RANGE-WIDE POPULATION SIZE OF THE LESSER PRAIRIE-CHICKEN: 2012 TO 2020

Photos: Colorado Parks and Wildlife

Prepared for:

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EXECUTIVE SUMMARY

- We estimated lesser prairie-chicken population sizes annually from 2012 – 2018 and 2020 in the 2011 estimated occupied range of the lesser prairie-chicken in Kansas, Colorado, New Mexico, Oklahoma, and Texas.
- We estimated lesser prairie-chicken population sizes and abundances of leks in four ecoregions of the estimated occupied range. We also estimated population sizes and abundances of leks of greater prairie-chicken and hybrid prairie-chicken in the Short Grass Prairie/Conservation Reserve Program (CRP) Region of northwest Kansas.
- There were 536 total grid cells in the study area from 2012 to 2017 and 514 total grid cells in the study area in 2018 and 2020. The study area was reduced in 2018 by dropping grid cells in the Mixed-Grass Prairie Region of central Kansas where no lesser prairie-chickens or leks were observed from 2012 to 2017.
- Sample cells were selected by an equal probability procedure. Two-hundred-fifty-six (256) grid cells were surveyed in 2012 and 283 grid cells were surveyed from 2013 through 2016. A total of 303 cells were surveyed in 2017 and 2018 and a total of 302 cells were surveyed in 2020. A rotating panel design was implemented in 2017, 2018, and 2020 by selecting new grid cells for approximately 20% of the sampled area in each of the ecoregions. The same field survey methods were used from 2012 to 2020; two transects were surveyed in each grid cell and the two transects covered 8% of the grid cell.
- Eighty and/or ninety percent confidence intervals (CI) were computed on estimated parameters to account for variation in the estimates due to unsampled grid cells, detection probability, and surveying two transects in each sampled grid cell.
- A total of 1,112 prairie-chicken clusters were detected from 2012 to 2020; 58.1% of the observations were in short-grass grassland, 21.4% were in cropland, 11.3% were in tall-grass grassland including CRP grassland (with little or no shrubs), 6.2% were in sand-sage prairie, 2.3% were in shinnery oak (including other shrub dominated land), and 0.6% were on bare ground.
- We estimated probability of detection on transects using a pooled data set of 1,112 prairie-chicken clusters. We improved the models and method for estimation of probability of detection of clusters of prairie-chickens as a function of distance from transect. Analysis methods became available to estimate the effect of the size of a cluster of prairie-chickens on probability of detection in all the models as well as the effect of habitat type.
- Probability of detection increased as the size of a prairie-chicken cluster increased. In addition, a difference in probability of detection by habitat was observed with observations in cropland, on bare ground, and in short-grass grassland having the highest probability of detection. Probability of detection decreased as distance from the transect line increased.

- We estimated the probability of detection of clusters of prairie-chickens using model-averaged distance sampling models scaled by the estimated probability of detection on the inside edge of the field of view of the rear seat observers. We adjusted counts of lesser prairie-chicken, greater prairie-chicken, and hybrid prairie-chicken by covariate-specific, scaled, model-averaged probabilities of detection to estimate population sizes in ecoregions and the total study area.
- In general, use of improved models for probability of detection resulted in an increase in the estimated probability of detection of larger clusters.
- Estimates of lesser prairie-chicken population sizes from 2012 to 2018 decreased slightly relative to estimates reported previously (Nasman et al. 2018).
- For the study of trends, we estimated the total population sizes of lesser prairie-chicken to be:
    - 28,366 (90% CI: 17055, 40581) LPC in 2012;
    - 15,397 (90% CI: 8145, 22406) in 2013;
    - 18,142 (90% CI: 10234, 25706) in 2014;
    - 22,899 (90% CI: 13486, 32871) in 2015;
    - 19,913 (90% CI: 12111, 27423) in 2016;
    - 26,606 (90% CI: 16401, 35700) in 2017;
    - 33,094 (90% CI: 20860, 45013) in 2018; and
    - 34,408 (90% CI: 21270, 47946) in 2020.
- There was a statistically significant annual rate of increase in the total lesser prairie-chicken population size from 2013 to 2020 (p-value = 0.01).
- We estimated a total population increase of 1,314 lesser prairie-chicken from 2018 to 2020 (4% increase); however, the increase was not statistically significant at the 80% confidence level. The 80% CI around the estimated increase ranged from negative (-7,956) to positive (11,301), indicating there was not a statistically significant increase in lesser-prairie chicken between 2018 and 2020.
- We observed a stable to increasing population of lesser prairie-chickens from 2015 to 2020 in the Shinnery Oak Prairie Region of eastern New Mexico and western Panhandle of Texas.

- We observed a stable to increasing population of lesser prairie-chickens from 2014 to 2018 in the Sand Sage Prairie Region of southeastern Colorado, southwestern Kansas, and the northwest Oklahoma Panhandle, with a decrease in the lesser prairie-chicken in 2020. Note that the survey was designed to measure trends in the range-wide population of lesser prairie-chicken over time, and estimates can be variable in low-density ecoregions such as the Sand Sage Prairie Region.
- We observed a stable to increasing population of lesser prairie-chickens from 2013 to 2015 in the Mixed Grass Prairie Region of northeast Panhandle of Texas, northwest Oklahoma, and south-central Kansas. There was a slight decrease in the population of lesser-prairie chickens in 2016, and since then, the population has remained steady through 2020.
- We observed a stable to increasing population of lesser prairie-chickens from 2013 to 2020 in the Short Grass Conservation Reserve Program Prairie Region of northwest Kansas.
- The abundances of lesser prairie-chicken leks in the total population were estimated to be:
    - 2,769 (90% CI: 1466, 4175) in 2012;
    - 1,827 (90% CI: 927, 2675) in 2013;
    - 2,186 (90% CI: 1190, 3180) in 2014;
    - 1,344 (90% CI: 730, 1980) in 2015;
    - 1,673 (90% CI: 797, 2631) in 2016;
    - 2,637 (90% CI: 1584, 3650) in 2017;
    - 2,498 (90% CI: 1503, 3478) in 2018; and
    - 4,862 (90% CI: 2784, 6957) in 2020.
- We observed an increase in lesser prairie-chicken leks from 2018 to 2020; however, there were fewer individuals per lek observed per lek.

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INTRODUCTION

Ascertaining estimates of wildlife population size is valuable information for natural resource agencies in the management of harvested and non-harvested species (Rabe et al. 2002). Acquiring precise and unbiased estimates of population size requires either a complete census or probabilistic sample of subunits with which to infer population size (Johnson 2002); however, limited funding and staffing have often precluded implementation of these sampling designs. The result has been the development of population indices to monitor population trends or to estimate a minimum population size. The limitation of such data is the unknown relationship to population size. Further, it must be assumed that population indices track population dynamics (McKelvey and Pearson 2001). These assumptions can be problematic when knowing the population size is critical to decision makers either in the context of harvest or population recovery of sensitive species.

Our objectives were to implement consistent, statistically robust survey and analysis methods to estimate lesser prairie-chicken (*Tympanuchus pallidicinctus*; LPC) population size from 2012 to 2018 and 2020. To achieve this, we addressed issues of regional variation as well as the co-occurrence of greater prairie-chicken (*Tympanuchus cupido*; GPC) and of hybrid prairie-chickens (HPC) in northwestern Kansas. We estimated LPC abundance for four ecoregions: 1) Shinnery Oak (*Quercushavardii*) Prairie Region (SOPR), located in eastern New Mexico and the southwest Texas Panhandle; 2) Sand Sagebrush Prairie Region (SSPR), located in southeastern Colorado, southwestern Kansas, and the western Oklahoma Panhandle; 3) Mixed-Grass Prairie Region (MGPR), located in the northeastern Texas Panhandle, north-western Oklahoma, and south-central Kansas; and 4) Short Grass Conservation Reserve Program (CRP) Prairie Region (SGPR), located in northwestern Kansas (Figure 1).

STUDY AREA

Our study area included the 2011 Estimated Occupied Range (EOR) of LPC as defined by the LPC Interstate Working Group (LPCIWG) and mapped on the Western Association of Fish and Wildlife Agencies' web site (2020; LPCIWG 2011, McDonald et al. 2012). In addition, we included habitats with relatively high probability of lek occurrence in northwest Kansas as measured by the Western Governors' Association Southern Great Plains Crucial Habitat Assessment Tool (SGP CHAT; Kansas Applied Remote Sensing [KARS] 2015). The study area for 2020is illustrated in Figure 1, indicating grid cells selected and not selected for surveys. In 2018, the study area was reduced by 22 grid cells in the MGPR where LPC were not observed from 2012 to 2017. The 2018 and 2020 estimates accounted for the reduced survey area.

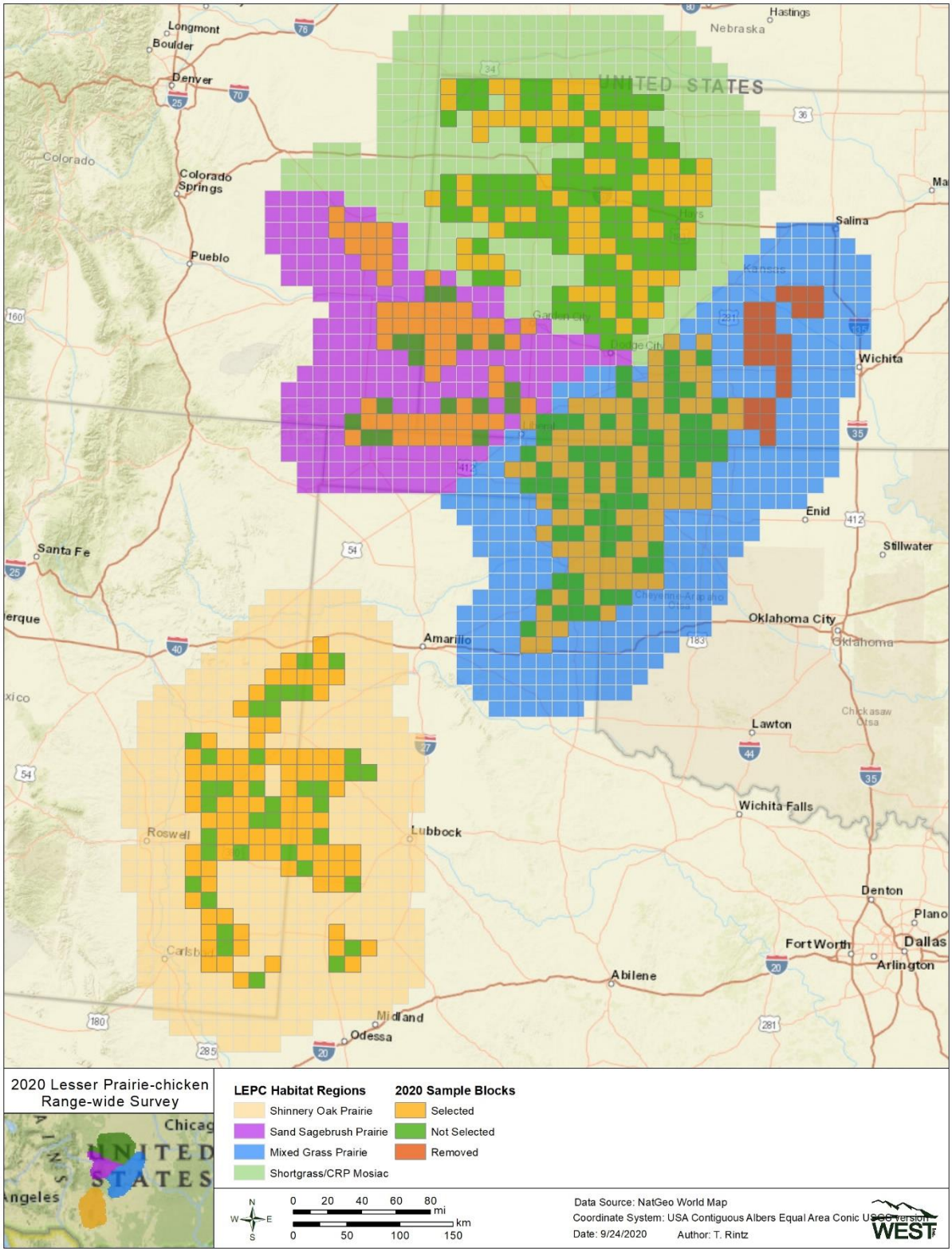

Figure 1. Study area for 2020 lesser prairie-chicken surveys illustrated with grid cells selected for surveys. The colored areas surrounding the study areas indicate an approximate 77.7-kilometer (30-mile) buffer into which the survey may be expanded in the future.

