HABITAT ASSOCIATIONS OF THE MEXICAN PLATEAU WINTER GRASSLAND BIRD COMMUNITY

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ABSTRACT

In January 1997, as part of an ongoing study of the Mexican Plateau grassland bird community, we conducted widespread surveys of grassland birds in the northern half of the state of Chihuahua, México. Completion of approximately 100 pilot area search plots in 1996 and 384 in 1997 affirmed use of this technique for gathering data on wintering grassland birds. We collected vegetation data to assess horizontal cover and vertical structure within each area search plot. Sixty-four species were recorded in 1997 with 14 species (including an *Ammodramus* spp. and an unidentified sparrow species category) occurring on at least 25 plots. We analyzed vegetation structure association using Principal Components Analysis (PCA). For the twelve species and two additional categories examined, five clusters were identified indicating primary associations with grass (Savannah Sparrow, Baird's Sparrow, Grasshopper Sparrow, *Ammodramus* spp., Sparrow spp. and Western Meadowlark), shrub (Loggerhead Shrike, Cassin's Sparrow, Brewer's Sparrow, Vesper Sparrow, and Black-throated Sparrow), bare ground (Horned Lark), or forb (Sprague's Pipit), with one species an apparent grassland generalist (Chestnut-collared Longspur). Some of our original target species (*e.g*., McCown's Longspur and Lark Bunting) were not found in sufficient numbers to study. We worked in a small part of the Mexican Central Plateau and our results address only the northern portion of the plateau. Undoubtedly, densities of species change as one moves south or east and west. We hope in future years of this project that the entire plateau may be covered allowing the study of distribution as well as habitat associations. This will take a well-coordinated effort among a large number of partners. It is distressing to note that the 12 most common bird species we found on the plateau are all declining, according to continental BBS trends, nine with statistical significance ($p<0.05$).

INTRODUCTION

As a group, native prairie grassland birds have the largest proportion of declining species demonstrating the steepest population declines of any behavioral or ecological bird guild in North America (Knopf 1994). According to the Breeding Bird Survey, of the prairie-dependent birds showing statistically significant trends over a thirty-year period (1966-1996) at least 80% are declining (Table 1). The numbers and magnitudes of the declines are so great that these species and their principal habitat should receive greater conservation attention.

Many of these species, including the majority of shortgrass and mid-grass prairie birds, winter in vast numbers in the semi-desert grasslands of the Mexican Plateau (Howell and Webb 1995). The distribution and natural history of birds in this area are among the least known of both the United States and Mexico (Phillips 1977). In addition to the species mentioned above, the list of declining and/or little-known grassland species that winter on the Mexican Plateau includes: Northern Harrier, Long-billed Curlew, Burrowing Owl, Short-eared Owl, Cassin's Sparrow, Brewer's Sparrow, Lark Bunting, Baird's Sparrow, Sprague's Pipit, McCown's Longspur, and Chestnut-

collared Longspur (Sauer *et al.* 1996, Howell and Webb 1995).

Knopf (1994) reported that causes of grassland bird population declines are difficult to determine. He concluded that the lack of understanding of grassland birds' winter ecology precludes optimistic projections, especially for those species experiencing widespread declines, since the cause is likely to be from events occurring on the winter grounds. Such steep and widespread declines, however, warrant investigations on both breeding and wintering grounds.

In January 1997, as part of an ongoing study of the Mexican Plateau grassland bird community, we performed widespread surveys of grassland birds in the northern half of the state of Chihuahua, Mexico. We conducted inventories and vegetation surveys to describe species distributions and habitat associations. Species of particular concern for this study were Mountain Plover, Sprague's Pipit, Cassin's Sparrow, Baird's Sparrow, Grasshopper Sparrow, Lark Bunting, and McCown's Longspur. A portion of the species distribution information has already been reported (Leukering and Bradley, 1997), detailing eight extra-limital sightings of what appear to be, primarily, regularly wintering species of the Plateau, rather than vagrants. Here, we report on habitat associations of common birds of the Mexican Plateau grassland within the state of Chihuahua, Mexico.

