Evaluation of Farm Bill Programs to benefit Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*)

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ABSTRACT

The Lesser Prairie-Chicken (LEPC) is an iconic bird of the Southern Great Plains. However, its populations have declined by >90% through habitat loss and fragmentation. New and continued threats caused the U.S. Fish and Wildlife Service to propose the bird for listing as a Threatened species under the U.S. Federal Endangered Species Act. Farm Bill conservation programs administered through the Natural Resources Conservation Service provide some of the best opportunities for conservation and restoration of prairie ecosystems essential for LEPC survival. Thus, a new initiative, the Lesser Prairie-Chicken Initiative, was created to target federal conservation dollars toward conserving this species. The purpose of this project was to evaluate the potential for Farm Bill programs included in the LPCI to provide benefit to LEPC. We evaluated landscape composition (Grassland, Conservation Reserve Program grasslands, and Environmental Quality Incentive Program fields) at multiple spatial scales to understand both lek presence and density. We found that Grassland and CRP was higher at Lek points than No Lek points at multiple spatial scales, however, EQIP was not related to LEPC presence at any scale. Low Density points had more Grassland than High or None points at small scales (<510 m) and large scales (>4020 m), but CRP was greater at High density points than Low or None across all spatial scales except the smallest (150 m) and largest (10000 m). In addition, there was more EQIP at High density points at two spatial scales (4020 m and 5010 m). Finally, preliminary analyses of landscape structure variables at one spatial scale (10000 m) showed that Largest Patch Index and Contiguity Index were significantly higher at Lek points and Contiguity Index was higher at High density points. These results demonstrate the importance of Farm Bill programs to conservation of LEPC and support current conservation efforts to target grassland conservation at expanding blocks of grassland to increase size and connectivity.

INTRODUCTION

In 2003, a multi-agency effort initiated the Conservation Effects Assessment Project (CEAP) to quantify environmental benefits of U.S. Department of Agriculture (USDA) conservation programs such as the Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), and Environmental Quality Incentives Program (EQIP). This project is part of the Wildlife Component of CEAP which was created to quantify effects of conservation programs on wildlife in agricultural landscapes.

The Playa Lakes Joint Venture (PLJV) and Natural Resources Conservation Service (NRCS) designed this CEAP project to evaluate the potential for Farm Bill programs included in the Lesser Prairie-Chicken (LEPC) Initiative to provide benefit to Lesser Prairie-Chickens.

Background
The PLJV is a non-profit partnership of federal and state wildlife agencies, conservation groups, private industry, and landowners dedicated to conserving bird habitat in the western Great Plains. We provide science-based guidance and decision-support tools for all-bird conservation throughout the region, as well as outreach, coordination and financial support to our partners and local groups to conduct on-the-ground habitat work. The PLJV works in the western Great Plains which includes eastern Colorado and New Mexico, western Nebraska, Kansas, and Oklahoma, and the Texas Panhandle (figure 1). The region largely encompasses the shortgrass and mixed-grass Bird Conservation Regions (BCR 18 and 19, respectively; figure 1). The PLJV also works cooperatively with Rainwater Basin Joint Venture (RWBJV) which spans the northern portion of BCR19.

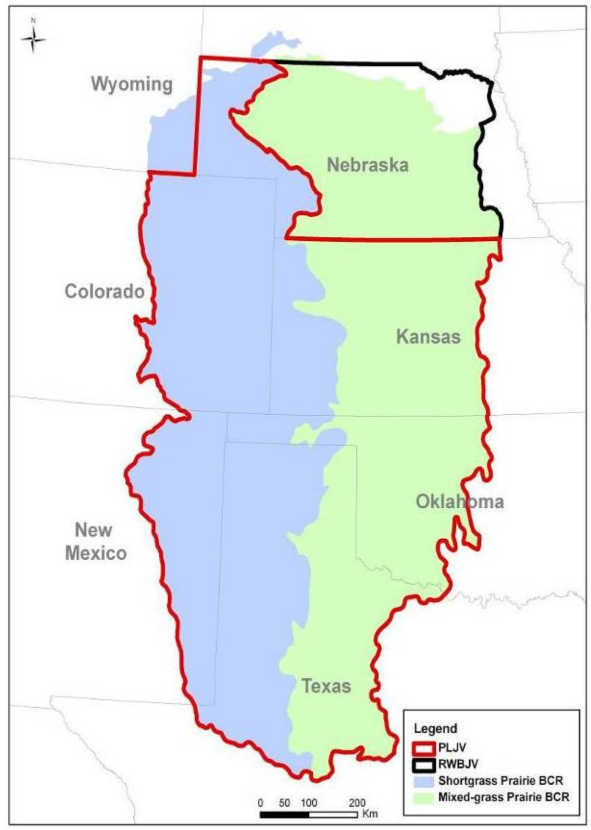


Figure 1. The shortgrass prairie and mixed-grass prairie Bird Conservation Regions (BCRs 18 and 19) and the boundaries of the Playa Lakes Joint Venture (PLJV) and Rainwater Basin Joint Venture (RWBJV).

Justification
The Food Security Act of 1985 (one of a series of USDA policy bills commonly referred to as "Farm Bill") established a conservation funding program. The Conservation Reserve Program (CRP) was the first program established under this new funding. Since that time, due to the success of the CRP, a number of additional conservation programs have been established under succeeding Farm Bills, such as Environmental Quality Incentive Program (EQIP), Wildlife Habitat Improvement Program (WHIP), Grassland Reserve Program (GRP) and Farm and Ranch Protection Program (FRPP) to name a few.

Under CRP, private landowners voluntarily remove highly erodible and environmentally sensitive land from crop production and establish vegetative cover on it. Landowners are paid for enrolling their land through an annual, per-acre rental rate and enrollment contracts which span 10 to 15 years. The main goals of the CRP are to reduce soil erosion, improve water and air quality, and provide wildlife habitat. Over 35 million acres of marginal cropland are currently enrolled in CRP nation-wide. Of those, more than 25 million acres are planted to vegetation dominated by grasses (U.S. Department of Agriculture 2004a), including nearly 4.8 million acres in the short and central mixed-grass prairies (BCRs 18&19).

EQIP and WHIP are land improvement programs that provide financial assistance in the form of cost-share payments to producers to implement conservation practices on their property to address natural resources concerns. WHIP programs specifically address wildlife habitat. In Federal Fiscal Year 2011, ≥ 13 million acres were treated with EQIP programs (totaling approximately $864 million) with greater than 848,000 acres also enrolled in WHIP, totaling approximately $60 million.

The GRP and FRPP are both easement programs in which farmers voluntarily restrict the current and future development and cropping uses of their property for the purpose of protecting grazing operations and the related wildlife resources. In Fiscal Year 2011, 129 GRP easements were enrolled totaling 105,119 acres. Over the life of the program (2003-2011), 138 easements have been enrolled in states with Lesser Prairie-Chickens, totaling over 141,000 acres.

In 2011, the NRCS announced the LEPC Initiative. The purpose of this initiative is to use various Farm Bill programs to do conservation for the benefit of the LEPC. The focus of the initiative is on EQIP, WHIP, GRP and FRPP, although CRP is recognized as an important tool in LEPC conservation.

While, few formal studies of LEPC breeding success or habitat use in CRP have been conducted to date, numerous observational studies and anecdotal evidence suggest that CRP is an important tool for conserving LEPC. Field studies conducted in the Colorado and Kansas portions of the LEPC range have documented LEPCs lekking, nesting, and roosting in grassland provided by the CRP (Fields et al. 2006, Davis et al. 2008). In Kansas, LEPC nests were found predominately in CRP with mid to tall native warm season grasses (Fields et al. 2006). In Colorado, leks were found in CRP fields with stunted 'sod-like' grass cover, providing the sparse and low-stature vegetation associated with leks (Davis et al. 2008). Biologists think that native CRP located within 2-miles of native grassland has the most potential to serve as suitable nesting habitat (Davis et al. 2008). Conversely, in the Texas, New Mexico, and Oklahoma portions of the LEPC range, it appears that CRP may not be providing suitable LEPC habitat, although LEPC have been observed in CRP fields in the southwest Texas Panhandle. In these states, CRP fields are predominately characterized by weeping lovegrass (*Eragrostis curvula*) and non-native bluestem species (*Bothriochloa* spp). Two previous CEAP assessments by the PLJV (McLachlan and Rustay 2007, McLachlan and Carter 2009) quantified the current benefit of CRP to LEPC, showing that the degree of benefit varied by state and BCR, with CRP in Kansas providing the most benefit (CRP in Kansas is planted to native species unlike other states in the LEPC range; McLachlan and Rustay 2007, McLachlan and Carter 2009).

Numerous studies have documented impacts of CRP on wildlife, particularly grassland birds. However, a literature search showed that there has been no evaluation of Farm Bill programs such as EQIP and WHIP on grassland wildlife, the primary focus of the LEPC Initiative. This may be for two reasons. First, the EQIP and WHIP programs are relatively new programs in the Farm Bill. Second, and most likely, unlike CRP which converts agricultural fields to permanent grass cover, thus demonstrating a quantifiable shift from one landcover to another, EQIP and WHIP are habitat improvement programs that change grassland structure. These are generally grasslands or expiring CRP fields that are enrolled to improve grazing practices thus making quantification of shifts difficult to document. This is the first study to attempt to document impacts of EQIP and WHIP on LEPC.

The purpose of this project was to evaluate the potential for Farm Bill programs included in the LPCI to provide benefit to LEPC. Therefore we ask the following questions: 1) Is there a difference in landcover composition (CRP, Grassland and EQIP contracts) between Lek and No Lek points and High lek density versus Low lek density points? 2) Is there a difference in the number of EQIP contracts between Lek and No Lek points and High lek density versus Low lek density points? 3) At what spatial scale are differences among landcover types at Lek and No Lek points and High versus Low lek density points observed?