METHODS

Probabilistic Samples for Trend

We ranked 15- × 15-km (9.3- × 9.3-mi) grid cells (cells) in the study area from one to 536 by an equal probability sampling procedure known as the Generalized Random Tessellation Stratified (GRTS) sampling (McDonald et al. 2012, 2014; Stevens and Olsen 2004). Cells selected by the GRTS procedure maintained a spatially balanced sample for aerial resources such that any contiguous subset, if taken in order, was an equal probability sample of the target population.

In 2012, 256 grid cells were selected for survey (Table 1). A total of 283 grid cells were surveyed from 2013 to 2016. Details on the sampling design and strata for these survey years are outlined in McDonald et al. (2012 and 2014).

In 2017, 2018, and 2020, funds became available to survey additional cells in two of the ecoregions. Ten additional cells were surveyed in the SOPR (nine in 2020) and 10 additional cells were surveyed in the MGPR for a total sample size of 303 (302 in 2020) probabilistically selected grid cells. A rotating panel design was also implemented in 2017, 2018, and 2020 within each ecoregion. A panel of approximately 20% of the top ranked grid cells on the GRTS list were dropped and a panel of equal size grid cells next on the GRTS list were added from each ecoregion.

Table 1. Total number of grid cells surveyed by year and region for survey years 2012 to 2018 and 2020.

	Ecoegion				
Year	SOPR	SSPR	MGPR	SGPR	Overall
2012	75	29	72	80	256
2013	77	55	78	73	283
2014	77	55	78	73	283
2015	77	55	78	73	283
2016	77	55	78	73	283
2017	87	55	88	73	303
2018	87	55	88[1]	73	303
2020	86[2]	55	88[1]	73	302

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass Conservation Reserve Program Prairie Region (northwest Kansas).

[1]The total number of grid cells in the sampling frame in the MGPR was reduced from 176 grid cells 2012 - 2017 to 154grid cells in 2018.

[2]One grid cell was unable to be surveyed in the SOPR.

Aerial Survey Methods

Surveys were conducted from a Raven II (R-44; Robinson Helicopter Company, Torrance, California) helicopter able to accommodate 3 observers; two observers in the rear left and right

seats, and a third observer in the front left seat. Three helicopters and survey crews simultaneously conducted surveys within the study area each year. Transects were flown north to south or south to north a speed of 60 km/hour (37 mi/hour) and height of 25 meters (m; 82 feet [ft]) above ground. Surveys were conducted from sunrise until approximately 2.5 hours after sunrise during the lekking period from March 15 – May 15.

Two 15-km north-south parallel transects were selected in each of the survey cells. The starting point for the first transect was randomly located from 300 to 7,200 m (984 ft to 23,622 ft) from the west side of the cell. The second transect was located 7,500 m (24,606 ft) to the east of the first transect. Survey strip width was 300 m on each side of the transect lines. The area surveyed in each grid cell was 8% of the total 225 square km. Survey methods were the same for all eight years of surveys. For more information regarding survey methods, please see McDonald et al. (2012).

Statistical Methods

Probability of Detection

We improved the models and methods for estimation of probability of detection of clusters of prairie-chickens as a function of distance to transect and covariates in 2018. These same improved methods were used to estimate the probability of detection function in 2020. The package “Rdistance” in the R language and environment (version 2.1.5; R Development Core Team 2020) was used to fit all possible models with size of a cluster and habitat as covariates. Key functions considered included the negative exponential, hazard rate, and half normal distributions. Based on the pooled data set and the improved models, we estimated population sizes for 2020, and adjusted estimates of population sizes for all survey years from 2012 – 2018.Populationestimates for 2012 – 2018 were expected to differ slightly from previous results reported in Nasman et al. (2018).

The estimates of probability of detection as a function of distance to transect and covariates were then scaled by the estimates of probability of detection near the transect line to obtain overall probabilities of detections. For details on the analysis and modeling methods please refer to McDonald et al. (2014).

Estimation of Population Parameters in the Short Grass Prairie Region

The proportion of LPC, GPC, and HPC in the SGPR in northwestern Kansas were estimated using ground survey data collected from 2008 through 2013. All ground survey data and initial data processing were provided by the Kansas Department of Wildlife, Parks and Tourism (KDWPT) and the Kansas Biological Survey (J. Pitman and M. Houts, pers. comm.).

Estimation of Precision of Estimated Population Parameters

We used bootstrapping techniques (Manly 2006) to estimate confidence intervals (CIs) for density and population totals of LPC, HPC, and GPC individuals and leks, by year and ecoregion. From each bootstrapped sample, we generated new estimates of densities, population totals, and

differences. We calculated CIs based on the central 80% and/or 90% of the bootstrap distribution (the percentile method) for each estimated parameter.

Estimation of Trends in Population

To evaluate trends in LPC population over time, a generalized simple linear regression model was fit to the population estimates. The random error terms followed a first-order autoregressive process to account for autocorrelation in populations between years (Kutner et al. 2005).

RESULTS

We detected 141 clusters of LPC, GPC, and HPC in 2012, 73 in 2013, 92 in 2014, 133 in 2015, 129 in 2016, 172 in 2017, 172 in 2018, and 200 in 2020 while surveying on transects (i.e., within 300 m [984 ft] of the transect line) for a total of 1,112 detections of prairie-chickens in the combined data set (Table 2).There were 368 LPC detected in 2012, 203 in 2013, 224 in 2014, 276 in 2015, 251 in 2016, 336 in 2017, 493 in 2018, and 438 in 2020 (Table 3). Note that fewer cells were surveyed in 2012 (256 cells), while survey effort increased to 283 cells from 2013 to 2016, then to 303 cells in 2017 and 2018, and to 302cells in 2020.

Of the 1,112 prairie-chicken clusters detected from 2012 to 2020, 58.1% were in short-grass grassland, 21.4% were in cropland, 11.3% were in tall-grass grassland including CRP grassland (with little or no shrubs), 6.2% were in sand-sage prairie, 2.3% were in shinnery oak (including other shrub dominated land), and 0.6% were on bare ground Table 2).

Estimates of LPC population size were calculated for 2020. Counts of observed LPC were adjusted for LPC missed in the 600 m transects using the estimated probability that at least one of the two observers detected a cluster, and the estimated probability of detection of the cluster as a function of distance from transect and covariates. Estimates of LPC population size and density were also updated for survey years from 2012to 2018.

Table 2. Trends in numbers and percent of detections of leks and non-lekking clusters of lesser prairie-chicken, greater prairie-chicken, and hybrid prairie-chicken by habitat type in the data sets for survey years 2012 to 2018 and 2020.

	Habitat						
Year	Bare Ground	Cropland	Short-Grass Grassland	Shinnery Oak (including other shrub dominated land)	Sand-Sage Prairie	Tall-Grass Grassland Including CRP Grassland (with little or no shrubs)	Total
2012	0 (0%)	27 (19.1%)	91 (64.5%)	6 (4.3%)	3 (2.1%)	14 (9.9%)	141
2013	0 (0%)	14 (19.2%)	49 (67.1%)	2 (2.7%)	7 (9.6%)	1 (1.4%)	73
2014	0 (0%)	11 (12.0%)	66 (71.7%)	2 (2.2%)	2 (2.2%)	11 (12.0%)	92
2015	0 (0%)	21 (15.8%)	85 (63.9%)	1 (0.8%)	10 (7.5%)	16 (12.0%)	133
2016	1 (0.8%)	32 (24.8%)	63 (48.8%)	1 (0.8%)	17 (13.2%)	15 (11.6%)	129
2017	2 (1.2%)	49 (28.5%)	92 (55.8%)	5 (2.9%)	4 (2.3%)	20 (11.6%)	172
2018	3 (1.7%)	37 (21.5%)	93 (54.1%)	8 (4.7%)	3 (1.7%)	28 (16.3%)	172
2020	1 (1.7%)	47 (21.5%)	107 (54.1%)	1 (4.7%)	23 (1.7%)	21 (16.3%)	200
Total	**7 (0.6%)**	**238 (21.4%)**	**646 (58.1 %)**	**26 (2.3%)**	**69 (6.2%)**	**126 (11.3 %)**	**1,112**

CRP=Conservation Reserve Program

Table 3. Trends in numbers of lesser prairie-chickens detected by ecoregion (estimated number detected in SGPR) and overall for survey years 2012 to 2018 and 2020. "On transect" indicated observations were made between start and end points of transects. "Off transect" indicated observations were made while traveling to and from selected transect lines or greater than 300 m from the transect. Two-hundred-fifty-six cells were surveyed in 2012, 283 cells were surveyed in 2013, 2014, 2015, and 2016, 303 cells were surveyed in 2017 and 2018, and 302 cells were surveyed in 2020.

	Ecoregion									
	SOPR		SSPR		MGPR		SGPR (estimated[1])		Total	
Year	On transect	Off transect	On transect	Off transect	On transect	Off transect	On transect	Off transect	On transect	Off transect
2012	44	7	22	6	86	0	216	16	**368**	**29**
2013	24	12	35	5	39	4	105	12	**203**	**33**
2014	17	10	8	7	70	2	129	9	**224**	**28**
2015	10	7	14	13	87	19	165	9	**276**	**48**
2016	42	12	22	0	61	0	126	0	**251**	**12**
2017	35	18	23	1	80	0	198	2	**336**	**21**
2018	90	1	57	3	95	4	251	15	**493**	**23**
2020	81	6	3	12	61	2	293	55	**438**	**75**

[1]Estimated to account for greater prairie-chicken and hybrid prairie-chicken in the SGPR

Mark-Recapture Models

We used the observations of LPC, GPC, and HPC by the front left and back left observers in "mark-recapture" models. For example, clusters of prairie-chickens seen by the front left observer were "marked"; some of those same clusters were "recaptured" by the back left observer. These models estimated the probability that at least one of the two observers would detect a cluster given that it was in the field of view of the back left observer (i.e., greater than the nominal value 6.8 m [22.3 ft] from the transect line). The sample sizes recorded and used from each observer (365 and 337, respectively) for all survey years were given equal weight for modeling the components of the covariates specific, scaled, model averaged probability of detection (Table 4).

