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Effects of grazing on vegetation structure, prey availability, and reproductive success of Grasshopper Sparrows

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ABSTRACT. Populations of Grasshopper Sparrows (*Ammodramus savannarum*) have been declining, and agricultural practices, such as grazing by domestic cattle (*Bos taurus*), are likely contributing factors. Grazing can alter the composition and structure of vegetation and influence prey availability, and such changes can impact the nesting success of grassland birds. Our objective was to examine the nesting success of Grasshopper Sparrows in grazed and ungrazed habitats on the Blue Grass Army Depot in Madison County, Kentucky. Clutch sizes of female Grasshopper Sparrows nesting in grazed and ungrazed areas differed significantly, with mean clutch sizes of 4.48 in ungrazed areas and 3.91 in grazed areas. In addition, nest success was higher in ungrazed areas (70%) than grazed areas (25%). Insect sweeps revealed that invertebrate biomass in ungrazed areas was greater than in grazed areas, and analysis of vegetation indicated that grazed areas had less litter, more shrubs, and shorter, less dense vegetation than ungrazed areas. Most unsuccessful nests were depredated, and the higher predation rates on nests in grazed areas may have been due to differences in vegetation structure. Shorter, less dense vegetation in grazed areas may make it easer for predators to observe adults and locate nests, while taller, denser vegetation in ungrazed areas may provide greater concealment. While the results of previous studies suggest that light to moderate grazing can produce habitat suitable for Grasshopper Sparrows, more intense grazing, as on our study area (one animal unit/ha), creates habitat less suitable for these sparrows.

SINOPSIS. **Efecto del pastoreo en la estructura de la vegetación disponibilidad de presas y exito reproductivo de *Ammodramus savannarum***

Las poblaciones del gorrión *Ammodramus savannarum* se han ido reduciendo, y practicas agrícolas tales como el pastoreo por parte de ganado vacuno (*Bos taurus*) son factores que han contribuido al asunto. El pastoreo puede alterar la composición y la estructura de la vegetación e influir en la disponibilidad de presas. Estos cambios pueden afectar el éxito de anidamiento del ave. Nuestro objetivo fue examinar el éxito de anidamiento del gorrión en lugares en donde no había pastoreo vs. lugares en donde lo hubo. El trabajo se hizo en el Blue Grass Army Depot en el condado de Madison, Kentucky. El tamaño de la camada resultó significativamente diferente en áreas en donde no lo hubo, comparado con las pastoreadas con una camada promedio de 4.48 y 3.91, respectivamente. Además el éxito de anidamiento en áreas no pastoreadas resultó mayor (70%) que en áreas en donde hubo pastoreo (25%). El barrido con redes para atrapar insectos, reveló que la biomasa de invertebrados resultó mayor en áreas no pastoreadas que en las que hubo ganado. Un análisis de la vegetación señalo que en las áreas en donde hubo pastoreo, tenían menos desperdicios, más arbustos y vegetación más corta y menos densa que en las áreas en donde no hubo pastoreo. La depredación fue la causa principal del fracaso de nidos. La tasa mayor de depredación en las áreas en donde hubo pastoreo puede haber sido el resultado de diferencias en la estructura de la vegetación. La vegetación más corta y menos densa en áreas que fueron pastoreadas puede facilitar el que los depredadores detecten a los adultos y a los nidos, mientras que la vegetación mas alta y densa, en lugares en donde no hubo pastoreo, puede tener el efecto de nidos más escondidos y que estos pasen inadvertidos. Aunque los resultados de estudios previos sugieren que el pastoreo de poco a moderado puede proveer hábitat para el gorrión, el pastoreo intensivo, como demuestra nuestro estudio, puede hacer el hábitat menos favorable y adecuado para el ave.

Key words: *Ammodramus savannarum*, cattle, Grasshopper Sparrow, grazing, nest success

Populations of grassland passerines have been declining throughout the U.S. For example, Herkert (1994) reported that populations of Grasshopper Sparrows (*Ammodramus savannarum*) had declined nearly 70% since the late 1960s. Habitat loss and fragmentation, as well as degradation of available grassland habitat, are thought to be responsible for these declines (Vickery 1996), and current agricultural practices are responsible for much of this loss or degradation. The conversion of native prairie to crop fields, the practice of early hay cropping, and overgrazing by domestic cattle (*Bos taurus*) have reduced populations of several species of

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grassland birds (Vickery 1996), including Grasshopper Sparrows (Bollinger 1995).

