at the Mangaurcu, Ecuador, locality had grasshopper remains in its stomach.

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EFFECTS OF HABITAT STRUCTURE ON PATCH USE BY LOGGERHEAD SHRIKES WINTERING IN A NATURAL GRASSLAND[1]

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Recent attempts to explain the decline of many Loggerhead Shrike (*Lanius ludovicianus*) populations (Bystrak and Robbins 1977, Geissler and Noon 1981, Morrison 1981) have focused on habitat loss due to modern agricultural practices (Brooks and Temple 1990; Smith and Kruse 1992; Yosef and Grubb 1992, 1993; Gawlik and Bildstein 1993). Degree of habitat loss is consistent with the differential declines of shrike populations observed in various regions of the United States. Populations in the intensive agricultural areas of the midwest, south, and southeast are declining more severely than those in the western United States dominated by grasslands (Arbib 1977, Morrison 1981). Although a considerable amount of information exists on shrikes in agricultural systems, none is available regarding habitat changes and the mechanisms affecting shrikes in natural grasslands. Understanding shrike use of natural grasslands can lead to a better understanding of shrike response to land-use changes.

Recent emphasis on conservation of wintering grounds and migration corridors (Terborgh 1992) have underscored the significance of identifying essential

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habitat components in all ecosystems in which a species occurs which are critical for conservation of migratory birds. Grasslands are the primary habitats used by shrikes on the Texas coastal region where shrikes are common during winter (Rappole and Blacklock 1985, Root 1988). The importance of open areas with short vegetation, particularly improved pastures and grasslands, as habitat for shrikes has been previously noted (Bohall-Wood 1987, Brooks and Temple 1990, Smith and Kruse 1992, Gawlik and Bildstein 1993). In agricultural systems, shrikes forage in grassy areas from elevated perches (i.e., above canopy level) (Bildstein and Grubb 1980, Scott and Morrison 1990) and exhibit high use of foraging substrate within 10 m of elevated perches (Morrison 1980, Yosef and Grubb 1992). Indeed, perches are a necessary habitat component for shrikes to utilize foraging substrate and density of elevated perches reflects territory quality (Brooks and Temple 1990, Yosef and Grubb 1992).

Depending on height and density of ground cover, shrikes will increase their perch height, to enlarge the utilizable foraging area and allow for greater prey encounter rates (Mills 1979). However, in the absence of elevated perches, shrikes in a grassland frequently hunt from lower herbaceous perches (Chavez-Ramirez and Gawlik, pers. observ.). Mills (1979) argued that by perching closer to the ground, shrikes reduced handling time of prey, increased capture success, and decreased energy expenditure when returning to perches, factors that are influenced greatly by vegetation structure. Natural grassland vegetation provides greater structural heterogeneity, both vertical and horizontal, than agricultural lands. Thus, we predicted that in a grassland, reduced density of elevated perches would not result in a concomitant reduction in the use of the area by shrikes. This study represents the first experimental study of perch use by Loggerhead Shrike conducted in a grassland presently maintained only by natural processes.

STUDY AREA AND METHODS

This study was conducted on Matagorda Island National Wildlife Refuge and State Natural Area in Calhoun County, Texas, USA. This 22,934-ha barrier island, includes saltmarshes, sand dunes, and upland barrier flats. Upland flats, the primary areas used by shrikes, are coastal grasslands dominated by marshhay cordgrass (*Spartina patens*), gulfdune paspalum (*Paspalum monostachyum*), and seacoast bluestem (*Schizachyrium scoparium*). Woody vegetation, primarily mesquite (*Prosopis glandulosa*) and false willow (*Baccharis helmenifolia*), is sparse and scattered throughout.

For the purposes of this study, we classify all shrike habitat into the broad categories of agricultural lands and grasslands. We define agricultural lands as those lands maintained either through crop cultivation, intensive grazing, or regular mowing (i.e., lawns, roadsides, and hay fields). Grasslands are those lands maintained through natural processes such as fire and low-intensity grazing.