Table 4. Sample sizes recorded and used for logistic regression models in order to estimate the probability that at least one of the two observers will detect a cluster for survey year 2012 to 2018 and 2020.

Year	Front Left	Back Left
2012	57	50
2013	24	28
2014	33	40
2015	49	46
2016	54	46
2017	64	50
2018	53	61
2020	32	19
Total	**365**	**337**

Covariates used in the "mark-recapture" models were perpendicular distance to the cluster (distance), cluster size (size), and the categorical variable habitat type (habitat; Table 5). Due to the similarity of detection probability of prairie-chicken clusters in cropland and short-grassland, we combined those habitat types into one habitat category. The four levels considered for habitat type were: short-grass/cropland, shinnery oak, sand-sage prairie, and tall-grass grassland. Another categorical variable, flushed or not flushed, was not used in the models in this report because of the very small proportion of observed clusters of prairie-chickens not flushed. Weighted average estimates of probability of detection were obtained for combinations of covariates associated with detections of clusters of prairie-chickens using model averaging with the corrected Akaike Information Criterion (AICc; Akaike1973).

Table 5. Logistic Regression models used for estimation of probabilities of detection on the inside edge of the field of view of the back left observers. Distance = perpendicular distance to detected clusters, none = no covariates, size = size of cluster, and habitat = habitat type occupied. The back left observer models estimated the probability that the back left observer detected a cluster given that the cluster was detected by the front left observer. Similarly, the front left observer models estimated the probability that the front left observer detected a cluster given that the cluster was detected by the back left observer.

Back Left Observer Model			Front Left Observer Model		
Covariates	**AICc**	**Model Weight**	**Covariates**	**AICc**	**Model Weight**
distance + size	449.27	0.74	distance + size	471.84	0.85
distance + size + habitat	452.29	0.16	distance + size + habitat	475.30	0.15
size	453.94	0.07	size	482.65	<0.01
size + habitat	456.48	0.02	size + habitat	485.90	<0.01
distance	459.41	<0.01	distance	499.31	<0.01
None	463.17	<0.01	distance + habitat	500.11	<0.01
distance + habitat	463.33	<0.01	None	507.22	<0.01
habitat	466.76	<0.01	habitat	508.10	<0.01

AICc=Akaike Information Criterion

Probability of Detection – Distance Sampling Analysis

We dropped 19 observations from the distance sampling analysis that were greater than 300 m from the transect line as they were outside the viewshed specified in the survey protocol. Buckland et al. (2001) recommended dropping up to 5% of observations with the largest distances to the transect line to remove the influence of outliers prior to modeling probability of detection. Data were grouped into 15 intervals for fitting models for probability of detection with the all intervals encompassing 20 m (Figures 2a and 2b). The midpoint of each interval was used in the modeling in order to compensate for potential errors in assigning the perpendicular distance from the transect line.

Data collected from surveys in 2012 (256 grid cells), 2013 to 2016 (283 grid cells), 2017 to 2018 (303 grid cells), and 2020 (302 grid cells) were used to estimate the detection function. Probability of detection was estimated as a function of distance from the transect (Figures 2a and 2b). In addition, cluster size and habitat were considered as covariates in the models. Cluster size of prairie-chickens detected varied by year and ecoregion (Table 6). The average cluster size of LPC detected decreased from 4.2 to 3.3 LPC per cluster from 2018 to 2020 (Table 6) and a decrease in average cluster size was observed in all ecoregions from 2018 to 2020. In addition, habitat where prairie-chickens were detected varied slightly between years and was considered as a covariate in modeling probability of detection (Table 2).

Table 6. Trends in average cluster sizes of lesser prairie-chicken detected by ecoregion and overall for survey years 2012 to 2018 and 2020.

	Ecoegion				
Year	**SOPR**	**SSPR**	**MGPR**	**SGPR**	**Overall**
2012	3.4	7.3	6.6	4.3	**4.6**
2013	2.4	5.8	5.6	4.9	**4.7**
2014	2.4	4.0	4.4	3.9	**3.9**
2015	1.4	1.8	3.0	3.8	**3.3**
2016	2.5	2.8	3.8	3.6	**3.4**
2017	2.7	3.3	3.5	3.3	**3.3**
2018	3.5	3.8	3.8	4.6	**4.2**
2020	2.6	1.0	2.4	3.7	**3.3**

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas).

We pooled data collected from 2012 to 2020 to estimate the probability of detection of clusters of prairie-chickens because the survey methods remained unchanged between years and the models accommodated changes in cluster size and habitat by year. The probability of detection for all clusters of prairie-chickens was estimated as a function of distance from transect, cluster size, and habitat (Table 7 and Figures 2a, 2b, 3, and 4). In general, probability of detection was highest for large clusters in cropland, bare ground, and short grass. Estimated probability of detection decreased as distance from transect increased (Figure 3). In addition, probability of detection increased as cluster size increased (Figure 4). Annual variation of the estimated probability of detection of clusters of prairie-chickens was illustrated in Appendix A (Figures A-1 and A-2).

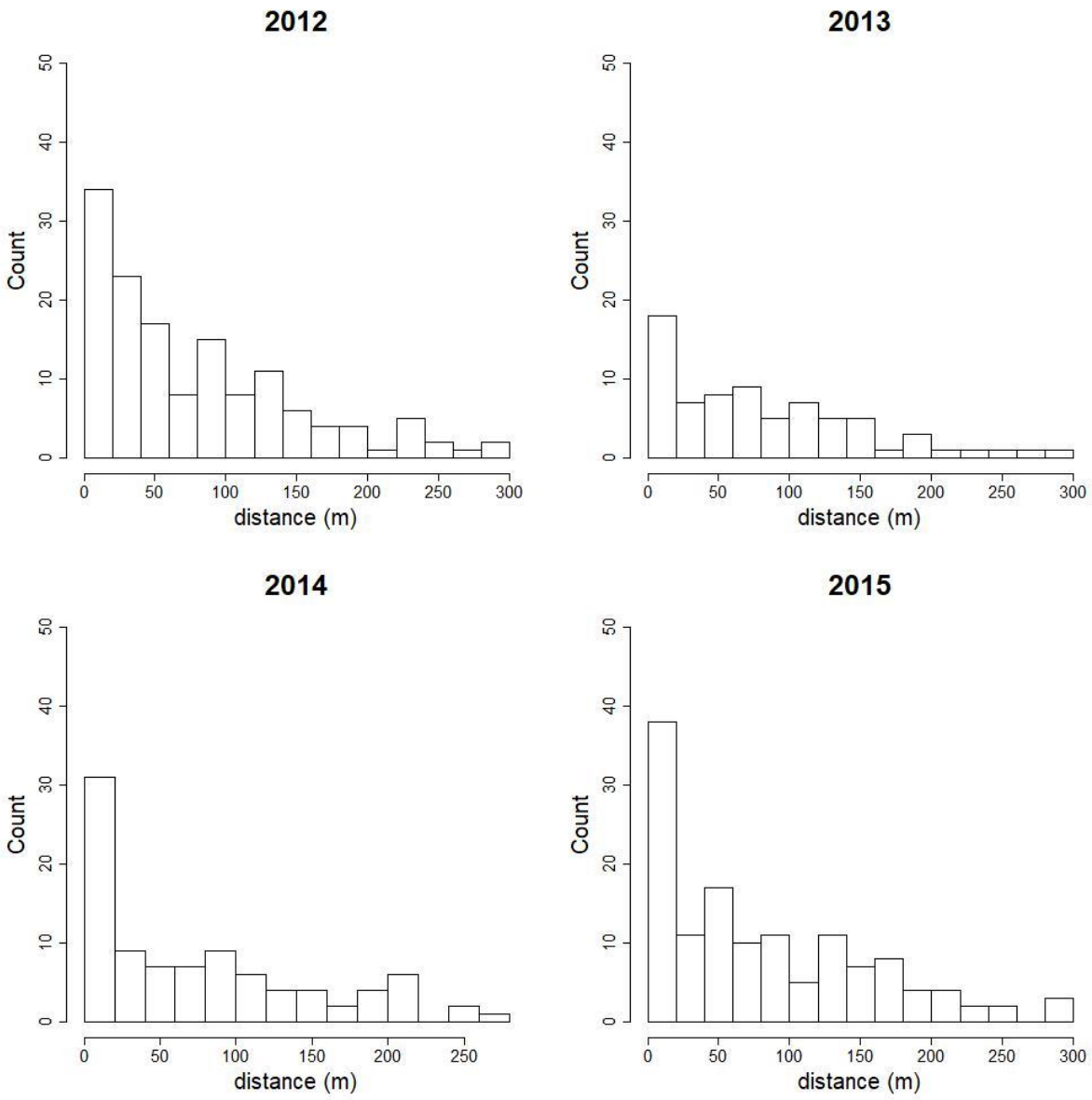

Figure 2a. Histograms showing the counts of observed distances of detected clusters of prairie-chickens from the transect line to the center of the clusters (density of detections in 20 meter [m] bins).

