Effects of Fire on Bird Populations in Mixed-grass Prairie

Douglas H. Johnson

The mixed-grass prairie is one of the largest ecosystems in North America, originally covering about 69 million hectares (Bragg and Steuter 1995). Although much of the natural vegetation has been replaced by cropland and other uses (Samson and Knopf 1994, Bragg and Steuter 1995), significant areas have been preserved in national wildlife refuges, waterfowl production areas, state game management areas, and nature preserves. Mixed-grass prairie evolved with fire (Bragg 1995), and fire is frequently used as a management tool for prairie (Berkey et al. 1993).

Much of the mixed-grass prairie that has been protected is managed to enhance the reproductive success of waterfowl and other gamebirds, but nongame birds now are receiving increasing emphasis. Despite the importance of the area to numerous species of birds and the aggressive management applied to many sites, relatively little is known about the effects of fire on the suitability of mixed-grass prairie for breeding birds. Several studies have examined effects of fire on breeding birds in the tallgrass prairie (e.g., Tester and Marshall 1961, Eddleman 1974, Halvorsen and Anderson 1983, Westenmeier and Buhnerkempe 1983, Zimmerman 1992, Herkert 1994), in western sagebrush grasslands (Peterson and Best 1987), and in shrubsteppe (Bock and Bock 1987).

Studies of fire effects in the mixed-grass prairie are limited. Huber and Steuter (1984) examined the effects on birds during the breeding season following an early-May prescribed burn on a 122-ha site in South Dakota. They contrasted the bird populations on that site to those on a nearby 462-ha unburned site that had been lightly grazed by bison (*Bison bison*). Pylypec (1991) monitored breeding bird populations occurring in fescue prairies of Canada on a single 12.9-ha burned area and on an adjacent 5.6-ha unburned fescue prairie for three years after a prescribed burn.

This chapter describes the effects of prescribed fire on common terrestrial birds at a mixed-grass prairie site in east-central North Dakota. Birds were censused annually during 1972-95 on seven plots subjected to various regimes of prescribed fire.

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Study Area

The Woodworth Study Area consists of 1,231 ha of mixed-grass prairie pothole habitat in east-central North Dakota (Higgins et al. 1992). It is situated on the Missouri Coteau, a morainal belt extending from southcentral to northwestern North Dakota. The rolling terrain contains 548 wetlands on the study area, totaling 10% of the land area. Most of these are seasonally flooded (classified according to Stewart and Kantrud 1971), but many temporary and semipermanent wetlands also are present.

Prior to purchase by the U.S. Fish and Wildlife Service in the mid 1960's, land use on the study area was a mixture of grazing by cattle, haying, and crop production (Bayha 1964). Those practices continue on the privately owned portions of the study area. On the Service-owned portions (87% of the area), management of the uplands since acquisition has emphasized restoration of grassland. Some formerly cropped fields were replanted to grasses or grass-legume mixtures. Unplowed grasslands have been managed mostly by prescribed burning.

Study plots were located in relatively homogeneous areas within seven different quarter-sections, the units that received various treatments under the management of the study area. I located study plots so as to avoid large wetlands, in order to concentrate on upland bird communities. Plots were measured and marked by use of compass and pacing. Surveyor's flags were placed at 40-m intervals on a grid throughout each plot to facilitate recording of bird locations. One plot served as a control. The other six plots were subjected to burning under different regimes; intervals between burns averaging 3 to 5 years. Spring burns were slightly more frequent than fall burns. The seven study plots were denoted by the quarter-section in which they were located (e.g., Plot 13 was located within Quarter-section 13).

Plot 13, the control, had been grazed from 1906 to 1961 but has been left idle subsequently. Originally 8.09 ha in size, Plot 13 was increased to 10.12 ha in 1973. All or portions of eight seasonal and two temporary wetland basins lie within the plot, totaling about 1.2 ha. Upland vegetation is a mixture of grasses, forbs, and woody plants. Common species are Kentucky bluegrass (*Poa pratensis*), needle-and-thread (*Stipa comata*), stiff sunflower (*Helianthus rigidus*), and Canada goldenrod (*Solidago canadensis*). Wolfberry (*Symphoricarpos occidentalis*), silverberry (*Eleagnus commutata*), and Woods' rose (*Rosa woodsii*) form shrubby patches of various sizes. One thicket of chokecherry (*Prunus virginiana*), surrounded by wolfberry and silverberry, became decadent during the years of the surveys.

Plot 2, 8.68 ha in size, was surveyed during 1977-82, after which the trail to it became difficult. It had been grazed or hayed from 1906 to 1967, then left idle except for five prescribed burns. Plot 2 contains all or portions of seven seasonal wetlands, totaling about 0.9 ha. Kentucky bluegrass is abundant, and needle-and-thread, yarrow (*Achillea lanulosa*), fringed sage (*Artemisia frigida*), and prairie wild rose (*Rosa arkansana*) are common. Stands of wolfberry and silverberry also occur.

Plot 7, 6.07 ha in extant, was hayed during 1904-55. It was plowed in 1956 for one year of crop production. Alfalfa (*Medicago sativa*) and possibly some tame grasses were planted in 1958, after which it was grazed or hayed until 1970. Plot 7 has since been subjected to four prescribed burns. Six seasonal and two temporary wetlands, covering 1.1 ha, are included in the plot. Dominant upland plants are needle-and-thread, green needlegrass (*Stipa viridula*), alfalfa, Kentucky bluegrass, rigid goldenrod (*Solidago rigida*), and stiff sunflower. Patches of silverberry and wolfberry have increased in area during the study.

Plot 9, 6.07 ha in size, consists of unbroken sod that had been hayed and probably grazed from 1908 to 1965. There have been five burns since 1965. Two small seasonal and one ephemeral wetland cover 0.2 ha. Dominant plant species are Kentucky bluegrass, needle-and-thread, yellow sweetclover (*Melilotus officinalis*), white prairie aster (*Aster ericoides*), and stiff sunflower. Wolfberry occurs in several patches.

Plot 11, 4.86 ha in size, had been cropped during 1917-27 and from 1934 to about 1940. It then reverted to grass and was grazed through 1970. Since then, it has been burned four times. Plot 11 contains one ephemeral and portions of two seasonal wetlands, totaling about 0.5 ha. The uplands are dominated by Kentucky bluegrass and, to a lesser extent, smooth brome (*Bromus inermis*).

Plot 16 is 6.07 ha in size. It was grazed from 1906 to 1968, after which it was treated with a total of six prescribed fires. Five seasonal wetlands and small portions of two seasonal to semipermanent wetlands lie within the plot, comprising about 0.6 ha. Common plants are Kentucky bluegrass, quackgrass (*Agropyron repens*), needle-and-thread, and little bluestem (*Andropogon scoparius*), as well as wolfberry and silverberry.

Plot 18, also 6.07 ha in size, is unbroken prairie sod that had been grazed from 1906 to 1968. The plot was burned seven times between 1969 and 1990. In addition, it was intensively grazed by sheep during 1973 and 1974. The plot contains four small wetlands--one ephemeral, two temporary, and one seasonal--covering <0.1 ha. At the beginning of the surveys, the plot had several thickets of chokecherry and hawthorn (*Crataegus chrysocarpa*). The various fire and grazing treatments, as well as nest-searching with a cable-chain device (Higgins et al. 1969), have reduced the thickets considerably. Other common plants include Kentucky bluegrass, blue grama (*Bouteloua gracilis*), and fringed sage.

I excluded Plot 18 in 1974-75 because it had been crowd-grazed by sheep during the previous growing seasons. I excluded two plots for one year each (Plot 9 in 1982, Plot 18 in 1993) because portions were burned during the survey period. In 1977, two plots were burned on 1 June. Several surveys of both plots had been completed before the burns, other surveys were conducted after the burns. The pre-burn and post-burn results were used separately in the analysis.

Field Methods

Each year during 1972-95 (1977-82 for Plot 2) the breeding bird community of each plot was estimated by conducting several surveys and mapping territories. Standard survey methods (Hall 1964, Van Velzen 1972) were used, and annual reports were published in *American Birds* or the *Journal of Field Ornithology*. See Johnson (1996) for listing of references. About eight visits were made to each plot during late May through mid-June. Surveys were conducted from just before dawn to late morning. Early-morning surveys emphasized concurrent registrations of indicated pairs of the same species, to define multiple territories. Surveys later in the morning, when vocalizations were reduced, focused on reflushing birds to delineate their territories (Wiens 1969).

In most years, one other observer and I conducted independent surveys and compared results. I estimated the number of territories from the locations plotted on field maps. There were two exceptions. In 1972, P. F. Springer conducted all surveys and estimated territories on Plot 9 for the *American Birds* report. C. A. Faanes conducted surveys and estimated territories on all plots in 1983. For consistency in the analyses presented here (Best 1975), I reviewed all original field data forms associated with these exceptions and independently estimated the number of territories. To conform with guidelines for publishing results of breeding bird censuses, the number of territories was estimated to the nearest half. Sometimes such rounding either over- or under-estimated the true number of territories in a plot, so I modified the counts with a + or -. For analyses here, such modified counts were adjusted by 0.2 territory; for example, a 1+ was converted to 1.2. Also, partial territories, recorded as + in summary reports, were converted to 0.2 for analysis. Visitor species (those recorded on only one to three of the surveys) were credited with 0.1 territory. For Brown-headed Cowbirds, the average number of females seen during the surveys was used as the number of territories.

The reliability of censuses of small plots is greater for species with small home ranges than for those with large ones. Accordingly, results for sparrows, Red-winged Blackbirds (*Agelaius phoeniceus*), Bobolinks (*Dolichonyx oryzivorus*), and warblers may be more reliable than those for wider-ranging species such as Western Meadowlark (*Sturnella neglecta*) and shorebirds.

