestern Wisconsin, Grasshopper Sparrows were more abundant in continuously grazed pastures than in rotationally grazed pastures or in 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

Alberta, Grasshopper Sparrows were present only in tame pastures of crested wheatgrass (*Agropyron cristatum*) that were grazed from late April to mid-June, and were absent from continuously grazed native pastures and from native pastures grazed in early summer and those grazed after 15 July (Prescott and Wagner 1996). In southcentral Saskatchewan, Grasshopper Sparrows were more frequent in pure crested wheatgrass pastures and wheatgrass (*Agropyron*)/grass (smooth brome and bluegrass [*Poa*]) pastures than in native mixed-grass pastures, and more frequent in fields of pure crested wheatgrass than wheatgrass/alfalfa pastures (Davis and Duncan 1999). In southwestern Saskatchewan, no significant difference in abundance was found between lightly grazed mixed-grass prairie and lightly grazed stands of crested wheatgrass (Sutter and Brigham 1998).

In Minnesota and North Dakota, abundance of Grasshopper Sparrows was higher in CRP than in 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) (Koford 1999). McCoy et al. (1999) reported that fecundity of Grasshopper Sparrows over 3 yr in Missouri CRP fields was high enough to maintain a stable population. Within native Kansas CRP, Grasshopper Sparrows were common (Hull et al. 1996). In Texas, nest density within native or tame CRP fields did not differ by cover type (blue grama [*Bouteloua gracilis*]/sideoats grama [*Bouteloua curtipendula*], blue grama/Kleingrass [*Panicum coloratum*], and blue grama/Turkestan bluestem [*Andropogon ischaemum*]) (Berthelsen and Smith 1995).

Grasshopper Sparrows occasionally nest in cropland. In Iowa, Grasshopper Sparrows preferred untilled fields of corn and that were idle in fall and spring and contained year-round crop residue, rather than tilled fields (Basore et al. 1986). They nested at low densities in strip cover, such as waterways, terraces, fencerows, and roadside ditches (Basore et al. 1986, Bryan and Best 1994). Grasshopper Sparrows also nested in oat fields in Iowa (Laubach 1984). Within strip-intercropped fields (i.e., planting rowcrops, legumes, and small grains in a series of adjacent, narrow strips) in Iowa, Grasshopper Sparrows were present in low numbers, although no nests were detected (Stallman and Best 1996). In South Dakota, restoration of corn fields and soybean fields to prairie was beneficial to Grasshopper Sparrows (Blankespoor 1980). A 2-yr drought in combination with 1 yr of grazing on restored fields caused a decrease in effective plant height and in vertical and horizontal plant density; these vegetative changes were favored by Grasshopper Sparrows. In Wisconsin, Grasshopper Sparrows were the first bird species to occupy a restored native tallgrass prairie (Volkert 1992).

In a Texas study examining the effects on avian density of discing, spraying of 2,4,5-T about 14 yr prior to the study, and construction of brush shelters, grassland sparrows, as a group, were more abundant in the treated than untreated areas; effects on particular species, such as Grasshopper Sparrow, composing the group of grassland sparrows, were not examined (Gruver and Guthery 1986). In Maine, territory density of Grasshopper Sparrows 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:

Provide areas of suitable habitat large enough to support breeding populations. In Illinois, the minimum area on which Grasshopper Sparrows were found was 10-30 ha (Herkert 1991), and the minimum area needed to support a breeding population may be ≥30 ha (Herkert 1994*b*). In Nebraska, minimum area was ≥8 ha (Helzer 1996), and in New York, Bollinger and Gavin (1992) recommend creating patches >10-15 ha whenever possible. Shape, as well as area, of management units must be taken into consideration; perimeter-area ratio strongly influenced occurrence of Grasshopper Sparrows in Nebraska (Helzer and Jelinski 1999).