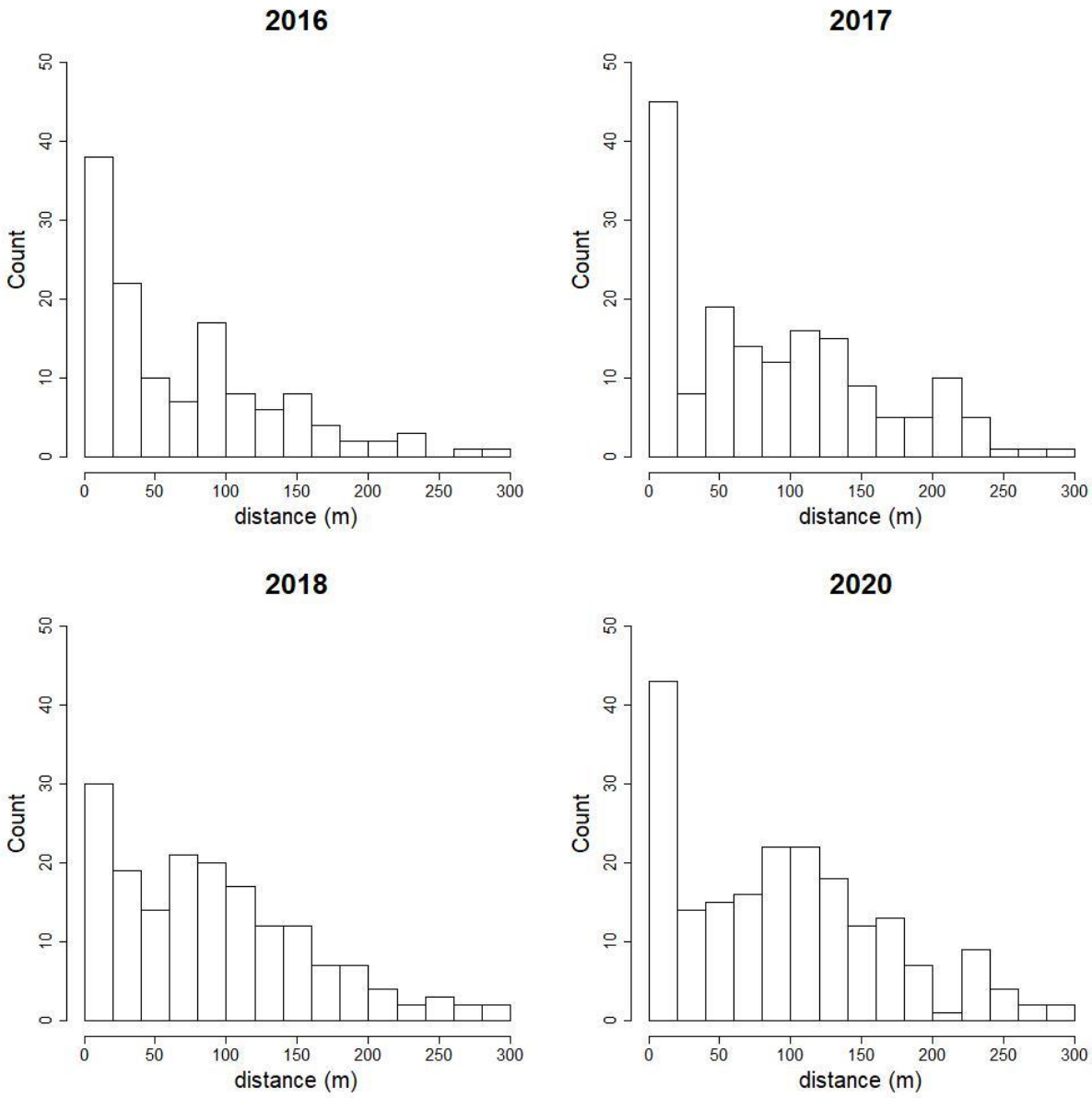

Figure 2b. Histograms showing the counts of observed distances of detected clusters of prairie-chickens from the transect line to the center of the clusters (density of detections in 20 meter [m] bins).

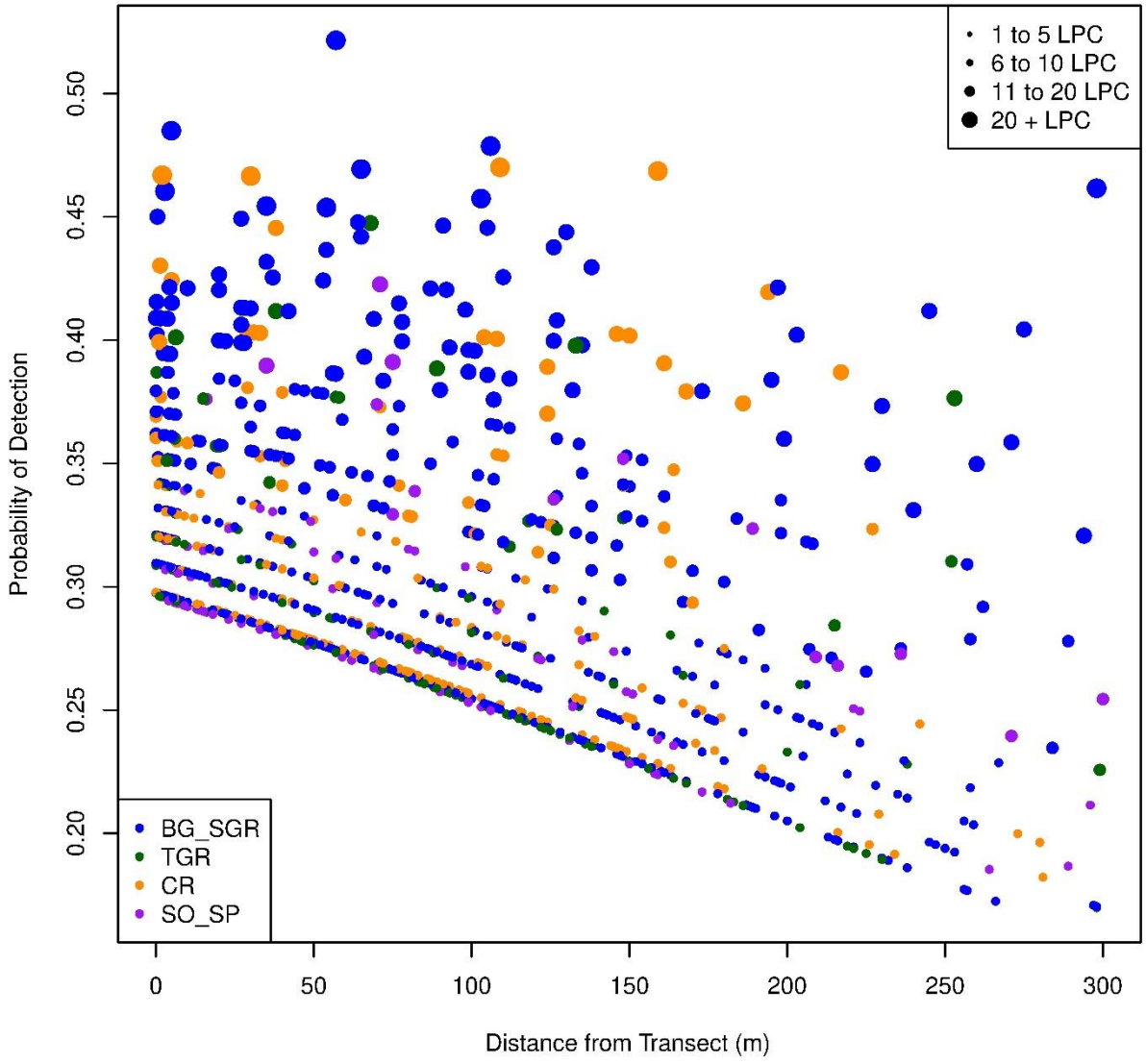

Figure 3. Estimated probability of detection of clusters of prairie-chickens plotted as a function of distance from transects with the effect of cluster size illustrated by the size of the point, and effect of habitat by color. Habitat classes were: CR = cropland, BG = bare ground, SGR = short-grass grassland, TGR = tall-grass grassland, SO = shinnery oak, and SP = sand-sage prairie.

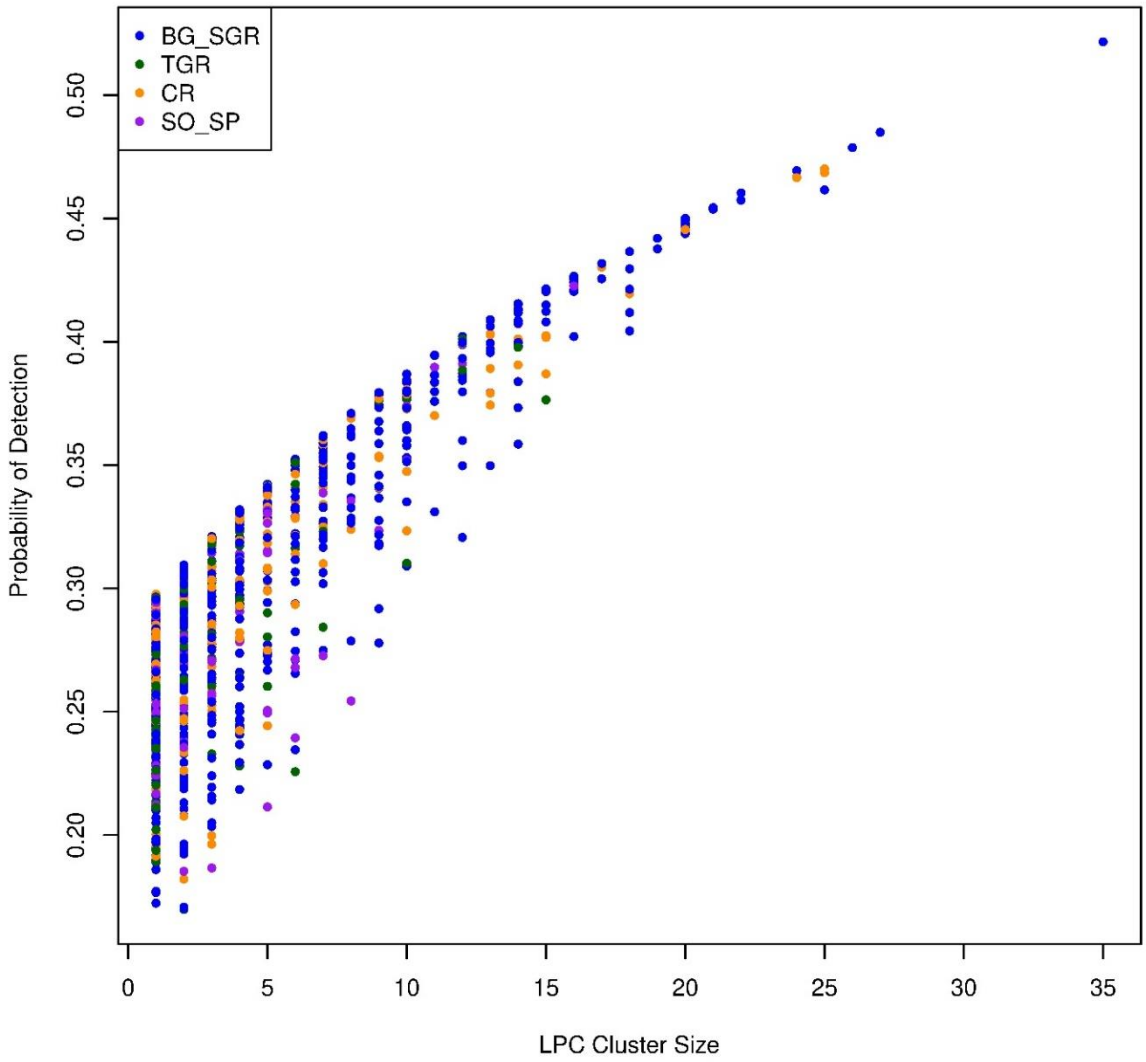

Figure 4. Estimated probability of detection plotted as a function of prairie-chicken cluster size with the effect of habitat type illustrated by the color of points. Habitat classes were: CR = cropland, BG = bare ground, SGR = short-grass grassland, TGR = tall-grass grassland, SO = shinnery oak, and SP = sand-sage prairie.

Table 7. Distance sampling models used to estimate probability of detection as a function of distance from the transect line and other covariates. Distance to detected clusters was in all models.