Analytic Methods

Analyses were intended to determine effects on bird populations of the length of time since a plot was burned. The response variable was the density of indicated pairs of a species in a plot during a particular year. Analyses also were carried out using the log-transformed values, log(Density + 1). For all species, however, models for the untransformed data provided a better fit to the data; results of the analyses of log-transformed data will not be discussed further. Primary interest was in the influence on density of the number of years since the most recent burn. Years since burn were coded in whole years for burns conducted in spring (April-June) and in half-years for burns conducted in fall (August-October).

The first approach used related the density to the number of years since burn. This simple approach ignores effects due to the different plots and to the various years. Effects of these confounding variables can complicate interpretation of the effects of the explanatory variables of interest. The density of birds varies from plot to plot because of intrinsic differences in habitat. Also, densities vary annually due to climatic variation, regional changes in the population size, and other influences. To eliminate the effects of these "nuisance" variables and focus on the treatment effects, I also took a second approach, which involved two steps. First, I modeled the density of a species as a linear function of plot and year:

$$DENSITY_{it} = PLOT_i + YEAR_t + RESIDUAL_{it}.$$

In the second step, residuals from that models, termed *adjusted densities*, were related to the explanatory variable, years since burn. PROC GLM (SAS Institute 1990) was used for the first step. In the second step, the locally weighted regression (loess) procedure of S-PLUS (Statistical Sciences, Inc. 1993) was used. Because there was no variation in the explanatory variable for the control plot (Plot 13), effects were totally confounded with year, so data from that plot were excluded from the analysis of residuals.

The analysis was conducted on 17 of the most common terrestrial species recorded on the plots (Table 1). The American Goldfinch (*Carduelis tristis*) was omitted because it nests later in the season, so the surveys were inadequate to assess their breeding densities. The Western Kingbird (*Tyrannus verticalis*), Gray Catbird (*Dumetella carolinensis*), and swallows were omitted because they nest mostly outside the plots and used the plots only for foraging.

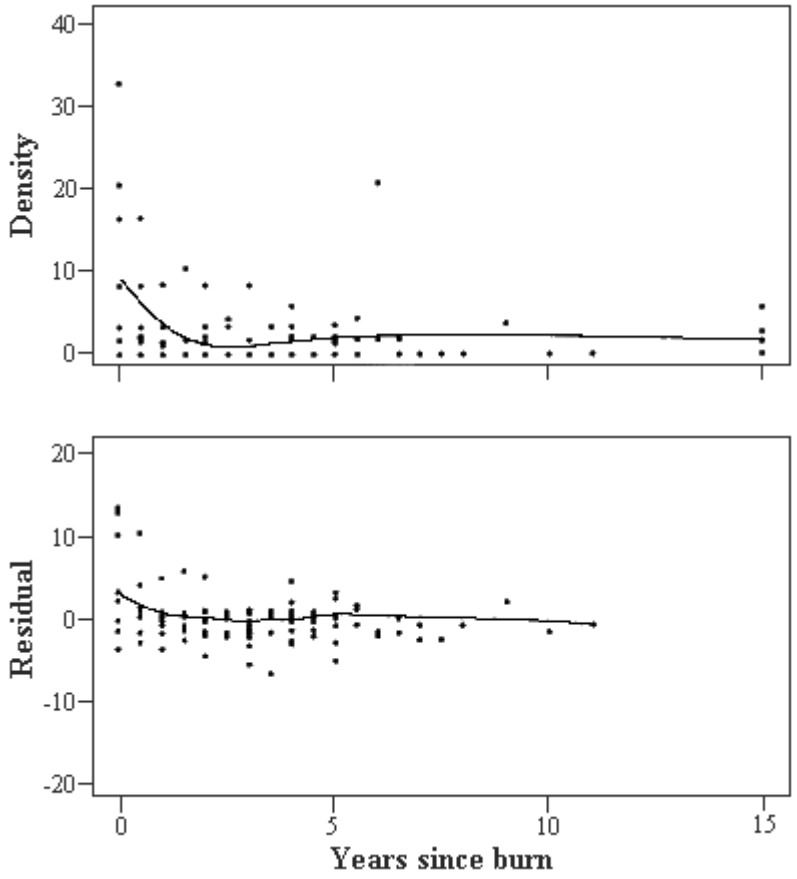
Table 1. Total numbers of indicated pairs of common terrestrial bird species recorded in surveys at Woodworth Study Area, North Dakota., 1972-95

Species	Total count
Clay-colored Sparrow	275.5
Red-winged Blackbird	199.2
Bobolink	158.2
Brown-headed Cowbird	133.1
Grasshopper Sparrow	115.1
Western Meadowlark	110.7
Common Yellowthroat	77.6
Eastern Kingbird	76.1
Willow Flycatcher	35.6
Savannah Sparrow	34.0
Yellow Warbler	28.9
Upland Sandpiper	25.2
Sedge Wren	19.8
Killdeer	17.6
Marbled Godwit	7.9
Willet	7.9
Baird's Sparrow	6.7

Results and Discussion

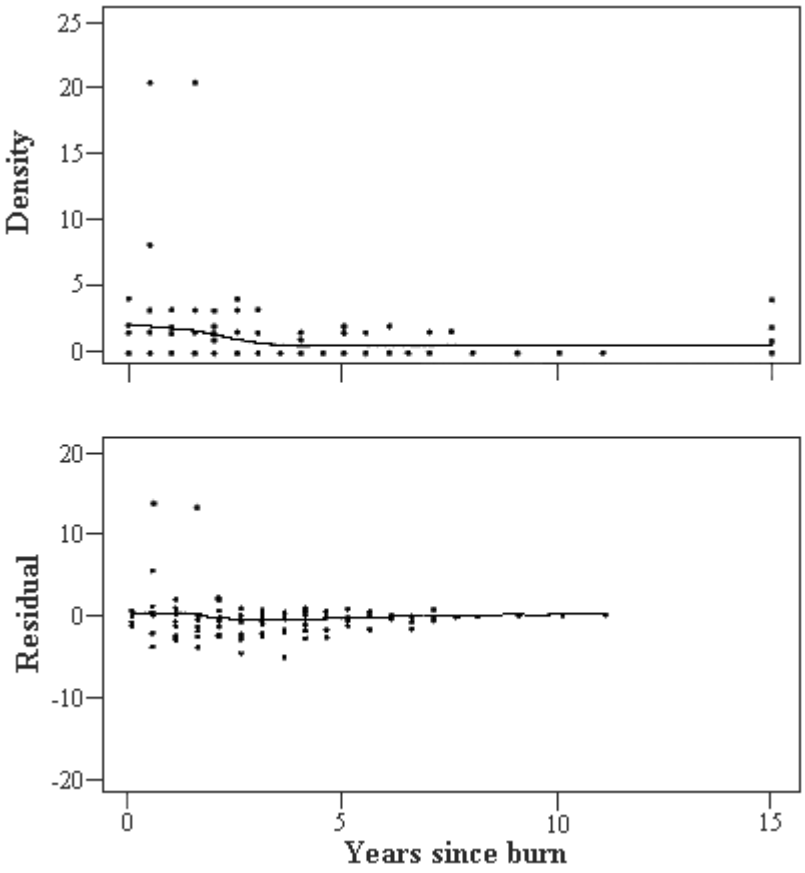
Killdeers (*Charadrius vociferus*) were most common at Woodworth immediately after a burn (Fig. 1). Densities and adjusted densities declined sharply with age of burn. Killdeer prefer open habitats with bare ground or very short vegetation, little residual vegetation, and no woody vegetation (Sample 1989, Best et al. 1995). These habitats include cultivated fields, heavily grazed pastures, bare shorelines of lakes and ponds, and exposed gravel and sand (Stewart 1975, Kantrud 1981). Open habitat with sparse cover is created immediately following a burn, which accounts for Killdeer favoring such plots at Woodworth. Huber and Steuter (1984) reported a noticeable absence of killdeers on unburned areas.

Figure 1. Killdeer



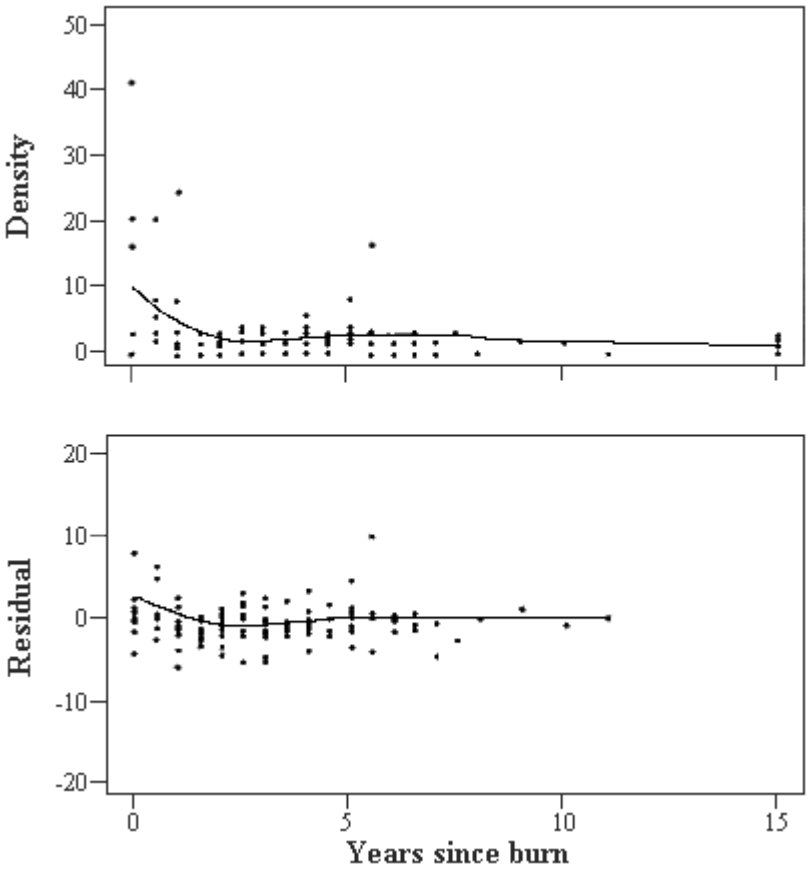
Marbled Godwits (*Limosa fedoa*) were not common at Woodworth, but highest densities were found in plots during the first two years after a burn (Fig. 2). Godwits often forage in wetlands but they nest and forage in upland areas, sometimes a considerable distance from water (Stewart 1975). They often feed in upland areas immediately after a burn. Preferred habitats of breeding godwits include idle grasslands and pastures with short vegetative cover (Ryan et al. 1984). They nest in cover of low to intermediate density and height (Kantrud and Higgins 1992). At Woodworth, the occasional high densities of Marbled Godwits were in plots within two years of a prescribed burn, where the lack of litter and low vegetation profile facilitated feeding. Ryan et al. (1984) recommended periodic disturbance by fire, grazing, or mowing, to produce the shorter-grass habitats favored by this species.