METHODS

Study area

BCR18 is located in the western portion of the Great Plains of North America, encompassing portions of seven states including Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 1). BCR18 spans over 95 million acres of gently sloping terrain comprised of a variety of habitats, both naturally occurring (e.g., prairie, wetlands, streams) and man-made (e.g., cropland, urban areas, reservoirs). The shortgrass prairie is dominated by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) interspersed with small amounts of tallgrass species in the east (e.g., little bluestem (*Schizachyrium scoparium),* Indian grass (*Sorghastrum nutans*)). Common shrub species occurring in BCR18 are sand sagebrush (*Artemisia filifolia*) and sand shinnery oak (Q*uercus havardii rydb*.). Woodland habitat ranges from scattered cottonwood trees (*Populus* spp.), small clustered plantings of Siberian elm (*Ulmus pumila*) and Russian olive (*Elaeagnus angustifolia*) to large expanses of honey mesquite (*Prosopis glandulosa)* and eastern redcedar (*Juniperus virginiana*). Historically dominated by grassland and shrubland habitat, BCR18 now has as much cropland (comprising about 43% of its total landcover) as it does native grassland and shrubland combined. Major crop types are wheat, sorghum, corn, soybeans, sunflowers, and alfalfa. Over 3 million acres of former cropland in BCR18 (about 8%) are currently enrolled in the CRP.

BCR19 is located in the eastern portion of the Great Plains of North America, encompassing portions of four states including Kansas, Nebraska, Oklahoma, and Texas (figure 1). BCR19 spans over 97 million acres of gently sloping terrain comprised of a variety of habitats, both naturally occurring (e.g., prairie, wetlands, streams) and man-made (e.g., cropland, urban areas, reservoirs). Mixed-grass prairie vegetation is an integration of the shortgrass species to the west (e.g., blue grama, buffalo grass) and the tallgrass species to the east (e.g., little bluestem*,* Indian grass). Common shrub species occurring in BRC19 are sand sagebrush and sand shinnery oak. Woodland habitat ranges from scattered cottonwood trees, and small clustered plantings of Siberian elm, Russian olive, and eastern redcedar to large expanses of honey mesquite, juniper (*Juniperus* spp.), and eastern redcedar. Historically dominated by mixed-grass prairie, BCR19 is now dominated by cropland (comprising nearly 54% of its total landcover). Major crops are corn, soybeans, wheat, sorghum, sunflowers, and alfalfa. Approximately 1.7 million acres of former cropland in BCR19 (about 4%) are currently enrolled in CRP.

Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*)

The LEPC, a resident grouse species endemic to the Southern Great Plains, is a species of high conservation concern. In November 2012, it was proposed for listing under the Federal Endangered Species Act as Threatened. It is currently considered a Watch List Species according to Partners in Flight, a species of Highest Continental Concern according to the American Bird Conservancy, a State Threatened species in Colorado and it was petitioned in Kansas to be listed as a state threatened species.

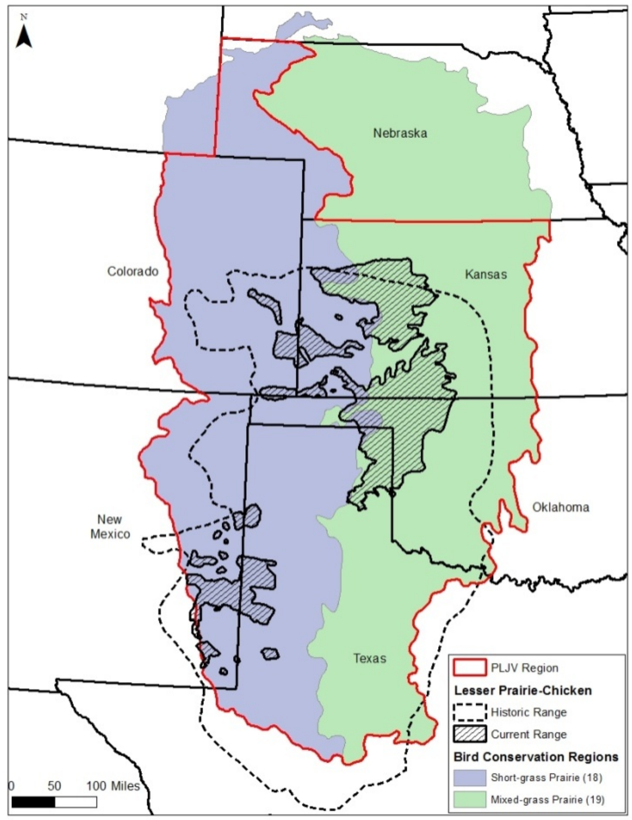


Figure2. The historical and current estimated occupied range of the Lesser Prairie-Chicken

Lesser Prairie-Chickens were once found abundantly throughout the short- and central mixed-grass prairie regions in Colorado, Kansas, New Mexico, Oklahoma and Texas. Since European-American settlement, their population range has been reduced to 10% of its original extent (Figure 2; currently about 16 million acres) and population numbers have also declined by >90%. The decline is due to habitat degradation, fragmentation and loss due to agriculture and energy development.

Lesser Prairie-Chickens currently are patchily distributed in southern portions of BCRs 18 and 19 in Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 2). They are most abundant in the northwestern portion of Kansas (McDonald et al. 2012). Habitat use varies across their range but generally consists of dwarf shrub-mixed-grass vegetation types associated with sandy soils, which may be interspersed with shortgrass or mixed-grass prairie (Taylor and Guthery 1980; see Hagan 2005). Habitat is comprised of sandsage brush prairie in Kansas (Andrews and Righter 1992, Giesen 1994, Busby and Zimmerman 2001) and Colorado, mixed-grass prairie and CRP in Kansas, and sand shinnery oak prairie in Oklahoma, Texas (Riley et al. 1992, Jackson and DeArment 1963; see Hagan 2005) and New Mexico. This species also uses CRP in some areas outside of Kansas (Davis et al. 2008) as well as cropland (Crawford and Bolen 1976).

Lek Data

Lek data were obtained from all five of the LEPC states. In 2012 the Lesser Prairie-Chicken Interstate Working Group (IWG) piloted a helicopter survey throughout the LEPC range. The pilot survey used a random sampling approach to select blocks and transects to survey, thus, providing publicly available, randomly sampled, lek data using a consistent protocol. The IWG helicopter surveys randomly selected 256 15km X 15km blocks throughout the LEPC region. Two transects, 750 m apart, were flown within each block. Three observers noted lek location and number of birds on each lek. Additional details can be found in the report (McDonald et al. 2012). These data were supplemented with data from states that also had random sampling design for lek surveys including Colorado, Oklahoma and Texas. Sixty-seven leks were used in the analysis; 18 leks in Colorado, 30 leks in Kansas, 5 leks in New Mexico, 3 leks in Oklahoma, and 11 leks in Texas.

We also collected landcover data at 30 pseudo-absence points. These points were randomly selected from within surveyed blocks of the IWG group helicopter survey in which a LEPC lek was not observed. Pseudo-absence points were selected from these blocks to increase probability that "true" absence points were measured. In addition, pseudo-absence points were >20km from the next nearest lek point or pseudo-absence point to reduce buffer overlap (buffers described below).

Landcover data

The PLJV maintains a seamless six-state landcover with a 30 m spatial resolution (see details in McLachlan et al. 2007). This landcover was updated with 2011 CRP data. In the landcover, there are 22 habitat types designated. We aggregated these landcover types into six categories (Cropland, CRP, Developed, Grassland, Wetland, and Woodland). However, only CRP and Grassland were used in statistical analyses. Cropland was negatively correlated with Grassland and because we are more interested in describing grassland dynamics, Cropland was excluded from analyses.

A seventh category was EQIP which was a broad category that included EQIP, WHIP, GRP and FRPP programs, programs included in the LEPC Initiative. We included data from 2008-2012. We further narrowed the focus of these programs to include only those fields which were enrolled in a LEPC Initiative approved practice. EQIP and WHIP in particular have a large number of programs for grassland improvement, however, not all are thought to improve habitat for LEPC. Thus the NRCS created a list of approved practices for LEPC which are also described in the 2011 conference report between the NRCS and USFWS. Finally, we removed LEPC Initiative practices such as fence marking that are linear features or those that have no acreages associated with them. Table 1 lists the practices included in this analysis.

Table 1. List of EQIP practices included in the CEAP analysis.

Practice Number	Description
314	Brush Management
338	Prescribed Burning
528	Prescribed Grazing
550	Range Planting
643	Restoration of Rare and Declining Habitat
645	Upland Wildlife Habitat Management

Unlike the CRP dataset which is a polygon shapefile of the fields that are enrolled in CRP, the EQIP dataset is a point shapefile which has each point attributed for the program in which the land owner or manager is enrolled and the number of acres enrolled (e.g., the points are not necessarily associated with a field). Therefore, several assumptions must be made about the data. First, we assume that the point is located in the field in which the practice is employed. However, we recognize that the point may be located at the physical address of the land owner/manager (e.g., on the house) or that the contract may be for several fields which may be either adjacent or scattered throughout the property or landscape. Second, we assumed that the point was at the center of a circle whose area was equivalent to the number of acres attributed to that point. This was done for two reasons; 1) to deal with the limitations of the first assumption and 2) for ease of processing. Third, because no pre- or post-practice condition data were recorded, we assume that the practice has been completed to a condition that would benefit LEPC. For these reasons, the EQIP data were not incorporated into the landcover but analyzed separately. Finally, because EQIP was not incorporated into the landcover and is present on already established grasslands, there is the potential to have grass acres represented in both the Grassland category and the EQIP category (e.g., EQIP may be redundant with some Grassland areas). Therefore, we analyzed EQIP separately. If the amount of Grassland was different between Lek and No Lek points or among High Low or None lek density points, we asked the follow-up questions: 1) Is there a difference in amount of EQIP acres? 2) Is there a difference between the proportion of points with EQIP contracts at LEPC Lek vs No Lek points and among High, Low and None lek density points?