STUDY AREA

The Mexican Plateau is located in north-central Mexico and the southwestern U.S. encompassing a third of Mexico, it slopes gently upward to the south between Mexico's two primary mountain ranges, the Sierra Madre Occidental and Sierra Madre Oriental. From the international border it rises from roughly 750m until merging on the southern end with the Transvolcanic Belt at about 2000m (Howell and Webb 1995). Within this region, the grassland portion of the Plateau occurs as a mosaic between Chihuahuan desert scrub in the lowlands and dry oak and pine-oak woodlands at the higher elevations. Within the state of Chihuahua the principal habitats are desert scrub (41%), pine forest (16%), and farm/pasture lands (36%) (Flores Villela and Gerez 1994). The proportion of the latter underwent a 7% increase in the decade between 1981 and 1992 as the overall proportion of perturbed lands increased. While governmental data indicate that, as recently as 1981, 24% of the state was unperturbed grassland, more recent federal assessments do not recognize any natural grasslands remaining in the state (Flores Villela and Gerez 1994).

FIELD METHODS

We adapted the area search technique (Ambrose 1989) for use with wintering grassland birds. Area search in this context allows observers to flush and pursue inconspicuous species for greater identification accuracy. By doing so, it facilitates detailed assessments of generally difficult-to-quantify species (Ralph *et al*. 1993).

Although several researchers (*e.g.* Gutzwiller 1993, Hutto *et al.* 1986) have successfully surveyed winter birds with modified point-counts in other habitats, in grassland that approach is precluded by the inconspicuous nature of many of the species present. Completion of approximately 100 pilot area search plots in 1996, and an additional 384 in 1997, affirmed use of this technique for gathering data on the wintering grassland birds of the Mexican Plateau.

Area search plots were located in grassland habitats from bare ground to savanna, and generally within 1km of roads. The size of each plot was set at three hectares (173m x 173m), determined as the amount of terrain that could be censused thoroughly in a 20 minute time frame. Birds flushed out of the area were pursued for identification; birds flying into the area during the census were not counted; birds flying over the area were recorded separately and were excluded from analyses, unless evidence existed that the species was utilizing the area in some way (*e.g.*, Northern Harrier actively hunting).

Vegetation data were taken to assess horizontal cover and vertical structure within each area search plot (Table 2). For this, a transect with a randomly determined bearing was established across each plot. From this first randomly determined point on the transect, three additional points were established at 50m intervals. At each point, four 90cm dowels were gently tossed over one's shoulder into four different quadrants. The intercepts (horizontal cover) with vegetation structure class (i.e., grass, forb, shrub, etc.) were recorded at ten points at 10cm intervals along each dowel. Data were recorded as a total per class per dowel. The number of vertical structure intercepts was recorded for each of the four dowels. Data were recorded as a total per vegetation structure class per 10cm height interval per dowel. A visual estimate of percent cover of all vegetation structure classes was also completed.

ANALYSIS METHODS

In the course of conducting 384 area searches 64 species were recorded. Of these, 12 appeared on at least 20 plots (Table 1). These 12 (Horned Lark, Sprague's Pipit, Loggerhead Shrike, Cassin's Sparrow, Brewer's Sparrow, Vesper Sparrow, Black-throated Sparrow, Savannah Sparrow, Baird's Sparrow, Grasshopper Sparrow, Chestnut-collared Longspur, and Western Meadowlark), plus the two categories *Ammodramus* spp. and Sparrow spp., were selected for analysis for vegetation structure association using principal components analysis (PCA). PCA, which creates new variables (components) that are exact combinations of the original vegetation variables, determines components so that maximal amounts of variance are explained (Wilkinson *et al.* 1996). The principal components we use are simply linear combinations of the original variables into one or more new components that are useful in summarizing differences in habitat associations among species of birds.