Model Covariates	Key Function	AICc	Model Weight
size	ne	12010.00	0.414
size	hn	12011.17	0.230
No Adj. Terms	ne	12011.31	0.215
size + habitat	hn	12014.07	0.054
No Adj. Terms	hr	12015.38	0.028
habitat	ne	12015.71	0.024
No Adj. Terms	hn	12016.53	0.016
size	hr	12017.08	0.012
habitat	hn	12019.06	0.004
habitat	hr	12021.04	0.002
size + habitat	hr	12022.80	0.001

AICc =Akaike Information Criterion

Size = size of cluster, and habitat = habitat occupied by detected clusters. Pooled data from 2012 to 2020 were used to fit the distance sampling models. Key Functions were ne = negative exponential model, hr = hazard rate, and hn = half normal.

Estimated Trends in Densities and Abundances of LPC

We adjusted counts of LPC by covariate specific, scaled, model averaged probabilities of detection to estimate population sizes in four ecoregions and the original study area (Table 3 Figure 2). Use of improved models resulted in an increase in the estimated probability of detection. Estimates of LPC population sizes from 2012 to 2018 decreased relative to estimates reported previously due to an increase in the estimated detection probability (Table 8 and 9; Figures 5, 6a, and 6b). We estimated the total population size of LPC to be:

- 28,366 (90% CI: 17055, 40581) LPC in 2012;
- 15,397 (90% CI: 8145, 22406) in 2013;
- 18,142 (90% CI: 10234, 25706) in 2014;
- 22,899 (90% CI: 13486, 32871) in 2015;
- 19,913 (90% CI: 12111, 27423) in 2016;
- 26,606 (90% CI: 16401, 35700) in 2017;
- 33,094 (90% CI: 20860, 45013) in 2018; and
- 34,408 (90% CI: 21270, 47946) in 2020.

To evaluate trends in the LPC population over time, a generalized simple linear regression model with random error terms following a first-order autoregressive process was fit to LPC population estimates from 2013 to 2020. The estimated average rate of increase of 3,237 (standard error = 461) LPC in total LPC by year was statistically significant (p-value = 0.01). An estimated total population increase of 1,314 LCP was observed from 2018 to 2020 (4.0% increase); however, this increase was not statistically significant at the 80% confidence level (80% CI: -7956, 11301; Table 10a).

Table 8. Trends in estimated densities of lesser prairie-chickens per 100 kilometer^2 (km^2; 39 mile^2) by ecoregion and overall for survey years 2012 to 2018 and 2020. Bootstrapped 90% confidence intervals were reported on the densities of lesser prairie-chicken per 100 km^2.

	Ecoregion				
Year	SOPR	SSPR	MGPR	SGPR	Overall
2012	11.22 (3.82, 20.67)	12.39 (1.67, 24.69)	19.06 (7.37, 34.88)	42.12 (21.94, 62.26)	23.52 (14.14, 33.65)
2013	6.41 (2.63, 10.83)	10.44 (3.32, 18.47)	8.49 (2.54, 14.89)	23.01 (8.74, 38.26)	12.77 (6.75, 18.58)
2014	4.38 (0.94, 7.90)	2.70 (0.00, 6.46)	14.30 (4.24, 25.72)	29.01 (15.02, 43.21)	15.04 (8.49, 21.31)
2015	2.92 (0.61, 5.77)	4.60 (1.22, 8.93)	20.26 (10.84, 29.92)	35.69 (17.23, 56.97)	18.99 (11.18, 27.26)
2016	9.32 (3.85, 15.96)	7.54 (1.81, 13.79)	13.68 (6.37, 22.33)	28.68 (15.27, 42.61)	16.51 (10.04, 22.74)
2017	7.43 (2.67, 13.40)	7.75 (1.81, 14.79)	15.88 (6.73, 24.70)	45.57 (24.39, 65.96)	22.06 (13.6, 29.6)
2018	17.35 (5.71, 29.46)	17.06 (6.31, 28.46)	17.87 (8.44, 26.67)	51.88 (28.55, 79.03)	28.62 (18.04, 38.92)
2020	18.57 (8.70, 29.76)	1.07*	13.72 (4.96, 24.55)	65.18 (36.43, 94.65)	29.75 (18.39, 41.46)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas).

*Confidence Interval not calculated due to low sample size of observed lesser prairie-chickens (n < 5)

Table 9. Trends in estimated population sizes of lesser prairie-chickens by ecoregion and overall for survey years 2012 to2018 and 2020. Bootstrapped 90% confidence intervals were reported on the population sizes of lesser prairie-chicken.

	Ecoregion				
Year	SOPR	SSPR	MGPR	SGPR	Overall
2012	3,106 (1058, 5722)	1,980 (267, 3944)	7,550 (2929, 13811)	15,730 (8196, 23256)	28,366 (17055, 40581)
2013	1,773 (728, 2996)	1,668 (530, 2951)	3,362 (1006, 5898)	8,594 (3264, 14289)	15,397 (8145, 22406)
2014	1,211 (260, 2187)	431 (0, 1032)	5,664 (1678, 10183)	10,836 (5609, 16138)	18,142 (10234, 25706)
2015	808 (170, 1597)	735 (196, 1427)	8,025 (4293, 11847)	13,332 (6435, 21277)	22,899 (13486, 32871)
2016	2,578 (1066, 4417)	1,204 (289, 2204)	5,417 (2524, 8844)	10,713 (5702, 15917)	19,913 (12111, 27423)
2017	2,057 (740, 3708)	1,239 (289, 2363)	6,289 (2666, 9780)	17,021 (9108, 24634)	26,606 (16401, 35700)
2018	4,802 (1581, 8154)	2,726 (1008, 4547)	6,190 (2923, 9242)	19,376 (10663, 29519)	33,094 (20860, 45013)
2020	5,138 (2408, 8237)	171*	4,754 (1719, 8506)	24,345 (13605, 35350)	34,408 (21270, 47946)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas).

*Confidence Interval not calculated due to low sample size of observed lesser prairie-chickens (n < 5)

Table 10a. Estimated differences in population estimates for lesser prairie-chickens between years with bootstrapped 80% confidence intervals on the differences (Δ Year).

Δ Year	Ecoregion				Total
	SOPR	SSPR	MGPR	SGPR	
2013 minus 2012	-1333 (-3196, 315)	-312 (-1786, 1239)	-4188 (-8528, -147)	-7136 (-13414, -849)	-12969 (-21483, -4390)
2014 minus 2013	-562 (-1637, 506)	-1237 (-2231, -218)	2302 (-1473, 6147)	2243 (-3112, 7327)	2745 (-3658, 9295)
2015 minus 2014	-403 (-1295, 495)	304 (-280, 915)	2361 (-1849, 6121)	2495 (-2772, 8400)	4757 (-2291, 11949)
2016 minus 2015	1770 (415, 3187)	469 (-419, 1283)	-2608 (-5938, 990)	-2619 (-8308, 3168)	-2987 (-9572, 4111)
2017 minus 2016	-521 (-1991, 1018)	34 (-910, 1120)	872 (-2692, 4020)	6308 (-383, 12179)	6693 (-1344, 13424)
2018 minus 2017	2745 (-23, 5285)	1487 (-99, 2933)	-99 (-3448, 3076)	2355 (-5077, 10912)	6489 (-2673, 15804)
2020 minus 2018	336 (-2769, 3822)	-2555 *	-1436 (-4494, 2250)	4970 (-3925, 13111)	1314 (-7956, 11301)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas).

*Confidence Interval not calculated in 2020 due to low sample size of observed lesser prairie-chickens (n < 5).

Table 10b. Estimated differences in population estimates for lesser prairie-chickens between years with bootstrapped 90% confidence intervals on the differences (Δ Year).

Δ Year	Ecoregion				Total
	SOPR	SSPR	MGPR	SGPR	
2013 minus 2012	-1333 (-3808, 759)	-312 (-2393, 1674)	-4188 (-10549, 854)	-7136 (-15768, 1463)	-12969 (-24673, -2056)
2014 minus 2013	-562 (-1928, 706)	-1237 (-2573, -19)	2302 (-2223, 7401)	2243 (-4812, 9244)	2745 (-5553, 11569)
2015 minus 2014	-403 (-1560, 700)	304 (-454, 1078)	2361 (-2967, 7190)	2495 (-4425, 10266)	4757 (-4362, 14587)
2016 minus 2015	1770 (144, 3564)	469 (-710, 1551)	-2608 (-7069, 1775)	-2619 (-10753, 4832)	-2987 (-12268, 5796)
2017 minus 2016	-521 (-2541, 1439)	34 (-1244, 1462)	872 (-3577, 4902)	6308 (-2066, 14128)	6693 (-2641, 15527)
2018 minus 2017	2745 (-615, 6315)	1487 (-575, 3440)	-99 (-4455, 4352)	2355 (-7611, 12920)	6489 (-5373, 18924)
2020 minus 2018	336 (-3809, 4774)	-2555 *	-1436 (-5470, 3281)	4970 (-6762, 16270)	1314 (-10913, 14945)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas).

*Confidence Interval not calculated in 2020 due to low sample size of observed lesser prairie-chickens (n < 5)