From 14 to 17 October 1992, before most wintering shrikes arrived, we selected for manipulation six fences approximately 0.8 km in length and at least 0.8 km apart, with one fence containing a 90° bend. All wire above the vegetation canopy was removed so that each fence appeared as a line of fence posts, thus eliminating the confounding effect of barbed wire as a perching and impaling site. To reduce variability among fences, we removed all elevated perches within 20 m and mowed the vegetation within 10 m of fences to a height of 18 cm. Thus, each of our six habitat patches consisted of similar 800 × 20 m mowed strips of vegetation centered lengthwise on a line of fence posts and including 10 m of surrounding natural grassland vegetation.

To determine if shrikes reduced use of the habitat patches in response to reduced perch density, we used a completely randomized block design with two blocks and three treatments per block. Each habitat patch received only one treatment. Treatments were applied on 10 and 11 January 1993, and consisted of reducing the density of fence posts in each patch from an initial density of approximately 158 posts/ha to either 0 posts/ha (100% reduction), 16 posts/ha (90% reduction), or 158 posts/ha (0% reduction) as a control. The 90% reduction (distance between posts >20 m) provided foraging habitat greater than 10 m away from any elevated perch, the distance where the majority of shrike foraging attacks occur (Morrison 1980, Yosef and Grubb 1992). Any reduction less than 90% would still provide elevated perches within 10 m of some portion of a habitat patch. Initially we intended to use a statistical test accounting for blocks in data analysis. However, because our a priori expectation was no difference among treatments, we were more concerned with committing a Type II error rather than a Type I (Freund and Wilson 1993). Therefore, we chose a more powerful test (Kruskall-Wallis test; Conover 1980).

To control for seasonal and annual variation, we conducted our experiment within one winter season, a period during which we did not expect movements or changes in shrike numbers. We determined patch use from 30-min observation periods conducted weekly from 8 November 1992 to 7 February 1993. Observations were conducted during the morning hours on three habitat patches/day for two consecutive days. During observation periods we instantaneously scanned the entire patch each minute and recorded the number of shrikes present. The dependent variable was calculated as total number of shrike-minutes (e.g., two shrikes seen on one scan and three shrikes seen on another scan result in five shrike-minutes) per observation period, averaged over four pre-treatment and four post-treatment observation periods.

In addition to reducing the variability among patches, mowing reduced vegetation height and may have improved habitat quality for shrikes (Bohall-Wood 1987, Brooks and Temple, 1990, Smith and Kruse 1992, Gawlik and Bildstein 1993). To determine if mowing increased patch use by shrikes, we compared two additional habitat patches that received no mowing or perch removal with two unmowed control patches in the perch manipulation experiment. The unmowed patches also lacked wire above the vegetation canopy and possessed similar densities of posts as our experimental habitat patches. We surveyed each habitat patch for 30 min weekly during the morning hours on two habitat patches per day for two consecutive days, following the same procedure described above. We used a Wilcoxon Signed Rank test (Conover 1980) to determine differences in shrike use between mowed and unmowed patches.

TABLE 1. Habitat patch use by Loggerhead Shrikes pre-treatment (n = 4 surveys per habitat patch) and post-treatment (n = 4 surveys). Treatments were 0 post/ha (100% reduction), 16 posts/ha (90% reduction), and 158 posts/ha (0% reduction) as a control.

Treatment	Block	Shrike-minutes Pre-treatment mean (SD)	Post-treatment mean (SD)	% Change
0% removal	1	7.3 (7.9)	8.7 (8.9)	+20
	2	5.0 (4.6)	2.0 (2.4)	−60
90% removal	1	18.8 (14.2)	0.8 (1.4)	−96
	2	5.8 (6.0)	0.0 (0.0)	−100
100% removal	1	17.0 (9.9)	7.5 (7.5)	−56
	2	4.0 (2.7)	0.0 (0.0)	−100

As an independent measure of perch use by shrikes on unmanipulated areas of Matagorda Island we conducted road surveys for raptors and shrikes where we noted specific substrates on which shrikes were perched. We used a Chi-Square Goodness-of-Fit test (Conover 1980) to determine differences among perch substrates.