GIS analysis

We wanted to determine if there was a spatial scale at which landscape composition no longer differed between LEPC Lek and No Lek points and among High and Low lek density points (described below). This information is useful for understanding the appropriate spatial scale at which conservation efforts will be most important. Using PLJV's landcover data, we calculated the number of acres of CRP, Grassland, and EQIP within circular buffers around Lek and No Lek points at several spatial scales. We used 150, 240, 420, 510, 810, 1020, 1620, 2010, 3000, 4020, 5010, 7500, and 10000 m radius buffers. A study by Fuhlendorf et al. (2002) showed that landscape change at 4.8 km best explained the difference between leks classified as declining versus stable. In a follow-up conversation with Fuhlendorf, we were advised to expand our spatial scales beyond 5000m because the spatial relationship they describe had not yet reached a threshold (e.g., LEPC were likely responding to landcover changes at scales greater than 4.8 km).

We used FRAGSTATS (McGarigal et al. 2012) to collect data on landscape structure at the 10000 m buffer scale for four different variables. We calculated these variables at the 10000 m scale because preliminary analyses indicated this was the largest scale at which a difference between landscape composition was detected. We defined habitat as Grassland only and Grassland+CRP, these two measures of habitat were analyzed separately. We included a Grassland+CRP habitat category to determine if effect of landscape structure was different when CRP was included. We treated each 10000 m buffered lek as a separate landscape. Largest Patch Index describes the largest patch of habitat within the landscape (e.g., 10000 m buffer) as a function of the total amount of area in the landscape. Area-weighted mean patch size calculates the mean of the areas of all the patches in the landscape weighted toward the larger patch sizes. This metric is considered a better description of impact of patch area on the landscape because it better reflects how an organism relates to the landscape. Area-weighted Shape Index calculates the amount a patch shape deviates from a square. Area-weighted Contiguity Index calculates the degree to which a patch extends across a landscape. Complete descriptions of the metrics used can be found at the Fragstats website (McGarigal et al. 2012): http://www.umass.edu/landeco/research/fragstats/documents/fragstats_documents.html.

Statistical analysis

We analyzed differences in landcover among LEPC leks in two different ways. First, we characterized landcover between Lek (n=67) versus No Lek points (n=30). Then we characterized leks as either High density, Low density or None (pseudo-absence points). High and Low density leks were determined by creating a 4.8 km buffer around each lek point, then counting the number of other lek points which fell within the buffer. If there were no other lek points within the buffer, the lek was classified as Low density lek. If there was more than one lek point within the buffer, the lek was classified as a High density lek. There were 42 Low density leks, 25 High density leks and 30 non-lek points or pseudo-absence points (None, hereafter).

To avoid pseudo-replication at the various spatial scales (e.g., the amount of landcover in the 150m buffer is also present in the 240m buffer and thus would be analyzed twice), we subtracted the number of hectares of a landcover of the smaller buffer from the next larger buffer (e.g., Grassland at 240m – Grassland at 150m). This gives us a series of rings or "donuts". This allowed us to evaluate the relative contribution of the landcover at each distance to LEPC lek presence/absence or density independently.

By definition our lek density data were spatially auto-correlated. Therefore, we used a Generalized Linear Mixed Model with a spatial autocorrelation correction to account for the spatial relationship (Dormann et al. 2007). For lek density analyses (High, Low and None points) we used a normal distribution; for the Lek vs No Lek analyses we used a binomial distribution. We used the MASS package in program R to complete statistical analyses. Because all the buffers were selected *a priori* and we analyzed buffer rings, not the entire buffer distance, we did not correct for multiple comparisons. In addition, the landscape variables were selected *a priori*, and thus no correction for multiple comparisons was needed. We used a significance level of $\alpha = 0.10$.

RESULTS

Lek/No Lek

Landscape Composition

Amount of Grassland and CRP was significantly greater at Lek points than at No Lek (None) points at all spatial scales except 150 m (Table 2, Figures 3, 4). Because amount of Grassland was significant, we then asked if amount of EQIP was a significant explanatory factor (Table 3). Amount of EQIP was not significantly different at Lek points compared to No Lek points.

Landscape Structure

For Grass only calculations, Largest Patch Index (LPI) and Contiguity Index were significantly greater at Lek points (LPI: mean = 17.2, sd = 22.01, n = 67; Contiguity: mean = 0.94, sd = 0.03, n=67; Table 4) than No Lek points (LPI: mean = 10.73, sd = 15.82, n = 30; Contiguity: mean = 0.91, sd = 0.07, n = 30; Table 4). For Grass+CRP calculations, Largest Patch Index and Contiguity Index were significantly greater at Lek points (LPI: mean = 19.03, sd = 22.09, n = 67; Contiguity: mean = 0.95, sd = 0.02, n = 67; Table 4) than No Lek points (LPI: mean = 14.29, sd = 18.19, n = 30; Contiguity: mean = 0.93, sd = 0.03, n = 30; Table 4).

Area-weighted mean and Shape Index were not significantly different at Lek (Area: mean = 3930.6, sd = 6672.4, n = 67; Shape: mean = 5.21, sd = 5.26, n = 67; Table 4) and No Lek (Area: mean = 2156.0, sd = 4115.3, n = 30; Shape: mean = 4.25, sd = 3.49, n = 30; Table 4) points for Grass only calculations. Area-weighted mean and Shape Index were not significantly different at Lek (Area: mean = 4164.3, sd = 6722.5, n = 67; Shape: mean = 5.29, sd = 5.36, n = 67; Table 4) and No Lek (Area: mean = 3042.5, sd = 5044.0, n = 30; Shape: mean = 4.79, sd = 3.98, n = 30; Table 4) points for Grass+CRP calculations.

Table 2: GLMM spatial model results of differences in Grassland and CRP at Lek and No Lek points at different spatial scales. * indicates a significant difference at the p = 0.1 level. †indicates that the test was significant at the p = 0.1 level, but these scales were not part of the original hypothesis.

distance	variable	value	SE	df	t-value	p-value
150	Intercept	-0.57	0.51	94	-1.12	0.27
	Grass	0.06	0.04	94	1.4	0.16
	CRP	0.08	0.05	94	1.47	0.14
240	Intercept	-0.68	0.5	94	-1.37	0.17
	Grass	0.06	0.03	94	1.91	0.06*
	CRP	0.08	0.04	94	2.1	0.04*
420	Intercept	-0.87	0.5	94	-1.76	0.08
	Grass	0.02	0.1	94	2.4	0.02*
	CRP	0.04	0.02	94	2.96	0.004*
510	Intercept	-0.94	0.5	94	-1.9	0.06
	Grass	0.04	0.01	94	2.53	0.01*
	CRP	0.08	0.02	94	3.08	0.003*
810	Intercept	-1.07	0.51	94	-2.08	0.04
	Grass	0.009	0.003	94	2.62	0.01*
	CRP	0.02	0.006	94	3	0.003*
1020	Intercept	-0.96	0.52	94	-1.85	0.07
	Grass	0.01	0.004	94	2.19	0.03*
	CRP	0.01	0.006	94	2.53	0.01*
1620	Intercept	-1.13	0.54	94	-2.09	0.04
	Grass	0.003	0.001	94	2.55	0.01*
	CRP	0.005	0.002	94	2.73	0.008*
2010	Intercept	-1.07	0.54	94	-1.99	0.05
	Grass	0.003	0.001	94	2.33	0.02*
	CRP	0.005	0.002	94	2.5	0.01*
3000	Intercept	-1.15	0.57	94	-2.01	0.05
	Grass	0.001	0.0004	94	2.21	0.03*
	CRP	0.002	0.001	94	2.28	0.02*
4020	Intercept	-1.26	0.58	94	-2.18	0.03
	Grass	0.001	0.0003	94	2.36	0.02*
	CRP	0.002	0.001	94	2.37	0.02*
5010	Intercept	-1.19	0.6	94	-1.97	0.05
	Grass	0.001	0.0003	94	2.1	0.04*
	CRP	0.001	0.001	94	1.96	0.05*
7500	Intercept	-1.67	0.66	94	-2.53	0.01
	Grass	0.0003	0.0001	94	2.94	0.004*
	CRP	0.001	0.0003	94	2.04	0.04*
10K	Intercept	-1.76	0.72	94	-2.43	0.02

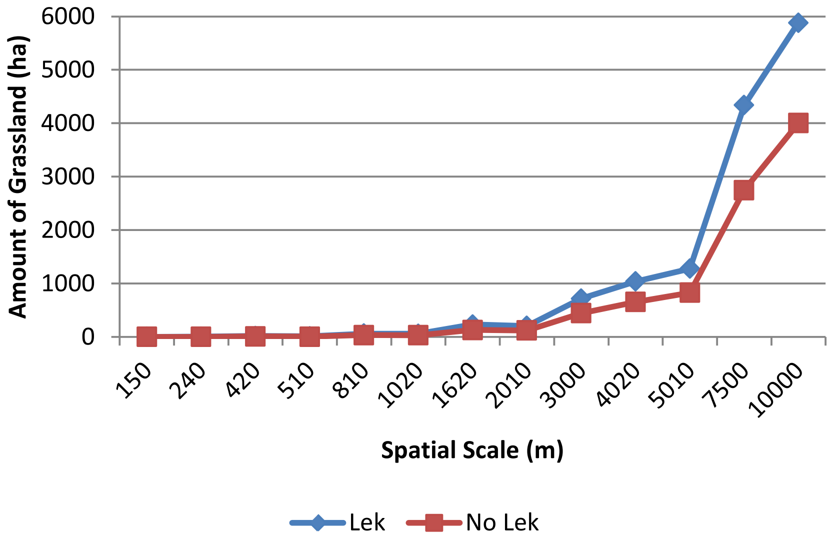
	Grass	0.0002	0.0001	94	2.77	0.007*
	CRP	0.0004	0.0002	94	1.9	0.06*
15K	Intercept	-2.28	0.86	94	-2.66	0.009
	Grass	0.0001	0.00004	94	2.87	0.005†
	CRP	0.0002	0.0001	94	2.01	0.05†
20K	Intercept	-2.05	0.93	94	-2.2	0.03
	Grass	0.0001	0.00003	94	2.48	0.01†
	CRP	0.0001	0.0001	94	1.42	0.16

