SAND PLUM RELATIONSHIPS WITH AVIAN ABUNDANCE IN OKLAHOMA

By

BRETT S. COOPER

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Thesis Approved:

Dr. R. Dwayne Elmore

Thesis Adviser

Dr. Fred S. Guthery

Dr. Craig A. Davis

Dr. A. Gordon Emslie

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

One of the most threatened ecosystems in the United States is grasslands. Native grassland loss has been overwhelming. The loss of these ecosystems in North America has been estimated at 80% since the 19th century (Knopf 1994). In many states, tallgrass prairies have virtually disappeared and mixed-grass prairies have declined 70–80% (Johnson 2005). The fragmentation of remaining grasslands, largely by agriculture, has left limited habitat for grassland birds (Brennan and Kuvlesky 2005, Johnson 2005). The improper management of existing grasslands, woody plant encroachment, and disruption of historic disturbance regimes are additional threats (Johnson and Igl 2001). All of these factors are occurring in the southern Great Plains of northwestern Oklahoma. The mixed-grass prairies that occur there contain both grassland and shrubland avian species due to the heterogeneity of the plant composition and structure. As this area is continually converted into other uses, remaining grasslands likely become disproportionately more important to the viability of these birds.

Many shrubland and grassland bird species have shown large declines from 1966–2007 (Sauer et al. 2008). Western kingbird (*Tyrannus verticalis*), Bell's vireo (*Vireo bellii*), and loggerhead shrike (*Lanius ludovicianus*) have all decreased at a rate of

≥4.47%/yr in Oklahoma from 1966–2007 (Sauer et al. 2008). Eastern kingbird (*Tyrannus tyrannus*), grasshopper sparrow (*Ammodramus savannarum*), Cassin's sparrow (*Aimophila cassinii*), western meadowlark (*Sturnella neglecta*), eastern meadowlark (*S. magna*), northern bobwhite (*Colinus virginianus*), and field sparrow (*Spizella pusilla*) have decreased in Oklahoma at a rate of ≥0.9%/yr from 1966–2007 (Sauer et al. 2008). With these rates of decline, only 10–25% of avian populations within the mixed-grass prairie have been estimated to remain in 40 years (Johnson 2005). The long-term decline of many of these avian species highlights the need to determine seasonal habitat preferences if we are to manage the remaining grasslands to sustain them.

While tree cover was historically limited within the Great Plains, native shrub species were present and constituted a key habitat component within the mixed-grass prairies. One of the most dominant of these is the Chickasaw plum (*Prunus angustifolia*), also known as sand plum. Sand plum is found mostly in the southern half of the United States but can be found on the east coast as far north as Rhode Island (Gilman and Watson 1994).

Sand plum forms a dense thicket sometimes called a motte. These thickets are often the only dense woody cover found within mixed-grass prairies. Even when other shrubs are present, the structure of the sand plum thickets make them unique as a cover type. As shrub habitat is considered an important cover type for several avian species, sand plum thickets are important for cover and nesting habitat (Stoddard 1931, Bock and Bock 1987, Vickery and Herkert 1999, Budnik et al. 2000, Dunkin 2008). Sand plum is favored by northern bobwhite for cover and as a food source (Stoddard 1931). The transplantation of wild plum has been promoted for increasing quail habitat since at least the 1930's (Stoddard 1931). The importance of sand plum as a food source for species other than northern bobwhite is unknown. Dunkin (2008) observed and inferred some species in northwestern Oklahoma that nested in sand plum including Bell's vireo, blue grosbeak (*Passerina caerulea*), brown thrasher (*Toxostoma rufum*), field sparrow, greater roadrunner (*Geococcyx californianus*), mourning dove (*Zenaida macroura*), northern cardinal (*Cardinalis cardinalis*), and northern mockingbird (*Mimus polyglottos*).

Shrub cover in general has been shown to be important for several species within the southern Great Plains. Wintering grassland species in southern Texas had their highest densities in shrub-grassland habitats. Specifically, eastern meadowlarks and savannah sparrows (*Passerculus sandwichensis*) had higher densities in shrub-grassland habitat (Igl and Ballard 1999). However, several species favor larger grassland patches, with little woody cover, within prairies (Johnson and Igl 2001). They included Le Conte's sparrow (*Ammodramus leconteii*), sedge wren (*Cistothorus platensis*), and grasshopper sparrow (Igl and Ballard 1999).

Based on our limited knowledge of how sand plum specifically fills habitat needs seasonally, I designed a study to gather information which would further our understanding of avifauna-sand plum relationships. My objective was to determine relationships between sand plum and avian abundance. Specifically, I attempted to correlate vegetation measures of composition and structure to measures of avian abundance to develop habitat associations for selected grassland and shrubland obligate birds during breeding and winter seasons.

STUDY AREA

This study was conducted on 3 sites (Sutter Ranch, Selman Ranch, and TLW Land & Cattle Company; hereafter referred to as TLW), in northwestern Oklahoma (Fig. 1). All 3 sites are characterized by 56–66 cm of rainfall annually with a mean annual temperature of 15.3º C (Tyrl et al. 2002, Chapman et al. 2004). The sites exhibit mixed-grass prairie or sand sagebrush (*Artemesia filifolia*)-bluestem (*Andropogon* sp.) grassland with sand sagebrush, sand plum, and fragrant sumac (*Rhus aromatica*) as dominant shrub species in the landscape. Topography varies from flat to steep rolling hills of moderately sandy soils (Tyrl et al. 2002). Dominant grass species are little bluestem (*Shizachyrium scoparium*), side-oats grama (*Bouteloua curtipendula*), big bluestem (*A. gerardii*), buffalograss (*Buchloe dactyloides*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorgastrum nutans*) (Woods et al. 2005). The Sutter Ranch is in Ellis County 5 km west of Fargo, Oklahoma (Fig. 1). The ranch includes 4,856 contiguous ha of short grass sand sagebrush-bluestem prairie and lies in the Southwestern Tablelands Canadian Cimarron Breaks (Woods et al. 2005). Soils consist of sandy and loamy bottomland; limy, sandy, hummocky soil; sandy duned soil; and limy, loamy, rolling soils (Cole et al. 1966). The Selman Ranch is in Harper County 35 km north of Woodward, Oklahoma (Fig. 1). The ranch consists of 5,665 contiguous ha, lies in the Central Great Plains Rolling Red Hills, and is characterized by mixed-grass prairie (Woods et al. 2005). Soils consist of Lincoln and Jester sand, Tivoli fine sand, and clay loam (Collier and Alspach 1998). TLW Land & Cattle Company is in Woods County 13 km east of Waynoka, Oklahoma (Fig. 1). The ranch lies in the Central Great Plains Pleistocene Sand Dunes and is characterized by stabilized sand dunes consisting of a sand sagebrush-bluestem prairie
Woods et al. 2005). The loose, deep sandy soils are permeable to very permeable and

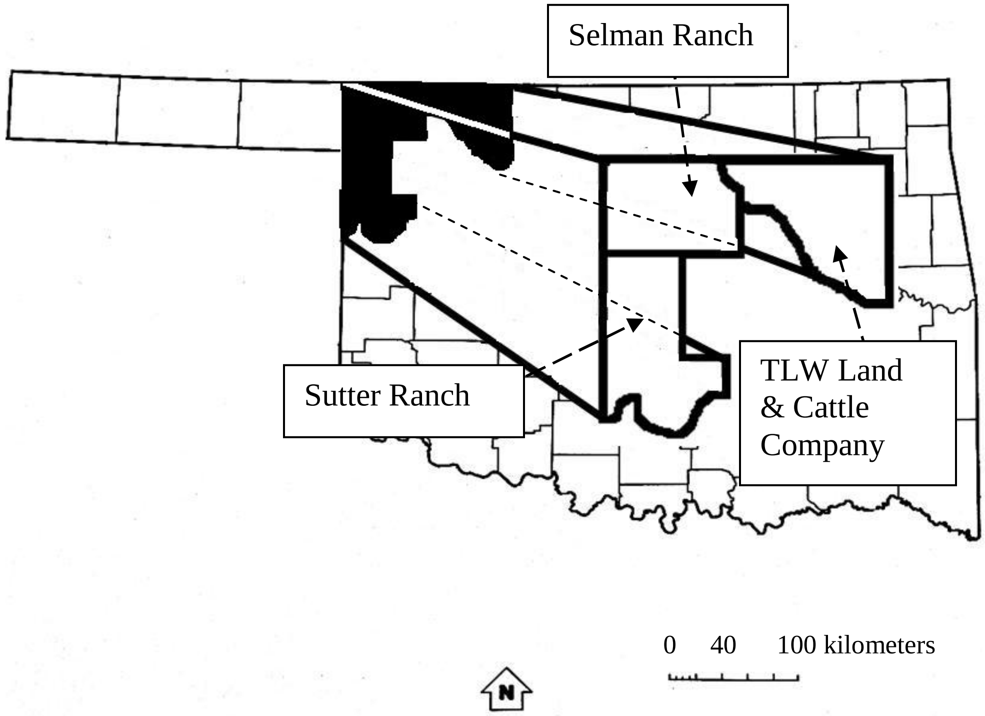

Figure 1. Locations of Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma.

highly susceptible to wind erosion (Woods et al. 2005). All of the ranches are managed primarily for cattle production, white-tailed deer (*Odocoileus virginianus*), and northern bobwhite.