RESULTS

Sixty-five vegetation variables were collected and then considered for use in the PCA (Table 2). Species, sample size, and means for the untransformed vegetation variables are shown in Table 3. Since most count data of randomly occurring events (particularly vegetation hits) are Poisson distributed, we used $x=\sqrt{(x+0.5)}$ as a transformation to normalize variables (Zar 1984). We chose the number of principal components to be selected based on rules of thumb that components should have eigenvalues above 1.0 and have more than three of the original variables with loadings above 0.3 (Wilkinson *et al*. 1996). Based on these recommendations, we selected two components which explained 71.11% of the variance (38.79% for PCI and 32.32% for PCII) (Table 4).

DISCUSSION

Throughout the species accounts, we refer to the PCA results (Figure 1) and the univariate means among the untransformed vegetation variables for each species (Table 3). Within Table 3, we compare the means for a species for a vegetation variable to the means for all plots for the same vegetation variable. This univariate approach is not the same as the multivariate PCA approach, which strives to explain a maximal amount of variation and separates species by examining all variables at the same time. Species which are associated with grassy habitats (as is this community) will be separated from each other in a PC analysis by variables which may or may not be important to the species. The technique used in conjunction with a univariate analysis is, however, useful in describing what vegetation varaibles a species is associated as well as which ones separate members of a bird community.

Horned Lark -- No other species was positively associated only with bare ground in the univariate analysis (Table 3) placing Horned Lark with no other species in the bare ground portion of the PCA plot (Fig. 1). This species is a widespread inhabitant of grassland and agricultural areas having little to no cover.

Sprague's Pipit -- We believe that this species has very specific habitat requirements not completely defined by our current vegetation sampling. However Sprague's Pipits are associated with with forbs and horizontal grass cover (Table 3). PCA placed the species in a space tied to forbs due the strength of the association with forbs and few other variables. This area of the plot may also represent avoidance of shrubs and litter. We define the species' wintering habitat as a mosaic of low grass and forbs with little bare ground and few shrubs.

Loggerhead Shrike -- This species is a sit-and-wait predator and requires perches from which to hunt prey typically found on the ground. It is within the cluster of five species that responded positively to increasing shrub cover (Fig. 1) but was also associated with tall grass, shrubs and litter in the univariate analysis (Table 3).

Cassin's Sparrow -- This species is another whose presence is correlated with shrub cover (Fig. 1) with the univariate analysis adding areas with bare ground, litter and tall

grass (Table 3). Where we found Cassin's Sparrows, they were skulking in thick cover, usually grass, with perch sites.

Brewer's Sparrow -- This species was associated with shrub cover (Fig. 3) but also horizontal and vertical grass cover (Table 3). We found this species in grassy areas with a structural compontent (shrubs).

Vesper Sparrow -- This species showed positive responses to horizontal and vertical grass cover and shrub cover (Table 3) which placed it in the shrub-utilizing group of species (Fig. 1). Vesper Sparrow, like Brewer's Sparrow, is probably a grassland generalist requiring grass with a structural component (shrubs).

Black-throated Sparrow -- This species showed the strongest positive response to increasing shrub cover (Fig. 1) but was also associated with forbs (Table 1). Members of this genus, *Amphispiza*, typically forage by running along bare ground, using available shrubs for cover.

Savannah Sparrow -- This species showed a strong positive response to grass cover and height and forbs (Table 3) and was located in the grassy portion of the PCA plot (Fig.1). This suggests that wintering Savannah Sparrows in Chihuahua require dense cover, without a shrub structural component. However, we also observed the species in relatively shrubby open habitats.