Table 3: GLMM spatial model results of differences of EQIP at Lek and No Lek points at different spatial scales. * indicates a significant difference at the p = 0.1 level. †indicates that the test was significant at the p = 0.1 level, but these scales were not part of the original hypothesis.

distance	variable	value	SE	df	t-value	p-value
240	Intercept	-0.32	0.51	95	-0.64	0.53
	EQIP	-0.01	0.03	95	-0.22	0.83
420	Intercept	-0.32	0.51	95	-0.64	0.53
	EQIP	-0.002	0.01	95	-0.22	0.83
510	Intercept	-0.32	0.51	95	-0.64	0.53
	EQIP	-0.003	0.01	95	-0.23	0.82
810	Intercept	-0.33	0.51	95	-0.64	0.52
	EQIP	-0.001	0.003	95	-0.18	0.86
1020	Intercept	-0.33	0.51	95	-0.65	0.51
	EQIP	-0.0001	0.003	95	-0.04	0.97
1620	Intercept	-0.33	0.51	95	-0.66	0.51
	EQIP	-0.00002	0.001	95	-0.02	0.98
2010	Intercept	-0.33	0.51	95	-0.66	0.51
	EQIP	0.00002	0.001	95	0.02	0.99
3000	Intercept	-0.34	0.51	95	-0.66	0.51
	EQIP	0.00002	0.0005	95	0.04	0.97
4020	Intercept	-0.38	0.51	95	-0.74	0.46
	EQIP	0.0002	0.0004	95	0.49	0.63
5010	Intercept	-0.37	0.51	95	-0.73	0.47
	EQIP	0.0002	0.0004	95	0.44	0.66
7500	Intercept	-0.38	0.52	95	-0.73	0.47
	EQIP	0.00005	0.0001	95	0.37	0.71
10K	Intercept	-0.53	0.57	95	-0.94	0.35
	EQIP	0.0001	0.0002	95	0.82	0.42
15K	Intercept	-0.48	0.57	95	-0.85	0.4
	EQIP	0.00003	0.00005	95	0.61	0.55
20K	Intercept	-0.8	0.61	95	-1.31	0.19
	EQIP	0.0001	0.00004	95	1.57	0.12

Figure 3: Mean amount of Grassland at Lek and No Lek points at multiple spatial scales, a) All spatial scales, b) 150 m, 240 m, 420 m, 510 m, 810 m, 1020 m scales, c) 1620 m, 2010 m, and 3000 m scales, d) 4020 m, 5010 m, 7500 m, and 10K scales. Note the changing scale on the y-axis.

a



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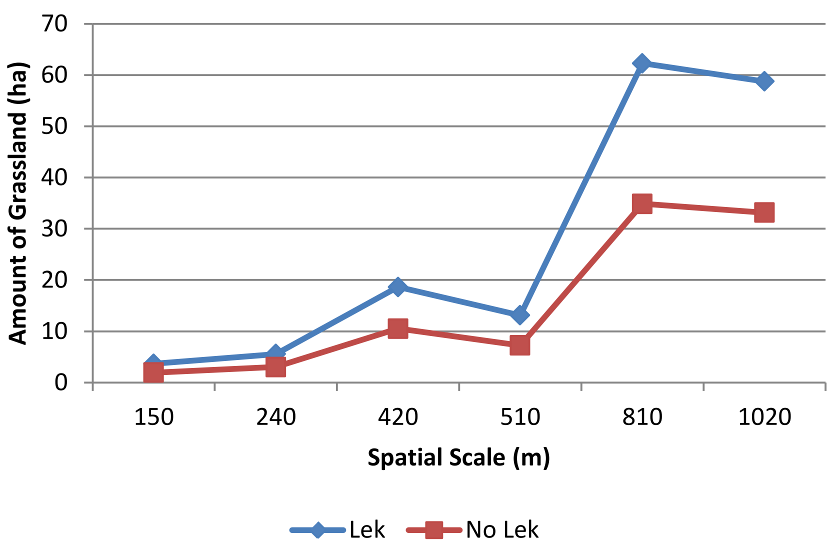
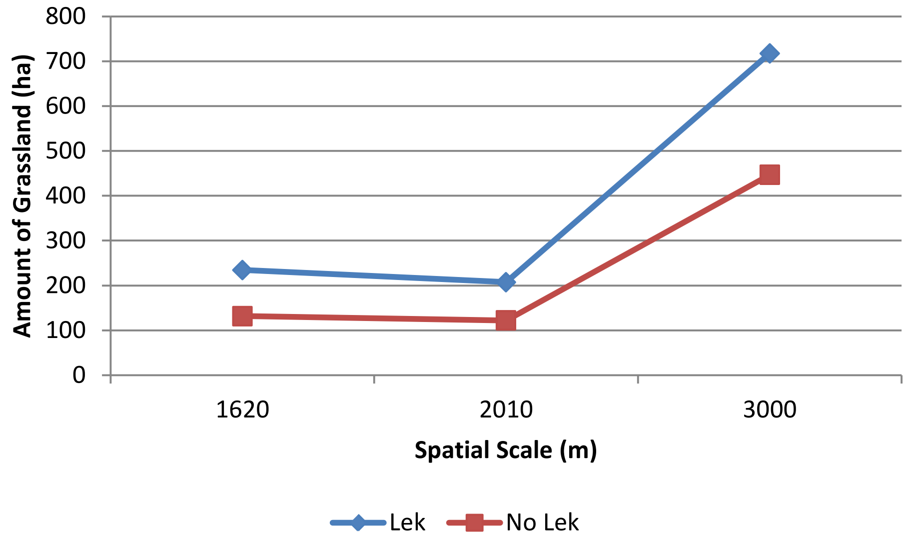


c


800
700
600
500
400
300
200
100
0
Amount of Grassland (ha)
1620
2010
3000
Spatial Scale (m)
Lek
No Lek

d.

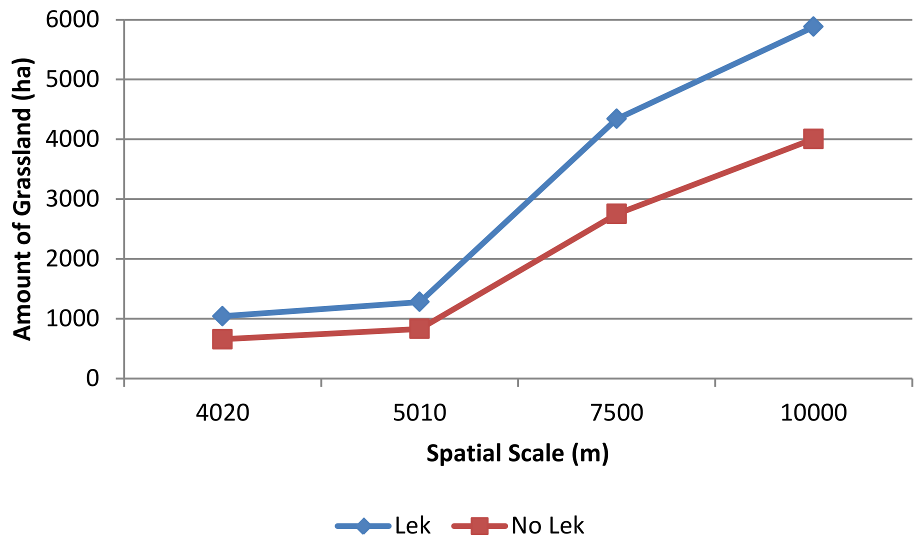
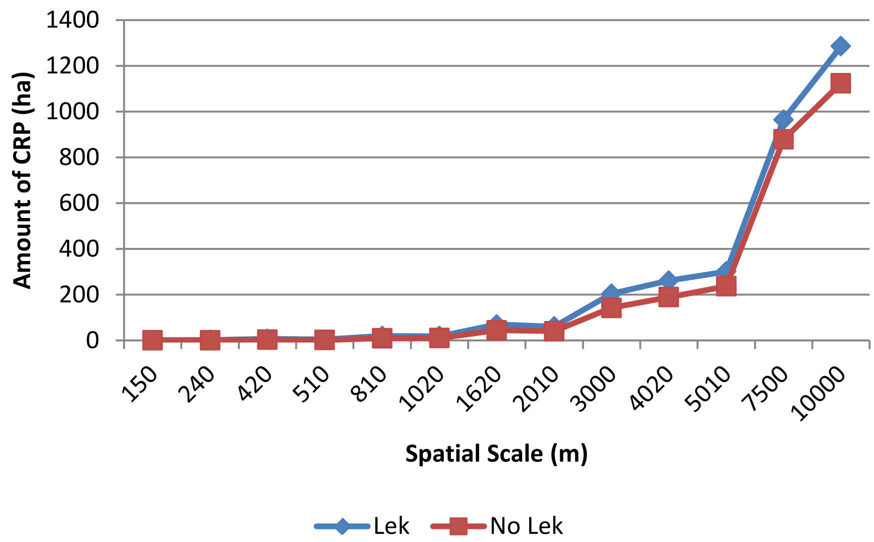
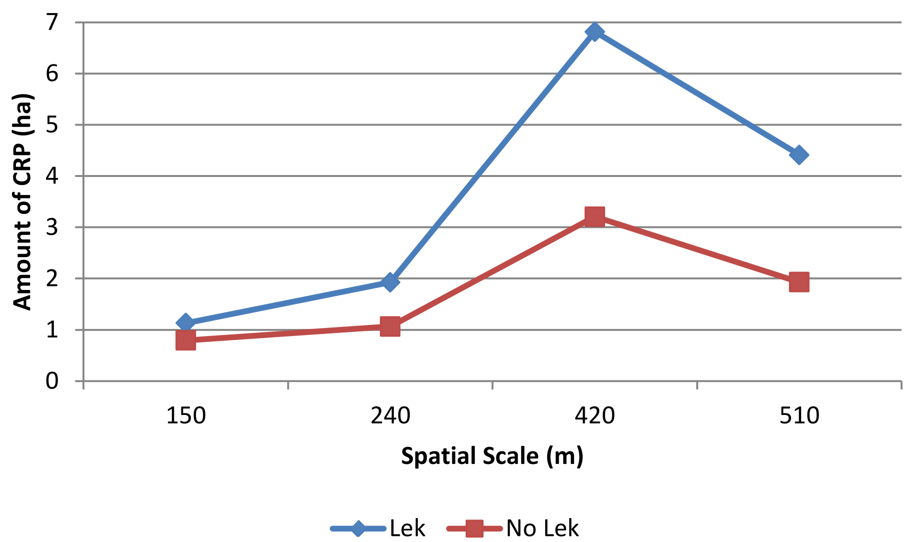