Figure 2. Marbled Godwit



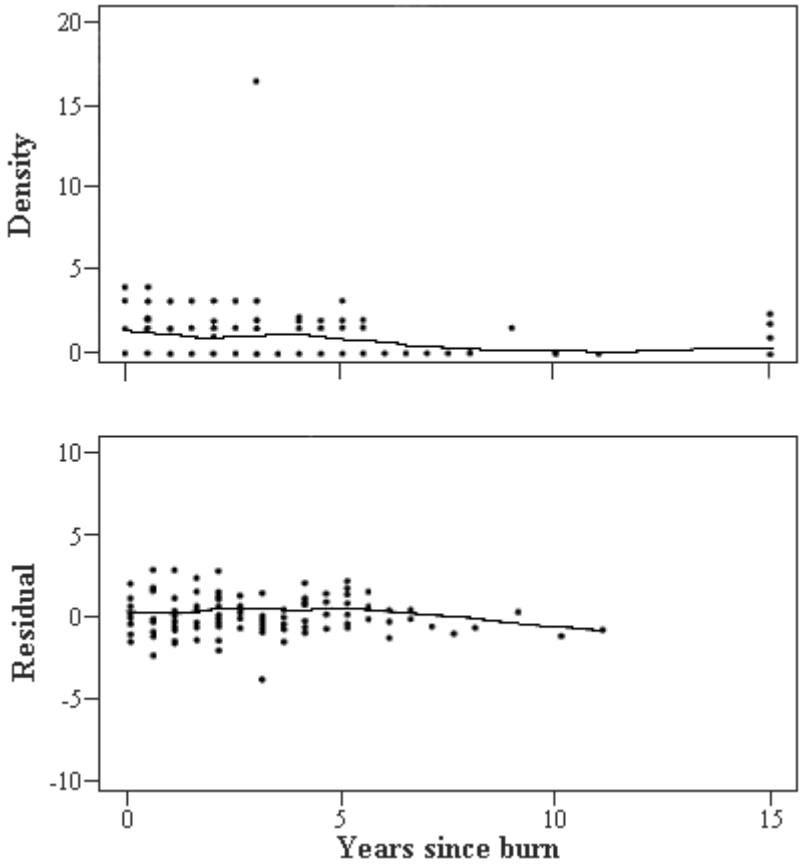
Upland Sandpipers (*Bartramia longicauda*) at Woodworth had highest densities and adjusted densities immediately after a burn and for about a year following a burn (Fig. 3). This appropriately named shorebird spends little time near water, nesting and foraging on dry land. It favors open grassland, with short vegetation and little woody cover (Skinner 1982, Sample 1989), and uses bare-ground habitats such as cropland (Stewart 1975). Although the Upland Sandpiper favors somewhat heavier cover for nest sites (Kantrud and Higgins 1992, Bowen and Kruse 1993), it uses open habitats for foraging (Kantrud 1981). Such selection for feeding areas is consistent with the higher-than-average use of recently burned plots at Woodworth. Huber and Steuter (1984) also reported that Upland Sandpipers used burned fields more often than unburned ones.

Figure 3. Upland Sandpiper



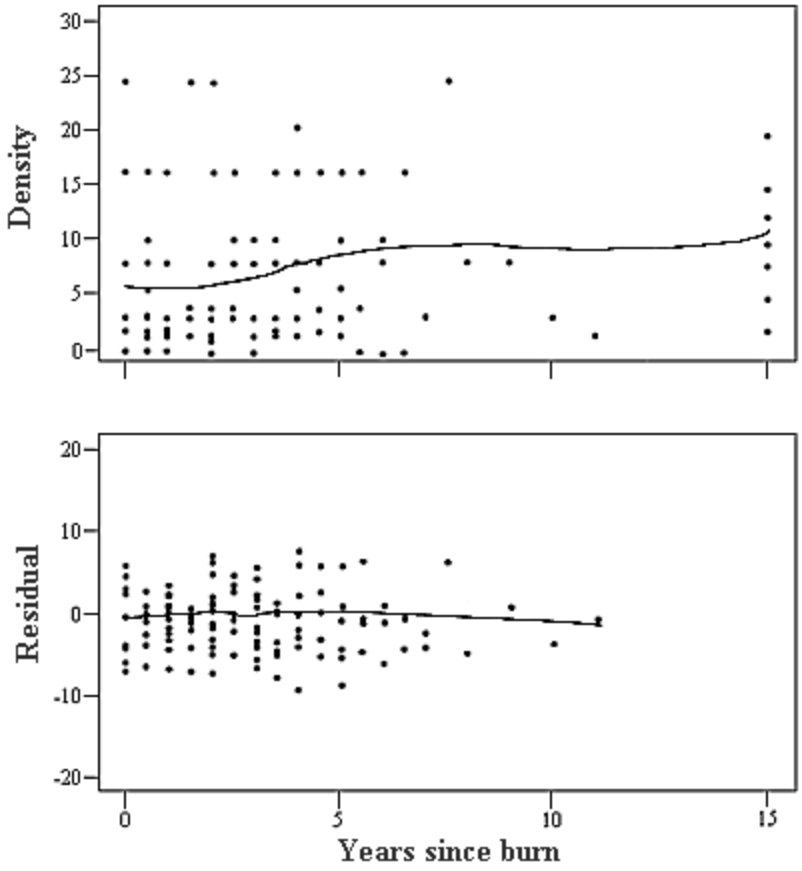
The Willet (*Catoptrophorus semipalmatus*) was uncommon on the Woodworth study plots; both densities and adjusted densities appeared unrelated to the age of burn (Fig. 4). Willets are most common in marshy areas and nearby uplands (Ehrlich et al. 1988). In North Dakota, Stewart (1975) indicated that they use mostly semipermanent and seasonal wetlands. Ryan and Renken (1987), however, found that, relative to the available area, Willets prefer less-permanent wetland types and alkali wetlands. Willets nest in the upland, often a considerable distance from water (Stewart 1975, Ryan and Renken 1987), typically in short, grassy cover (Higgins et al. 1979). Although Willets make little use of uplands except for nesting, they tend to favor short, native vegetation (Ryan and Renken 1987, Kantrud and Higgins 1992). With the Willet's affinity for wetlands and its large territory size, no selection of habitats at Woodworth was evident.

Figure 4. Willet



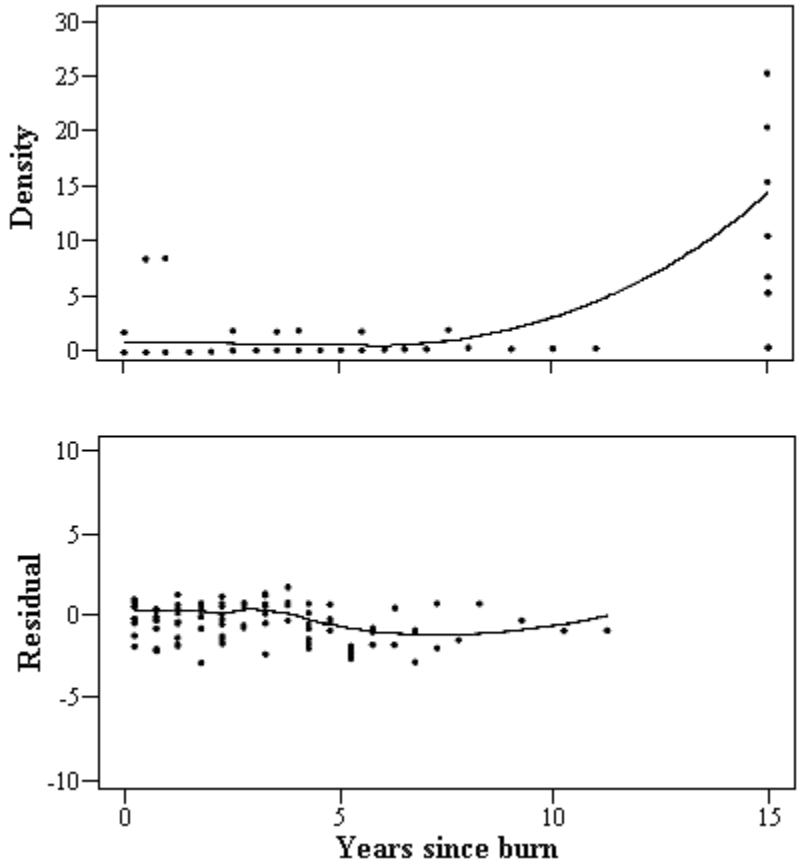
Densities of Eastern Kingbirds (*Tyrannus tyrannus*) at Woodworth were slightly lower than average for the first three years after a burn, although there was much variation around the loess line (Fig. 5). Adjusted densities were virtually unaffected by the recency of burn. Eastern Kingbirds use woodlands with open canopies and habitats with scattered stands of small trees or shrubs (Stewart 1975). Sample (1989) indicated that the species uses a variety of open habitats, with the nearby presence of tall, woody vegetation. At Woodworth, Eastern Kingbirds require only a small thicket of chokecherry or other woody species, from which they range out to forage into the grassland. Despite repeated fires, Woodworth still retains sufficient thickets for nesting eastern kingbirds. Should the small trees and shrubs be eliminated, use of the area by Eastern Kingbirds will diminish (Arnold and Higgins 1986).