METHODS

Point Selection Protocol

To evaluate avian abundance relationships to sand plum and other habitat components, I used point-count methodology with a fixed-radius distance (Ralph et al.

1995). I conducted stratified random sampling, to sample the full range of sand plum habitats available, from no plum (grassland) to areas with high sand plum cover.

Initially, I located and recorded (using Universal Transverse Mercatur [UTM] coordinates and a North American Datum ([NAD]-83) the position of each sand plum thicket in my study sites with a Garmin (Garmin Inc., Olathe, Kansas) portable hand-held global positioning system (GPS) and assigned each thicket a unique number. Using a random number generator, I randomly selected 15 thickets within each study site. I chose 15 as this was determined to be the maximum number of points that could be surveyed each morning during the survey period. From these random thickets, I then created random numbers for a compass direction (0–360º) and chose a random distance between 15–30 m. The distance depended on optimal locations for observation and to avoid any unnecessary flushing within thickets. Therefore, the points were not located directly in or adjacent to a sand plum thicket. ArcView 9.2 (Environmental Systems Research Institute, Redlands, California) was used to make sure that the distance between each point was ≥250 m. This distance was chosen to avoid double sampling between points (Ralph et al. 1995). This new random point became the center for each point-count for detecting birds. I recorded each point position with a Garmin handheld GPS and marked that location with a permanent wooden stake (Appendix A).

Count of Avian Species

I conducted point-count surveys following distance sampling protocols weekly during the breeding season (early May to mid June) in 2007 and 2008 (Buckland et al. 2001). I recorded all avian species detected and conducted ≥4 surveys each year at each point. Each point-count observation began with a 1-min period to allow the birds to resume normal activity (Reynolds et al. 1980). I recorded all birds within a 5-min detection period that were observed within a 100-m radius of the point, and began my surveys at legal sunrise and continued until 1030. I did not conduct surveys when the wind was >20 km/hr or when any precipitation or fog occurred (Ralph et al. 1995). I measured wind speed with a Turbo Meter Wind Speed Indicator handheld anemometer (Davis Instruments, Haywood, California). I randomly rotated the starting point for the point count surveys every sampling day and then the closest points were visited in order (Ralph et al. 1995). I counted any birds flushed while walking within 100 m of the point (prior to the 5-min survey period for that point) and tracked any unknown bird for identification (Ralph et al. 1995). I used a Bushnell Laser Pro 400 laser rangefinder (Bushnell Corporation, Overland Park, Kansas), with an accuracy of ±1 m to a distance of 400 m to determine the distance to each bird and used a compass to record the bearing from point to bird. This method minimizes error by observers with proper training from distance estimations in the area surveyed (Scott et al. 1981). Repeated sampling of a point count at the same location is acceptable when used with distance sampling protocols (Somershoe et al. 2006).

Vegetation Measurements

Herbaceous vegetation measurement.— I measured vegetation along 4 100-m transects that extended from each permanent point in each cardinal direction. I selected 5 random distances (0–100 m) along each 100-m transect and placed a 20-×-50-cm quadrat at each point (Daubenmire 1959). Therefore, for each point, there were 20 vegetation quadrats sampled. I estimated percent grass, forb, and shrub cover from the Daubenmire quadrat and recorded all plants to species. I measured the maximum herbaceous height for each Daubenmire quadrat with a steel measuring tape, and calculated vegetation species richness as the total plant species per point. I sampled vegetation in early September 2007 and late August 2008.

Sand plum measurement.—I measured (using a Garmin GPS) and digitized the area of each sand plum thicket located within a 100-m radius of each point to correspond with avian detection truncation. I downloaded the digitized points into ArcView 9.2 and converted them into shape files with the extension X-Tools Pro Version 4.2 to determine the total area of thickets. I truncated sand plum thickets that extended beyond the 100-m radius (Crozier and Niemi 2003). For each sand plum thicket, I calculated thicket height from ≥4 measures. I recorded these measures at random points 2–3 m apart along a straight line determined by a random compass bearing (0–360º) and also along a perpendicular line from the center of the random line. The number of measurements varied for each thicket because each had a different length and width. Thus, I was able to construct the mean height of the thickets regardless of the overall size of the thicket. I measured sand plum thicket stem density using the point-centered quarter method (Cottam and Curtis 1956). I chose 2 random points by bearing and distance from the approximate center of each thicket. I then made measurements from each of these 2 fixed points to the nearest stem in each of the 4 quadrants with a steel measuring tape. These points were averaged by thicket. Dunkin et al. (2008) developed a model for sand plum thicket age. Using this model as a guide, I used calipers to measure the diameter of the largest aboveground stem per thicket (above the soil surface). I inserted this diameter measurement into the following model:

$$y = 0.3x$$

where *y* = thicket age (yr) and *x* = the caliper measurement (mm) (Dunkin et al. 2008). I calculated sand plum cover from the total amount of thicket cover within a point-count radius and divided by the total point area. Finally, I calculated the mean area of each sand plum thicket within each point-count radius as a measure of patchiness of thickets.

Data Analysis

I calculated the mean detections of each avian species for each point for each year. I used distance sampling methodology to estimate bird densities and detection probabilities using DISTANCE (Borchers et al. 2002, Thomas et al. 2006). DISTANCE models were selected using AIC_c (Borchers et al. 2002). However, I used raw data for further analysis due to concerns about the reliability of distance methodology (Buckland 2006, Johnson 2008). I considered all species that had ≥60 pooled detections for analysis. A minimum range of 60–100 detections has been suggested to calculate detection probabilities and densities (Burnham and Anderson 2002). The species chosen for analysis based on an adequate number of detections were Bell's vireo, Cassin's sparrow, dickcissel, eastern meadowlark, field sparrow, grasshopper sparrow, lark sparrow, northern bobwhite, and western meadowlark.

I used SAS statistical software (SAS Institute Incorporated, Cary, North Carolina) to graph mean avian species detections and habitat variables to determine if relationships were biologically meaningful or correlated (Zar 1999). I chose habitat variables for further analysis based on scatter plots with trendlines that revealed correlations. For habitat variables that showed a relationship to the mean avian detections, I used 95% confidence intervals to compare avian detections between habitat variables that were collapsed into categories. I grouped sand plum cover into 4 categories that included 0 %,

>0–10 %, >10–20 %, and >40 %. I had no sand plum cover between 20 % and 40%. This categorization allowed me to associate mean species detections to no, low, moderate, and high mean sand plum cover and to simplify any management implications resulting from these associations. I also grouped shrub cover into 4 categories that included 0 %, >0–10 %, >10–20 %, and >21 %. Avian species with low detections or weak associations were described descriptively with weighted means.

Independent sand plum variables examined were mean thicket area, thicket height, thicket stem density, cover, and thicket age. Additionally, I examined the following independent variables: maximum herbaceous height, grass cover, forb cover, shrub (all shrubs) cover, and vegetation species richness.

I converted distance and compass bearing measurements of each avian detection for northern bobwhite, Bell's vireo, Cassin's sparrow, dickcissel, field sparrow, lark sparrow, eastern meadowlark, western meadowlark, and grasshopper sparrow to UTM coordinates (NAD-83 datum) with a geographic calculator. I digitized these points, buffered sand plum thickets at 30 m, and dissolved their boundaries from each sand plum thicket in ArcView 9.2. I chose 30 m based on previous research for the northern bobwhite that indicated this distance was biologically relevant (Hiller et al. 2007). While this distance is arbitrary for other species, due to the lack of data regarding shrub association, it served as a starting point to determine avian species affinity to sand plum cover. I truncated the buffers at the 100-m point count boundaries. Then, I summed the points within the buffers and out of the buffers to determine percent of detections for each avian species within the 30-m buffer relative to the proportion of the total point-count area. This allowed me to assess avian species affinity to sand plum cover.

Finally, I calculated avian species richness to be the total number of species detected during sampling per point.

RESULTS

I sampled 42 independent points ≥4 times per year for 2 years from early May to mid June during 2007–08. I sampled 15 points each at Sutter ranch and Selman ranch. I only sampled 12 points at TLW because of time and travel constraints to meet the point-count protocol. Of the 42 points, 16 were grassland with no plum cover, 23 had sand plum cover of <50 %, and 3 had sand plum cover of >50 %.

Avian Detections

I detected 51 avian species during the breeding seasons of 2007–08 (Appendix B). The most commonly detected species (≥35 detections in descending order) were northern bobwhite, Cassin's sparrow, eastern meadowlark, grasshopper sparrow, dickcissel, field sparrow, lark sparrow, western meadowlark, Bell's vireo, brown-headed cowbird (*Molothrus ater*), and mourning dove (Appendix B). I additionally conducted winter surveys in 2008 and identified 31 species (Appendix C). These winter species are not considered in this thesis.

I calculated densities and detection probabilities for all species with sufficient detections (Table 1). Detection numbers between years were similar for these 9 species except Cassin's sparrow which was present in greater numbers in 2008.