Baird's Sparrow, Grasshopper Sparrow, and *Ammodramus* spp. -- Difficulty with non-breeding field identification of both Baird's and Grasshopper Sparrows leads us to discuss these three categories together. In this genus, we generally identified to species only those individuals that perched in the open, providing opportunity to ascertain field marks. It follows that plots on which we identified *Ammodramus* to species are biased toward more open habitats than when we only identified them to genus (Fig. 1).

Baird's and Grasshopper Sparrows both showed positive responses to horizontal grass cover (Table 3) and Baird's also associated with tall grass. Compared to each other, Grasshopper Sparrow was placed further along the grass end of the bare ground-grass gradient than was Baird's Sparrow. It is uncertain, though, whether the difference is meaningful, particularly considering that the placement of *Ammodramus* spp. was even further out on the grass end of the gradient. We believe that Baird's and Grasshopper Sparrows do strongly select grassy habitat. We also suspect from personal observation that there is a difference between these two *Ammodramus* spp. in their micro-habitat selection, with Baird's Sparrow selecting patchier grassland than Grasshopper Sparrow.

The conservative identification (*e.g.*, the field crew didn't count a sighting as Baird's or Grasshopper Sparrow unless absolutely sure) provides an interesting habitat description problem. Our habitat descriptions for the category *Ammodramus* spp. may be more indicative of Baird's or Grasshopper habitat association than habitat

descriptions for either of these when identified to species. We are shown that the *Ammodramus* spp. have a stronger association with grass than the component species, Grasshopper Sparrow and Baird's Sparrow. This is undoubtedly due to identification of cryptic species being easier when they are not hiding in grass, so those birds identified to species were generally more in the open. If *Ammodramus* spp. and Baird's Sparrows had been identified to species the locations (Fig. 1) for both Grasshopper and Baird's Sparrows would be shifted to the left, resulting in more discreet clusters for the grass-associated species.

Sparrow Species -- This group is mostly comprised of individual birds that were either Savannah Sparrows or either of the two *Ammodramus* sparrows, but could not be identified even to genus. This is borne out in Fig. 1 where the location for Sparrow Species falls along the bare ground-grass gradient intermediate to Savannah Sparrow and the two *Ammodramus* spp.

Chestnut-collared Longspur -- This species did not have a positive response to any of the variables in the PCA but was positive for horizontal and vertical grass cover in the univariate analysis (Table 3). Apparently Chestnut-collared Longspurs utilize grassy habitat but are more of a generalist when compared to other grass-utilizing species.

Western Meadowlark -- This species shows a strong positive response to grass cover and height (Table 3) which places it in the grass group of Fig. 1. Unfortunately, we did not obtain sufficient sample size for Eastern Meadowlark, so we could not attempt to determine differences in habitat preferences between these two closely related species.

The Mexican Plateau hosts a large number of species during winter and remains poorly known. At least in the grassy habitats we sampled, the bird community is dominated by 12 species that sort themselves among 5 gross habitat categories: thick grass cover, bare ground, shrubby areas, a habitat correlated with forb cover but not necessarily a "forb habitat," and a generalists category. We believe the PCA presented here provides an adequate description of the bird community and the habitat upon which it is dependent. The five clusters of species identified by PCA are relatively discreet, though Grasshopper Sparrow (a predominantly grass-related species) indicates some shrub associations, while Vesper Sparrow and Brewer's Sparrow (predominantly shrub related) indicate slight grass preferences. Additionally, these results are not without practical or methodological problems.

There may be habitat variables we did not measure that would be useful in further describing the bird community and habitat association of certain species such as Sprague's Pipit and Cassin's Sparrow. For Cassin's Sparrow, we thought cactus cover would be useful. We collected visual estimates of cactus cover at each plot, but these proved useless in the analysis because of non-normality and low frequency of occurrence of cactus in visual estimates. Our quantitative methods with dowels failed to register sufficient cactus "hits" also. A follow-up analysis to this one, in which we collected bird-centered habitat measurements, may help clarify these habitat differences or give more precise descriptions of habitat use.