6000
5000
4000
3000
2000
1000
0
Amount of Grassland (ha)
4020
5010
7500
10000
Spatial Scale (m)
Lek
No Lek

Figure 4: Mean amount of CRP at Lek and No Lek points at multiple spatial scales, a) All spatial scales, b) 150 m, 240 m, 420 m, 510 m scales, c) 810 m, 1020 m, 1620 m, and 2010 m scales, d) 3000 m, 4020 m, 5010 m, 7500 m, and 10,000 m scales. Note the changing scale on the y-axis.

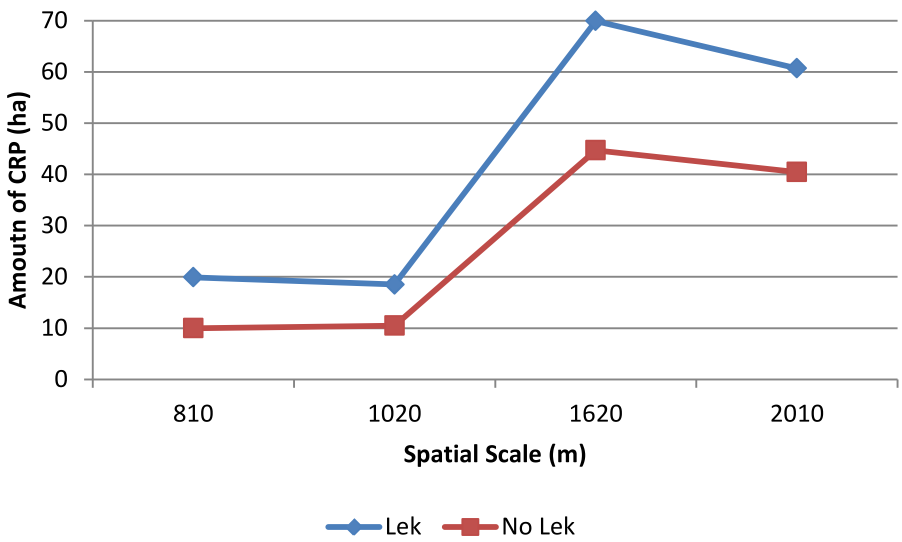
a



b



c


70
60
50
40
30
20
10
0
Amoutn of CRP (ha)
810
1020
1620
2010
Spatial Scale (m)
Lek
No Lek

d.

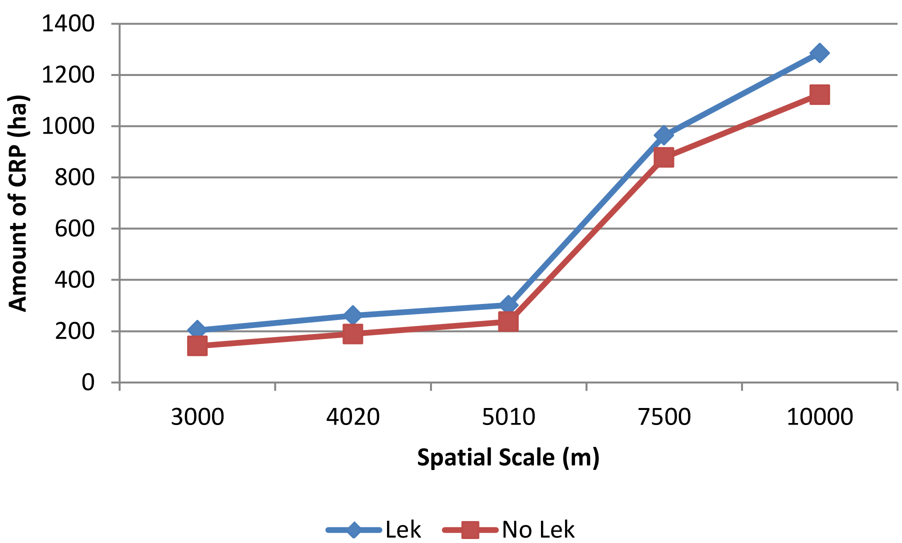

1400
1200
1000
800
600
400
200
0
Amount of CRP (ha)
3000
4020
5010
7500
10000
Spatial Scale (m)
Lek
No Lek

Table 4: GLMM spatial model results testing the difference in landscape structure at Lek and No Lek points in a 10,000 m buffer for a) Grass only patches and b) Grass+CRP patches. * indicates that the variable was significant at the p = 0.1 level. LPI = Largest Patch Index, Area = Area-weighted mean of patch size, Shape = Area-weighted Shape Index, and Contiguity = Area-weighted Contiguity Index.

a. Lek and No Lek Points and Landscape Variables with Grass Only

Variable	value	SE	df	t-value	p-value
LPI	0.03	0.02	95	1.73	0.09*
Area	0.0001	0.0001	95	1.59	0.11
Shape	0.08	0.06	95	1.34	0.18
Contiguity	11.18	6.48	95	1.73	0.09*

b. Lek and No Lek Points and Landscape Variables with Grass+CRP

Variable	value	SE	df	t-value	p-value
LPI	0.02	0.01	95	1.77	0.08*
Area	0.0001	0.00004	95	1.53	0.13
Shape	0.07	0.05	95	1.25	0.21
Contiguity	27.79	10.02	95	2.77	0.01*

s

Lek Density

Landscape Composition

Amount of Grassland was significantly greater at Low lek density points than at High or None points at multiple spatial scales: 420 m, 510 m, 4020 m, 5010 m, 7500 m, and 10000 m (Table 5, Figure 5). Amount of CRP was greater at Low lek density points than High or None points at smaller spatial scales: 240 m, 420 m, 510 m, 810 m, and 1020 m (Table 5, Figure 6). High lek density points had a greater amount of CRP at larger spatial scales: 3000 m, 4020 m, 5010 m, and 7500 m (Table 5, Figure 6). Amount of CRP was lower at None points at the 1620 m and 2010 m scales (Table 5, Figure 6). Because amount of Grassland was significant, we then asked if amount of EQIP was a significant explanatory factor. Amount of EQIP was significantly greater at High lek density points than Low or None points at the 4020 m and 5010 m buffer (Table 6). Proportion of points with EQIP contracts was significantly greater at High lek density points than Low or None at 3000 m and 4020 m (Figure 7).

Based on LEPC biology, we would have predicted that High lek density points would have had less Cropland and more Grassland than Low or None points. We investigated this pattern further. The nine lek points from the Colorado survey (leks not counted as part of the helicopter survey but as separate sampling design) were all High density points and many were in a cropland and CRP matrix. Therefore, we dropped these nine leks from the analysis as potential outliers, due to their apparent landscape configuration and the fact that these data were collected with a different sampling design than the other lek points (even the additional lek points from Oklahoma and Texas were collected using a helicopter survey similar to the one employed by the IWG). However, the same pattern appeared (e.g., the High lek density points had similar Grassland values as None points). Therefore, we report and discuss results from analyses with all leks included.

Landscape Structure

Contiguity Index for Grassland+CRP was significantly higher in High density lek point landscapes than Low or None. Largest Patch Index, Area, and Shape Index were not significant (Table 7). No landscape variables were significant when calculated with Grassland only (Table 7).