Selected species relationships to sand plum variables

Grasshopper sparrow.— The data for grasshopper sparrow were heteroscedasitic so the relationships were described by comparing means and 95 % confidence intervals (Fig. 2, 3). Grasshopper sparrow did not select for sand plum cover as only 19% of their detections were ≤30 m from a sand plum thicket while 23% of the landscape fell within that buffer distance (Table 2). The relationship between grasshopper sparrow and mean sand plum cover indicated higher detections at the lower sand plum categories with detections decreasing as sand plum increased (Fig. 2, Table 3). The trend for total shrub cover was similar with higher grasshopper sparrow detections at the lower mean shrub cover categories (Fig. 3, Table 4). Specifically, grasshopper sparrows had higher mean detections at point-counts with <5 % sand plum cover than at points with ≥5 % sand plum cover ($\bar{x}$ = 0.5, SE = 0.1, n = 31; $\bar{x}$ = 0.1, SE = 0.03, n = 23 respectively).

Table 1. Avian density estimates based on pooled detections during the breeding season from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species[a]	*n*	P_a	D	CV
Bell’s vireo	67	0.69	0.07	27.4
Cassin’s sparrow	152	0.53	0.23	16.2
Dickcissel	129	0.64	0.16	17.5
Eastern meadowlark	151	0.66	0.17	15.7
Field sparrow	92	0.65	0.09	21.4
Grasshopper sparrow	133	0.50	1.37	13.0
Lark sparrow	89	0.49	0.15	21.7
Northern bobwhite	169	0.65	0.16	15.4
Western meadowlark	76	0.67	0.07	22.7

[a] Abbreviations: P_a = detection probability, D = birds/ha, and CV = coefficient of variation for detection probabilities

Table 2. Mean percent of pooled avian detections by point-count within a sand plum thicket or ≤30 m from a thicket edge during the breeding season from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species	$\bar{x}$ (%)[a]	SE	*n*
Bell's vireo	72.9	9.3	20
Cassin's sparrow	47.8	6.9	30
Dickcissel	41.0	6.8	39
Field sparrow	47.9	7.7	31
Grasshopper sparrow	18.8	5.8	34
Lark sparrow	53.7	7.7	30
Northern bobwhite	44.9	6.6	39
Western meadowlark	16.4	6.6	20

[a] A mean of 23.4 % (SE = 3.6) of the total point-count area was within ≤30 m buffer distance and 5.9 % (SE = 2.0) of the total point-count area consisted of sand plum.

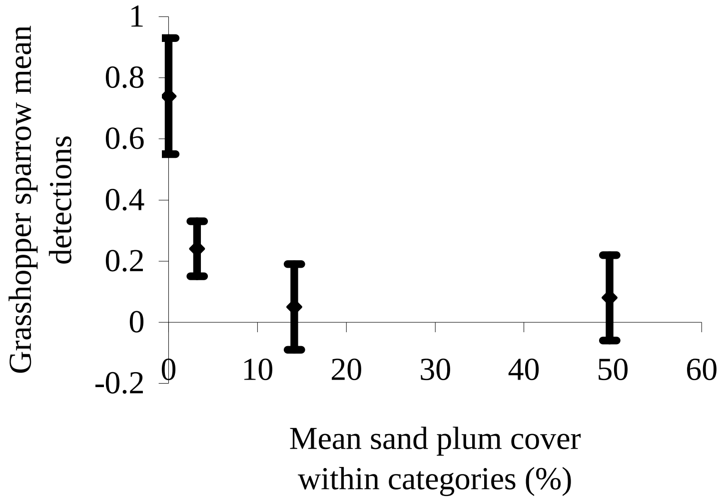

Figure 2. Grasshopper sparrow detections (95 % CIs) relationship with 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover from Selman Ranch, Sutter Ranch, and TLW Land and Cattle Company in northwestern Oklahoma, 2007–08.

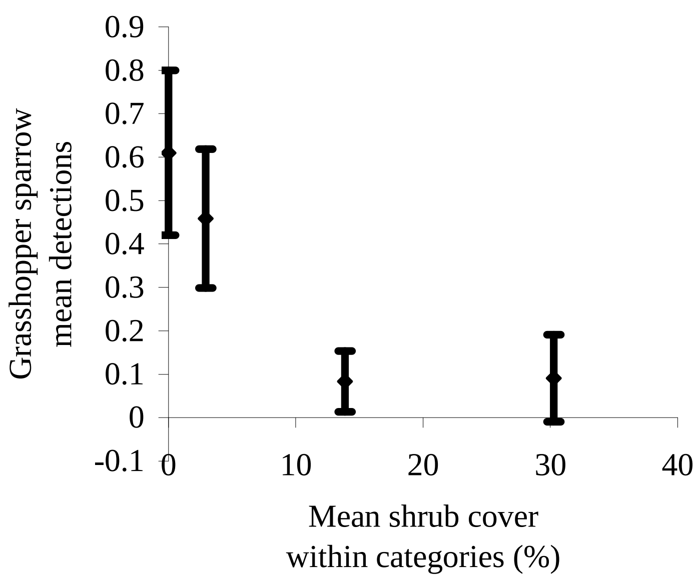

Figure 3. Grasshopper sparrow detections (95 % CIs) relationship with 0 (*n* = 25), >0–10 (*n* = 36), >10–20 (*n* = 12), and >21 (*n* = 11) % shrub cover from Selman Ranch, Sutter Ranch, and TLW Land and Cattle Company in northwestern Oklahoma, 2007–08.

Table 3. Mean detections and 95 % CIs for selected avian species relationships to 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover during the breeding season from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species	0 %	>0–10 %	>10–20 %	>40 %
Bell's vireo	0.02 ± 0.03	0.2 ± 0.1	1.2 ± 1.3	0.4 ± 0.4
Grasshopper sparrow	0.7 ± 0.2	0.2 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
Western meadowlark	0.4 ± 0.2	0.1 ± 0.1	0.0 ± 0.0	0.04 ± 0.1

Table 4. Mean detections and 95 % CIs for selected avian species relationships to 0 (*n* = 25), >0–10 (*n* = 36), >10–20 (*n* = 12), and >21 (*n* = 11) shrub cover (%) during the breeding season from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species	0 %	>0–10 %	>10–20 %	>20 %
Grasshopper sparrow	0.6 ± 0.2	0.5 ± 0.2	0.1 ± 0.1	0.1 ± 0.1
Western meadowlark	0.2 ± 0.2	0.3 ± 0.1	0.1 ± 0.2	0.2 ± 0.2

Bell's vireo.— Bell's vireo were positively associated with mean sand plum cover as 73% of their detections were ≤30 m from a sand plum thicket while only 23% of the landscape was within this buffer (Table 2). Thus, they were nearly 3 times as likely to be near sand plum as not. This is supported by Figure 4 which indicates that at >0–10 %

sand plum cover, only 0.2 mean Bell's vireo were detected, while between >10–20 % sand plum cover as many as 1.2 mean Bell's vireo were detected. Mean detections decreased when sand plum cover was >40 % (Table 3). However, the higher sand plum categories had low sample sizes and large variance, which resulted in overlapping confidence intervals. Bell's vireo showed similar relationships with mean sand plum thicket area (Fig. 5). Thus, Bell's vireos responded positively to increasing sand plum cover up until about 20 % cover, but this relationship was not statistically significant in my sample.

Western meadowlark.— Western meadowlark was negatively associated with mean sand plum cover as only 16% of their detections were ≤30 m from a sand plum thicket while 23% of the landscape was within that buffer distance (Table 2). Western meadowlark had the highest detections at the lowest sand plum covers (Table 3). Figure 6 indicates that at 0 % sand plum cover, the majority of western meadowlarks were detected and then detections decreased as sand plum increased. Thus, western meadowlark responded negatively to increased sand plum cover in the landscape.

Lark sparrow, Northern bobwhite, Dickcissel, Cassin's sparrow, Eastern meadowlark, and Field sparrow.— I found no strong habitat correlations or results that were biologically meaningful for northern bobwhite, dickcissel, lark sparrow, Cassin's sparrow, field sparrow, and eastern meadowlark. I used weighted means to describe habitat associations for these species (Table 5, 6).