We worked in a small part of the Mexican Central Plateau, and our results address only the plateau's northern portion. Undoubtedly, densities of species change as one moves south or east and west. Species which we were originally focussed upon (*e.g.*, McCown's Longspur and Lark Bunting) were not found in sufficient numbers to study. We hope in future years of this project that the entire plateau may be covered allowing the study of distribution as well as habitat associations. This will take a well-coordinated effort among a large number of partners.

Eleven of the fourteen species/categories analyzed using PCA showed strong species preferences for either grass and/or shrub cover. As the proportion of perturbed land in Chihuahua and elsewhere on the Mexican Plateau continues to increase, these preferred habitats will be under increasing pressures. It is distressing to note that the 12 most common bird species we found on the plateau are all declining, according to continental BBS trends, nine with statistical significance ($p<0.05$) (Table 2). We know these species are declining in the U.S., and we can strongly suspect the same for Mexico and that the two may be related. Managers and decision makers in both countries should better track, manage, and conserve our remaining grassland resources.

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TABLE 1. Number of plots on which bird species were detected (including “fly-overs”) on
384 area searches conducted in the Mexican Plateau grasslands of Chihuahua, Mexico, January, 1997. Species in bold were found on 25 or more plots and were used in PCA. Also provided are 30 year (1966-1996) Breeding Bird Survey continental population trends.

Species	n	$\bar{x}$	SD	BBS[1]
Greater White-fronted Goose (*Anser albifrons*)	1	0.11	2.24	np
Snow Goose (*Chen caerulescens*)	7	0.23	1.89	np
Ross’ Goose (*Chen rossii*)	1	0.00	0.10	np
Mallard (*Anas platyrhynchos*)	1	0.07	1.28	1.99***
Mexican Duck (*Anas platyrhynchos diaz*)	1	0.02	0.36	
Northern Shoveler (*Anas clypeata*)	1	0.00	0.05	1.11***
Turkey Vulture (*Cathartes aura*)	5	0.01	0.11	1.03***
White-tailed Kite (*Elanus leucurus*)	1	0.00	0.05	4.46
Northern Harrier (*Circus cyaneus*)	19	0.05	0.23	-0.58*
Harris’ Hawk (*Parabuteo unicinctus*)	3	0.01	0.15	-5.00
Red-tailed Hawk (*Buteo jamaicensis*)	3	0.01	0.09	3.20***
Ferruginous Hawk (*Buteo regalis*)	1	0.00	0.05	5.20***
American Kestrel (*Falco sparverius*)	11	0.03	0.17	-0.08
Merlin (*Falco columbarius*)	3	0.01	0.09	12.47***
Scaled Quail (*Callipepla squamata*)	6	0.16	1.61	-3.43***
Sandhill Crane (*Grus canadensis*)	4	0.19	2.41	6.02***
Killdeer (*Charadrius vociferans*)	1	0.00	0.05	-0.41
Mountain Plover (*Charadrius montanus*)	2	0.01	0.14	-2.66
Long-billed Curlew (*Numenius americanus*)	3	0.04	0.62	-1.38
Mourning Dove (*Zenaida macroura*)	15	0.15	0.90	-0.29***
Burrowing Owl (*Speotyto cunicularia*)	3	0.01	0.13	0.73
Short-eared Owl (*Asio flammeus*)	17	0.08	0.70	-2.79
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	1	0.00	0.05	1.27
Ladder-backed Woodpecker (*Picoides scalaris*)	3	0.01	0.09	-2.02***
Say’s Phoebe (*Sayornis saya*)	12	0.04	0.21	1.86***
Horned Lark (*Eremophilia alpestris*)	**91**	**3.23**	**11.80**	**-1.34*** **
Gray-breasted Jay (*Aphelocoma ultramarina*)	1	0.00	0.05	-0.35
Chihuahuan Raven (*Corvus cryptoleucus*)	26	0.10	0.42	-1.79
Common Raven (*Corvus corax*)	14	0.10	0.92	3.22***
Raven Species (*Corvus spp*.)	2	0.01	1.11	np
Bridled Titmouse (*Parus wollweberi*)	1	0.01	0.10	0.80**
Verdin (*Auriparus flaviceps*)	2	0.01	0.07	-3.81
Cactus Wren (*Campylorhynchus brunneicapillus*)	12	0.07	0.53	-1.36
Rock Wren (*Salpinctes obsoletus*)	1	0.00	0.05	-1.40
Bewick’s Wren (*Thryomanes bewickii*)	1	0.01	0.10	-0.28
Ruby-crowned Kinglet (*Regulus calendula*)	2	0.01	0.11	-0.81