The impacts of grazing by domestic cattle on grassland birds varies with species, location, and on cattle numbers and density. For example, Grasshopper Sparrows in Arizona did not occupy or attempt to breed in grazed habitats (Bock and Webb 1984). In addition, Delany et al. (1985) suggested that the conversion of native prairie to intensively-grazed pasture may have contributed to population declines of Grasshopper Sparrows in Florida. However, other investigators have suggested that light to moderate grazing may benefit some grassland birds (Messmer 1990; Smith and Smith 1992; Herkert et al. 1993). For example, Grasshopper Sparrows prefer sparsely vegetated habitats with grasses of low to medium height with open or bare ground (Whitmore 1979, 1981; Delany et al. 1985; Vickery 1996), and grazed areas can exhibit such characteristics (Klute et al. 1997).

While some grazing could be beneficial for Grasshopper Sparrows, little is currently known about how differences in the characteristics of vegetation might affect the reproductive success of Grasshopper Sparrows breeding in grazed versus ungrazed areas. In addition, little is known about possible variation in availability and density of prey within grazed and ungrazed areas and how such variation might influence reproductive success. The objectives of our study were to examine the reproductive success of Grasshopper Sparrows in grazed and ungrazed areas; compare the vegetation features of successful and unsuccessful nest sites and territories; compare the vegetation features of used and randomly-selected, unused sites in grazed and ungrazed areas; and compare the insect biomass of territories and unused sites in grazed and ungrazed areas.

METHODS

We studied Grasshopper Sparrows on the Blue Grass Army Depot (BGAD), located southeast of Richmond, Madison County, Kentucky, during the breeding seasons of 2002 (1 May–8 August) and 2003 (30 April–5 August). The BGAD is a munitions-storage facility encompassing about 6070 ha. About one-third of the BGAD (2102 ha) is grazed by domestic cattle (N = 2005; with 220 present year round and 1785 present from 1 March–30 October each year) to reduce vegetation height and biomass and reduce the likelihood of uncontrolled fire (A. Colwell, pers. comm.). Ungrazed grasslands on the BGAD are mowed once per year during the period from mid-July through August.

Beginning in mid-April, male Grasshopper Sparrows were captured in mist nets using playback of conspecific songs and, later, females were captured by placing nets near nest sites. Once captured, sparrows were banded with a numbered aluminum band plus a unique combination of three colored bands to permit individual recognition. Territories of male sparrows were delineated by observing and noting the movements of males as well as the locations of interactions with neighboring males.

Grasshopper Sparrow territories were located at 12 different locations distributed throughout the BGAD in 2002 and at nine different locations in 2003. All locations in 2002 and 2003 were at least 0.95 km apart, with a mean distance between sites of 1.65 km in 2002 and 1.37 km in 2003. Most sites were separated by areas of unsuitable habitat (i.e., wooded areas). However, for some grazed areas, habitat between sites consisted of unused (i.e., no Grasshopper Sparrows present) grazed pasture. The number of contiguous breeding territories at the various locations varied from one (at five locations in 2002 and two in 2003) to six, with a mean number of territories per location of 2.17 in 2002 and 2.22 in 2003.

After pairing, nests were located by observing the behavior of focal pairs (e.g., adults carrying nest material or prey items) and searching likely nest sites within territories. For each nest, we noted clutch size, brood size, and, if successful, number of fledglings. In addition, nests of Grasshopper Sparrows were covered with a "dome" of grasses that created a single entrance on the side and, for each nest, the orientation of this entrance was noted (north, northeast, east, southeast, south, southwest, west, or northwest).