Table 5: GLMM spatial model results of differences in Grassland and CRP at High, Low and None lek density points at different spatial scales. * indicates a significant difference at the p = 0.1 level. †indicates that the test was significant at the p = 0.1 level, but these scales were not part of the original hypothesis.

distance	variable	value	SE	df	t-value	p-value
150	Intercept	0.45	0.15	94	3.06	0.003
	Grass	0.02	0.01	94	1.26	0.21
	CRP	0.02	0.02	94	1.27	0.21
240	Intercept	0.43	0.15	94	2.87	0.01
	Grass	0.02	0.01	94	1.44	0.15
	CRP	0.02	0.01	94	1.64	0.1*
420	Intercept	0.37	0.15	94	2.45	0.02
	Grass	0.01	0.003	94	1.71	0.09*
	CRP	0.01	0.005	94	2.42	0.02*
510	Intercept	0.37	0.15	94	2.43	0.02
	Grass	0.009	0.005	94	1.69	0.09*
	CRP	0.02	0.008	94	2.56	0.01*
810	Intercept	0.36	0.15	94	2.34	0.02
	Grass	0.002	0.001	94	1.6	0.11
	CRP	0.005	0.002	94	2.4	0.02*
1020	Intercept	0.41	0.16	94	2.65	0.01
	Grass	0.001	0.001	94	0.94	0.35
	CRP	0.004	0.002	94	1.92	0.06*
1620	Intercept	0.39	0.16	94	2.39	0.02
	Grass	0.0004	0.0004	94	1.08	0.28
	CRP	0.001	0.0006	94	2.12	0.04*
2010	Intercept	0.42	0.16	94	2.57	0.01
	Grass	0.0002	0.0004	94	0.57	0.57
	CRP	0.001	0.001	94	2.01	0.05*
3000	Intercept	0.37	0.17	94	2.16	0.03
	Grass	0.0001	0.0001	94	0.86	0.39
	CRP	0.001	0.0002	94	2.27	0.03*
4020	Intercept	0.25	0.18	94	1.39	0.17
	Grass	0.0002	0.0001	94	1.9	0.06*
	CRP	0.0005	0.0002	94	2.17	0.03*
5010	Intercept	0.2	0.18	94	1.1	0.27
	Grass	0.0002	0.0001	94	2.35	0.02*
	CRP	0.0003	0.0002	94	2.06	0.04*

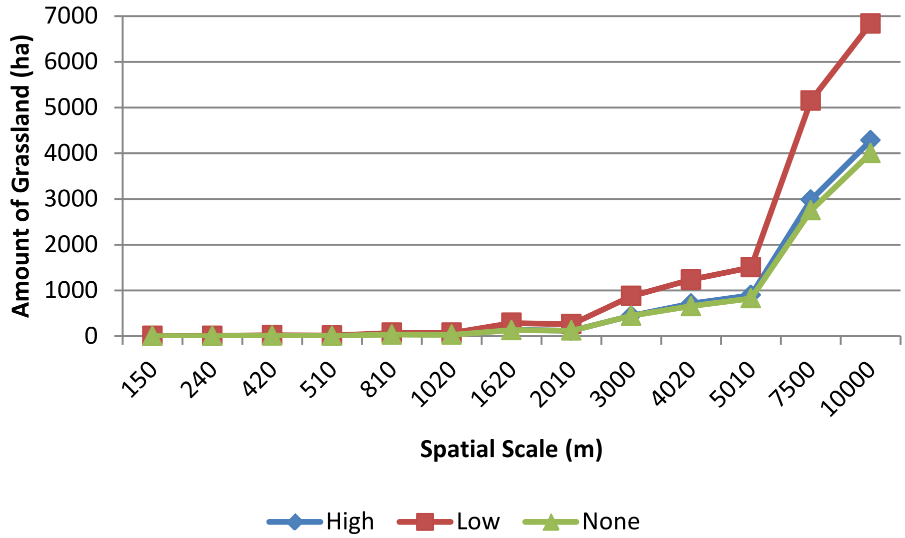
7500	Intercept	0.008	0.2	94	0.04	0.97
	Grass	0.0001	0.00003	94	3.01	0.003*
	CRP	0.0002	0.0001	94	2.8	0.006*
10K	Intercept	0.12	0.22	94	0.55	0.58
	Grass	0.0001	0.00003	94	2.43	0.02*
	CRP	0.0001	0.0001	94	1.4	0.16
15K	Intercept	0.07	0.25	94	0.3	0.76
	Grass	0.00002	0.00001	94	2.04	0.04†
	CRP	0.00005	0.00003	94	1.62	0.11
20K	Intercept	0.01	0.27	94	0.05	0.96
	Grass	0.00002	0.00001	94	2.29	0.02†
	CRP	0.00003	0.00002	94	1.27	0.21

Table 6: GLMM spatial model results of differences of EQIP at High, Low and None lek density points at different spatial scales at which Grassland was a significant predictor. * indicates a significant difference at the p = 0.1 level. †indicates that the test was significant at the p = 0.1 level, but these scales were not part of the original hypothesis.

distance	variable	value	SE	df	t-value	p-value
420	Intercept	0.53	0.14	95	3.73	0.0003
	EQIP	-0.00005	0.003	95	-0.01	0.99
510	Intercept	0.53	0.14	95	3.74	0.0003
	EQIP	-0.0002	0.005	95	-0.05	0.96
4020	Intercept	0.45	0.15	95	3.04	0.003
	EQIP	0.0003	0.0002	95	2.02	0.05*
5010	Intercept	0.44	0.15	95	2.94	0.004
	EQIP	0.0003	0.0001	95	2.38	0.02*
7500	Intercept	0.48	0.15	95	3.2	0.002
	EQIP	0.00004	0.00005	95	0.9	0.37
10K	Intercept	0.46	0.16	95	2.83	0.006
	EQIP	0.00004	0.00005	95	0.79	0.43
15K	Intercept	0.55	0.16	95	3.37	0.001
	EQIP	-0.000005	0.00002	95	-0.29	0.77
20K	Intercept	0.36	0.18	95	2.04	0.04
	EQIP	0.00003	0.00001	95	1.73	0.09†

Figure 5: Mean amount of Grassland at High, Low and None lek density points at multiple spatial scales, a) All spatial scales, b) 150 m, 240 m, 420 m, 510 m, 810 m, 1020 m scales, c) 1620 m, 2010 m, and 3000 m scales, d) 4020 m, 5010 m, 7500 m, and 10,000 m scales. Note the changing scale on the y-axis.

a



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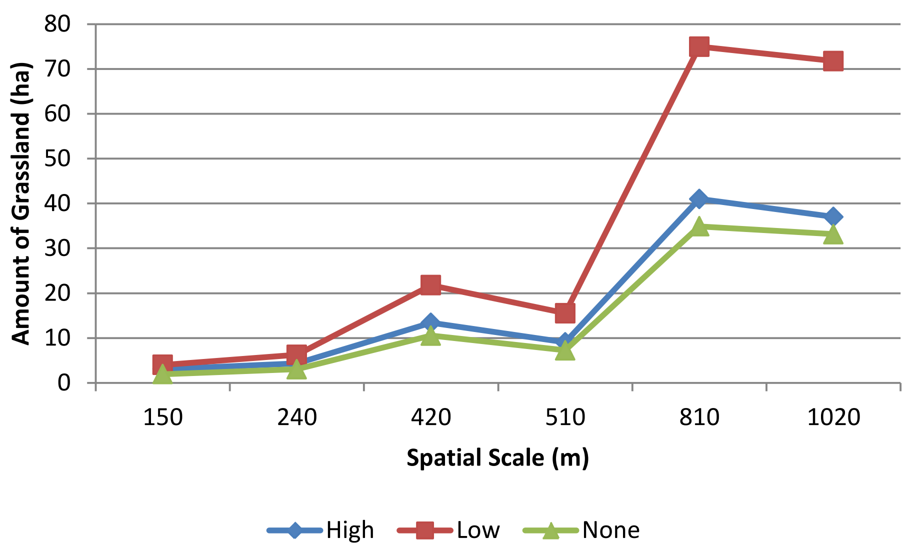

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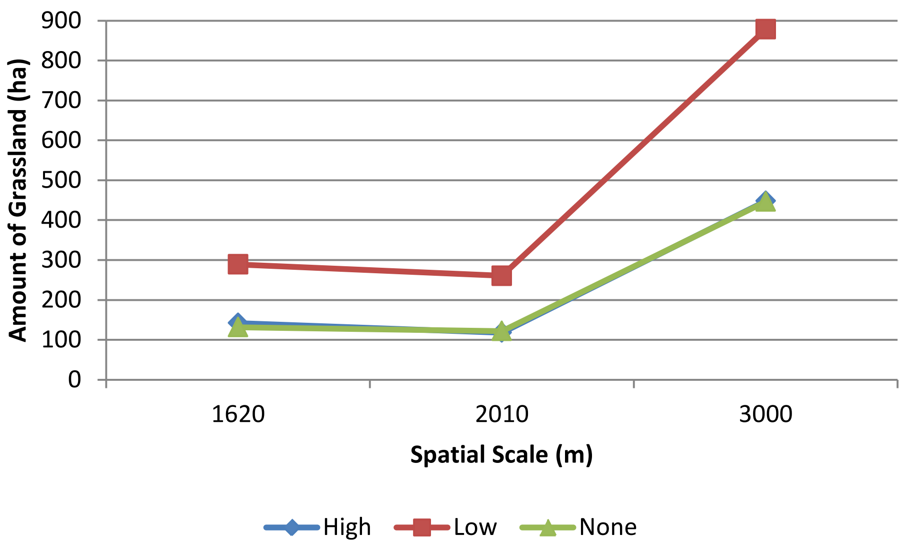

900
800
700
600
500
400
300
200
100
0
Amount of Grassland (ha)
1620
2010
3000
Spatial Scale (m)
High
Low
None