Figure 5. Eastern Kingbird



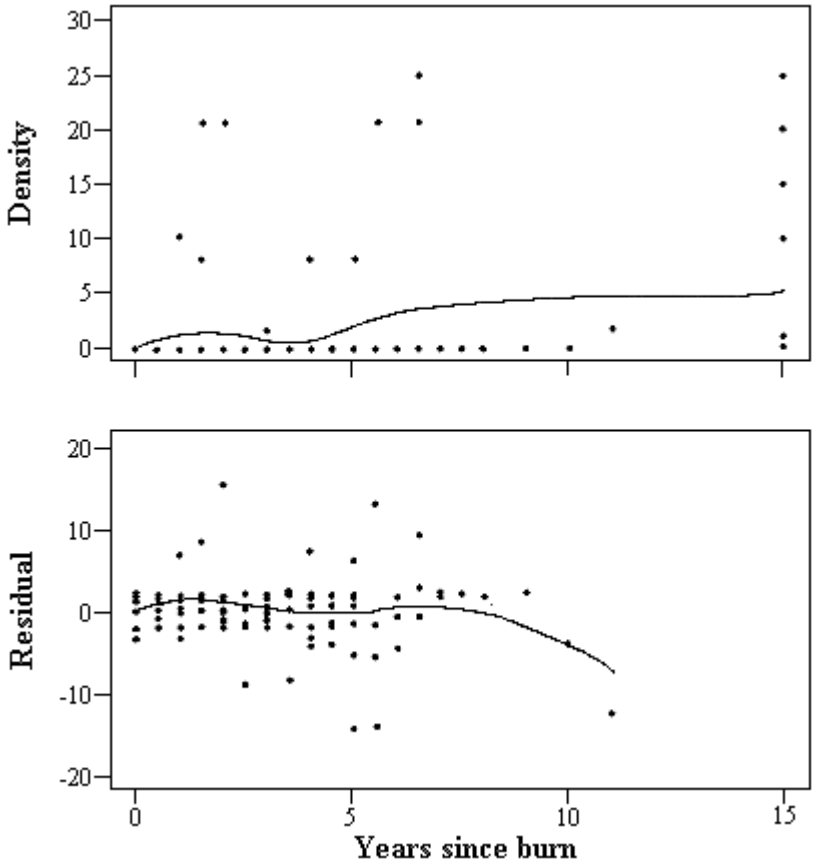
Willow Flycatchers (*Empidonax traillii*) at Woodworth were seen only in thickets of chokecherry, hawthorn, or similar vegetation. The species occurred regularly only in the control plot, where they used a large thicket in almost every year. Adjusted densities for this species showed no pattern following a burn (Fig. 6). The Willow Flycatcher is a species of swamps and thickets, especially of willow (*Salix* spp.; Ehrlich et al. 1988, Sedgwick and Knopf 1992). Kahl et al. (1985) described the species' breeding habitat as having intermediate to tall ground vegetation; a low, open canopy; dense ground vegetation; at least a few woody stems $\geq$ 2.5 cm dbh; an intermediate to high number of smaller woody stems; with a litter layer of intermediate depth and intermediate to dense coverage. In North Dakota, Willow Flycatchers use natural prairie thickets, consisting of species such as chokecherry, hawthorn, and wild plum (Stewart 1975). Similar vegetation occurs at Woodworth; these habitats are reduced by repeated fires. Clearly the species would disappear once the habitat it requires was eliminated (Arnold and Higgins 1986).

Figure 6. Willow Flycatcher



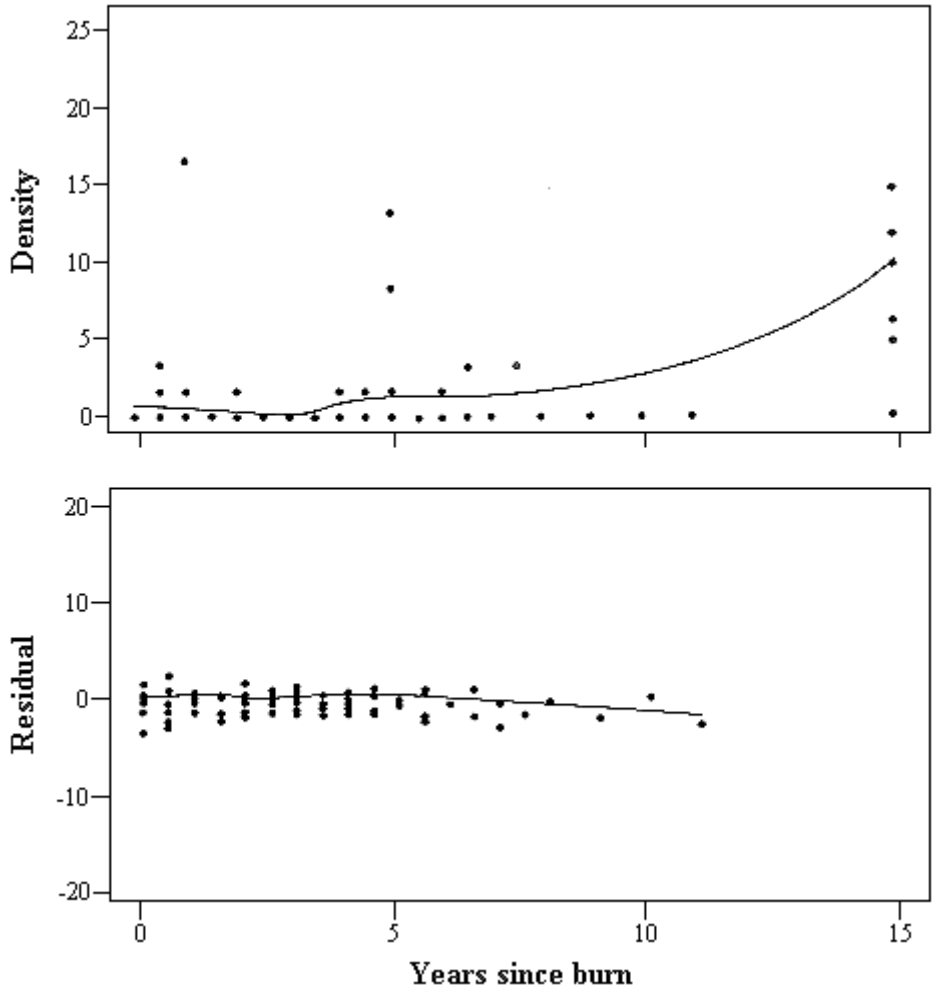
Sedge Wrens (*Cistothorus platensis*) were common at Woodworth only in some years. Densities were mostly zero, but none of the positive values occurred within a year after a burn (Fig. 7). Adjusted values likewise demonstrated little response with time post-burn. In the study plots at Woodworth, the species was rarely found in emergent wetland vegetation during years with average water conditions, but was frequent in upland grasses during unusually wet years, such as 1995. The breeding habitat of Sedge Wrens consists of tall and dense vegetation (Skinner 1982, Schramm et al. 1986) found in emergent wetland vegetation (Stewart 1975), dry marshes or wet meadows (Bent 1968), moist grasslands, old fields, dense cultivated grainfields (Dobkin 1992), or retired cropland (Stewart 1975). Tall and dense vegetation and dense, prostrate residual vegetation appear to be important (Sample 1989). Such habitats are eliminated by a burn, suggesting why the species did not occupy recently burned plots at Woodworth. In contrast, for the tallgrass prairie of Illinois, Schramm et al. (1986) suggested Sedge Wrens prefer a clear understory and ground area, and indicated that the wrens were most attracted to recently burned areas, although they used, and perhaps required, unburned areas nearby to gather material for nest construction. In that study, the recently burned areas had taller and denser vegetation than did the unburned areas.