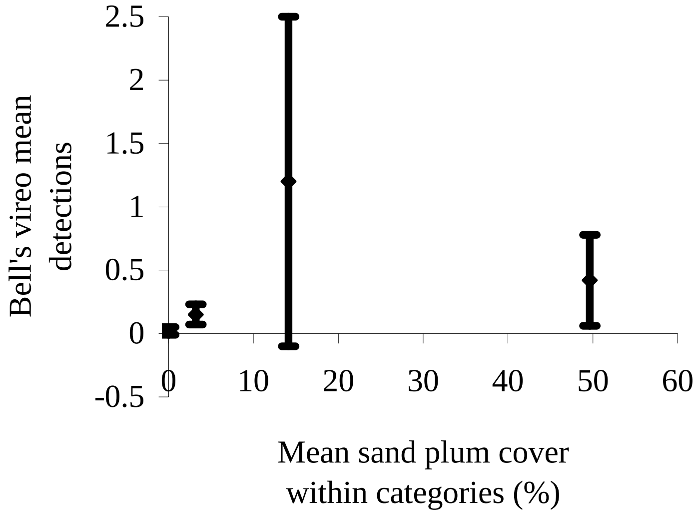

Figure 4. Bell's vireo detections (95 % CIs) relationship with 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

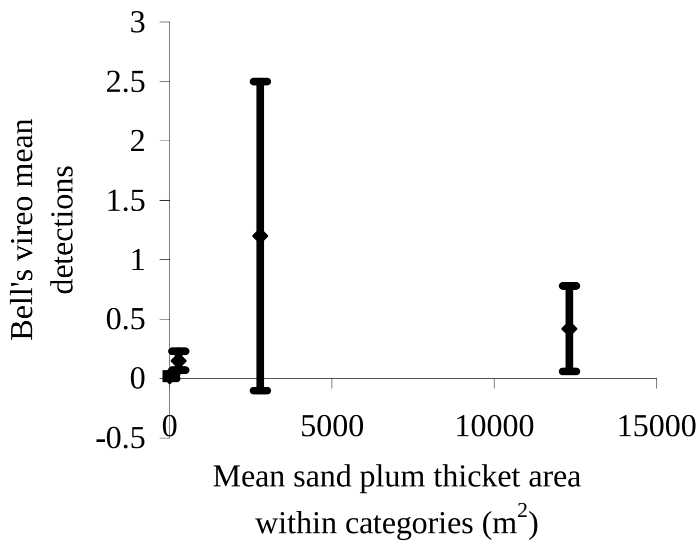

Figure 5. Bell's vireo detections (95 % CIs) relationship to mean sand plum thicket area sorted by 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover

from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

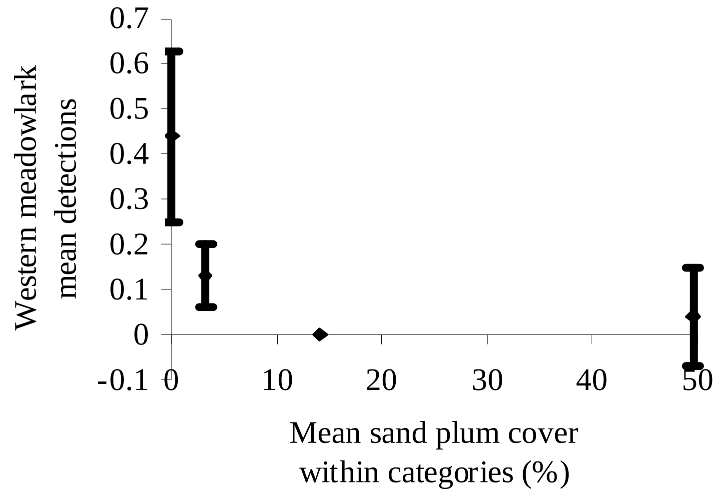

Figure 6. Western meadowlark detections (95 % CIs) relationship with 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Finally, when comparing avian species richness to sand plum cover, I found that richness did not differ as the 95 % confidence intervals overlapped (Fig. 7). Avian species richness mean detections by sand plum cover category included $\bar{x}$ = 5.9 (SE = 0.3) 0 % sand plum cover, $\bar{x}$ = 6.9 (SE = 0.4) >0–10 % sand plum cover, $\bar{x}$ = 7.6 (SE = 0.9) >10–20 % sand plum cover, and $\bar{x}$ = 7.7 (SE = 0.8) >40 % sand plum cover.

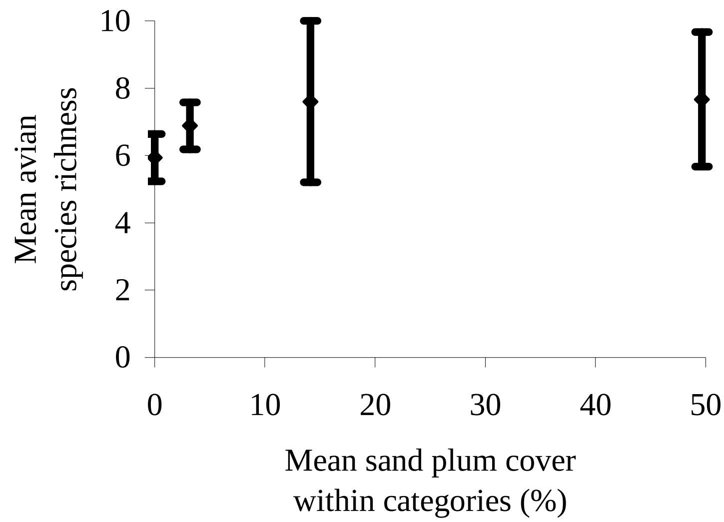

Figure 7. Avian species richness (95 % CIs) relationship to mean sand plum cover sorted by with 0 (*n* = 31), >0–10 (*n* = 42), >10–20 (*n* = 5), and >40 (*n* = 6) % sand plum cover from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Table 5. Weighted mean (SE) sand plum habitat variables calculated from detections only for 9 selected avian species for Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species	*n*	Asd[a]	Amh	Amar	Amag	Pmc
Bell's vireo	23	2.8	1.42	4,257.1	18.3	16.9
		(2.9)	(0.03)	(1,290.3)	(0.9)	(4.1)
Northern bobwhite	38	2.5	1.35	755.3	15.9	4.2
		(0.2)	(0.03)	(404.5)	(0.5)	(1.9)
Field sparrow	33	3.0	1.40	3,022.8	17.1	12.2
		(0.2)	(0.02)	(821.5)	(0.6)	(2.8)
Eastern meadowlark	28	3.1	1.37	1,431.1	15.9	7.9
		(0.2)	(0.03)	(535.7)	(0.7)	(2.5)
Lark sparrow	28	2.9	1.42	2,559.9	17.7	14.0
		(0.2)	(0.03)	(908.6)	(0.7)	(3.3)
Western meadowlark	14	2.9	1.27 (0.1)	1,037.3	16.6	5.7
		(0.4)		(1,366.7)	(1.0)	(4.2)
Cassin's sparrow	27	2.9	1.37	511.6	16.8	4.9
		(0.2)	(0.04)	(253.8)	(0.6)	(1.8)

Species	n	Asd[a]	Amh	Amar	Amag	Pmc
Dickcissel	27	2.6	1.42	655.8	16.7	5.6
		(0.2)	(0.04)	(309.3)	(0.6)	(1.8)
Grasshopper sparrow	26	2.9	1.32	885.3	15.3	4.2
		(0.1)	(0.03)	(767.2)	(0.7)	(2.8)

[a]Abbreviations are: Asd = mean sand plum thicket stem density (stems/m^2), Amh = mean sand plum thicket height (m), Amar = mean sand plum thicket area (m^2), Amag = mean sand plum thicket age (yr), Pmc = mean sand plum cover (%).

Table 6. Herbaceous vegetation and shrub weighted means (SE) calculated from detections only for 9 selected avian species from Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Species	n	Apg[a]	Apf	Aps	Mhh	Vsr
Bell’s vireo	26	32.6	16.6	13.1	0.84	15.4
		(2.7)	(1.6)	(2.6)	(0.06)	(0.8)
Northern bobwhite	60	41.6	14.9	7.0	0.73	15.1
		(2.1)	(1.5)	(1.4)	(0.02)	(0.6)
Field sparrow	43	34.0	18.3	8.7	0.78	15.4
		(2.5)	(1.6)	(1.7)	(0.04)	(0.6)

Species	*n*	Apg[a]	Apf	Aps	Mhh	Vsr
Eastern meadowlark	48	43.1	11.3	6.3	0.67	13.6
		(2.5)	(1.6)	(1.5)	(0.03)	(0.7)
Lark sparrow	40	27.3	19.7	9.4	0.67	16.0
		(3.1)	(2.0)	(1.9)	(0.04)	(0.7)
Western meadowlark	33	32.2	20.3	5.9	0.60	16.5
		(1.9)	(2.4)	(1.6)	(0.03)	(0.6)
Cassin's sparrow	37	29.7	15.2	10.0	0.62	16.0
		(2.4)	(1.8)	(1.5)	(0.03)	(0.5)
Dickcissel	43	43.3	18.0	4.7	0.71	16.1
		(2.9)	(1.8)	(1.2)	(0.03)	(0.7)
Grasshopper sparrow	53	38.6	12.9	1.8	0.62	12.7
		(2.5)	(1.6)	(0.9)	(0.03)	(0.7)

[a]Abbreviations are: Apg = mean grass cover (%), Apf = mean forb cover (%), Aps = mean shrub cover (%), Mhh = mean maximum herbaceous height (m), Vsr = vegetation species richness.

Vegetation

I measured 840 vegetation quadrats in summer 2007 and 2008 for a total of 1,680 and identified 118 plant species (Appendix D).

Sand plum thicket means for Selman Ranch (*n* = 15) included 903.8 m^2 (SE = 294.6) for area, 1.5 m (SE = 0.04) for height, 2.5 stems/m^2 (SE = 0.3) for stem density, 16.7 yr (SE = 0.6) for age, and 9.03 % (SE = 3.0) for sand plum cover.