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

Treat portions of large areas on a rotational schedule to provide a mosaic of successional stages (Renken 1983, Renken and Dinsmore 1987, Herkert 1994*a*, Madden 1996, Johnson 1997, Rohrbaugh et al. 1999). Herkert (1994*a*) suggests that on areas >80 ha, annually treated (burned, mowed, or grazed) subunits should be ≥30 ha, or about 20-30% of the total area.

Treat small, isolated areas as part of a larger mosaic, ensuring a variety of successional stages (Renken 1983, Renken and Dinsmore 1987, Herkert 1994*a*, Madden 1996, Johnson 1997). Burn (or possibly mow or graze) ≤50-60% of small, isolated prairie fragments at a time (Herkert 1994*a*). Winter (1998) suggested burning no more than 20-30% of tallgrass prairie fragments annually in a rotational manner.

In eastern portions of Grasshopper Sparrow range, create or maintain patches of relatively sparse, grass-dominated vegetation resembling old (>8-10 yr since planted) hayfields (Bollinger and Gavin 1992, Bollinger 1995). Plant bunch grasses on disturbed sites; bunch grasses allow openings in vegetation that facilitate foraging by Grasshopper Sparrows (Smith 1963, Whitmore 1981).

In eastern and Great Plains grasslands, discourage woody vegetation (Whitmore 1981). This can be accomplished by disturbing (mowing, burning, or grazing) idle grassland (Skinner 1974). Remove woody vegetation within and along the periphery of grassland fragments to discourage predators that may use woody vegetation as travel corridors and to enlarge the amount of interior grassland (Winter 1998, O'Leary and Nyberg 2000).

Maintain open grassland by burning habitat once every 2-4 yr (Whitmore 1981, Madden 1996, Johnson 1997, Madden et al. 1999). In Minnesota, Johnson and Temple (1990) found lower rates of nest depredation on nests in recently burned (≤3 yr) areas.
Monitor population responses to burning, especially during unusually dry years. Treatment schedules should be adjusted during droughts as burning may reduce above-ground productivity to levels unacceptable to birds (Zimmerman 1992).

Eastern grasslands can be burned in late winter to prevent encroachment of shrubs (Whitmore 1981). Disturbance should occur prior to or following the breeding season (Whitmore 1981, Frawley 1989, Rodenhouse et al. 1995), and disturbance should occur every 2-3 yr (Bollinger

and Gavin 1992). However, in western shrubsteppe, removal of shrubs may be detrimental, possibly because shrubs are used as song perches in shrubsteppe habitat (Bock and Bock 1987).

In Missouri, mowing on a 1-3 yr rotation provided vegetation heights (<30 cm) suitable for Grasshopper Sparrows (Swengel 1996). Interval between management depends on grassland type, as mesic prairie regains litter more rapidly (1-3 yr) than dry prairie (4-6 yr), and sooner in southern than northern prairie (Swengel 1996).

Graze areas of tall, dense vegetation to provide diverse grass heights and densities (Skinner 1974, Kantrud 1981, Whitmore 1981). A rotational system may be most beneficial (Skinner 1974, Berkey et al.1993). Berkey et al. (1993) suggested that short-term (2-4 wk in May) grazing in North Dakota may be detrimental to Grasshopper Sparrow populations. Graze native, tallgrass CRP fields to improve the breeding habitat by reducing vegetative height, and by increasing canopy and forb coverage and invertebrate biomass (Klute 1994).

Use various grazing systems (e.g., early-season, deferred [after 15 July], and continuous grazing of native grasslands, and spring-grazing [late April to early June] of tame grasslands) to maintain a mosaic of grassland types (Prescott and Wagner 1996). By allowing tame pastures to be grazed in spring, suitable habitat is maintained in the tame pastures for Grasshopper Sparrows, and grazing in native pastures can be deferred (Prescott and Wagner 1996).

In arid western regions, maintain relatively dense grasslands by curtailing grazing and burning activities (Bock and Webb 1984, Bock and Bock 1987).