d

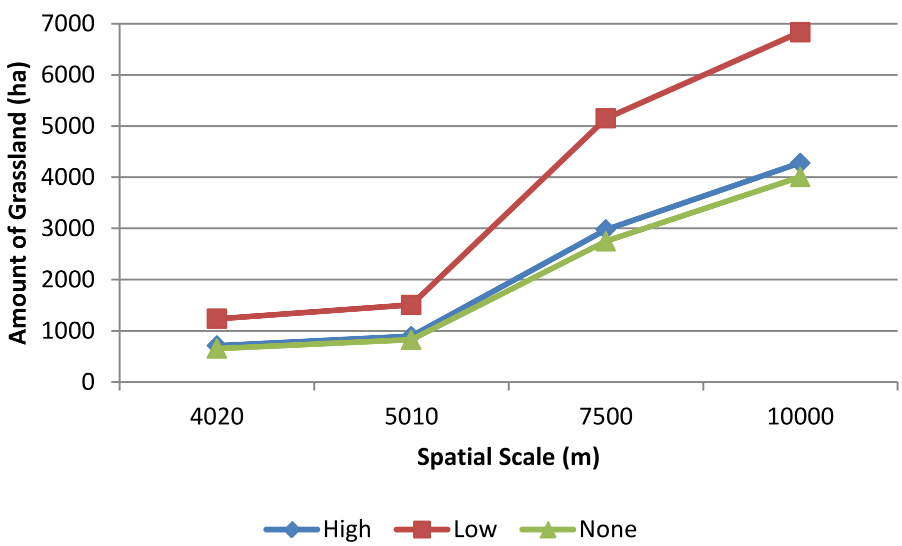
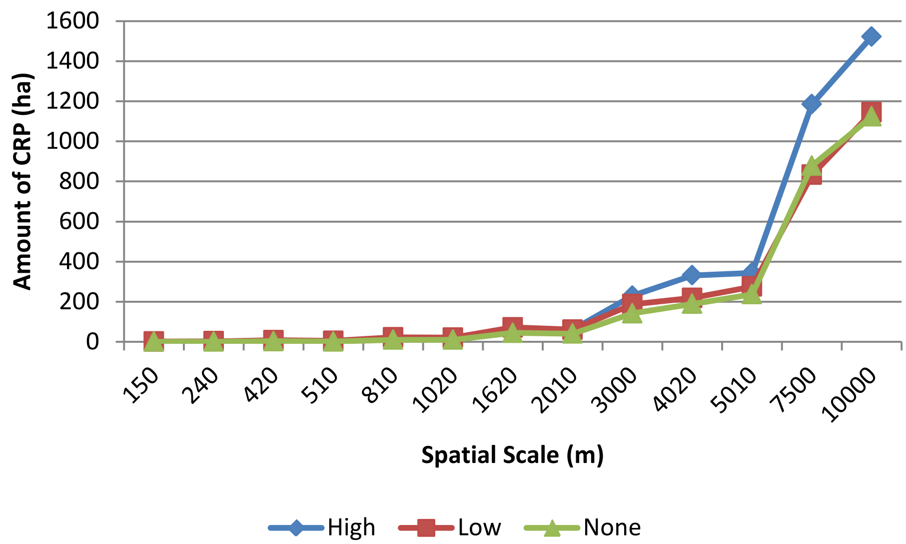
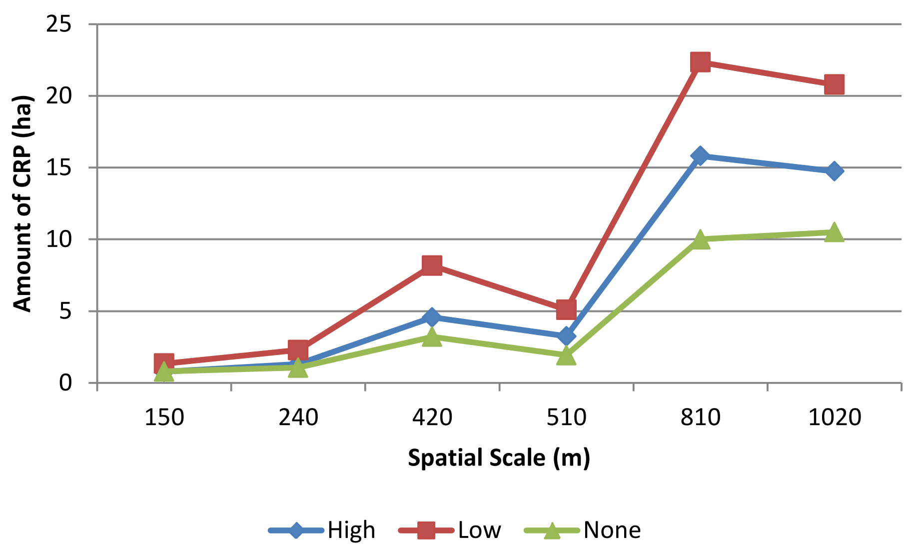

7000
6000
5000
4000
3000
2000
1000
0
Amount of Grassland (ha)
4020
5010
7500
10000
Spatial Scale (m)
High
Low
None

Figure 6: Mean amount of CRP at High, Low and None lek density points at multiple spatial scales, a) All spatial scales, b) 150 m, 240 m, 420 m, 510 m, 810 m, and 1020 m scales, c) 1620 m, 2010 m, 3000 m, 4020 m, and 5010 m scales, d) 7500 m, and 10,000 m scales. Note the changing scale on the y-axis.

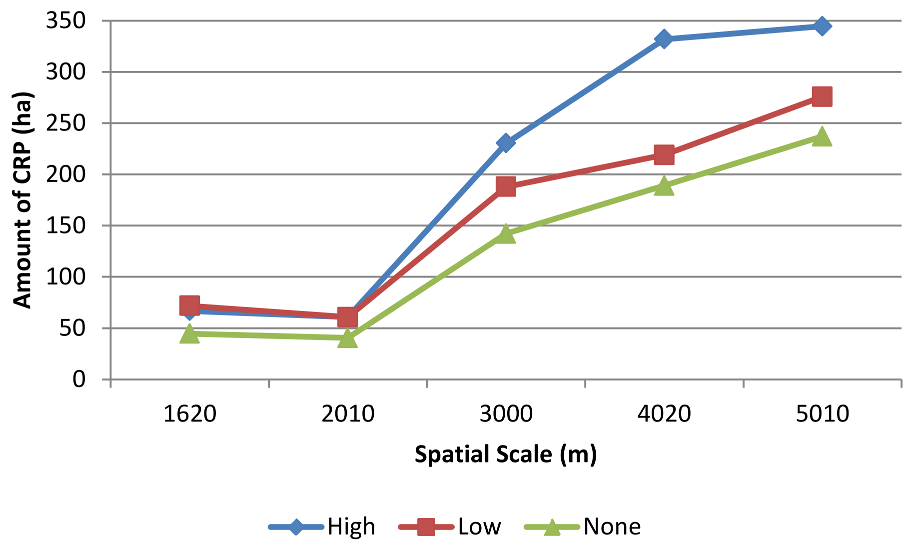
a



b



c.


350
300
250
200
150
100
50
0
Amount of CRP (ha)
1620
2010
3000
4020
5010
Spatial Scale (m)
High
Low
None

d.

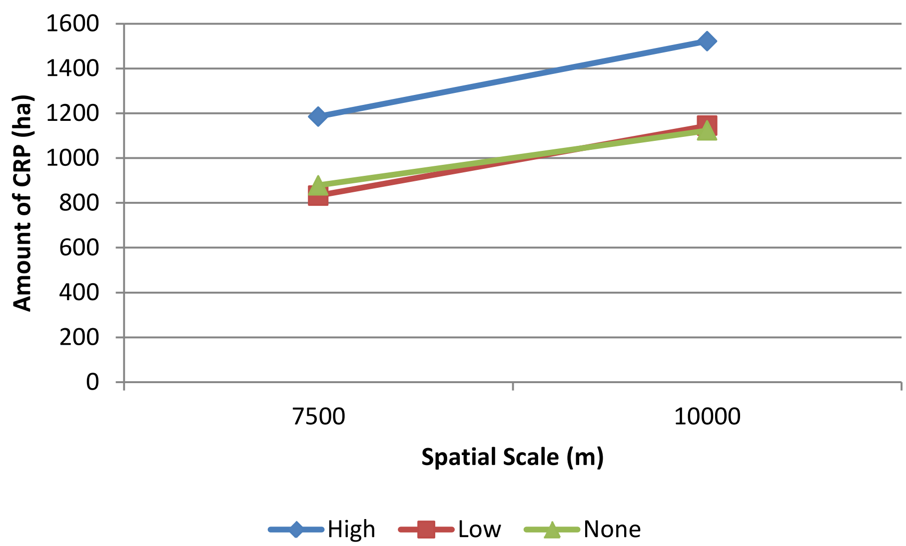

1600
1400
1200
1000
800
600
400
200
0
Amount of CRP (ha)
7500
10000
Spatial Scale (m)
High
Low
None

Figure 7. Proportion (number of points in a density category with an EQIP contract/total number of points in that density category) of EQIP practices at High, Low and None lek density points in 3000 m and 4020 m buffers.

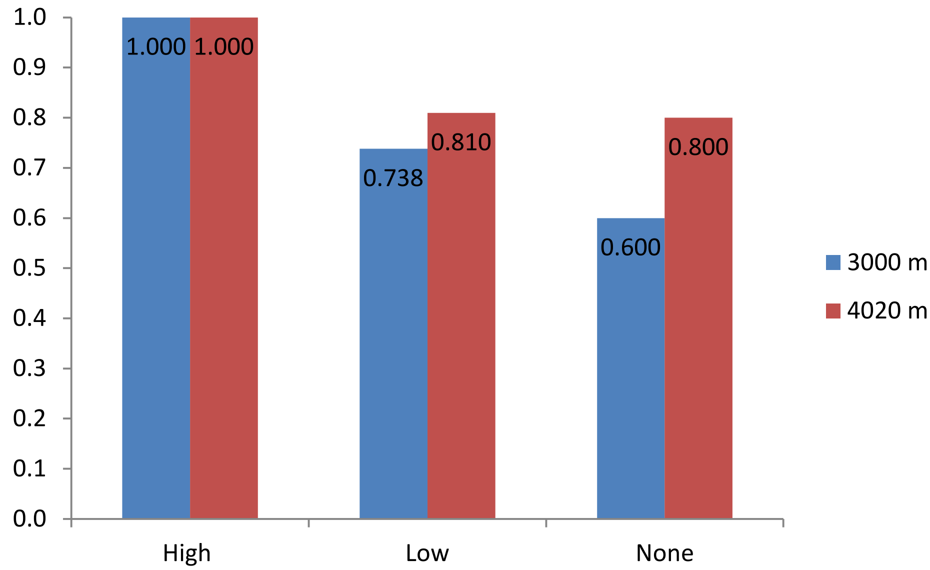


Table 7: GLMM spatial model results testing the difference in landscape structure at High, Low and None lek density points in a 10,000 m buffer for a) Grass only patches and b) Grass+CRP patches. * indicates that the variable was significant at the p = 0.1 level. LPI = Largest Patch Index, Area = Area-weighted mean patch size, Shape = Area-weighted Shape Index, and Contiguity = Area-weighted Contiguity Index.

a. Lek Density and Landscape Variables with Grass only

Variable	value	SE	df	t-value	p-value
LPI	0.005	0.004	95	1.12	0.26
Area	0.00002	0.00001	95	1.18	0.24
Shape	0.02	0.02	95	1.13	0.26
Contiguity	1.83	1.43	95	1.28	0.2

b. Lek Density and Landscape Variables with Grass+CRP

Variable	value	SE	df	t-value	p-value
LPI	0.004	0.004	95	0.88	0.38
Area	0.00001	0.00001	95	0.88	0.38
Shape	0.01	0.02	95	0.78	0.44
Contiguity	6.7	2.6	95	2.58	0.01*

DISCUSSION

Amount of Grassland was significantly greater at Lek points than No Lek points. This pattern was persistent at all but the smallest spatial scale evaluated. LEPC is known to require large areas of grassland, thus we were curious to determine the spatial extent at which this relationship is no longer apparent. Therefore, we collected data at two additional scales (15000 m and 20000 m) after completing the original analyses and repeated the statistical analyses. We found that Grassland continued to be significantly greater at Lek points than No Lek points at both larger scales (Table 2). CRP however, appeared to approach a threshold at 20000 m (Table 2).