RESULTS

Patch use by shrikes did not change following the reduction in fence posts (H = 2.28, df = 2, P = 0.32, Table 1). It appeared that shrikes perched more frequently on lower nonwoody vegetation. Natural vegetation surrounding the mowed strips approximated 100% ground cover and occurred in clumps up to 1.1 m in height, and provided adequate support for perching shrikes. This was reflected in the wide range of natural perches that shrikes in unmanipulated areas of Matagorda Island used. Shrikes used abundant nonwoody perch structures significantly more (χ^2 = 24.6, df = 3, P < 0.05) than other substrates. Of 51 shrikes observed perched during surveys, 57% were on nonwoody plant perches (sunflower *Helianthus* spp. 33%, partridge pea *Cassia* spp. and sesbania *Sesbania* spp., 14%, and grass 10%), 22% perched on woody vegetation (mesquite 16% and false willow 6%), 10% were observed on posts, and 11% perched on other structures (e.g., wood piles, signs, and concrete structures). Also, shrikes in our experiment did not utilize mowed patches (χ = 6.75, SD = 9.4, and χ = 3.5, SD = 4.24) significantly more (z = 0.73, df = 12, P > 0.05) than unmowed patches (χ = 3.1, SD = 6.6 and χ = 2.9, SD = 3.7).

DISCUSSION

The lack of differences in shrike use between mowed and unmowed patches and nonsignificant decline in use to reduced perch density observed in our study is not consistent with studies of shrike habitat use conducted in agricultural systems (Bohall-Wood 1987, Brooks and Temple 1990, Smith and Kruse 1992, Gawlik and Bildstein 1993, Yosef and Grubb 1993), where shrikes exhibit high use of short grassy vegetation. However, results obtained on a natural grassland in Alberta suggest that, like our study, shrikes did not prefer short grassy areas (Prescott and Collister 1993). Unfortunately, the authors did not report information on perch use.

The most striking difference between agricultural and grassland systems is the scale or size of habitat patches. In agricultural systems, vegetation is uniform within fields relative to vegetation among fields and therefore, short grassy patches occur at the scale of individual fields much larger than shrike foraging areas. Hunting perches used by shrikes are primarily fence posts, utility lines, and woody vegetation (Bohall-Wood 1987, Yosef and Grubb 1992, Gawlik and Bildstein 1993) usually arranged in linear strips along the edges of fields. Thus, the resulting landscape consists of large monotypic habitat patches adjacent to linear strips of elevated perches. Yosef and Grubb (1992) suggested that a reduced density of perches in agricultural habitats diminished the amount of available foraging habitat because shrikes restricted their use of foraging substrate to within 10 m of elevated perches. Thus, much of the potential foraging substrate in areas of low perch density was unusable.

In contrast to agricultural areas, the landscape on Matagorda Island consists of relatively small habitat patches that occur at the scale of several meters with nonwoody perches distributed evenly throughout (see also Prescott and Collister 1993). The birds in our study utilized the abundant nonwoody perches significantly more than other substrates, unlike shrikes in agricultural systems where elevated woody substrates are the primary hunting perches. Thus, the diverse vegetation structure present on Matagorda Island allowed shrikes to use a high proportion of the vegetation as potential foraging habitat thereby compensating for any habitat manipulations at the scale we provided.

Our results suggest that shrike populations in natural grasslands do not behave like those in agricultural systems, with respect to foraging habitat and perch use, as previously reported (Bohall-Wood 1987, Brooks and Temple 1990, Smith and Kruse 1992, Gawlik and Bildstein 1993, Yosef and Grubb 1993). We found no evidence that mowing vegetation or manipulating density of man-made perches affects shrike use of habitat patches in a natural grassland.

Our results pertain directly to the conservation of shrikes and other declining species because they suggest that management strategies should not be applied universally across all ecosystems. Although habitat manipulation may increase shrike populations in agricultural ecosystems, such alterations may not be appropriate in less disturbed, more natural settings. In addition, we must consider the effects of short vegetation and increased perch density on the entire bird community. For example, increasing perch density may attract higher numbers of raptors (potential predators), which could ultimately have a negative impact on shrikes. In our study site 65% of Northern Harriers (*Circus cyaneus*) and White-tailed Hawks (*Buteo albicaudatus*) observed during biweekly raptor surveys were perched on fence posts, whereas only 35% perched on natural vegetation. Although we recognize the urgent need to implement management strategies for shrikes on a large scale, we urge caution in applying management strategies for shrikes developed in agricultural systems directly on natural grasslands until more information is available, particularly on community-wide effects.

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