In cultivated areas, use no-till/minimum-till methods when possible (Berkey et al. 1993, Rodenhouse et al. 1995, Koford and Best 1996).

Table. Grasshopper Sparrow habitat characteristics.

Author(s)	**Location(s)**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Basore et al. 1986	Iowa	Cropland, idle	Preferred to nest in untilled fields (idle in fall and spring and which contain year-round crop residue) in which corn had been planted into sod residue, rather than tilled fields or strip cover
Berthelsen and Smith 1995	Texas	Conservation Reserve Program (CRP; idle seeded-native, idle seeded-native/tame), cropland	Nested in CRP planted to blue grama (*Bouteloua gracilis*)/sideoats grama (*Bouteloua curtipendula*), blue grama/Kleingrass (*Panicum coloratum*), and blue grama/ Turkestan bluestem (*Andropogon ischaemum*); density was equal in all CRP cover types
Birkenholz 1973	Illinois	Idle, idle tallgrass, idle tame, wetland, wet meadow	Occurred only in stands of Kentucky bluegrass (*Poa pratensis*), which had drier soils and lower foliage cover at 30 cm than nearby native prairie
Blankespoor 1980	South Dakota	Idle seeded-native, seeded-native pasture	Nested in areas with decreased vertical and horizontal plant density and effective plant height, and increased vegetation evenness caused by drought and grazing
Bock and Bock 1987	Montana	Burned shrubsteppe, idle shrubsteppe	Abundance was lower on burned vs. unburned shrubsteppe due to elimination of sagebrush (*Artemisia*) cover
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; no difference in abundance between lowland and 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
Bock and Webb 1984	Arizona	Idle semidesert grassland, semidesert grassland pasture	Used habitat with 5% woody cover, 72% grass cover, 4% forb cover, 23% bare ground, and mean grass height 30 cm; were found only on ungrazed sites
Bollinger 1995	New York	Tame hayland	Occurred only in oldest haylands characterized by relatively short, sparse, patchy, grass-dominated vegetation, and greater litter cover; breeding density was positively correlated with field size
Bryan and Best 1994	Iowa	Cropland, idle tame, tame hayland	Nested only in grassed waterways (planted to smooth brome [*Bromus inermis*]) that were mowed the previous year
Davis and Duncan 1999	Saskatchewan	Mixed-grass pasture, tame pasture	Were more frequent in pure crested wheatgrass (*Agropyron cristatum*) pastures and wheatgrass (*Agropyron*) /grass (*Bromus inermis*, *Poa*) pastures than in native mixed-grass pastures, and were more frequent in pure wheatgrass pastures than wheatgrass/legume (*alfalfa* [*Medicago sativa*]) pastures; occurrence was positively associated with vegetation height, crested wheatgrass, thick-spike wheatgrass (*Agropyron dasystachyum*), bluegrass, and needlegrass (*Stipa* spp.)
Delisle 1995, Delisle and Savidge 1997	Nebraska	CRP (burned seeded-native, idle seeded-native, idle tame, seeded-native hayland, tame hayland)	Were found in plantings of cool-season grasses and legumes, and plantings of warm-season native grasses; abundance was positively related to litter cover and grass cover, and negatively related to vertical density and litter depth; occupied cool-season plantings had short, sparse vegetation and shallow litter; occupied warm-season native planting was mowed 3 of 4 yr; only one of 31 territories had $\geq$50% of its area within 50 m of an edge; none of the 10 nests found were placed $\leq$50 m from an