Figure 7. Sedge Wren



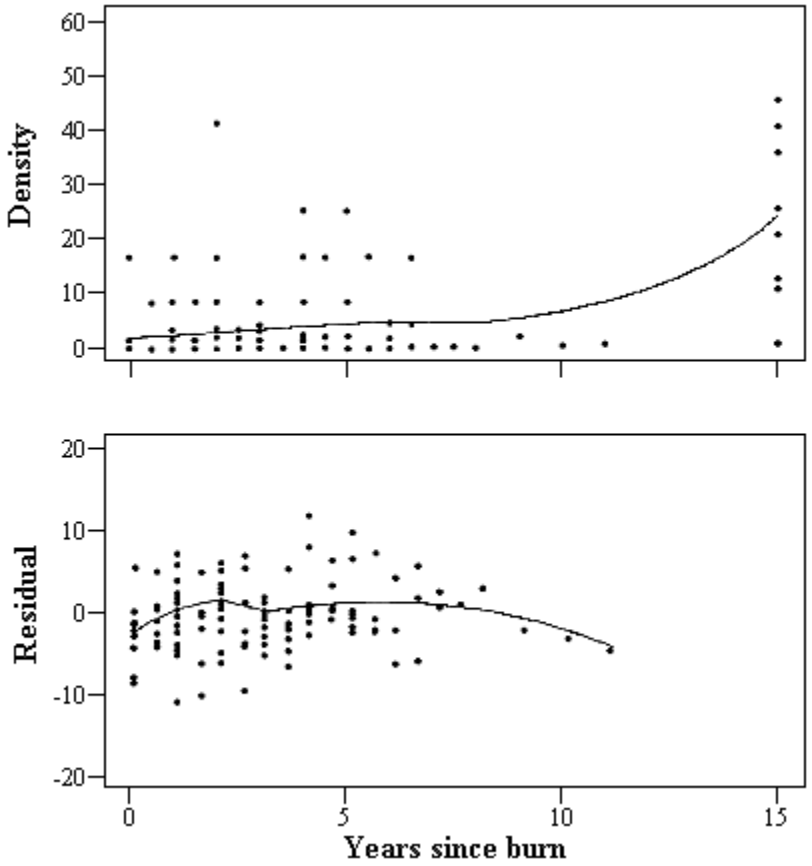
Yellow Warblers (*Dendroica petechia*) were most common at Woodworth in the control plot. Adjusted densities showed no pattern following a burn (Fig. 8). The Yellow Warbler favors thickets of small deciduous trees or tall shrubs (Stewart 1975, Dobkin 1992). Knopf and Sedgwick (1992) defined more precisely the habitat features associated with nest sites, primarily characteristics of the vegetation patch. At Woodworth, Yellow Warblers were most common in the control plot, especially in the large woody thicket. This species likely would disappear once the taller woody vegetation was eliminated (Arnold and Higgins 1986).

Figure 8. Yellow Warbler



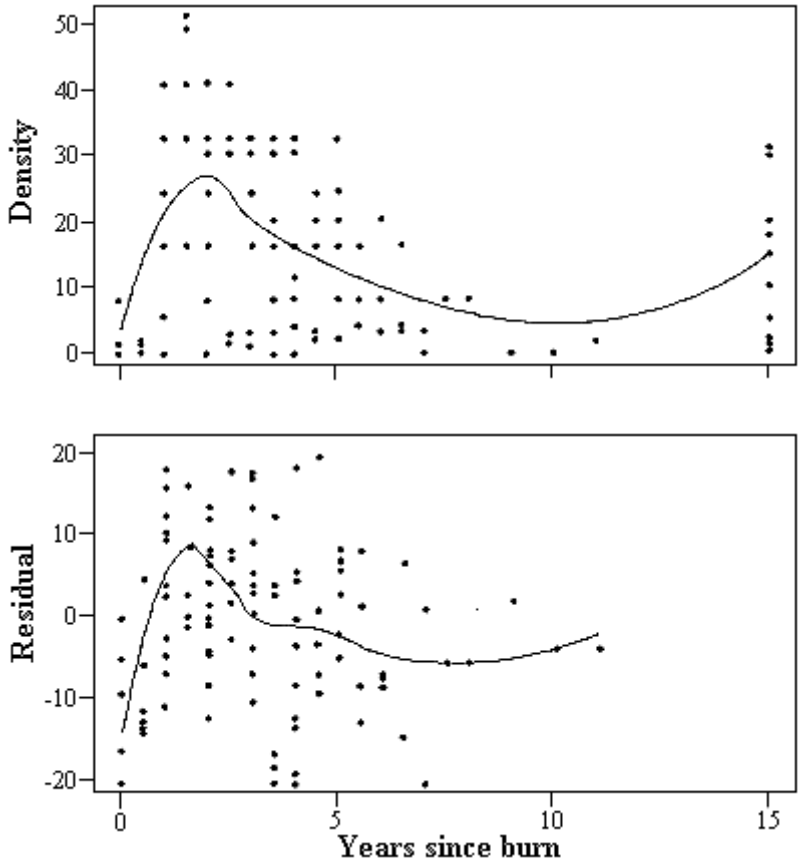
The Common Yellowthroat (*Geothlypis trichas*) had highest densities at Woodworth in the control plot. Adjusted densities indicated no trend, except for a modest depression immediately after a burn (Fig. 9). The yellowthroat usually nests in tall, dense herbaceous vegetation. Breeding habitat can be either in emergent wetland vegetation or in uplands with lush vegetation, possibly including shrubs or small trees (Stewart 1975, Kahl et al. 1985). Sample (1989) noted that the species prefers the presence of some standing residual cover and dense, prostrate residual vegetation. At Woodworth, wetland habitats were not usually affected markedly by fires, so yellowthroats used those habitats even immediately after a fire. Upland thickets sometimes were affected by the burns, and the species would avoid those areas until the vegetation had a chance to regrow. Huber and Steuter (1984) found yellowthroats more common, but not significantly so, in unburned than in burned grassland. Repeated fires that eliminate the brushy vegetation will reduce the suitability of the upland habitat for this species (Arnold and Higgins 1986).

Figure 9. Common Yellowthroat



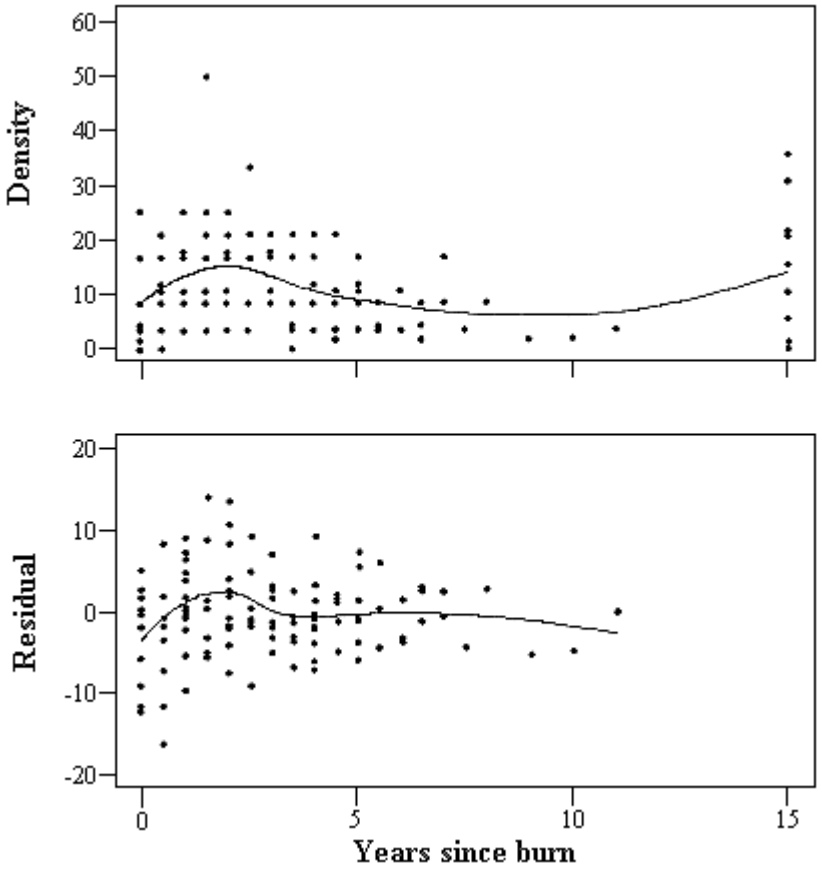
Densities of Bobolinks at Woodworth were low immediately post-burn, peaked one to three years after a burn, and began to decline about five years post-burn (Fig. 10). Densities in the control plot remained high, however. Adjusted densities showed the same pattern. Breeding habitats of the bobolink include mixed-grass and tallgrass prairies, wet-meadow zones of wetlands, domestic haylands, retired croplands, and occasionally active croplands (Stewart 1975). Bobolinks prefer grasslands with a high coverage of fairly lush vegetation of intermediate height, with some residual vegetation (Wiens 1969, Sample 1989). The species favors areas with deep litter and a preponderance of grasses over legumes (Wiens 1969, Bollinger and Gavin 1992). Its preference for lush vegetation and deep litter is consistent with its reduced use of recently burned plots at Woodworth. Huber and Steuter (1984) also found that Bobolinks avoided burned grasslands. In contrast, Johnson and Temple (1986) found Bobolink nests most frequently in tallgrass prairie a single growing season after a burn, and less frequently in fields burned less recently.