[1] * $P<0.10$; ** $P<0.05$; *** $P<0.01$, (Sauer *et al*., 1996), np=not provided by BBS.

TABLE 1 (continued).

Species	n	$\bar{x}$	SD	BBS	
Black-tailed Gnatcatcher (*Polioptila melanura*)	1	0.01	0.10	-2.71	
Mountain Bluebird (*Sialia currucoides*)	4	0.23	3.59	2.34*	
Curve-billed Thrasher (*Toxostoma curirostre*)	3	0.01	0.13	-3.59	
American Pipit (*Anthus rubescens*)	5	0.01	0.11	-14.25	
Sprague's Pipit (*Anthus spragueii*)	**37**	**0.18**	**0.63**	**-4.72****	
Loggerhead Shrike (*Lanius ludovicianus*)	**34**	**0.10**	**0.32**	**-3.55*****	
Green-tailed Towhee (*Pipilo chlorurus*)	1	0.00	0.05	-0.10	
Canyon Towhee (*Pipilo fuscus*)	5	0.03	0.30	-2.28	
Cassin's Sparrow (*Aimophila cassinii*)	**27**	**0.09**	**0.41**	**-2.51*****	
Chipping Sparrow (*Spizella passerina*)	18	0.32	2.05	-0.16	
Clay-colored Sparrow (*Spizella pallida*)	4	0.05	0.58	-1.15	
Brewer's Sparrow (*Spizella breweri*)	65	2.08	9.88	-3.68**	
Spizella spp.	5	0.10	1.14		
Vesper Sparrow (*Pooecetes gramineus*)	**151**	**2.35**	**4.12**	**-0.77*****	
Black-throated Sparrow (*Amphispiza bilineata*)	**23**	**0.17**	**1.09**	**-3.92**	
Sage Sparrow (*Amphispiza belli*)	1	0.00	0.05	0.33	
Lark Bunting (*Calamospiza melanocorys*)	11	0.65	7.91	-0.87***	
Savannah Sparrow (*Passerculus sandwichensis*)	**139**	**2.77**	**5.99**	**-0.61*****	
Baird's Sparrow (*Ammodramus bairdii*)	**35**	**0.12**	**0.47**	**-1.55**	
Grasshopper Sparrow (*Ammodramus savannarum*)	**40**	**0.15**	**0.51**	**-3.54*****	
Ammodramus spp.	**104**	**0.53**	**1.21**		
White-crowned Sparrow (*Zonotrichia leucophrys*)	4	0.02	0.22	-1.71	
Dark-eyed Junco (*Junco hyemalis*)	1	0.02	0.31		
Sparrow Species	**64**	**0.27**	**0.73**		
McCown's Longspur (*Calcarius mccownii*)	2	0.01	0.07	1.14	
Chestnut-collared Longspur (*Calcarius ornatus*)	**176**	**11.70**	**25.62**	**-0.08**	
Eastern Meadowlark (*Sturnella magna*)	18	0.08	0.46	-2.59***	
Western Meadowlark (*Sturnella neglecta*)	**48**	**0.18**	**0.53**	**-0.63*****	
Meadowlark Species (*Sturnella spp.*)	9	0.02	0.15		
Brewer's Blackbird (*Euphagus cyanocephalus*)	3	0.19	3.33	-3.82**	
House Finch (*Carpodacus mexicanus*)	4	0.06	0.83	1.93***	
Pine Siskin (*Carduelis pinus*)	3	0.01	0.09	-0.70***	
Lesser Goldfinch (*Carduelis psaltria*)	1	0.00	0.05	-1.87	
House Sparrow (*Passer domesticus*)	1	0.01	0.15	-2.16***	