Within each territory, characteristics of vegetation at the nest site and at two randomly selected sites were quantified. In addition, vegetation in apparently suitable areas not being used by Grasshopper Sparrows was also characterized to permit comparison of the vegetation of used and apparently unused areas. On maps of the study area, territories were divided into 10 m^2 grids, and sample points (at the center of grids) were selected randomly. Sites were sampled using circular plots with a radius of 11.3 m (0.04 ha; James and Shugart 1970). Parameters measured within each plot included: (1) foliage cover at vertical intervals of <0.25, 0.25–0.5 m, 0.5–1 m, and >1 m, (2) percent ground cover (grass, herbaceous vegetation, shrubs, trees, or bare ground), (3) litter depth, (4) vegetation height, and (5) lateral cover. Nest concealment (percent of nest obscured by vegetation when viewed from a distance of 1 m in the four cardinal directions plus from directly above) was also determined at each nest site. Foliage cover was determined by counting all stems within 10 cm of a pole at 21 locations within the plot (at the plot center plus at 2-m intervals along four sampling transects extending in the four cardinal directions from the plot center). At those same locations, ground cover was determined using a densitometer, and litter depth and vegetation height were measured. Lateral cover was determined using a canvas cloth (0. 5 × 2 m) divided into three sections (<0.5 m, 0.5–1 m, and 1–2 m), each of which was subdivided into a 49-section grid. The cloth was then placed at the edge of plots along a line extending from the plot center in the four cardinal directions. From a height of 1 m, an observer at the plot center then recorded the number of squares within each of the three sections at least half-obscured by vegetation (Noon 1981).

The number of shrubs and trees within each plot was also determined, with trees categorized by diameter breast height (dbh; either ≤8 cm dbh or ≥8 cm dbh). Additional parameters measured at sample sites (i.e., from the plot center) included distance to the nearest shrub, nearest tree, nearest woodlot edge, nearest available water, and nearest road. In many Grasshopper Sparrow territories on the BGAD, low-growing trees and shrubs of similar height (≤0.5 m) were present. All parameters were measured within 10 d after a nest either failed or fledged young.

Insect sweeps (N = 4 per territory and random site) were conducted during the 2002 field season and sampling periods were categorized as late June (16–30 June), early July (1–15 July), late July (15–31 July), and early August (1–15 August). In addition, insect sweeps were conducted at each randomly selected unused site. To assess potential prey availability, an insect sweep net (30 cm in diameter) was swung back and forth while walking straight in a randomly selected 25-m transect located either entirely within a territory or, for unused sites, along a randomly selected transect. Invertebrates captured along each 25-m transect were then weighed.

Nest success was determined in two ways. First, a successful nest was defined as one from which at least one young fledged. In addition, we also calculated nest success using the Mayfield method (Mayfield 1961; Johnson 1979). Comparison of Mayfield nest success estimates between grazed and ungrazed areas was made using the computer program Contrast (Sauer and Williams 1989). To maintain independence, only a pair's initial nesting attempt was used in calculating nest success, and nesting attempts in 2003 by pairs banded and present in 2002 were also omitted.

Wilcoxon tests were used to examine possible differences among nests in nest concealment and among sites in clutch sizes and invertebrate biomass. Chi-square tests were used to examine the possible non-random orientation of nest entrances and possible differences in nest success among sites. Seasonal variation in invertebrate biomass was examined using a Kruskal-Wallis test.

Multivariate analysis of variance was used to examine possible differences in vegetation parameters of different sites (e.g., grazed versus ungrazed). Significant results were further analyzed using discriminate analysis to determine which vegetation characteristic best discriminated (1) between nest sites and randomly selected sites within territories, (2) between successful and unsuccessful nest sites, (3) between grazed areas and ungrazed areas, and (4) between used and randomly selected sites. All analyses were performed using SAS statistical software (SAS Institute 1999). Values are presented as means ± 1 SE.

RESULTS

During the 2002 and 2003 breeding seasons, 68 Grasshopper Sparrows (N = 61 males and 7 females) were captured (N = 39 in 2002 and N = 29 in 2003). Most captured males (79% in 2002 and 71% in 2003) remained to establish breeding territories, attract mates, and attempt at least one nest.

Six of the 39 Grasshopper Sparrows (15.4%; five males and one female) banded in 2002 returned to our study area in 2003. All returning sparrows had occupied territories in ungrazed areas in 2002, and all returned to territories near those occupied in 2002. One returning female paired with different males in 2002 and 2003. The two males occupied adjacent territories in 2002, but the female's mate in 2002 did not return in 2003.

We located 46 Grasshopper Sparrow nests (N = 27 in 2002 and N = 19 in 2003). One nest was found in the territories of 23 pairs, two nests in the territories of 10 pairs, and three nests in the territory of one pair. Thirty-four nests were located in ungrazed areas, and 12 in grazed areas.