Figure 10. Bobolink



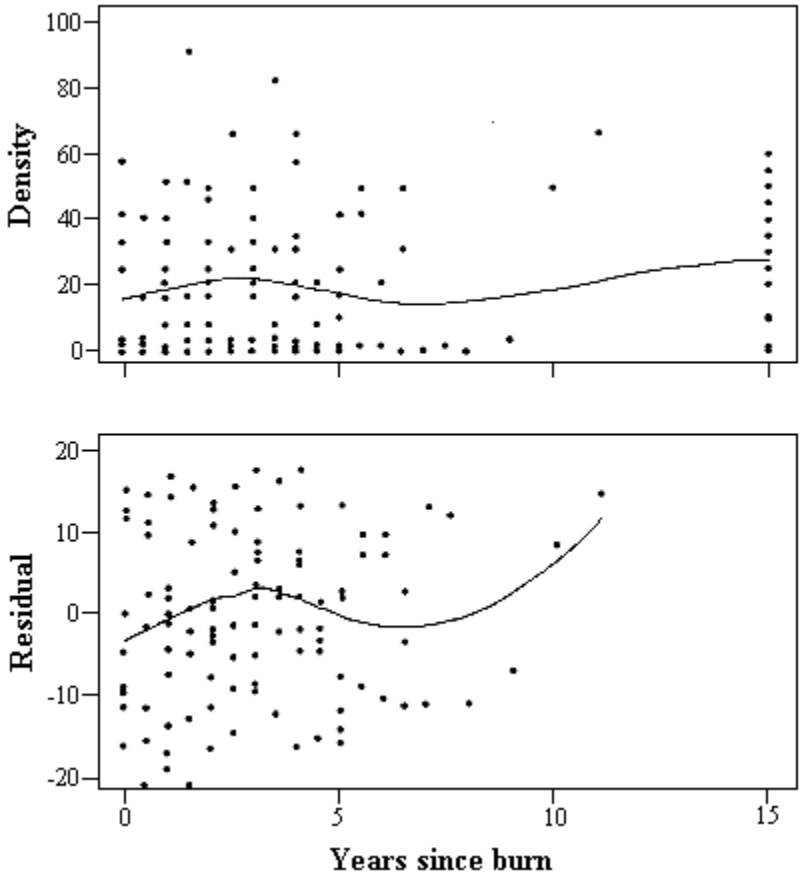
Densities of Western Meadowlarks at Woodworth were low immediately post-burn, highest two to four years after a burn, and lower after about five years following a burn (Fig. 11). The species was frequently common in the control plot, however. The loess line fitted to adjusted densities indicated a depression immediately post-burn, and a slight peak about three years after a fire. Western Meadowlarks are most common in native grasslands and pastures, but also occur in hayfields, roadsides, retired cropland, and other open areas (Stewart 1975, Lanyon 1994). A preference by meadowlarks for habitats with grass and litter cover was identified by Wiens and Rotenberry (1981) and Sample (1989). Ground cover and litter seem especially important, as nests are often constructed with a dome of interwoven grasses (Lanyon 1994). Fire removes most litter, which suggests why meadowlark densities at Woodworth were somewhat depressed for about a year after a burn. Bock and Bock (1987) noted the adaptability of the species and observed that it was equally common on burned and unburned sites. Pylypec (1991) observed that Western Meadowlarks were less common on a burned area than on an unburned area for two years following a fire, but densities in the two areas were comparable in the third year.

Figure 11. Western Meadowlark



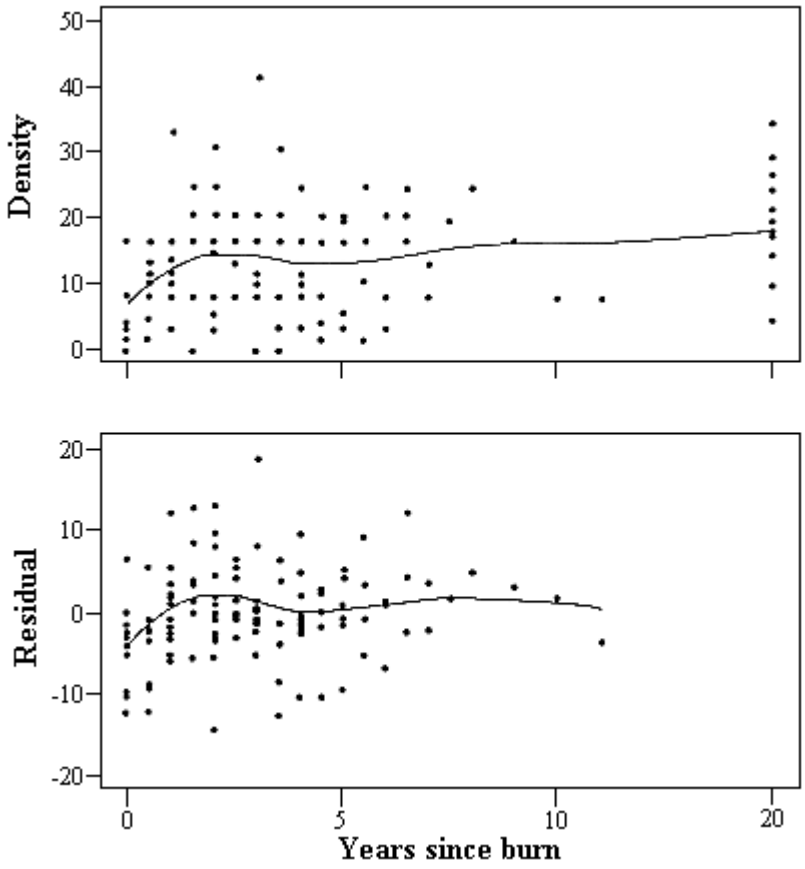
Red-winged Blackbird densities at Woodworth varied only slightly with age of burn, although adjusted densities were high about two to four years post-burn (Fig. 12). Their overall numbers varied dramatically among years, as is demonstrated by the variation in densities for the control plot. Red-winged Blackbirds use a wide variety of habitats for breeding, including marshes, riparian areas, ditches, hayfields, weedy fields, and active and retired croplands (Stewart 1975, Sample 1989). Sample (1989) reported that Red-winged Blackbirds prefer lush habitats with fairly tall, dense vegetation and with standing and prostrate residual vegetation. At Woodworth, Red-winged Blackbirds are most commonly associated with wetlands, and their numbers fluctuated in close relation to water conditions. For that reason, redwing densities did not exhibit any marked response to the fire regime but were widely variable around the loess line. Huber and Steuter (1984) indicated that Red-winged Blackbirds used the burned and unburned treatments similarly during June, but by July use was reduced on the burned treatment. Eddleman (1974) stated that Red-winged Blackbirds increased when long-term protection from burning causes increased shrub and forb cover. Arnold and Higgins (1986) also noted higher densities of Red-winged Blackbirds in grassland areas with more shrubby vegetation. Although Red-winged Blackbirds used brushy areas at Woodworth, they appeared to rely on the wetland habitat.

Figure 12. Red-Winged Blackbird



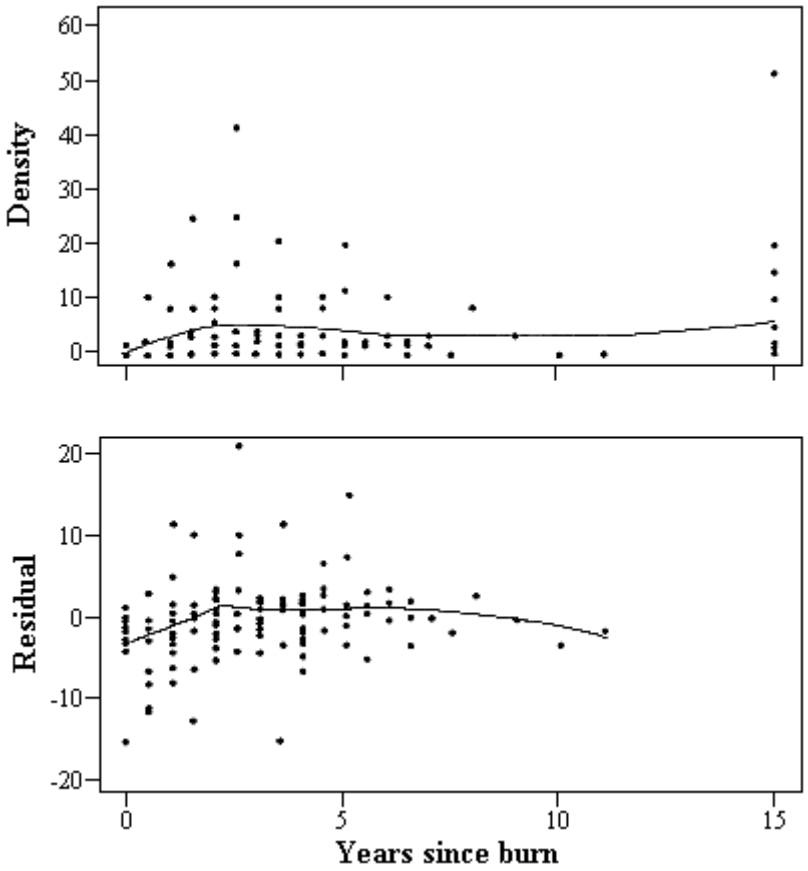
Densities of Brown-headed Cowbirds (*Molothrus ater*) at Woodworth were depressed for the first year or so after a burn, but were constant after that time (Fig. 13). Cowbirds are habitat generalists, preferring habitats with low or scattered trees among grassland vegetation (Lowther 1993). The slight reduction in cowbird densities following prescribed burns at Woodworth may reflect the reduction of potential host nests in those plots. Huber and Steuter (1984) found no response by cowbirds to spring burns.