Sand plum thicket means for Sutter Ranch (*n* = 15) included 284.9 m^2 (SE = 74.6) for area, 1.3 m (SE = 0.04) for height, 3.3 stems/m^2 (SE = 0.3) for stem density, 15.5 yr (SE = 0.4) for age, and 3.4 % (SE = 0.6) for sand plum cover.

Sand plum thicket means for TLW Land & Cattle Company (*n* = 12) included 2,552.4 m^2 (SE = 1,199.7) for area, 1.4 m (SE = 0.03) for height, 2.6 stems/m^2 (SE = 0.3) for stem density, 16.3 yr (SE = 1.1) for age, and 9.7 % (SE = 3.7) for sand plum cover.

DISCUSSION

Avian Species Breeding Habitat

Grasshopper sparrow.— Grasshopper sparrows prefer grassland habitats, and have been shown to be absent in habitats with >35 % shrub cover (Johnston and Odom 1956). In the southwestern United States, grasshopper sparrows prefer ≤11 % shrub cover (Bock and Bock 1987). My data support these studies, as grasshopper sparrows declined rapidly as shrub cover increased. Sand plum, as a shrub, is avoided by grasshopper sparrows based on current literature and my data which shows that only 19% of grasshopper sparrow detections were <30 m from the edge of a sand plum thicket. I also found that the highest grasshopper sparrow detections occurred when no sand plum occurred on the landscape.

Anecdotally, another point with several detections (*n* =14) was a monoculture of old world bluestem (*Bothriochloa ischaemum*) which lacked diversity because of low vegetation species richness (3) and low avian species richness (4). It appears that the grasshopper sparrow occurs in structurally simple habitats lacking significant shrub cover. This species would therefore benefit from frequent disturbances such as grazing or fire on deeper more productive soils. Shallow soil sites that do not support significant herbaceous cover would be favorable to grasshopper sparrows assuming they are relatively free of woody cover. This species is still abundant in Oklahoma. However, it is declining statewide according to Sauer et al. (2008) and this decline is likely related to the increases in woody cover such as eastern red cedar that has resulted from suppression of fire.

Bell's vireo.— Budnik et al. (2002) found that in the grassland habitats of Missouri, Bell's vireo preferred 66–78 % shrub cover. Overmire (1963) found that Bell's vireo abundance decreased by 50% in Oklahoma with the reduction of shrub cover through improper grazing. My data indicated that Bell's vireo was positively associated with mean sand plum cover at least up to a point. As mean sand plum cover increased, Bell's vireo detections increased up to about 20 % sand plum cover and then decreased gradually. However, as I only had 4 points that had high sand plum cover amounts, this decrease may not be a true representation. I lacked sand plum cover in my study area between 20–40 %. Thus I can not predict detections in that range. Further supporting the positive association with sand plum, 73% of Bell's vireo detections were ≤30 m from a sand plum thicket. Bell's vireo were virtually absent in landscapes that did not have sand plum cover in my study area.

Budnik et al. (2002) found that in the grassland habitats of Missouri, Bell's vireo preferred thickets >200 m^2 and Dunkin (2008) found they nested in 257-m^2 thickets. In my study, the highest numbers of Bell's vireo occurred in mean sand plum thickets that were much larger in area than previously reported. It is clear that Bell's vireos increase as mean sand plum cover increases (at least up to about 20%) and that a moderate percentage of the landscape should be occupied by sand plum or a similar cover type for this species.

Historically, Bell's vireo was likely most abundant in areas with moderate fire return intervals that allowed shrub cover to remain on the landscape. Anecdotally, 1 of my points had Bell's vireo detections in 2007 but not in 2008 as the area burned in early spring 2008. The habitat conditions prior to the burn consisted of 11 % sand plum cover. The entire sand plum cover was burned. It would appear that due to this burn, no Bell's vireos were present in 2008. This was expected with the loss of woody cover and dense vegetation that is required for Bell's vireo breeding habitat requirements.

Although it is unknown how frequent fire return intervals impact sand plum, other shrub species including shinnery oak (*Quercus harvardii*) and sand sagebrush in western Oklahoma appear to become structurally insignificant at 1–2-year fire intervals (Boyd 1999, Vermeire 2002). Some shrub cover should be maintained in grasslands if Bell's vireo is a management objective. This will entail either longer disturbance intervals or protection of shrub thickets. Precise management prescriptions for sand plum need to be identified in the future as Bell's vireo is a species of conservation concern.

Western meadowlark. —General breeding habitat requirements for western meadowlark are grasslands and prairies with high grass and forb cover (Dechant et al. 1999*b*). They avoid sparse or tall vegetation and woody cover (Dechant et al. 1999*b*). In western Oklahoma, habitat preference is similar, as they prefer higher grass cover with little to no woody cover (Reinking 2004). My results support this, as western meadowlark detections were negatively associated with sand plum cover and shrub cover in general. Detections decreased dramatically as sand plum cover increased. This species requires a low seral state and shrub cover does not appear to be selected for. Frequent disturbance would benefit this species and thus it should be compatible with moderate to heavy grazing and frequent fire regimes.

Anecdotally, Sutton (1967) and Nice (1931) found that the western meadowlark was historically common as far east as Woods County. In my study, no western meadowlarks were detected in Woods County (breeding or winter seasons) and few were detected further to the northwest in Harper County. The majority of the detections were in Ellis County in far western Oklahoma. Conversely, the majority of eastern meadowlarks were detected in Woods and Harper Counties. This may be an indication of eastern meadowlark range expansion into western Oklahoma. Mean forb cover was the highest at Sutter Ranch in Ellis County and that could explain the lack of detections at the 2 other study sites.

Dickcissel.— Dickcissel seemed to prefer smaller, taller sand plum thickets with higher grass and forb cover, and taller herbaceous vegetation heights. A possible explanation for this comes from the observation that dickcissel require taller more dense vegetation (0.6–1.0 m vegetation height) with a higher percentage of forb cover (>25%) which they often use for perching (Dechant et al. 2003). Rotenberry and Wiens (1980) found increasing grass and forb cover was positively correlated to increased dickcissel abundance in the tallgrass prairie. My data support those findings with weighted means of taller mean maximum herbaceous height, increased mean forb cover, and moderate mean grass cover. Management for other species that require some shrub cover such as sand plum should meet this species' habitat needs, as it is a generalist.

Cassin's sparrow.— Point-counts with the highest number of detections for Cassin's sparrow had taller mean grass cover and moderate mean shrub cover. The dominant shrub cover was sand sagebrush. This is consistent with their known habitat preferences. Cassin's sparrow will use sand plum as perches for their "skylarking" territorial displays (48% of their detections were <30 m from the edge of a sand plum thicket). However, they seem to prefer sand sagebrush in northwestern Oklahoma as areas occupied by this shrub were where the highest densities of Cassin's sparrow were found.

A marked increase in Cassin's sparrow densities was found at all 3 study sites from 2007 to 2008. During December 2006–March 2007, a total of 24.9 cm of precipitation was recorded versus 2008 which had only 3.8 cm during the same period. It is possible that Cassin's sparrow were in low abundance because of almost twice the normal 30-yr average precipitation during 2007 (average of Woodward and Arnett mesonet weather sites, 11.7 cm 30-yr average). An alternative explanation concerns fire. Fires with low humidity and high winds have been shown to preclude use by Cassin's sparrow for 2–3 years due to the resultant low grass cover and shrub cover loss (Bock and Bock 1992, Kirkpatrick et al. 2002). The increased Cassin's sparrow detections on the Sutter ranch could be attributed to a lightning induced wild fire that occurred on the site in the summer of 2006, which temporarily reduced sand sagebrush cover (K. Merrill, Sutter Ranch, personal communication). By 2008, the shrub cover had recovered. However, as I do not have data prior to this fire, the impacts are unknown.

Field sparrow.— Field sparrows use habitats that consist of woody edges or shrubby areas with an herbaceous vegetation component in grassland habitats (Sousa 1983). A mean shrub height of <1.5 m has been shown to be preferred by field sparrow (Sousa 1983), although Dunkin (2008) found they nested on 1.7-m sand plum stems. My mean sand plum thicket height data supported Sousa (1983) for field sparrow. Sand plum appears to be utilized by field sparrows in northwest Oklahoma as it is the dominant shrub on many sites and they require a shrub component in their breeding habitat.

Lark sparrow.— Lark sparrows occur on sites associated with poor, shallow soils or that have undergone a disturbance such as heavy grazing or fire (Zimmerman 1993). In fact, lark sparrows are often the first species detected after a disturbance (Martin and Parrish 2000). To illustrate this, after 1 of my points at TLW was burned in early March 2008, lark sparrows became the most-detected species at that point. Other species were adversely affected by the loss of sand plum thickets due to the wildfire. Dickcissel, grasshopper sparrow, western meadowlark, northern bobwhite, and field sparrow detections decreased or were not detected at these points after the disturbance. Additionally, lark sparrow detections increased at 2 points where natural gas well pads were built prior to the 2008 breeding season. Bell’s vireo, lark sparrow, and Cassin’s sparrow detections increased at these 2 points after the disturbance.