TABLE 2. Seventeen vegetation variables (of 65) considered for PCA. Many similar variables were eliminated due to lake of sample size, lack of normality, and/or colinearity with a more robust variable (e.g., vertical litter variables were eliminated since they had low sample size, were not normally distributed (before or after transformations), and were highly correlated with HLITTER). Variables in bold were those used in the final analysis in the PCA.

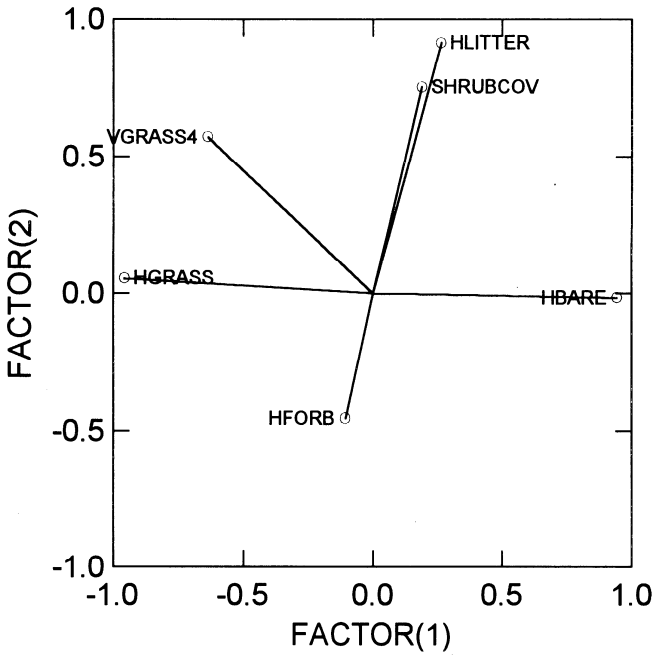
Variable Name	Definition
HBARE	**# bare ground point-intercepts**
HFORB	**# forb point-intercepts**
HGRASS	**# grass point-intercepts**
HLITTER	**# litter point-intercepts**
VFORB1	# forb vertical-intercepts (0-10cm)
VGRASS1	# grass vertical-intercepts (0-10cm)
VGRASS2	# grass vertical-intercepts (10-20cm)
VGRASS3	# grass vertical-intercepts (20-30cm)
VGRASS4	**# grass vertical-intercepts (30-40cm)**
VLITTER1	# litter vertical-intercepts (0-10cm)
TREECOV	visually-estimated % tree cover
SHRUBCOV	visually-estimated % shrub (>1m tall) cover
BUSHCOV	visually-estimated % shrubs (<1m tall) cover
CACTICOV	visually-estimated % cactus cover
GRASSCOV	visually-estimated % grass cover
FORBCOV	visually-estimated % forb cover
BARECOV	visually-estimated % bare ground

TABLE 3. Species, sample size, and means for untransformed vegetation variables used in PCA of habitat associations of wintering grassland bird species on the Mexican Plateau of Chihuahua, Mexico. Values greater than the mean for all plots are bold.