			edge; nest distance from an edge averaged 119 m
Frawley and Best 1991	Iowa	Tame hayland	Nested in first and second alfalfa crops
Harrison 1974	Michigan	Tame hayland	Preferred areas characterized by average vegetation measurements of 60.5% litter cover, 48.4 cm vegetation height, 5.1 vegetation contacts/dm at 5 cm high, and 12.7 vegetation contacts/dm^2; preferred low (1.5 m), artificial perches over high (2 m) perches
Helzer 1996, Helzer and Jelinski 1999	Nebraska	Wet-meadow hayland, wet-meadow pasture	Occurrence within management units was best predicted by perimeter-area ratio; densities were lower within 75 m of wooded edges and 50 m of cornfield edge
Herkert 1991	Illinois	Burned seeded-native, burned tallgrass, cropland, idle seeded-native, idle tallgrass, idle tame, tame hayland	Density was positively correlated with area, negatively correlated with mean grass height, mean vegetation height, and total number of live and dead vegetation contacts; was twice as abundant on areas mowed before 1 May as unmowed; was more abundant on large prairie areas ($\geq$30 ha), never occurred on areas <10 ha
Huber and Steuter 1984	South Dakota	Burned mixed-grass pasture, mixed-grass pasture	Preferred unburned areas to spring burned areas in the summer immediately following the burn
Horn and Koford 2000	North Dakota	CRP (idle tame, tame hayland)	Abundance was not significantly different in the year after mowing between idled and mowed portions of fields
Jensen 1999	Kansas	Burned tallgrass, burned tallgrass pasture, cropland, tallgrass hayland, tallgrass pasture, woodland edge	Nested in heavily grazed and recently burned (burned every 1-2 yr) pastures; nested in tallgrass prairie hay meadows; nest sites (0.25 m^2 around nests) had significantly less bare ground and greater live grass cover than areas 1-10 m around nests; mean vegetation variables at the nest site were 53% grass cover, 33 cm live

			grass height, 1% standing dead grass cover, 5 cm standing dead grass height, 13% forb cover, 23 cm live forb height, 0.2% live woody cover, 0.7 cm woody height, 16% bare soil cover, 17% litter cover, and 0.6% rock cover; mean nest distance from agricultural and woodland edges was about 67 m
Johnson 1997	North Dakota	Burned mixed-grass, burned tame, idle mixed-grass	Densities were depressed for 1 yr after burn, then increased until yr 5, then gradually declined
Johnson and Schwartz 1993	Minnesota, Montana, North Dakota, South Dakota	Cropland, CRP (idle seeded-native, idle tame)	Abundance was lower where legumes were more common
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 depredation was lower on nests in recently ($\leq$3 yr) burned areas; nest success decreased with increased number of growing seasons since vegetation was last burned
Kantrud 1981	North Dakota	Mixed-grass hayland, mixed-grass pasture	Occurred in lightly and moderately grazed areas; responded negatively to heavy grazing
Kantrud and Kologiski 1982	Colorado, Montana, Nebraska, North Dakota, South Dakota, Wyoming	Mixed-grass pasture, shortgrass pasture, shrubsteppe	Used lightly grazed areas with typic ustoll soils; average vegetation height of these areas was 28 cm
Kendeigh 1941	Iowa	Idle tallgrass (restored)	Used native prairie grasses, was absent in stands of

			Kentucky bluegrass
Klute 1994, Klute et al. 1997	Kansas	Burned tallgrass pasture, CRP (burned seeded-native)	Were more abundant in annually burned grazed pastures than in annually burned native CRP fields; nested only in pastures
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 more abundant in CRP than in WPA
Laubach 1984	Iowa	Burned tallgrass, idle tallgrass	Nested in shorter grasses and forbs; used fence posts as song perches; commonly nested in oat fields
Madden 1996	North Dakota	Burned mixed-grass, burned tame, idle mixed-grass, idle tame	Used areas with exotic grasses, low visual obstruction, low shrub cover, reduced vegetation density, high forb cover, and high grass cover compared to unused areas; used areas with 16 cm visual obstruction, 21% shrub cover, 26% forb cover, and 41% grass cover
McCoy et al. 1999	Missouri	CRP (idle seeded-native, idle tame)	Fecundity over 3 yr within CRP fields was high enough to support a stable population
McMaster and Davis 1998	Alberta, Manitoba, Saskatchewan	Cropland; Permanent Cover Program (PCP; idle tame, tame hayland, tame pasture)	Were more common in PCP than in cropland; frequency of occurrence was higher in grazed PCP than in hayed PCP
McMaster et al. 1999	Saskatchewan	Hayland, PCP (tame hayland)	Amount of cropland or wetland within 1.6 km of study areas did not affect number of indicated pairs
Messmer 1990	North Dakota	Idle mixed-grass/tame, mixed-grass/tame	Preferred grazed over idle areas; density was highest on short-duration, twice-over rotation, and season-long