Northern Bobwhite.— Northern bobwhite were associated with intermediate-aged sand plum thickets with a smaller mean sand plum thicket area. This habitat association also included taller, moderate grass cover. Northern bobwhites use sand plum in their breeding habitat as almost 44% of the detections were <30 m from the edge of sand plum thickets. Thus, it appears that this shrub is important habitat for northern bobwhite as sand plum is a dominant shrub in the landscape of northwestern Oklahoma and northern bobwhite require some woody cover.

Methodology Observations

Some possible biases in my study would include the assumptions that all birds at zero distance from the point were detected. Additionally, my presence in these habitats with sand plum thickets could have increased the likelihood that the birds would seek out thickets and the association with this cover could be biased. This is possible, but because of the time allowed for birds to resume activities before I began observation, and observation by 1 observer, I feel this bias was not a concern. Finally, as I had only 3 points with >50 % and none between 20–40 % sand plum cover and I specifically sampled and analyzed associations in sand plum habitat, my data were not representative of the total avian community in northwestern Oklahoma.

MANAGEMENT IMPLICATIONS

Field sparrow and lark sparrow have similar habitat preferences and thus could be managed for simultaneously. Dormant season (before migration and sand plum bloom) prescribed fire could be used as both species have shown a positive correlation either immediately or within 2 yrs of a burn (Dechant et al. 1999*a*, Martin and Parrish 2000). Because lark sparrow occupies habitats that have edge (shrub and woodland) and were frequently detected after a disturbance, management is not of great concern at this time as ample habitat exists for them in western Oklahoma (Martin and Parrish 2000).

Bell's vireo, dickcissel, field sparrow, and northern bobwhite would benefit from the establishment of sand plum or other shrub cover in areas lacking woody cover (Overmire 1963, Budnik et al. 2002, Dechant et al. 2003, Hiller et al. 2007, Dunkin

2008). Thickets planted to attain a 30-m radius (about 2,800 m^2) and dispersed at approximately ≤60 m intervals (optimal distance but any thicket should increase the habitat) across the landscape appears to be a good general prescription for these mixed-grass and shrub-obligate species. For Bell's vireo, sand plum cover should be about 10–20% of the landscape based on my data. Once the sand plum thickets are mature, low intensity prescribed fires that do not top kill the sand plum could be used to keep them taller in height and denser as Bell's vireo seem to prefer taller more dense thickets. In areas with mature thickets, thinning or prescribed fire could be used to create more dispersed thickets based on the requirements above. It is unknown what fire interval would best achieve this in sand plum thickets. Mowing, wet lines, or plowed breaks could be cut around mature thickets to help protect them from the fire. This would help preserve some thickets when management for shrub obligate species is a goal.

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APPENDICES

Appendix A. UTM coordinates of point-counts (NAD–83) for Selman Ranch, Sutter Ranch, and TLW Land & Cattle Company in northwestern Oklahoma, 2007–08.

Point-count	Easting	Northing
Selman 1	465761	4069395
Selman 2	468062	4070968
Selman 3	460287	4071723
Selman 4	460003	4070931
Selman 5	468539	4069984
Selman 6	467396	4071494
Selman 7	469429	4070124
Selman 8	459718	4071843
Selman 9	460635	4071037
Selman 10	459858	4071390
Selman 11	470152	4070443
Selman 12	460014	4072357

Point-count	Easting	Northing
Selman 13	460343	4070385
Selman 14	460746	4071711
Selman 15	460570	4072212
Sutter 1	436893	4028449
Sutter 2	436985	4027947
Sutter 3	436117	4023985
Sutter 4	439104	4023962
Sutter 5	436607	4023817
Sutter 6	434856	4024925
Sutter 7	435466	4024885
Sutter 8	436928	4024158
Sutter 9	437677	4023329
Sutter 10	434603	4024257
Sutter 11	438189	4024842
Sutter 12	435087	4023862
Sutter 13	434633	4023759
Sutter 14	435386	4024245
Sutter 15	435565	4023774
TLW 1	519258	4048529
TLW 2	518483	4051387
TLW 3	517999	4051340
TLW 4	518160	4050912

Point-count	Easting	Northing
TLW 5	517533	4051343
TLW 6	517629	4050884
TLW 7	517118	4050908
TLW 8	517206	4050443
TLW 9	517546	4050156
TLW 12	524096	4040704
TLW 14	523267	4045915
TLW 15	523243	4046377

Appendix B. Breeding season (May-June) avian species from Selman Ranch (SE), Sutter Ranch (SU), and TLW Land & Cattle Company (TL) in northwestern Oklahoma, 2007–08 ([a] detected using sand plum; [b] detected at sand plum points).

Species	Scientific name	SE	SU	TL	Total Detections
American goldfinch [a]	*Carduelis tristis*	4	1	0	5
Barn swallow [b]	*Hirundo rustica*	3	0	0	3
Bank swallow [b]	*Riparia riparia*	5	2	0	7
Bell's vireo [a]	*Vireo bellii*	13	17	37	67
Bewick's wren [a]	*Thryomanes bewickii*	0	2	1	3
Blue jay [a]	*Cyanocitta cristata*	0	0	1	1
Blue-gray gnatcatcher [b]	*Polioptila caerulea*	0	1	0	1

Species	Scientific name	SE	SU	TL	Total Detections
Bobolink [b]	*Dolichonyx oryzivorus*	2	2	0	4
Brown thrasher [a]	*Toxostoma rufum*	2	2	8	12
Brown-headed cowbird [a]	*Molothrus ater*	16	12	15	43
Bullock's oriole [b]	*Icterus bullockii*	0	1	0	1
Cassin's sparrow [a]	*Aimophila cassinii*	57	71	24	152
Chipping sparrow [b]	*Spizella passerina*	0	1	0	1
Clay-colored sparrow [a]	*Spizella pallida*	4	4	4	12
Common nighthawk	*Chordeiles minor*	14	4	1	19
Dickcissel [a]	*Spiza americana*	62	15	52	129
Eastern bluebird [a]	*Sialia sialis*	0	0	2	2
Eastern kingbird [a]	*Tyrannus tyrannus*	2	0	1	3
Eastern meadowlark [a]	*Sturnella magna*	93	3	55	151
Eastern wood pewee [a]	*Contopus virens*	0	0	1	1
Field sparrow [a]	*Spizella pusilla*	19	35	38	92
Grasshopper sparrow [b]	*Ammodramus savannarum*	51	35	47	133
Great-crested flycatcher [b]	*Myiarchus crinitus*	0	0	1	1
Greater roadrunner [b]	*Geococcyx californianus*	0	0	1	1
Harris's sparrow [b]	*Zonotrichia querula*	0	0	1	1
Horned lark [b]	*Eremophila alpestris*	0	2	0	2
Indigo bunting [a]	*Passerina cyanea*	0	1	0	1

Species	Scientific name	SE	SU	TL	Total Detections
Killdeer [b]	*Charadrius vociferus*	5	0	1	6
Lark bunting	*Calamospiza melanocorys*	1	1	2	4
Lark sparrow [a]	*Chondestes gammacus*	42	23	24	89
Mallard [a]	*Anas platyrhynchos*	0	2	0	2
Mourning dove [b]	*Zenaida macroura*	9	22	4	35
Northern bobwhite [a]	*Colinus virginianus*	66	43	60	169
Northern cardinal [a]	*Cardinalis cardinalis*	0	5	0	5
Northern flicker [b]	*Colaptes auratus*	1	0	0	1
Northern mockingbird [a]	*Mimus polyglottos*	2	2	2	6
Northern rough-winged swallow	*Stelgidopteryx serripennis*	0	1	0	1
Painted bunting [a]	*Passerina ciris*	6	3	5	14
Red-bellied woodpecker [b]	*Melanerpes carolinus*	0	0	1	1
Red-headed woodpecker [b]	*Melanerpes rythrocephalus*	0	1	1	2
Red-tailed hawk [b]	*Buteo jamaicensis*	1	0	0	1
Red-winged blackbird [a]	*Agelaius phoeniceus*	5	7	3	15
Ringed-necked pheasant [a]	*Phasianus colchicus*	4	2	1	7
Rufous-crowned sparrow [a]	*Aimophila ruficeps*	2	4	0	6
Scissor-tailed flycatcher [a]	*Tyrannus forficatus*	3	5	5	13

Species	Scientific name	SE	SU	TL	Total Detections
Vesper sparrow [a]	*Pooecetes gramineus*	0	1	7	8
Western kingbird [b]	*Tyrannus verticalis*	0	2	0	2
Western meadowlark [b]	*Sturnella neglecta*	16	60	0	76
White-crowned sparrow [a]	*Zonotrichia leucophrys*	0	3	2	5
Wild turkey [a]	*Meleagris gallopavo*	0	0	1	1
Yellow warbler [b]	*Dendroica petechia*	1	0	0	1

Appendix C. Avian species detected for winter (January-February) 2007 at Selman Ranch (SE), Sutter Ranch (SU), and TLW Land & Cattle Company (TL) in northwestern Oklahoma ([a] detected using sand plum; [b] detected at sand plum points).