Species	n	HBARE	HFORBS	HGRASS	HLITTER	VGRASS4	SHRUB
Horned Lark	91	**47.86**	**7.57**	75.65	28.00	4.93	0.46
Sprague's Pipit	37	39.87	**13.19**	**84.24**	22.27	9.76	1.11
Loggerhead Shrike	34	40.15	6.91	**79.44**	**32.21**	**19.29**	**3.64**
Cassin's Sparrow	27	**49.48**	6.82	71.52	**31.00**	**14.93**	**4.56**
Brewer's Sparrow	65	37.40	**7.48**	**83.65**	28.72	**15.92**	**5.73**
Vesper Sparrow	151	37.31	7.06	**81.85**	**31.83**	**19.15**	**4.56**
Black-throated Sparrow	23	41.87	**8.91**	76.35	28.61	12.35	**8.78**
Savannah Sparrow	139	32.64	**9.21**	**88.94**	28.19	**23.15**	2.25
Baird's Sparrow	35	37.74	6.09	**86.54**	27.74	**15.46**	1.53
Grasshopper Sparrow	40	34.08	4.98	**88.98**	**30.60**	11.40	1.95
Ammodramus spp.	104	32.21	6.23	**92.13**	27.33	**20.90**	**3.90**
Sparrow spp.	64	32.25	**9.92**	**89.27**	26.78	**16.20**	3.02
Chestnut-collared Longspur	176	40.80	6.83	**85.15**	26.22	**13.65**	1.50
Western Meadowlark	48	31.94	6.54	**90.69**	**29.52**	**14.54**	2.81
All Plots	384	43.37	7.18	78.56	29.41	12.57	3.03

TABLE 4. PCA loadings for vegetation variables. PCI accounted for 38.79% (eigenvalue=2.33) and PCII accounted for 32.32% (eigenvalue=1.94).

Vegetation Variable	PCI	PCII
HBARE	0.944	-0.016
HFORB	-0.106	-0.455
HGRASS	-0.957	0.055
HLITTER	0.264	0.914
VGRASS4	-0.636	0.573
SHRUBCOV	0.189	0.752



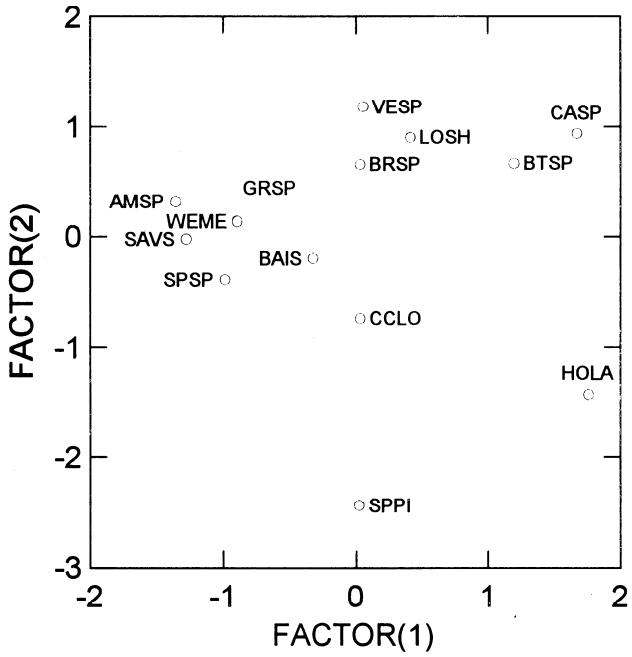


Figure 1. Species plotted on two principal component axes. The top illustration shows loadings of the original varaibles on the PCA axes. The lower illustration shows locations of species in PCA space. HOLA - Horned Lark, SPPI - Sprague's Pipit, LOSH - Loggerhead Shrike, CASP - Cassin's Sparrow, BRSP - Brewers's Sparrow, VESP - Vesper Sparrow, BTSP - Black-throated Sparrow, SAVS - Savannah Sparrow, BAIS - Baird's Sparrow, GRSP - Grasshopper Sparrow, AMSP - *Ammodramus* spp., SPSP - sparrow species, CCLO - Chestnut -collared Longspur, WEME - Western Meadowlark.