		hayland, mixed-grass/tame pasture, wet-meadow pasture	grazing systems than on idle areas, although density decreased as litter increased on grazed areas
Patterson and Best 1996	Iowa	Cropland; CRP (idle tame, tame hayland)	Avoided row-crops, negatively correlated with vertical cover of vegetation; associated with moderate grass height (<50 cm) and vertical cover (<30 cm); avoided thick smooth brome stands; colonized mowed areas with shorter vegetation
Prescott and Wagner 1996	Alberta	Mixed-grass pasture, tame pasture	Were present only in tame pastures of crested wheatgrass grazed from late April to mid-June, and were absent from continuously grazed native pastures and from native pastures grazed in early summer and those grazed after 15 July
Renken 1983, Renken and Dinsmore 1987	North Dakota	DNC (idle tame), idle mixed-grass, mixed-grass pasture	Territories were located in areas with shorter vegetation than unused areas; mean vegetation values for used areas were: 62.4% grass cover, 26.4% forb cover, 99.1% litter cover, 6.9% shrub cover, 0.4% bare ground, 40 cm effective height, and 2.8 cm litter depth; was negatively correlated with litter depth and effective vegetation height
Robel et al. 1998	Kansas	CRP (burned seeded-native, idle seeded-native)	Were nonsignificantly more abundant on spring-burned than burned CRP fields
Rotenberry and Wiens 1980	Colorado, Kansas, Montana, Nebraska, Oklahoma, Oregon, South Dakota, Texas,	Idle mixed-grass, idle shortgrass, idle shrubsteppe, idle tallgrass, montane meadow	Abundance was positively correlated with percent grass cover, percent litter cover, total number of vertical vegetation hits, effective vegetation height, and litter depth; abundance was negatively correlated with percent bare ground, amount of variation in litter depth, amount of variation in forb or shrub height, and the amount of variation in forb and shrub heights

	Washington, Wisconsin, Wyoming		
Sample 1989	Wisconsin	Burned tallgrass, 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	Highest density were in native vegetation on dry prairie; used areas with 3% woody cover, 76% herbaceous cover, 16% litter cover, 8% bare ground, 57 cm maximum vegetation height, 14 cm vegetation height/density; used hayfields that are weedy, sparsely vegetated; avoided habitats with tall, dense vegetation; abundance was positively correlated with percent bare ground and plant species richness; abundance was negatively correlated with maximum vegetation height and vegetation height/density
Schneider 1998	North Dakota	Mixed-grass pasture, tame pasture, wet- meadow pasture	Abundance was positively associated with percent grass cover, litter depth, visual obstruction (vegetation height/density), density of low-growing shrubs (western snowberry [*Symphoricarpos occidentalis*] and silverberry [*Elaeagnus commutata*]), vegetation density, plant communities dominated by shrubs and introduced grasses (smooth brome, Kentucky bluegrass, and quackgrass [*Agropyron repens*]), 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 and with plant communities dominated solely by native grass; the strongest vegetational predictors of the presence of Grasshopper Sparrows were decreasing clubmoss cover, decreasing bare ground, and increasing litter
Smith 1963	Rangewide	Cropland, hayland, idle,	Used cultivated grasslands, especially those with bunch-