The CRP has long been recognized as an important conservation program for grassland birds and other grassland obligate wildlife. CRP was not originally thought of as suitable habitat for LEPC, but these birds have been found in CRP grasslands and in landscapes that contain large amounts of CRP grasslands. However, the exact mechanism by which CRP is beneficial to LEPC is unknown. While numerous studies and observations have documented LEPC in CRP fields, few have sought to understand demographic impacts of LEPC use of CRP fields. One study in Kansas found that CRP was not a significant factor in nest or brood success (Fields et al. 2006). In fact, most of the nests and broods found in that study were in CRP fields of various types (Fields et al. 2006). Managers of LEPC have recognized the benefit of CRP to this bird in Kansas (CRP plantings in this state use native grass types) but there is debate about the benefit of CRP to LEPC in other states where native grasses were not commonly planted. However, in Colorado and Texas LEPC have been found in CRP fields, but no evaluation of nesting or brooding success has been completed in these states or in Oklahoma or New Mexico CRP fields. Therefore, CRP may provide suitable nesting and brood rearing habitat, and indeed has been documented as such in Kansas (Fields et al. 2006). Its benefit may also be to expand grassland patches to create larger, more continuous blocks of grassland, creating, for example, a buffer of less suitable grassland around a highly suitable block of native grassland. Additional studies should focus on nesting and brood rearing success of LEPC in CRP fields across the range of the bird and investigation of the mechanism by which CRP is beneficial to LEPC.

When leks were categorized based on density, amount of Grassland and amount of CRP was significantly greater at several spatial scales but not necessarily in the predicted direction (i.e., Low lek density points had greater Grassland than High and at small scales Low lek density points had greater CRP than High). There are several interesting patterns in these results. First, amount of Grassland was greater at two smaller scales (420 m and 510 m), indicating LEPC may have a small scale cue to establish a lek, but persistence may require large amounts of grassland at broader spatial scales. Indeed, amount of Grassland once again became significant at 4020 m, had the strongest relationship at 7500 m, was a persistent relationship out to 10000 m, and, in fact, persists in the analyses of the additional buffers (15000 m and 20000 m, Table 4). Fuhlendorf et al. (2002) found that Landscape Change Index was an important predictor of lek stability at the 4800 m scale. In personal communications with the author, we were advised to extend the spatial scales analyzed because LEPC were likely responding to landcover changes at scales greater than 4800 m. Indeed, we have found that LEPC presence and density is related to landscape composition at scales greater than previously recognized by many biologists and managers.

A second pattern is that Grassland was not significantly different among lek density points at the middle scales (810 m, 1020 m, 1620 m, 2010 m, and 3000 m), but CRP is greater at High and Low lek density points compared to None. This may be evidence of the hypothesis we posited earlier (i.e., CRP provides grassland context for LEPC to establish or to disperse through to other suitable habitats). Another hypothesis is that there is another mechanism at work; landscape structure becomes important at these scales, thus CRP adds to create a required minimum size of grassland patch or contiguity among smaller patches that still allow persistence. We are collecting landscape structure data using the methods and indices described above (Methods, GIS analysis) to evaluate this hypothesis.

The third interesting pattern is that amount of Grassland was not significant in the predicted direction; Low density lek points had greater amounts of Grassland than High. We measured amount of Grassland using a landcover dataset, with the implicit assumption that Grassland condition is suitable for LEPC. However, this may not be true. Most grasslands in this region are used for cattle forage and, thus, may be grazed to a level where vegetation structure is not suitable for LEPC. Therefore, even though High lek density points have less Grassland, that Grassland may be of higher quality than Low lek density points. Importance of vegetation structure condition has been investigated at nest (Haukos and Smith 1989, Riley et al. 1992, Giesen 1994, Pitman et al. 2005 and Bell et al. 2010) and brood (Riley and Davis 1993, Hagen et al. 2005 and Bell et al. 2010,) sites and has been used to infer structure needs at the home range scale (~ 2 km; Hagen et al. 2004), but vegetation structure and condition is difficult to assess at the broad scales used in this analysis. Improvements to remote sensing capabilities may alleviate this problem in the future but will likely remain expensive for at least the near future; thus, intensive field sampling at large spatial scales coupled with remotely sensed data are required to understand relationships among landscape composition, condition and structure to LEPC biology. Pressures on LEPC populations are on-going and intensifying; therefore, it is essential that we complete studies to understand the additional necessary characteristics of landscapes with High lek density to continue persistence of the LEPC.

However, this pattern (greater amounts of Grassland at Low lek density points) may be the result of how we classified leks or even of the lek surveys. We used lek locations from the 2012 LEPC Interstate Working Group pilot helicopter survey. The technique was vetted in Texas, and was determined to be an effective method for finding leks that would not unnecessarily harm the LEPC (McRoberts et al. 2011 a,b). Therefore, the methods were implemented across the LEPC range. However, grassland structure varies across the region, and detectability of leks may vary with density of grass cover. Therefore, many leks in high Grassland areas may not be detected in areas with high vegetation density. McDonald et al. (2012) did not test for differences in detectability among vegetation density though they did incorporate some element of detectability into their overall population estimates. Additional vetting in other regions of the LEPC range may help to understand differences in detectability in various grassland structures.

Given potential differences in detectability, it is important to note that we were assessing High and Low lek density with *apparent* lek densities. Therefore, we caution about drawing too many inferences from the lek density analysis until additional studies are completed that use better measures of density. Finally, we did not consider lek attendance in our density calculations. Low density lek points may have higher lek attendance per lek than High density lek points and be a better reflection of condition and persistence of the lek on the landscape. Of the lek data we used in our report that also reported number of LEPC observed, High density lek points had a mean = 6.5 LEPC (n = 14 sd = 6.2) and Low density lek points had a mean = 8.2 LEPC (n = 36, sd = 5.9), indicating further inquiry is needed.

Unlike CRP, which converts largely unsuitable (cropland) to suitable (native and non-native grassland plantings) landcovers, EQIP is a program whose purpose is to improve existing grassland for producers and the wildlife that use that grassland. The LEPC Initiative has identified several programs that are thought to improve habitat for LEPC. Our analysis suggests that EQIP practices included in our analyses may be providing some benefit to LEPC at large spatial scales. Amount of

EQIP was greater at High lek density points than Low or None points at the 4020 m and 5010 m scale. However, not much more inference can be drawn from this analysis because of the assumptions made in the analysis of these data (see above, Methods, Landcover Data, page 6). In addition, only 2 scales of 12 had significant results which may not be different from random, but these results warrant more investigation. To properly conduct this analysis we need to know which fields were enrolled in the various programs and understand the pre- and post-condition of the grassland. It is likely too late to collect condition data on the fields in this database, but exact field location could be added. In the future, it is essential to document a) which field(s) are enrolled in the practice, b) the desired future condition, and c) pre- and post-practice conditions. The LEPC Initiative has instituted collecting most of this data for fields enrolled in the initiative, but if additional analyses on the impact of EQIP on other grassland wildlife is to be conducted, these data need to be collected at all fields enrolled in EQIP. To summarize, the benefit to LEPC of grassland relative to cropland is easily measured, but the benefits of modification to grassland structure would be revealed only with direct measurements of the pertinent attributes of grassland structure in an experimental framework.

Although not an original objective of this project, we explored the relationship of landscape structure and LEPC lek presence and density at one spatial scale (10000 m). We found that landscape structure, as measured by patch size and contiguity, were important predictors of presence of LEPC. Woodward and Fuhlendorf (2001) and Fuhlendorf et al. (2002) showed that landscape change was an important predictor of LEPC population status. These three studies demonstrate the importance of spatial and temporal scales in persistence of LEPC and, therefore, their importance to LEPC conservation. Future research should explore these relationships. These preliminary results support current conservation efforts to maintain and expand blocks of grassland and provide connectivity among grassland patches.

This study demonstrates the importance of Farm Bill programs to LEPC. We confirm the importance of CRP and provide preliminary evidence of EQIP as an important conservation delivery mechanism for improving habitat condition for LEPC. Finally, we provide empirical support for targeted conservation delivery to expand and create large blocks of grassland habitat with high connectivity.

ACKNOWLEDGMENTS

We would like to thank the five states with LEPC (Colorado, Kansas, New Mexico, Oklahoma and Texas) for sharing the 2012 lek data collected in the pilot study. Thank you to Dave Haukos, Jim Pitman, Duane Pool, Susan Skagen and Misti Vazquez for comments that improved this report. A special thanks to Duane Pool for answering statistical questions. Andy Bishop, Roger Grosse and Chris Jorgensen at Rainwater Basin Joint Venture helped with GIS data collection.

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