Species	Scientific name	SE	SU	TL	Total detections
American goldfinch [a]	*Carduelis tristis*	6	5	0	11
American tree sparrow [a]	*Spizella arborea*	73	58	47	178
Bewick's wren [a]	*Thryomanes bewickii*	0	1	0	1
Carolina chickadee [a]	*Poecile carolinensis*	0	2	0	2
Chipping sparrow [a]	*Spizella passerina*	1	1	1	3
Dark-eyed junco [a]	*Junco hyemalis*	0	11	0	11
Eastern bluebird [a]	*Sialia sialis*	0	4	0	4
Eastern kingbird [b]	*Tyrannus tyrannus*	0	0	1	1

Species	Scientific name	SE	SU	TL	Total detections
Eastern meadowlark [a]	*Sturnella magna*	6	0	15	21
Field sparrow [a]	*Spizella pusilla*	3	7	24	34
Fox sparrow [a]	*Passerella iliaca*	1	1	0	2
Harris's sparrow [a]	*Zonotrichia querula*	1	21	3	25
Le Conte's sparrow	*Ammodramus leconteii*	2	0	1	3
Loggerhead shrike [a]	*Lanius ludovicianus*	0	1	0	1
Mourning dove	*Zenaida macroura*	0	2	0	2
Northern bobwhite [a]	*Colinus virginianus*	15	1	0	16
Northern cardinal [a]	*Cardinalis cardinalis*	1	1	1	3
Northern harrier	*Circus cyaneus*	0	1	0	1
Red-headed woodpecker [b]	*Melanerpes erythrocephalus*	0	2	0	2
Red-winged blackbird [b]	*Agelaius phoeniceus*	5	0	0	5
Ring-necked pheasant [b]	*Phasianus colchicus*	2	0	0	2
Rufous-crowned sparrow [a]	*Aimophila ruficeps*	2	0	7	9
Rusty blackbird [a]	*Euphagus carolinus*	0	7	0	7
Savannah sparrow [a]	*Passerculus sandwichensis*	38	164	26	228
Song sparrow	*Melospiza melodia*	0	3	0	3
Spotted towhee [a]	*Pipilo maculatus*	0	1	0	1
Vesper sparrow [a]	*Pooecetes gramineus*	0	0	1	1

Species	Scientific name	SE	SU	TL	Total detections
Western meadowlark [b]	*Sturnella neglecta*	0	65	0	65
White-crowned sparrow [a]	*Zonotrichia leucophrys*	0	5	0	5
White-throated sparrow [b]	*Zonotrichia albicollis*	0	1	0	1

Appendix D. Vegetation species (%) by study site by year at Selman Ranch (SE) (*n* = 300/yr), Sutter Ranch (SU) (*n* = 300/yr), and TLW Land & Cattle Company (TL) (*n* = 240/yr) in northwestern Oklahoma, 2007–08.

		SE		SU		TL	
Species	Scientific name	2007	2008	2007	2008	2007	2008
American licorice	*Glycyrrhiza lepidota*	0.12	0	0	0	0	0
American pokeweed	*Phytolacca americana*	0	0	0	0	0.41	0
Annual buckwheat	*Eriogonum annuum*	2.63	0	2.35	0.05	0.55	0.02
Asiatic dayflower	*Commelina communis*	0	0.51	<0.01	2.06	0	<0.01
Aster	*Aster sp.*	1.59	0.11	0.17	0	0.01	0.14
Barley	*Hordeum sp.*	<0.01	0	0	0	0	0

Species	Scientific name	SE		SU		TL	
		2007	2008	2007	2008	2007	2008
Bermuda grass	*Cynodon dactylon*	0	<0.01	0.71	<0.01	0	0.52
Big bluestem	*Andropogon gerardii*	2.12	1.7	0.22	0.63	0.42	0.3
Bitter sneezeweed	*Helenium amarum*	0	0	<0.01	0	0	0
Black locust	*Robinia pseudoacacia*	0	0	0	0	<0.01	0
Black willow	*Salix nigra*	0	0	0	0	<0.01	<0.01
Blue grama	*Bouteloua gracilis*	4	2.39	1.91	1.38	0	0
Buffalo bur	*Solanum rostratum*	0	<0.01	0	0	0	0
Buffalograss	*Bouteloua dactyloides*	1.68	1.32	0.88	3.98	0.42	0
Canada wild rye	*Elymus canadensis*	<0.01	<0.01	<0.01	<0.01	0	<0.01
Carolina geranium	*Geranium carolinianum*	<0.01	0	<0.01	0	0.23	0
Catclaw sensitivebriar	*Schrankia roemeriana*	<0.01	<0.01	0	0	0	0

Species	Scientific name	SE 2007	SE 2008	SU 2007	SU 2008	TL 2007	TL 2008
Cheatgrass	*Bromus japonicus*	0	0.53	<0.01	0.35	0	0
Clover	*Trifolium sp.*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common broomweed	*Gutierrezia dracunculoides*	1.23	0	<0.01	<0.01	0	0
Common mullein	*Verbascum thapsus*	0	0	<0.01	0	0	0
Common sunflower	*Helianthus annuus*	0	0	4.03	2.75	1	0.79
Curly dock	*Rumex crispus*	0	<0.01	0	0	0	0
Daisy fleabane	*Erigeron bellidiastrum*	<0.01	<0.01	<0.01	<0.01	0	0
Dodder	*Cuscuta sp.*	0	0	<0.01	0	<0.01	0
Dotted gayfeather	*Liatris punctata*	<0.01	0	<0.01	0	<0.01	0
Downy brome	*Bromus tectorum*	<0.01	0	<0.01	0	0	0
Eastern cottonwood	*Populus deltoides*	0	0	0	<0.01	<0.01	0
Fall witchgrass	*Digitaria cognata*	0.28	0.6	0.4	1.35	2.77	0.34

Species	Scientific name	SE 2007	SE 2008	SU 2007	SU 2008	TL 2007	TL 2008
False flatsedge	*Cyperus strigosus*	0	<0.01	<0.01	1.75	0.53	0.05
Fragrant cudweed	*Gnaphalium obtusifolium*	0	0	0	<0.01	0	0
Fragrant sumac	*Rhus aromatica*	0.13	0	1.02	0.25	2.52	0.37
Gaillardia sp.	*Gaillardia sp.*	<0.01	0	0	0	0	0
Gaura sp.	*Gaura sp.*	<0.01	0	0	0	0	0
Giant sandreed	*Calamovilfa gigantea*	<0.01	0	0	0	0	0
Goathead	*Tribulus terrestris*	1.3	0	0	0	0	0
Goat's rue	*Tephrosia virginiana*	0	0	0	0	0	0.21
Grain sorghum	*Sorghum bicolor*	0	0	0.39	0	0	0
Hairy grama	*Bouteloua hirsuta*	0.12	0.65	0.67	1.31	0	0
Hairy tridens	*Erioneuron pilosum*	<0.01	0	0	0	0	0
Heath aster	*Aster ericoides*	0	0	1.48	<0.01	0.05	0

Species	Scientific name	SE		SU		TL	
		2007	2008	2007	2008	2007	2008
Illinois bundleflower	*Desmanthus illinoensis*	<0.01	0	0	<0.01	0	0
Indiangrass	*Sorghastrum nutans*	0.35	0	<0.01	0	4.59	0
James' nailwort	*Paronychia jamesii*	<0.01	0	0	0	0	0
Japanese brome	*Bromus japonicus*	0.7	1.55	<0.01	0.41	0	0.56
Johnsongrass	*Sorghum halepense*	0	0	0	<0.01	<0.01	0
Knotgrass	*Paspalum distichum*	0	0.6	0	0	0	0
Kochia	*Kochia scoparia*	<0.01	0	0	0	0	0
Kochia	*Kochia sp.*	0	0	0	0	0	<0.01
Lambsquarters	*Chenopodium album*	<0.01	0	<0.01	0.15	0	0
Lemon beebalm	*Monarda citriodora*	0	0	<0.01	0	0	0
Lespedeza	*Lespedeza sp.*	0	0	0	0	0.34	0

Species	Scientific name	SE 2007	SE 2008	SU 2007	SU 2008	TL 2007	TL 2008
Little barley	*Hordeum pusillum*	<0.01	0	0.37	<0.01	0.08	0
Little bluestem	*Schizachyrium scoparium*	12.18	13.95	5.43	1.55	22.49	14.7
Lovegrass	*Eragrostis sp.*	0.18	0.35	2.03	1.18	5.38	3.45
Mare's tail	*Conyza canadensis*	0.56	0.15	0.55	0.03	1.48	0.38
Maximilian's sunflower	*Helianthus maximilianii*	<0.01	0	<0.01	0	0	0
Mexican hat	*Ratibida columnifera*	<0.01	0	0	0	0	0
Milkvetch	*Astragalus sp.*	<0.01	0	0	<0.01	0	0
Musk thistle	*Carduus nutans*	<0.01	<0.01	<0.01	0	<0.01	0
Narrowleaf hymenoxys	*Hymenoxys linearifolia*	<0.01	0	0	0	0	0
Old world bluestem	*Bothriochloa ischaemum*	0.23	0	0	0	9.19	6.08
Paspalum	*Paspalum sp.*	<0.01	0	0	0	0	0
Pennsylvania smartweed	*Polygonum pensylvanicum*	0	0	0	0	0.13	0