Figure 13. Brown-Headed Cowbird



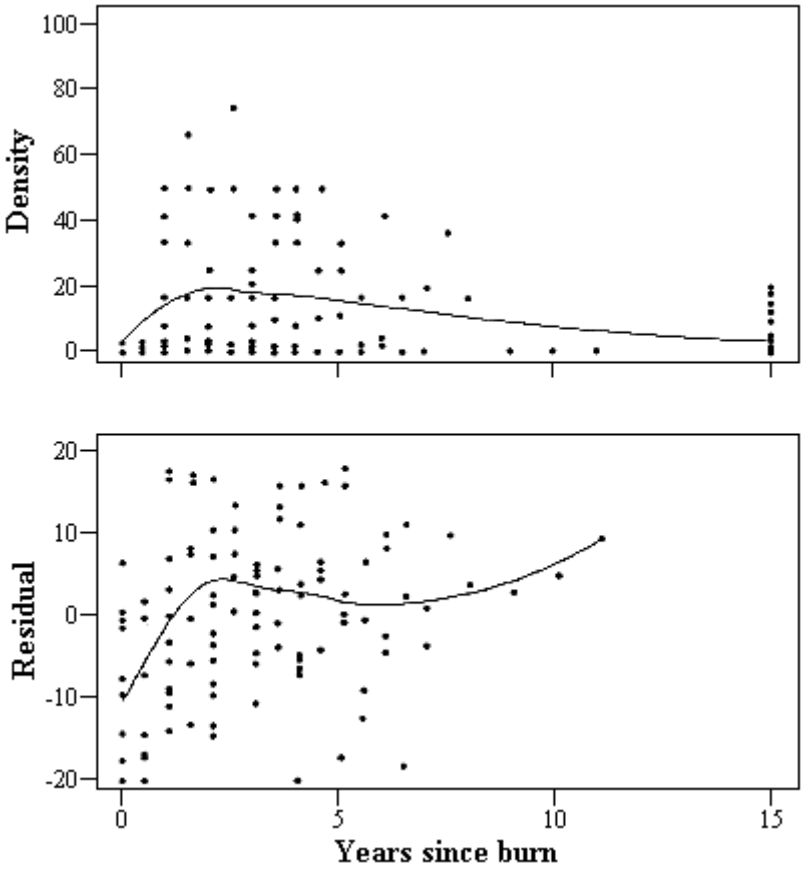
Savannah Sparrows (*Passerculus sandwichensis*) at Woodworth had highest densities one to five years post-burn, although they were occasionally common in the control plot (Fig. 14). The loess line fitted to adjusted densities indicated that the species was less common for about a year or so immediately after a burn, with possibly a longer-term depression as well. Favored breeding habitat of the Savannah Sparrow has been described in various ways: dense ground vegetation, especially grasses, and moist microhabitats (Wiens 1969); dry or wet habitats with little woody cover, moderate-to-high cover of fairly short vegetation, and medium litter depth (Sample 1989); and sparse ground cover and moderate above-ground cover (Skinner 1982). Wheelwright and Rising (1993) included grassy meadows, cultivated fields (especially alfalfa), lightly grazed pastures, roadsides, and sedge bogs as Savannah Sparrow habitats. In North Dakota, the species selects tallgrass prairie, lightly grazed mixed-grass prairie, wet-meadow zones bordering wetlands, hayfields, weedy fields, and retired croplands (Stewart 1975). Within plots at Woodworth, Savannah Sparrows were not regularly seen in areas with extensive shrub patches; Arnold and Higgins (1986) reported a similar response. At Woodworth, Savannah Sparrows avoided plots for a year or so after a burn, but no other responses to burns were evident. Halvorsen and Anderson (1983) also reported that Savannah Sparrow densities were reduced on burned fields, a finding they attributed to the reduction of residual cover. Huber and Steuter (1984) likewise noted that the species was absent from a field burned earlier in the spring. Pylypec (1991) indicated that Savannah Sparrows in a fescue prairie were reduced for three years following a burn.

Figure 14. Savannah Sparrow



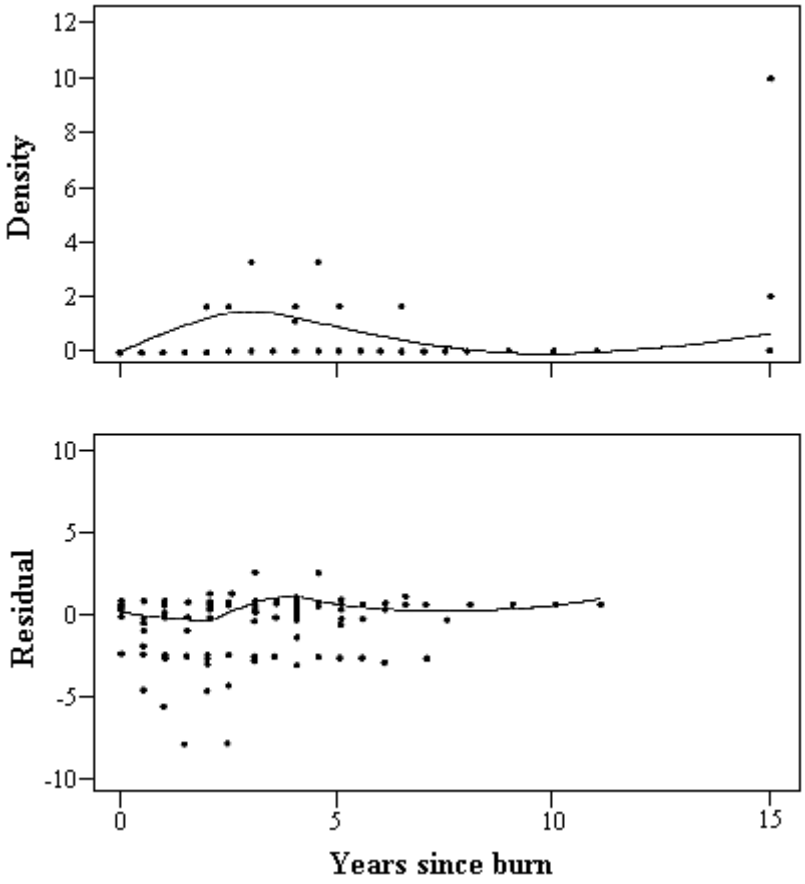
Densities of Grasshopper Sparrows (*Ammodramus savannarum*) at Woodworth were depressed for about a year post-burn; they increased after that time and appeared to decline gradually after about five years post-burn (Fig. 15). Adjusted densities were more marked, with values depressed for two years post-burn, and no effect of burning thereafter. Over its broad breeding range, the Grasshopper Sparrow uses a variety of habitats, but prefers grassland, old-field, and retired cropland (Smith 1963, Stewart 1975, Kahl et al. 1985, Johnson and Schwartz 1993). Dense ground vegetation and shallow-to-moderate litter accumulation were identified as habitat features by Huber and Steuter (1984) and Kahl et al. (1985). Preference for patchy vegetation was noted by Skinner (1982) and Sample (1989). Whitmore (1981) observed that Grasshopper Sparrows favor bunchgrass habitats, with gaps in vegetation that facilitate movement. Smith (1963) indicated that Grasshopper Sparrows abandon fields once they become filled with shrubs. The requirement by the species for some litter accumulation is consistent with the reduced use of Woodworth plots for a year or so post-burn. Although Grasshopper Sparrows used the control plot regularly, they tended to concentrate in areas that lacked heavy shrub cover, similar to the finding of Arnold and Higgins (1986). In Montana, Bock and Bock (1987) observed fewer Grasshopper Sparrows in burned than unburned shrubsteppe habitats. Huber and Steuter (1984) reported Grasshopper Sparrows recolonizing a spring-burned field by mid-July of the same year. In tallgrass prairie in western Minnesota, Johnson and Temple (1986) found Grasshopper Sparrow nests more commonly in fields with four or more growing seasons since a burn. Eddleman (1974) indicated that burning will partially provide the interspersion of cover heights necessary for the species, but a severe lack of litter will result in few nesting sites and a lack of nesting material.

Figure 15. Grasshopper Sparrow



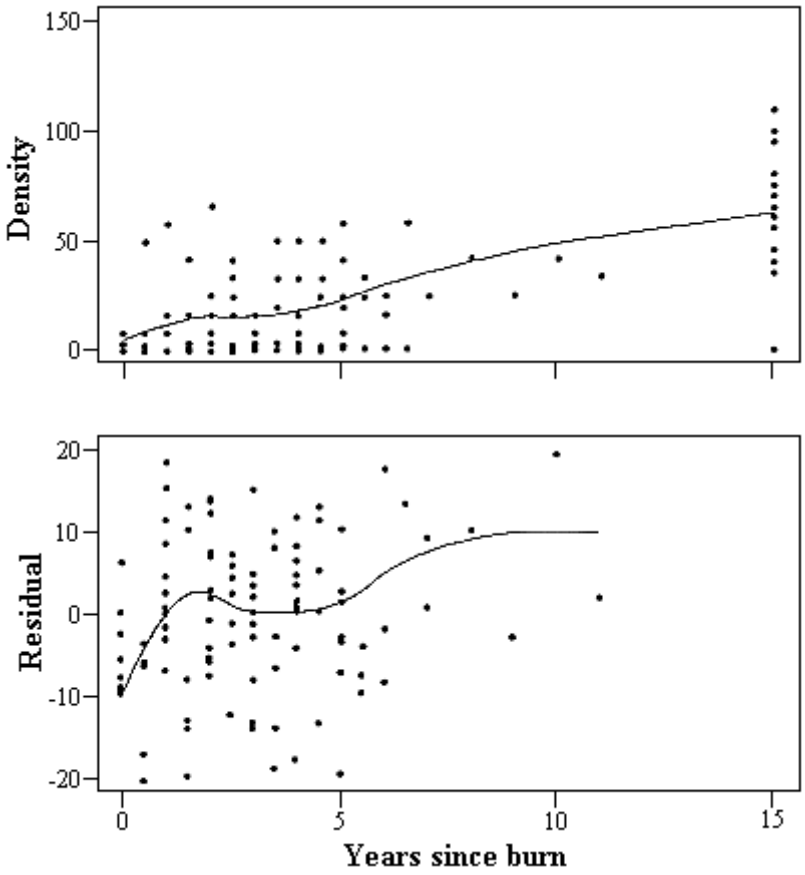
Baird's sparrows (*Ammodramus bairdii*) occurred infrequently at Woodworth. Densities tended to be highest in plots two to five years after a burn, although birds occasionally used the control plot (Fig. 16). The adjusted densities indicated a slight depression for the first couple of years post-burn, followed by a modest increase. The low observed densities caution against drawing any firm conclusions, however. The Baird's Sparrow is a mixed-grass prairie species, endemic to the northern Great Plains. In North Dakota it favors idle or lightly grazed areas, although it also uses more heavily grazed sites and, particularly in more arid locations, lowland areas (Stewart 1975). Baird's Sparrows favor abundant residual vegetation (Salt and Salt 1976) and a dense understory (De Smet and Miller 1989), which is consistent with its occurrence at Woodworth in plots several years after a burn. The species avoids areas with extensive bare ground (Davis and Duncan 1996). It has been reported to favor areas with some but not extensive coverage of shrubs (Arnold and Higgins 1986; Winter 1994; Dale et al., in press). Anstey et al. (1995) detected a positive association between Baird's Sparrow densities and litter depth. Winter (1994) suggested the species favored intermediate depths of litter. At Woodworth, the species was absent in recently burned plots, which typically have little remaining litter. Pylypec (1991) observed that Baird's Sparrows avoided a recently burned area, returned to the site the second year after burn, and in the third year had densities comparable to an unburned area.