Grasshopper Sparrow nests (N = 46) in our study were well-concealed, with a mean percent concealment of 88.85 ± 1.78%. We found no difference (z = 0.12, P = 0.90) in percent concealment between successful (N = 27; $\bar{x}$ = 88.92 ± 2.30%) and unsuccessful (N = 19; $\bar{x}$ = 88.74 ± 2.88%) nests. Similarly, we found no difference (z = 0.10, P = 0.92) in percent concealment between nests located in grazed (N = 13; $\bar{x}$ = 89.15 ± 3.17%) and ungrazed (N = 33; $\bar{x}$ = 88.73 ± 2.17%) areas.

The orientation of nest entrances was nonrandom (χ^2_1 = 10.52, P = 0.001). Most nest entrances were oriented to the northwest, north, northeast, and east (74%), rather than southeast, south, southwest, or west (26%).

The mean clutch size for female Grasshopper Sparrows was 4.17 ± 0.09 (range 3–5, N = 46), with no difference in clutch sizes between 2002 and 2003 (z = 0.69, P = 0.24). However, the mean clutch sizes of first and second nesting attempts did differ (z = 2.09, P = 0.037). The mean clutch size for first nests was 4.29 ± 0.11 (N = 34), while that for second nests was 3.82 ± 0.18 (N = 11). Clutch sizes also differed among months (Kruskal-Wallis test; H_2 = 21.0, P < 0.0001), with mean clutch sizes of 4.79 ± 0.11 for nests initiated in May (N = 14), 4.06 ± 0.13 for nests initiated in June (N = 17), and 3.71 ± 0.13 for nests initiated in July (N = 14). In addition, clutch sizes of Grasshopper Sparrows in grazed and ungrazed areas differed (z = 2.48, P = 0.013), with mean clutch sizes of 4.48 ± 0.12 (N = 23) in ungrazed areas and 3.91 ± 0.16 (N = 11) in grazed areas.

Overall, 19 of 35 (54%) Grasshopper Sparrow nests were successful (i.e., fledged at least one young), with nesting success greater (χ^2_1 = 6.31, P = 0.012) in ungrazed areas (70%) than grazed areas (25%). For all nests combined, the probability of nests surviving the incubation and nestling period (19 days) was 0.31. Nest success estimates for grazed and ungrazed areas differed significantly (χ^2_1 = 4.92, P = 0.027), with a probability of survival of 0.46 for nests in ungrazed areas and 0.09 for nests in grazed areas.

Invertebrate biomass in grazed and ungrazed areas (used and unused combined) of the BGAD differed significantly (z = 2.30, P = 0.022), with a mean biomass per sample of 2.10 ± 0.22 g (N = 53 samples) for ungrazed areas and 1.31 ± 0.17 g (N = 33 samples) for grazed areas. In addition, invertebrate biomass varied seasonally (Kruskal-Wallis test; H_3 = 9.56, P = 0.023), with biomass increasing from late June to early August in both grazed ($\bar{x}$ = 0.20 ± 0.06 g/sample in late June and 1.46 ± 0.25 g/sample in early August) and ungrazed ($\bar{x}$ = 0.64 ± 0.07 g/sample in late June and 2.93 ± 0.31 g/sample in early August) areas. For both grazed and ungrazed areas, we found no differences in invertebrate biomass between areas used by Grasshopper Sparrows and areas not used. For grazed areas, mean invertebrate biomass was 1.20 ± 0.27 g (N = 8) in used areas and 1.83 ± 0.47 g (N = 9) in unused areas (z = 1.06, P = 0.30). In ungrazed areas, mean invertebrate biomass per sample was 2.29 ± 0.46 g (N = 12) in used areas and 2.17 ± 0.54 g (N = 14) in unused areas (z = 0.43, P = 0.66).

We found no difference (Wilk's lambda = 0.24, $F_{29,15}$ = 1.65, P = 0.15) in the characteristics of successful and unsuccessful nest sites of Grasshopper Sparrows. However, we did find a difference between the characteristics of nest (N = 46) and territory (N = 46) plots (Wilk's lambda = 0.57, $F_{18,72}$ = 3.02, P = 0.0005). Discriminate analysis revealed six variables that best discriminated between nest and territory plots, including number of shrubs, percent shrub cover, percent tree cover, vertical cover from 0.5–1 m and 1–2 m, and foliage cover from 0.5–1 m above ground (Table 1). Nest-site plots generally had fewer shrubs, more

Table 1. Vegetation characteristics (mean ± 1 SE) permitting best discrimination between nest sites and randomly selected sites within territories of Grasshopper Sparrows on the Blue Grass Army Depot.