Species	Scientific name	SE		SU		TL	
		2007	2008	2007	2008	2007	2008
Pepperweed	*Lepidium virginicum*	0	0.1	0	0.76	0	0
Plains yucca	*Yucca campestris*	0	0.15	0.33	0.38	0.97	0.15
Plantain	*Plantago sp.*	0.07	0.1	0.59	0.07	0.02	0.02
Prairie cupgrass	*Eriochloa contracta*	0	0	0.24	0	0	0
Prairie ground cherry	*Physalis hispida*	<0.01	<0.01	0	<0.01	<0.01	0
Prairie spurge	*Euphorbia missurica*	0	0	<0.01	0.6	0	0
Prairie threeawn	*Aristida oligantha*	1.73	0.15	1.02	0.3	0	0
Prickly pear	*Opuntia macrorhiza*	0	0.05	0.26	<0.01	0	0
Prostrate spurge	*Euphorbia prostrata*	0.38	0	0	0.13	0	0
Pussy-toes	*Antennaria sp.*	<0.01	0	<0.01	0	<0.01	0
Redroot pigweed	*Amaranthus retroflexus*	0	0	<0.01	0	0	0

Species	Scientific name	SE 2007	SE 2008	SU 2007	SU 2008	TL 2007	TL 2008
Rescuegrass	*Bromus catharticus*	0	0	0.23	0	0.46	0
Roundhead lespedeza	*Lespedeza capitata*	0	0	0	0	0	0.24
Russian thistle	*Salsola tragus*	0	0	0.46	0.15	0	0
Sagewort	*Artemisia ludoviciana*	7.06	4.33	0.23	0.4	1.47	0.81
Salvia	*Lamiacae sp.*	0	0	0	0	0	<0.01
Sand dropseed	*Sporobolus cryptandrus*	0.13	1.68	0	3.82	0	0.4
Sand plum	*Prunus angustifolia*	1.71	1.41	2.19	2.83	2.16	2.82
Sandbur	*Cenchrus incertus*	0.27	1.58	4.84	3.62	2.19	0.25
Sandsage	*Artemisia filifolia*	10.51	5.14	3.68	2.02	0.79	0.08
Scribner's panicum	*Panicum oligosanthes*	0	0	0	1.03	0	1.15
Scurfpea	*Psoralidium tennuiflorum*	0	0.20	0.05	0.05	0	0
Sedge	*Carex sp.*	0	0	0	0	<0.01	0

		SE		SU		TL	
Species	Scientific name	2007	2008	2007	2008	2007	2008
Showy evening primrose	*Oenothera grandis*	0	0	<0.01	0	0	0
Showy partridge pea	*Chamaecrista fasciculata*	<0.01	0	0	0.05	1	<0.01
Sideoats grama	*Bouteloua curtipendula*	5.34	6.62	0.37	2.16	0.13	0.49
Silver bluestem	*Bothriochloa saccharoides*	2.27	0.85	0	0.1	0	0
Silverleaf nightshade	*Solanum elaeagnifolium*	0.02	0.4	0.23	0.05	0	0
Slickseed fuzzybean	*Strophostyles leiosperma*	0.06	0	0.47	0	0.82	0
Snow on the mountain	*Euphorbia marginata*	0.1	0	0	0	0	0
Solanaceae	*Solanaceae sp.*	0	0	0	0	<0.01	0
Splitbeard bluestem	*Andropogon ternarius*	0.13	0.23	0	0	0	0
Spurge	*Euphorbia sp.*	<0.01	0	0	0	0	0
Stellaria	*Stelleria sp.*	0	0	0	0	<0.01	0
Sumpweed	*Iva annua*	0	0	0	0.02	0	0

Species	Scientific name	SE		SU		TL	
		2007	2008	2007	2008	2007	2008
Switchgrass	*Panicum virgatum*	0.41	0.35	0.27	1.15	0	0.18
Tall dropseed	*Sporobolus asper*	3.28	0.25	2.12	0.28	0.12	0.02
Tenpetal blazingstar	*Mentzelia decapetala*	0.06	0.2	0.03	1.13	0	0
Texas croton	*Croton texensis*	1.45	0.3	0.26	0.59	0.26	0.19
Thin paspalum	*Paspalum setaceum*	0	0.16	2.31	2.72	0.07	0.06
Threeseed croton	*Croton lindheimerianus*	0.43	0	0	0.40	0	0.03
Tumblegrass	*Schedonnardus paniculatus*	0	0	0.45	0	0	0
Unknown forb		0.71	0.43	1.66	0.11	0.10	0.19
Unknown grass		0.09	0	0.55	0	0.07	0
Vente conmigo	*Croton glandulosus*	0	0.32	1.87	3.58	1.66	0.03
Wax goldenweed	*Haplopappus ciliatus*	0	0	0.12	0	0	0.03

		SE		SU		TL	
Species	Scientific name	2007	2008	2007	2008	2007	2008
Western ragweed	*Ambrosia psilostachya*	2.58	8.09	5.63	3.51	4.06	4.72
Western wheatgrass	*Elymus smithii*	0.36	0.2	0.05	0.58	0	<0.01
Wheat	*Triticum sp.*	0	0	0.17	0	0	0
Windmill grass	*Chloris verticillata*	0.05	0.05	0.14	<0.01	0.06	0
Woods bedstraw	*Galium circaezans*	0.05	0	0	0	0	0
Woodsorrel	*Oxalis sp.*	0.15	0	<0.01	<0.01	0.31	<0.01
Woolly loco	*Astragalus mollissimus*	0	0.05	0	0	0	0
Yarrow	*Achillea millefolium*	0.13	0	0	0	0	0

CURRICULUM VITA

Brett S. Cooper

Candidate for the Degree of

Master of Science

Thesis: SAND PLUM RELATIONSHIPS WITH AVIAN ABUNDANCE IN OKLAHOMA

Major Field: Natural Resource Ecology and Management

Biographical:

Education: Completed the requirements for the Bachelor of Science in Fisheries and Wildlife Biology at Northeastern State University, Tahlequah, Oklahoma in December 2006. Completed the requirements for the Master of Science in Natural Resource Ecology and Management at Oklahoma State University, Stillwater, Oklahoma in May 2009.

Experience: Graduate Research Assistant, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, Oklahoma, 2007–2009.

Research Assistant, Department of Natural Sciences, Northeastern State University, Tahlequah, Oklahoma, 2005–2006.

Professional Memberships: The Wildlife Society
American Fisheries Society

Name: Brett S. Cooper Date of Degree: May, 2009

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: SAND PLUM RELATIONSHIPS WITH AVIAN ABUNDANCE IN OKLAHOMA

Pages in Study: 56 Candidate for the Degree of Master of Science

Major Field: Natural Resource Ecology and Management

Scope and Method of Study: I collected avian detections with point-counts and vegetation measures at 3 study sites in northwestern Oklahoma during 2007–08. Sand plum (*Prunus angustifolia*) thicket measures included height, stem density, area, age, and average thicket area. Herbaceous measures included percent grass, forb, and shrub cover; maximum herbaceous height; and vegetation species richness. I used a hand-held global positioning system (GPS) and a geographical information system (GIS) to digitize and buffer detections for affinity to sand plum. I used means and confidence intervals to relate vegetation measures with avian relative abundance. I used weighted means to describe habitat variables for avian species that had no meaningful relationships to sand plum.

Findings and Conclusions: I sampled 42 independent points ≥4 times per year for 2 years from early May to mid June during 2007–08. Of the 42 points, 16 were grassland with no plum cover, 23 had sand plum cover of <50 %, and 3 had sand plum cover of >50 %. I grouped sand plum cover into 4 categories that included 0 %, 1–10 %, 11–20 %, and >40 %. I detected 51 avian species and identified 118 plant species. Species detections ≤30 m from a sand plum thicket ranged from 72.9 ± 9.3 % SE for Bell's vireo to 16.4 ± 6.6 % SE for western meadowlark. Bell's vireo mean detections were highest in the 11–20% sand plum cover category (1.2 ± 1.3, 95% CI) and lowest in 0% sand plum cover (0.02 ± 0.03, 95% CI). Grasshopper sparrow mean detections were highest in the 0% sand plum cover category (0.7 ± 0.2, 95% CI) and lowest in the 1–10% sand plum cover categories (0.1 ± 0.1, 95% CI). Western meadowlark mean detections were highest in the 0% sand plum cover category (0.4 ± 0.2, 95% CI) and lowest in the 1–10% sand plum cover categories (0; 0.04 ± 0.1, 95% CI). Bell's vireo, lark sparrow, and field sparrow were detected in the highest weighted mean sand plum cover (16.9 ± 4.1, 14.0 ± 3.3, and 12.2 ± 2.8 % SE respectively) and northern bobwhite, grasshopper sparrow, and Cassin's sparrow were detected in the lowest weighted mean sand plum cover (4.2 ± 1.9, 4.2 ± 2.8, and 4.9 ± 1.8 % SE respectively).

ADVISER'S APPROVAL: Dr. R. Dwayne Elmore