Figure 16. Baird's Sparrow



Densities of Clay-colored Sparrows (*Spizella pallida*) at Woodworth increased almost monotonically following a burn (Fig. 17). The occasional high densities in recently burned plots was due to the occupancy by Clay-Colored Sparrows of brush thickets that were not markedly affected by the fires. Adjusted densities showed a similar pattern. The enormous variability among those points reflects the high annual variation in abundance of the species. Although Clay-colored Sparrows breed in a variety of habitats, ranging from retired cropland and abandoned fields to forest edges (Stewart 1975, Knapton 1994), in North Dakota the prime habitats are low thickets of wolfberry and other shrubs (Stewart 1975). Those habitats are common at Woodworth, accounting for the abundance of the species. Thickets were especially prominent in the control plot, which had the highest densities of Clay-colored Sparrows. Densities tended to increase with the number of years since the most recent burn. Clay-colored Sparrows were common even in recently burned plots, however, particularly if the burn was incomplete and did little damage to thickets. Huber and Steuter (1984) noted that the species favored the dense grassland that resulted from light grazing and the absence of fire. Halvorsen and Anderson (1983) observed declines exceeding 90% for Clay-colored Sparrows immediately following a burn, a change they attributed to the reduction of residual cover. In Saskatchewan, Pylypec (1991) noted that a burned area supported Clay-colored Sparrows at only one-third the density of an unburned area, for the first three years after the burn. Long-term idling of grassland habitat will permit the encroachment of shrubby and other woody vegetation, which favors this species (Eddleman 1974, Arnold and Higgins 1986), as was observed in the control plot.

Figure 17. Clay-Colored Sparrow



Conclusions

The birds considered in these analyses can be grouped into three major categories, depending on their response to burning and successional changes in vegetation. In the first group are those species that respond positively and immediately to a burned area. Included are three of the common shorebirds at Woodworth: Killdeer, Marbled Godwit, and Upland Sandpiper. All three favor open areas with sparse vegetation, where they forage. The Killdeer and Marbled Godwit likewise nest in these open areas, but the Upland Sandpiper typically nests in heavier vegetation. Other species, not treated here in because of limited numbers observed, that likely would favor recently burned mixed-grass prairies include the Horned Lark (*Eremophila alpestris*) and Vesper Sparrow (*Pooecetes gramineus*).

The second category includes those species that use habitats enhanced by long-term protection from fire, specifically the woody vegetation that encroaches in unburned grassland. The most common species at Woodworth in this group are Eastern Kingbird, Willow Flycatcher, Yellow Warbler, Common Yellowthroat, Clay-colored Sparrow, and Brown-headed Cowbird. The Red-winged Blackbird also uses brushy vegetation, but at Woodworth relied more on wetland habitats.

In the third category are birds that avoid recently burned areas, but favor grassland with little or no woody vegetation. Several of these species are most common two to five years following a fire. These might be termed true grassland species. Included in this category are Bobolink, Western Meadowlark, Grasshopper Sparrow, Baird's Sparrow, and Savannah Sparrow.

Two species analyzed here did not fit into any of the three categories. The Willet, although commonly seen in the uplands, uses mostly wetland habitat except for nesting. No evidence of a response to burning was detected. The Sedge Wren used upland habitats, but usually only when long-term precipitation patterns resulted in luxuriant herbaceous growth. This species showed no response to grassland burning, except for a reduction immediately following a fire.

A Proposed Conservation Strategy

Results presented here suggest a conservation strategy for the northern Great Plains involving prescribed burning. On large areas, such as wildlife refuges, only portions should be burned in any particular year, and these on a rotational basis. The same prescription would apply to smaller areas that can be considered as components in a landscape, such as waterfowl production areas. They should be burned periodically, but not all in the same year. That strategy will assure that in any given year habitats in a variety of successional stages will be available for a variety of breeding bird species.

This prescription will provide habitat for birds in two of the three categories, although those that benefit from long-term protection from fire will suffer. True grassland species should be emphasized in the management of mixed-grass prairies. Birds that favor short and sparse vegetative cover are common and widespread, or have positive or neutral population trends, as indicated by Breeding Bird Survey results (Table 2). Also, many of these birds use habitats such as cultivated fields and heavily grazed pastures, which are made available from agricultural operations (Best et al. 1995), although the reproductive success in such habitats may be inadequate. Further, a regime of prescribed fires will provide suitable habitat for these species immediately following each fire.

Table 2. Trends from Breeding Bird Survey for Central Region, 1966-94 and 1980-94, and route averages for 1966-94.

	1966-94		1980-94
Species	**Route average**	**Trend[a]**	**Trend**
Killdeer	8.88	-0.3	-2.0 ⇊
Marbled Godwit	1.36	0.7	NA
Upland Sandpiper	3.92	2.1 ⇈	0.3
Willet	1.03	-1.8	-0.4
Eastern Kingbird	7.78	0.2	0.4
Sedge Wren	1.25	1.3	5.7 ⇈
Yellow Warbler	2.29	-0.2	2.7 ⇈
Common Yellowthroat	6.87	-0.9 ⇊	-2.1 ⇊
Bobolink	6.46	-2.4 ⇊	-3.0 ⇊
Western Meadowlark	95.69	-0.3	0.3
Red-winged Blackbird	85.09	-0.5 ⇊	-1.3 ⇊
Brown-headed Cowbird	26.17	-0.5 ↓	-0.2
Savannah Sparrow	6.98	0.5	1.5
Grasshopper Sparrow	8.95	-2.9 ⇊	-1.8 ⇊
Baird's Sparrow	1.82	-0.9	-0.5
Clay-colored Sparrow	6.67	-1.1	0.9

[a] Average annual change; ⇈increasing at P=0.01, ↑increasing at P<0.05, ↑increasing at P<0.10; ⇊decreasing at P=0.01, ↓decreasing at P<0.05, ↓decreasing at P<0.10.

Most of the species that favor woody vegetation also are common and widespread and have had neutral or positive population trends (Table 2). They can also rely on habitats provided on private land, including shelterbelts, suburban areas, and wetlands. Moreover, all these species have widespread distributions and are more common elsewhere than the mixed-grass prairies (Price et al. 1995). An exception is the Clay-colored Sparrow. That species has declined during the past 25 years or so, although not significantly, and its center of abundance is in the mixed-grass prairie. A prescribed-burning program that eliminated brushy vegetation would reduce breeding populations of Clay-colored Sparrows. Mitigating this concern is the fact that the species uses brushy habitat, which is common in private pastures, and retired cropland, such as offered by the Conservation Reserve Program (Johnson and Schwartz 1993).

Although true grassland birds suffer short-term habitat losses from a burn, they do require grassland, which in turn requires periodic fire for maintenance. Several of these species have suffered long-term population declines (Table 2). Moreover, they typically do not attain high densities or reproduce successfully in habitats other than grassland, as do birds in the other two categories. Furthermore, these species generally have breeding distributions centered in the grasslands of the midcontinent.

Concern about declining bird populations is widespread (Terborgh 1989), but grassland specialists seem particularly threatened. Numbers of many such species have suffered population declines, as judged by results of the Breeding Bird Survey (BBS), more consistently and severely than other groups of species (Peterjohn and Sauer 1993). More troubling, the BBS was begun in the mid 1960's; we lack quantitative evidence of how grassland birds responded to the massive conversion of native prairie to cropland that took place earlier (Johnson In press).

Further, uncultivated grasslands are vital for certain species. Although some species, such as Horned Lark and Vesper Sparrow, have adapted to cropland habitats (Best et al. 1995), many, such as Sprague's Pipit (*Anthus spragueii*) and Burrowing Owl (*Athene cunicularia*), have not. And even those species that use cultivated habitats may not be reproductively successful (Rodenhouse and Best 1983).

The fraction of native mixed-grass prairie that has been protected is small (Samson and Knopf 1994, Noss et al. 1995); most of what remains is privately owned and is used for grazing. Fortunately, much of the publicly owned mixed-grass prairie is included in the National Wildlife Refuge System, either as refuges or as waterfowl production areas. These areas also include many formerly cultivated fields that have been replanted to native or tame grasses and forbs. The areas are managed to benefit wildlife, particularly waterfowl. Also fortunately, a rotational system of prescribed burning, which is necessary to maintain grassland and provide habitat for nesting waterfowl, will provide breeding habitat for many of the terrestrial grassland birds.

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