Variable[a]	Nest (N = 46)	Territory (N = 46)
Number of shrubs	48.85 ± 8.74	52.96 ± 16.49
% shrub cover	5.00 ± 1.14	3.41 ± 1.69
% tree cover	3.96 ± 0.89	0.78 ± 0.29
% vertical cover, 0.5–1 m	82.55 ± 3.18	91.37 ± 1.64
% vertical cover, 1–2 m	48.88 ± 4.18	52.86 ± 4.71
Foliage cover, 0.5–1 m[b]	0.70 ± 0.09	0.33 ± 0.04

[a] Measured in three 0.04-ha circular plots in each territory; one centered at the nest site and two at randomly selected sites within territories.
[b] Measured as number of stems within 10 cm of a pole at 21 points in each plot.

trees, less vertical cover, and greater vegetation density from 0.5–1 m. Classification analysis using these variables correctly classified 32 of 46 (69.6%) nest sites and 39 of 46 (84.8%) territory plots (54% better than by chance alone; Cohen's *Kappa* $Z = 5.19$, $P < 0.001$).

The characteristics of vegetation in territory plots in grazed ($N = 16$) and ungrazed ($N = 30$) areas differed significantly (Wilk's lambda = 0.28, $F_{15,30} = 5.02$, $P < 0.0001$). Discriminate analysis revealed four variables that permitted best discrimination between grazed and ungrazed areas, including number of shrubs, litter depth, vegetation height, and foliage cover from 0.25–0.5 m above the ground (Table 2). In general, grazed areas had less litter, more shrubs, and shorter, less dense vegetation. Classification analysis using these four variables correctly classified 15 of 16 (93.8%) grazed areas and 28 of 30 (93.3%) ungrazed areas (86% better than by chance alone; Cohen's *Kappa* $Z = 5.38$, $P < 0.001$).

In grazed areas, the characteristics of nest sites and unused sites did not differ (Wilk's lambda = 0.07, $F_{21,1} = 0.63$, $P = 0.78$). Similarly, differences between the vegetation characteristics of nest sites and randomly selected, unused sites in ungrazed areas did not differ (Wilk's lambda = 0.30, $F_{28,23} = 1.91$, $P = 0.06$).

DISCUSSION

Clutch sizes of Grasshopper Sparrows in our study were significantly larger in ungrazed areas than in grazed areas. One possible explanation for such differences is variation in food availability. We found significantly greater invertebrate biomass in ungrazed areas than grazed areas, and other investigators have reported similar results (Rambo and Faeth 1999). The greater plant biomass and increased plant structural diversity in ungrazed areas are likely important factors in the increased abundance of insects (Rambo and Faeth 1999). Because clutch sizes of birds may be influenced by food availability (Ricklefs 1974), the greater availability of invertebrates in ungrazed areas in our study may have contributed to the larger clutch sizes of female Grasshopper Sparrows in those areas.

Most Grasshopper Sparrows in our study oriented nest entrances toward the northwest, north, northeast, or east. Similarly, Wiens (1969) reported that, of 15 openings of Grass-

Table 2. Vegetation characteristics (mean ± 1 SE) permitting best discrimination between territory plots in both grazed and ungrazed areas on the Blue Grass Army Depot.

Variable[a]	Grazed (N = 16)	Ungrazed (N = 30)
Number of shrubs	104.9 ± 43.4	25.3 ± 7.2
Litter depth (cm)	1.01 ± 0.15	1.95 ± 0.19
Vegetation height (cm)	44.59 ± 2.53	66.53 ± 1.93
Foliage cover[b], 0.25–0.5 m	1.32 ± 0.32	1.59 ± 0.18

[a] Measured in two 0.04-ha circular plots centered at each randomly selected territory site.
[b] Measured as number of stems within 10 cm of a pole at 21 points in each plot.

hopper Sparrow nests, 64% had a north to northeast orientation. Several factors could contribute to this tendency of female Grasshopper Sparrows to construct nests with entrances oriented toward the north and east. Vegetation structure may influence the placement of nest entrances. For example, prevailing winds on our study area tend to cause clumps of vegetation in open fields to bend toward the east-northeast. Because Grasshopper Sparrows often build nests in such clumps, females may position nest entrances toward the east-northeast simply because it is easier to enter the nests from this direction. However, orientation toward the east-northeast may also provide thermoregulatory advantages (With and Webb 1993).