		pasture	forming grasses; preferred relatively short and clumped grasses like orchard grass (*Dactylis glomerata*), alfalfa, red clover (*Trifolium pratense*), and bush clover (*Lespedeza*) for nesting
Smith 1968	Rangewide	Cropland, hayland, idle, pasture	Were abundant in managed grasslands, avoided areas with high shrub cover (>35%), occasionally used small-grain fields
Sutter and Brigham 1998	Saskatchewan	Mixed-grass pasture, tame pasture	No significant difference in abundance was found between lightly grazed mixed-grass prairie and lightly grazed stands of crested wheatgrass
Vickery et al. 1994	Maine	Eastern grassland-barren burned, mowed, and/or sprayed with herbicides	Abundance was positively correlated with higher grass cover, higher forb cover, and greater area
Volkert 1992	Wisconsin	Burned tallgrass (restored), idle tallgrass (restored)	Present 2 yr postseeding; highest densities observed 2-3 yr postburn, declining after burning occurred a second time
Whitmore 1979	West Virginia	Idle tame	Vegetation measurements during spring (near arrival date) were 29% basal area cover grass, 10% forb cover, 73% litter cover, 26% bare ground, 2 cm litter depth, 6 cm forb height, and 31 cm effective height (average maximum height of the leaf canopy). Vegetation measurements during peak breeding season were 5% basal area cover grass, 17% forb cover, 86% litter cover, 14% bare ground, 2 cm litter depth, 13 cm forb height, and 31 cm effective height
Whitmore 1981	West Virginia	Idle tame	Territories had 26% grass cover, 25% forb cover, 22% bare ground, mean herbaceous canopy height 44 cm; territories had sparser vegetation, lower percent grass,

			percent forb, shrub cover, vegetation height, and higher bare ground than non-territories
Wiens 1969	Wisconsin	Idle pasture, tame pasture	Unoccupied areas had lower forb density, greater forb height, vegetation density, and litter depth than occupied areas; used areas had 96% grass cover, 30% forb cover, 2% bare ground, and 41% effective cover <5 cm high; of 30 territories, mean distance from territory boundary to woods was 207.8 m, to fence line was 24.5 m, and to cultivated field was 82.8 m; 60% of territories included posts, 53% fence lines, 20% wire bales or tangles, and 10% trees
Wiens 1970	Colorado	Shortgrass pasture	Used heavily winter-grazed plots, but not heavily summer-grazed plots Areas used within winter-grazed pastures were characterized by 0.50 cm effective vegetation height; 0.4 cm litter depth; 87% percent grass cover; no forb, woody or cactus cover; 12% bare ground; and 34% litter cover
Wiens 1973	Colorado, Montana, New Mexico, Oklahoma, South Dakota, Texas	Idle mixed-grass, idle shortgrass, mixed-grass pasture, semidesert shrubsteppe pasture, shortgrass pasture, tallgrass pasture	Preferred sites with tall, emergent (i.e., extends above overall canopy) vegetation, and a high proportion of plant material >10 cm high. In tallgrass pasture, occupied grazed areas with relatively shorter vegetation, less litter, and a higher density of forbs than unused areas; mean vegetation values for grazed, occupied areas were: percent cover: 95% grass, 20% forb, 4% rock, and 0% woody, cactus, and bare ground; stem density in individuals/m^2:1003 forb, 0 woody, and 0 cactus; 51% open sky at ground level; litter: 1.19 cm deep, 57% cover; 15.2 cm emergent vegetation height; 44% density <10 cm (proportion of all vegetation contacts occurring within 10 cm of the ground); and 7.2 cm effective height

Wilson and Belcher 1989	Manitoba	Idle mixed-grass, idle tame	Was positively correlated with introduced Kentucky bluegrass, negatively correlated with native species Junegrass (*Koeleria cristata*)
Winter 1998	Missouri	Burned tallgrass, idle tallgrass, tallgrass hayland	Density decreased with increasing vegetation height and amount of woody cover; vegetation structure had more of an effect on density than fragment size

*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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