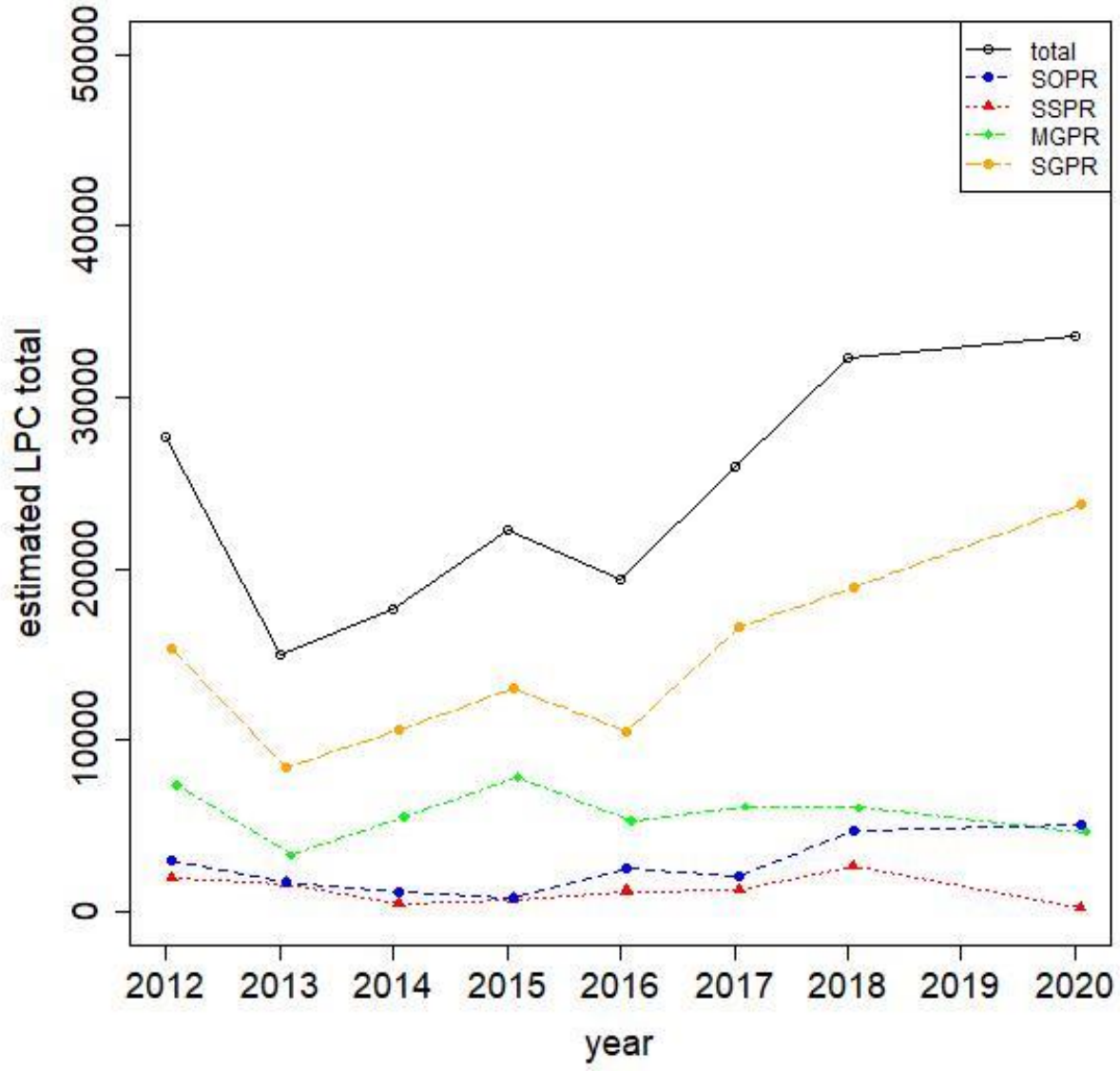

Figure 5. Trends in estimated total population sizes of lesser prairie-chicken for survey years 2012 to 2018 and 2020. SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass Conservation Reserve Program Prairie Region (northwest Kansas).

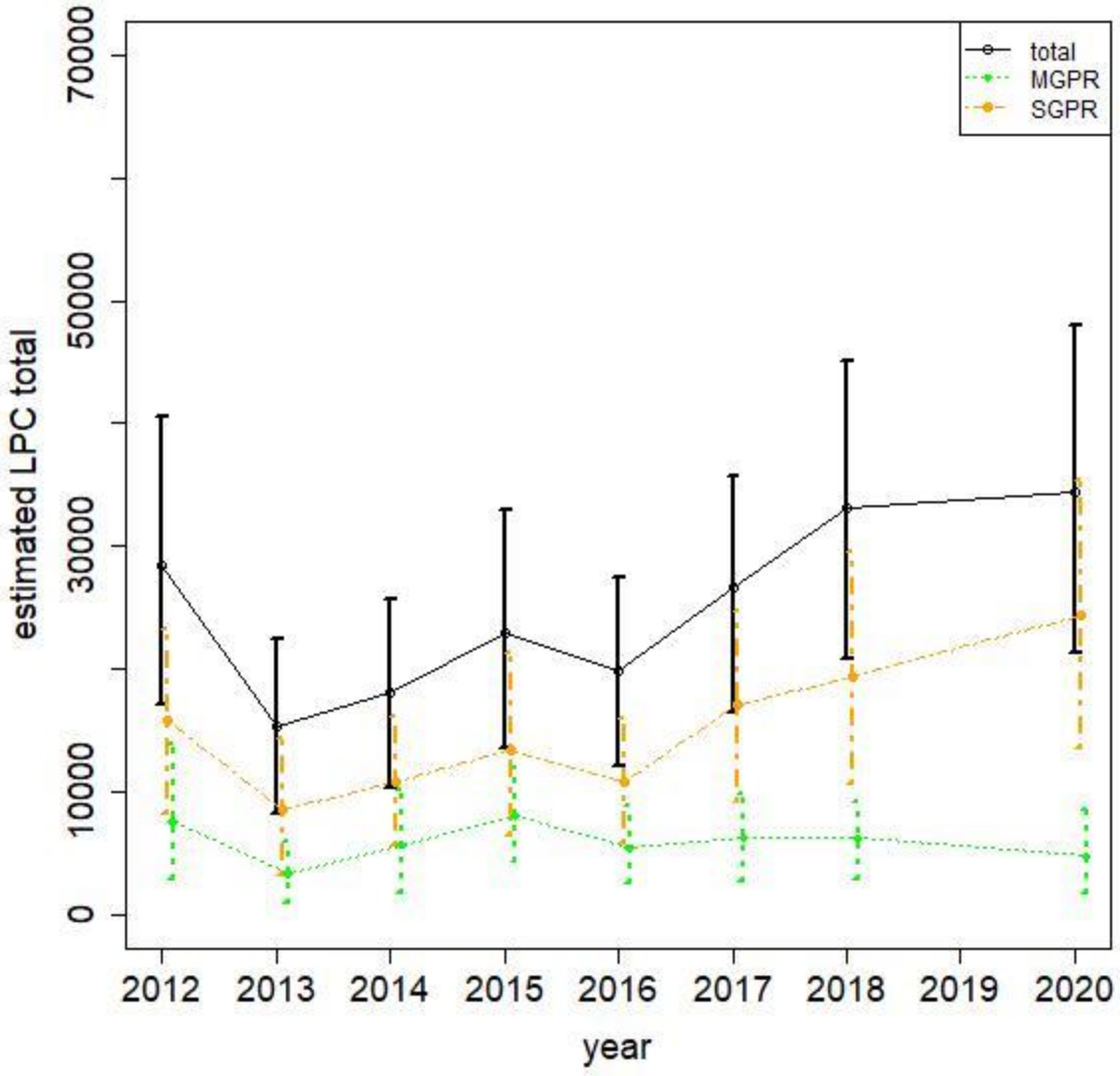

Figure 6a. Trends in estimated total population sizes of lesser prairie-chickens for survey years 2012 to 2018 and 2020 with 90% confidence intervals for the original study area, MGPR = Mixed-Grass Prairie Region (northeast Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass Conservation Reserve Program Prairie Region (northwestern Kansas).

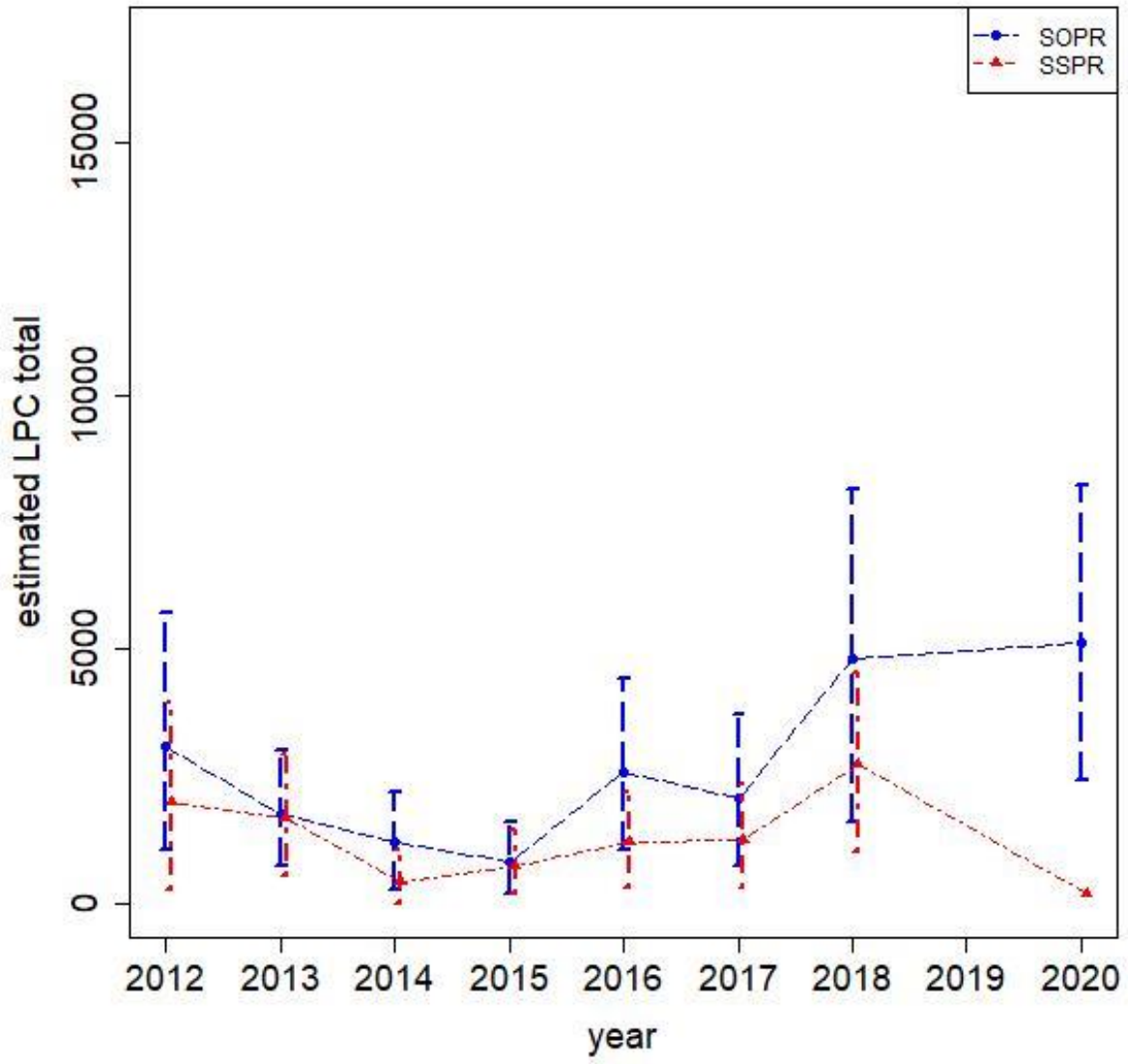

Figure 6b. Trends in estimated total population sizes of lesser prairie-chickens (LPC) for survey years 2012 to2018 and 2020 with 90% confidence intervals in the SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas) and SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle). Note that confidence intervals were not calculated for the SSPR due to a low sample size of observed LCP (n < 5).

Estimated Trends in LPC Leks

We estimated an increase in the density and abundance of LPC leks in 2020 relative to 2018 (Tables 11 and 12). The abundance of LPC leks was estimated to be:

- 2,769 (90% CI: 1466, 4175) in 2012;
- 1,827 (90% CI: 927, 2675) in 2013;
- 2,186 (90% CI: 1190, 3180) in 2014;
- 1,344 (90% CI: 730, 1980) in 2015;
- 1,673 (90% CI: 797, 2631)in 2016;
- 2,637(90% CI: 1584, 3650) in 2017;
- 2,498(90% CI: 1503, 3478) in 2018; and
- 4,862 (90% CI: 2784, 6957) in 2020.