In addition to nest-entrance preference, Grasshopper Sparrows selected nest sites (grazed and ungrazed combined) with vegetation characteristics that differed from those of other areas in their territories. Nest sites typically had shorter, denser vegetation (from 0.5–1 m), and had more trees and fewer shrubs. Similarly, Whitmore (1979) suggested that selection of nest sites by female Grasshopper Sparrows was likely influenced by the density of the ground cover, with vegetation in the vicinity of a nest site permitting movement while providing adequate concealment from potential predators. When provisioning nestlings, adult Grasshopper Sparrows typically do not fly directly to and from nests, but, rather, either land some distance away and walk to the nest or, when leaving the nest, walk some distance away before taking flight (Vickery 1996).

Overall, 54% of Grasshopper Sparrow nests located on the BGAD were successful (fledged at least one young), and nesting success was significantly greater for sparrows in ungrazed areas than in grazed areas. Nest success (percent of nests that fledged at least one young) for Grasshopper Sparrows at other locations varies considerably (Vickery 1996), ranging from <25% in Florida to 52% in Nebraska (Delisle and Savidge 1996; Vickery 1996). The primary cause of nest failure for Grasshopper Sparrows on the BGAD was predation, and other investigators have also reported that most nests of Grasshopper Sparrows fail due to predation (Vickery 1996). Because most depredated nests appeared undisturbed, it is likely that most were lost to snakes. However, a few depredated nests had clearly been disturbed, with nesting material lifted out of place, and such nests may have been lost to mammalian predators. In addition, three nests in grazed areas were destroyed by cattle, with two nests trampled and a third pulled apart by cattle grazing on the supporting vegetation.

Rates of nest failure in our study were higher for Grasshopper Sparrows in grazed areas than in ungrazed areas and the characteristics of vegetation in grazed areas may have contributed to this difference. Vegetation in grazed areas was shorter and less dense, and the foraging preferences of cattle also created areas consisting of numerous small clumps of ungrazed vegetation interspersed with variably sized patches of short vegetation. The short vegetation in grazed areas may provide easier access for predators, particularly mammalian predators. Similarly, Johnson and Temple (1990) suggested that tall, dense vegetation may restrict the activity of predators and therefore, shorter, less dense vegetation of grazed areas may better facilitate the movement of predators. Because of the shorter, less dense vegetation in grazed areas, adult sparrows are more easily observed (G. Ritchison, pers. obs.) and visible, and, as a result, predators may be more likely to locate nests by observing parental activity in the vicinity of nest sites.

Our results indicate that grazing by cattle was detrimental to Grasshopper Sparrows, both directly (destruction of nests by grazing cattle) and indirectly (effects on vegetation structure). In contrast, previous investigators have suggested that grazing by cattle can be beneficial for some grassland birds (Skinner 1975; Messmer 1990; Smith and Smith 1992; Herkert et al. 1993). Skinner (1975) suggested that grazing could potentially create suitable habitat for grassland birds because the increased heterogeneity and complexity of grazed areas can create areas for feeding, loafing, roosting, and nesting. However, where there are too many cattle, habitat complexity is reduced, and such areas may not be suitable for grassland birds. For example, Skinner (1975) studied seven grassland species of birds, including Grasshopper Sparrows, and found that species diversity decreased in heavily grazed areas (i.e., areas that retained little tall, dense vegetation). On our study area, cattle density was such that vegetation and habitat complexity was significantly impacted. In Florida, Delany et al. (1985) suggested that limited grazing by cattle could create suitable habitat for Grasshopper Sparrows, with limited grazing defined as the presence of about 1 animal unit/8 ha. However, grazing intensity during the breeding season on our study area was much higher than that, with a density of about 1 animal unit/ha.

Whitmore (1981) reported that the characteristics of territories of Grasshopper Sparrows in West Virginia differed from those of areas with no sparrows present. Within territories, vegetation was sparser, with fewer shrubs, shorter vegetation, and more bare ground (Whitmore 1981). Such results suggest that Grasshopper Sparrows apparently prefer areas with shorter, less dense vegetation than other grassland species, such as Henslow's Sparrows (*Ammodramus henslowii*; Smith and Smith 1992), and support the conclusions of other investigators that limited grazing may create suitable habitat for Grasshopper Sparrows (Delany et al. 1985). However, excessive grazing pressure, as on our study area, reduces habitat quality for Grasshopper Sparrows.

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