Table 11. Estimated trends in densities of lesser prairie-chicken leks per 100 kilometer^2 (km^2 39 miles^2) by ecoregion and overall for survey years 2012 to 2018 and 2020. Bootstrapped 90% confidence intervals were reported on the densities of lesser prairie-chicken leks per 100 km^2.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	1.22 (0.36, 2.32)	1.11 (0.00, 2.30)	2.00 (0.79, 3.61)	3.92 (1.30, 6.89)	2.30 (1.22, 3.46)
2013	0.69 (0.00, 1.50)	1.97 (0.70, 3.34)	0.89 (0.18, 1.74)	2.60 (0.79, 4.46)	1.51 (0.77, 2.22)
2014	0.78 (0.00, 1.53)	0.36 (0.00, 1.02)	1.75 (0.54, 3.11)	3.26 (1.41, 5.22)	1.81 (0.99, 2.64)
2015	0.24 (0.00, 0.62)	0.29 (0.00, 0.76)	1.74 (0.72, 2.91)	1.45 (0.49, 2.56)	1.11 (0.61, 1.64)
2016	0.65 (0.13, 1.31)	0.31 (0.00, 0.77)	1.33 (0.46, 2.39)	2.46 (0.71, 4.55)	1.39 (0.66, 2.18)
2017	0.87 (0.13, 1.99)	0.98 (0.21, 2.02)	2.02 (0.81, 3.21)	3.85 (1.89, 5.92)	2.19 (1.31, 3.03)
2018	1.79 (0.58, 3.11)	0.83 (0.00, 1.88)	2.37 (1.05, 3.62)	2.81 (1.10, 4.57)	2.16 (1.3, 3.01)
2020	1.76 (0.34, 3.69)	0.38*	2.13 (0.36, 4.36)	9.58 (4.97, 14.04)	4.20 (2.41, 6.02)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas)

*Confidence Interval not calculated due to low sample size of observed lesser prairie-chickens (n < 5)

Table 12. Estimated trends in abundances of lesser prairie-chicken leks by ecoregion and overall for survey years 2012 to 2018 and 2020. Bootstrapped 90% confidence intervals were reported on the abundances of lesser prairie-chicken leks.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	336 (100.78, 642.69)	177 (0.00, 367.69)	790 (314.44, 1430.38)	1466 (484.28, 2572.84)	2,769 (1466, 4175)
2013	192 (0.00, 415.94)	314 (111.56, 532.77)	351 (72.18, 688.05)	970 (293.66, 1667.10)	1,827 (927, 2675)
2014	215 (0.00, 423.89)	58 (0.00, 162.41)	694 (214.34, 1231.36)	1219 (528.23, 1949.96)	2,186 (1190, 3180)
2015	68 (0.00, 170.23)	46 (0.00, 121.05)	689 (284.20, 1151.73)	541 (182.28, 956.75)	1,344 (730, 1980)
2016	180 (36.14, 361.75)	49 (0.00, 123.63)	527 (183.53, 946.97)	917 (263.35, 1699.70)	1,673 (797, 2631)
2017	240 (35.67, 552.03)	156 (34.09, 322.15)	801 (320.58, 1272.09)	1440 (704.91, 2212.77)	2,637 (1584, 3650)
2018	494 (159.57, 861.94)	133 (0.00, 300.33)	822 (362.65, 1254.68)	1049 (411.67, 1708.40)	2,498 (1503, 3478)
2020	487 (93.36, 1020.21)	60*	736 (125.91, 1510.43)	3579 (1856.15, 5242.47)	4,862 (2784, 6957)

SOPR = Shinnery Oak Prairie Region (eastern New Mexico, western Texas), SSPR = Sand Sagebrush Prairie Region (southeastern Colorado, southwestern Kansas, Oklahoma Panhandle), MGPR = Mixed-Grass Prairie Region (northeastern Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass CRP Prairie Region (northwest Kansas)

*Confidence Interval not calculated due to low sample size of observed lesser prairie-chickens (n < 5)

DISCUSSION

We estimated LPC population sizes annually from 2012 to 2018 and 2020 in the 2011 EOR of the LPC in Kansas, Colorado, New Mexico, Oklahoma, and Texas to evaluate trends in the population. The objective of the study was to estimate the annual range-wide population size of LPC and evaluate trends in time of the range-wide population size of LPC. This objective was met and we determined that there was a statistically significant (p-value < 0.01) annual rate of increase of the total LPC population size from 2013 to 2020 with the average rate of increase being 3,237 LPC per year (standard error = 461).

Annual estimates within each ecoregion were also calculated; however, there is more uncertainty in these estimates relative to the range-wide population estimates, especially for ecoregions with a low density of LPC, and should be interpreted with caution. In addition, the study area was defined as the 2011 EOR of the LPC. In 2018, the study area was reduced by dropping grid cells in the MGPR of central Kansas where no LPC were observed. There may be additional changes to the EOR of LCP in the future, e.g., LPC located outside of the 2011 EOR of the LPC; therefore range-wide population estimates of the LPC, may be larger in an expanded survey area.

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Appendix A. Estimated Probability of Detection of Lesser, Greater, and Hybrid Prairie-Chickens

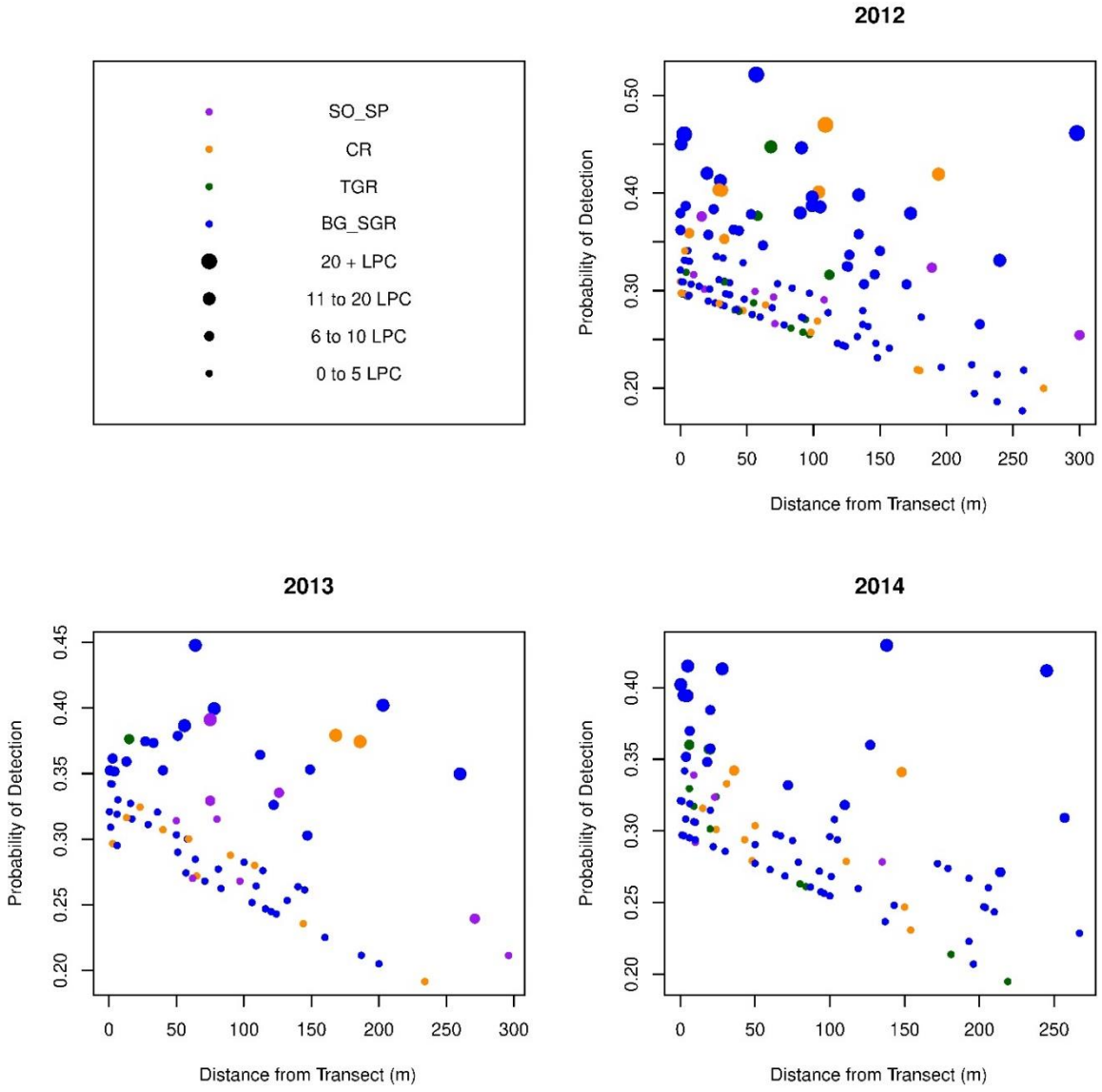

Figure A-1. Estimated probability of detection of clusters of prairie-chickens plotted as a function of distance from transects with the effect of cluster size illustrated by the size of the point and effect of habitat by color. Habitat classes were: CR = cropland, BG = bare ground, SGR = short-grass grassland, TGR = tall-grass grassland, SO = shinnery oak, and SP = sand-sage prairie.

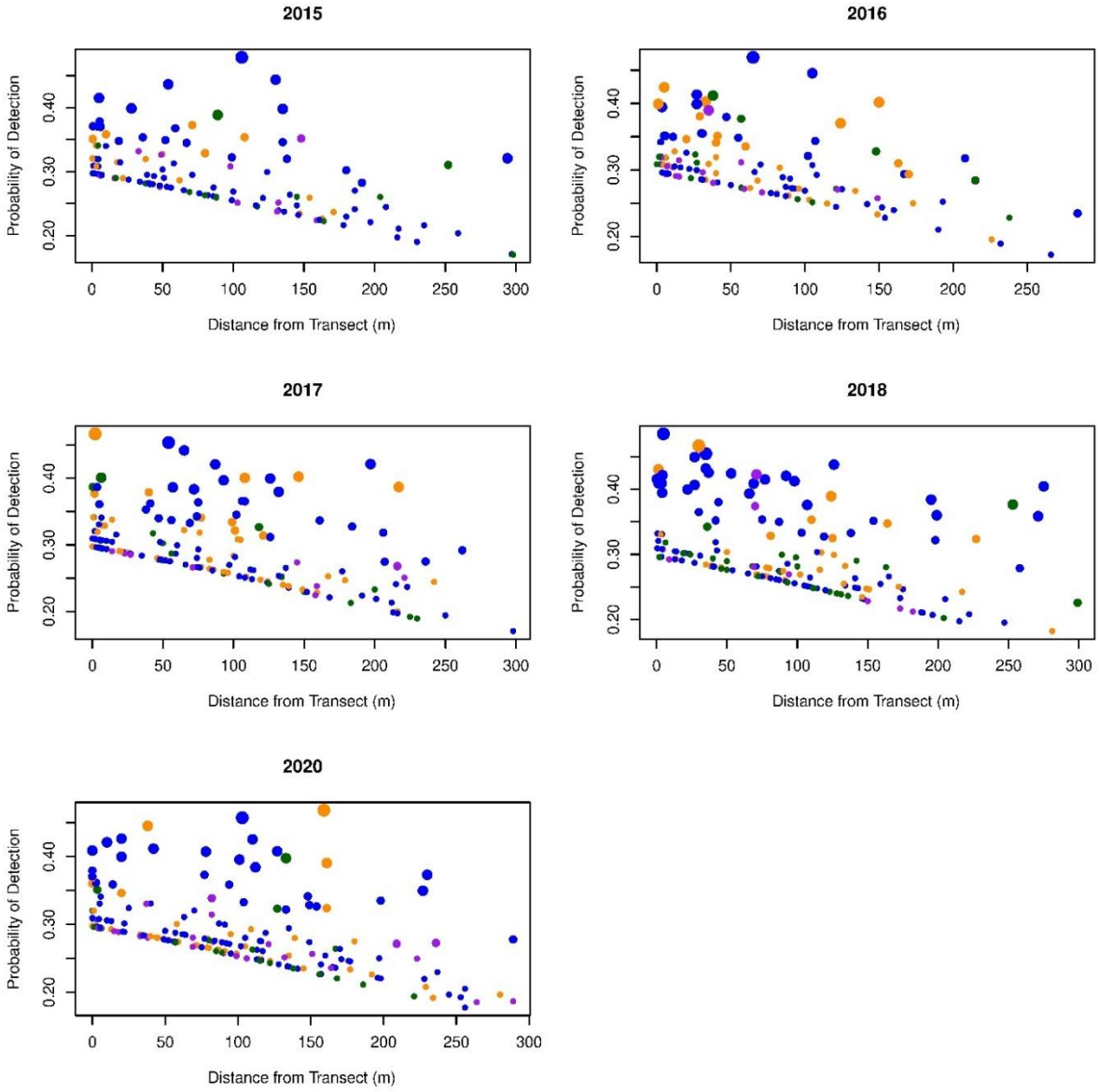

Figure A-2. Estimated probability of detection of clusters of prairie-chickens plotted as a function of distance from transects with the effect of cluster size illustrated by the size of the point and effect of habitat by color. Habitat classes were: CR = cropland, BG = bare ground, SGR = short-grass grassland, TGR = tall-grass grassland, SO = shinnery oak, and SP = sand-sage prairie.

Appendix B. Estimated Densities and Abundances of Greater Prairie-Chicken and Hybrid Prairie-Chicken

Densities (Table B-1, Table B-2, and Figure B-1) and abundances (Table B-3) of GPC and HPC were estimated in the SGPR of northwest Kansas. The population sizes of the GPC in the SGPR were estimated to be:

- 25,891(90% CI: 15409, 37328) in 2012;
- 12,291(90% CI: 7008, 17749) in 2013;
- 13,903(90% CI: 8044, 19905) in 2014;
- 18,943 (90% CI: 11182, 26536) in 2015;
- 22,498(90% CI: 12967, 32114) in 2016;
- 28,365(90% CI: 17863, 38201) in 2017;
- 29,330(90% CI: 16447, 42064) in 2018; and
- 26,079(90% CI: 15743, 36174) in 2020.

A decrease of 3,251 GPC was observed from 2018 to 2020; however, this decrease was not statistically significant (80% CI: -13252, 6540; Table B-4). There was a statistically significant annual rate of increase of abundance for the GPC in the SGPR in northwest Kansas from 2013 to 2020 (p-value < 0.01). The average rate of increase was 2,916 (standard error = 543) greater prairie-chickens per year in the SGPR.

We estimated the number of HPC in the SGPR (Figure B-2) to be:

- 273(90% CI: 147, 405) in 2012;
- 100(90% CI: 42, 177) in 2013;
- 82(90% CI: 43, 120) in 2014;
- 207(90% CI: 107, 317) in 2015;
- 238(90% CI: 118, 380) in 2016;
- 349(90% CI: 195, 494) in 2017;
- 247(90% CI: 122, 388) in 2018; and
- 193 (90% CI: 95, 296) in 2020.

Table B-1. Estimates of greater prairie-chicken (GPC) and hybrid prairie chicken (HPC) densities per 100 kilometer^2 (km^2; 39 miles^2) for survey years 2012 to 2018 and 2020 in the Short Grass Conservation Reserve Program Region of northwestern Kansas. Bootstrapped 90% confidence intervals were reported on the densities of GPC and HPC per 100 km^2.

Year	GPC	HPC
2012	69.32 (41.26, 99.94)	0.73 (0.39, 1.09)
2013	32.91 (18.76, 47.52)	0.27 (0.11, 0.47)
2014	37.22 (21.54, 53.29)	0.22 (0.12, 0.32)
2015	50.72 (29.94, 71.05)	0.55 (0.29, 0.85)
2016	60.24 (34.72, 85.98)	0.64 (0.32, 1.02)
2017	75.94 (47.83, 102.28)	0.94 (0.52, 1.32)
2018	78.53 (44.03, 112.62)	0.66 (0.33, 1.04)
2020	69.82 (42.15, 96.85)	0.52 (0.26, 0.79)

Table B-2. Estimates of greater prairie-chicken (GPC) and hybrid prairie-chicken (HPC) population sizes from 2012 to 2020 in the Short Grass Conservation Reserve Program Region of northwestern Kansas. Bootstrapped 90% confidence intervals were reported on the population sizes of GPC and HPC.

Year	GPC	HPC
2012	25891 (15409, 37328)	273 (147, 405)
2013	12291 (7008, 17749)	100 (42, 177)
2014	13903 (8044, 19905)	82 (43, 120)
2015	18943 (11182, 26536)	207 (107, 317)
2016	22498 (12967, 32114)	238 (118, 380)
2017	28365 (17863, 38201)	349 (195, 494)
2018	29330 (16447, 42064)	247 (122, 388)
2020	26079 (15743, 36174)	193 (95, 296)

Table B-3. Estimates of greater prairie-chicken (GPC) lek densities per 100 kilometer^2 (km^2; 39 miles^2) and abundances of GPC leks for survey years 2012 to 2018 and 2020 in the Short Grass Conservation Reserve Program Prairie Region of northwestern Kansas. Bootstrapped 90% confidence intervals were reported on the population sizes of GPC and abundances of GPC leks per 100 km^2.

Year	Density	Abundance
2012	5.16 (2.86, 7.39)	1929 (1067, 2759)
2013	3.64 (1.84, 5.34)	1360 (686, 1993)
2014	4.29 (2.42, 6.20)	1603 (903, 2316)
2015	3.18 (1.53, 4.84)	1188 (573, 1809)
2016	6.5 (3.38, 9.55)	2426 (1262, 3567)
2017	5.2 (3.01, 7.14)	1942 (1123, 2665)
2018	6.48 (3.34, 9.60)	2420 (1247, 3586)
2020	10.24 (6.04, 13.90)	3825 (2257, 5192)

Table B-4. Estimated differences in population estimates for greater prairie-chickens between years with bootstrapped 80% confidence intervals on the differences.

Δ Year	Estimate (80% Confidence Interval)
2013 minus 2012	-13600 (-21240, -5218)
2014 minus 2013	1612 (-3542, 6369)
2015 minus 2014	5040 (-1186, 11305)
2016 minus 2015	3556 (-3784, 10905)
2017 minus 2016	5867 (-2390, 13301)
2018 minus 2017	965 (-8311, 10805)
2020 minus 2018	-3251 (-13252, 6540)

Δ Year = change in year

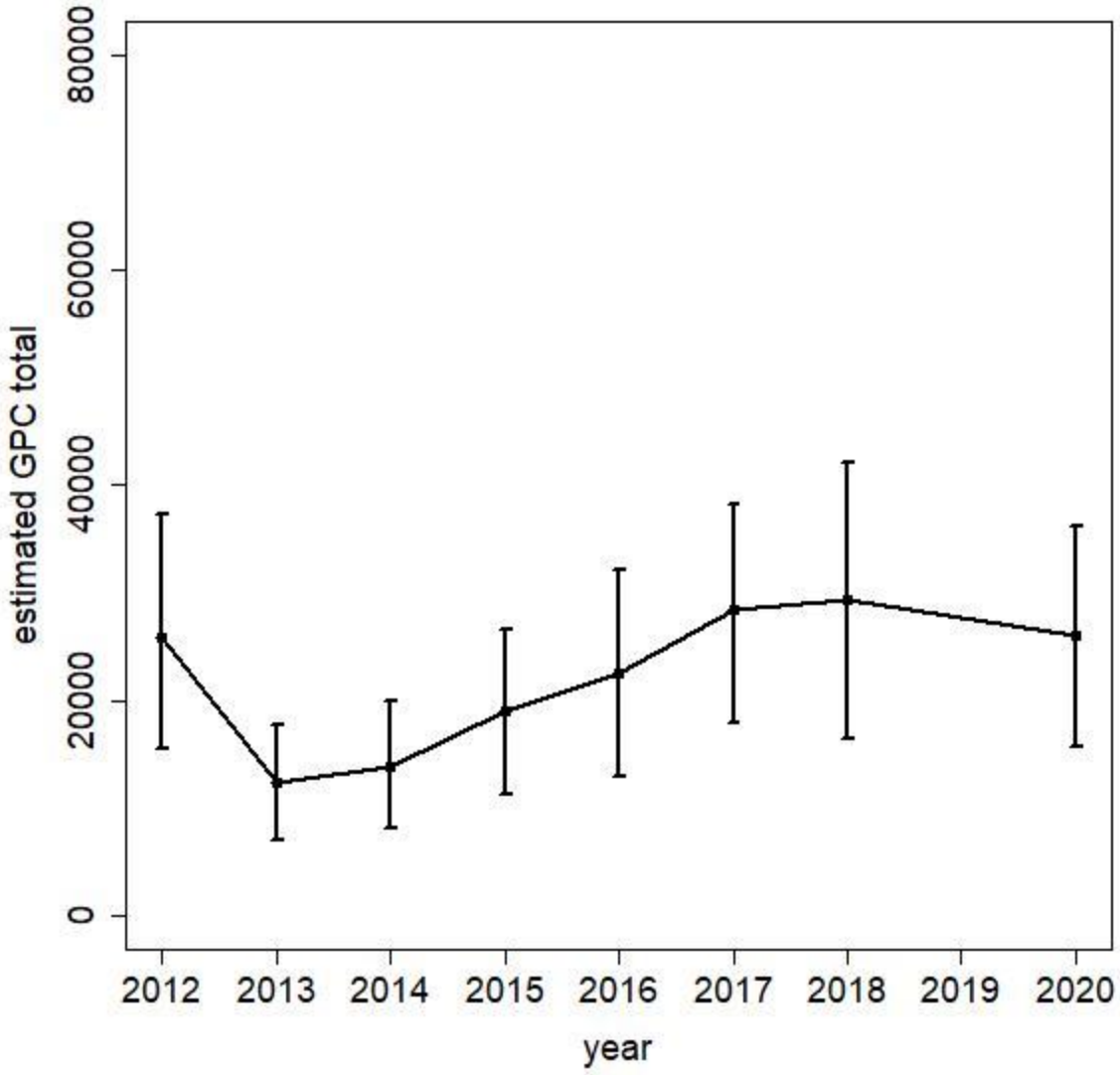

Figure B-1. Estimated population sizes of greater prairie-chickens (GPC) with 90% confidence intervals for survey years 2012 to 2018 and 2020 in the Short Grass Conservation Reserve Program Prairie Region (northwestern Kansas).

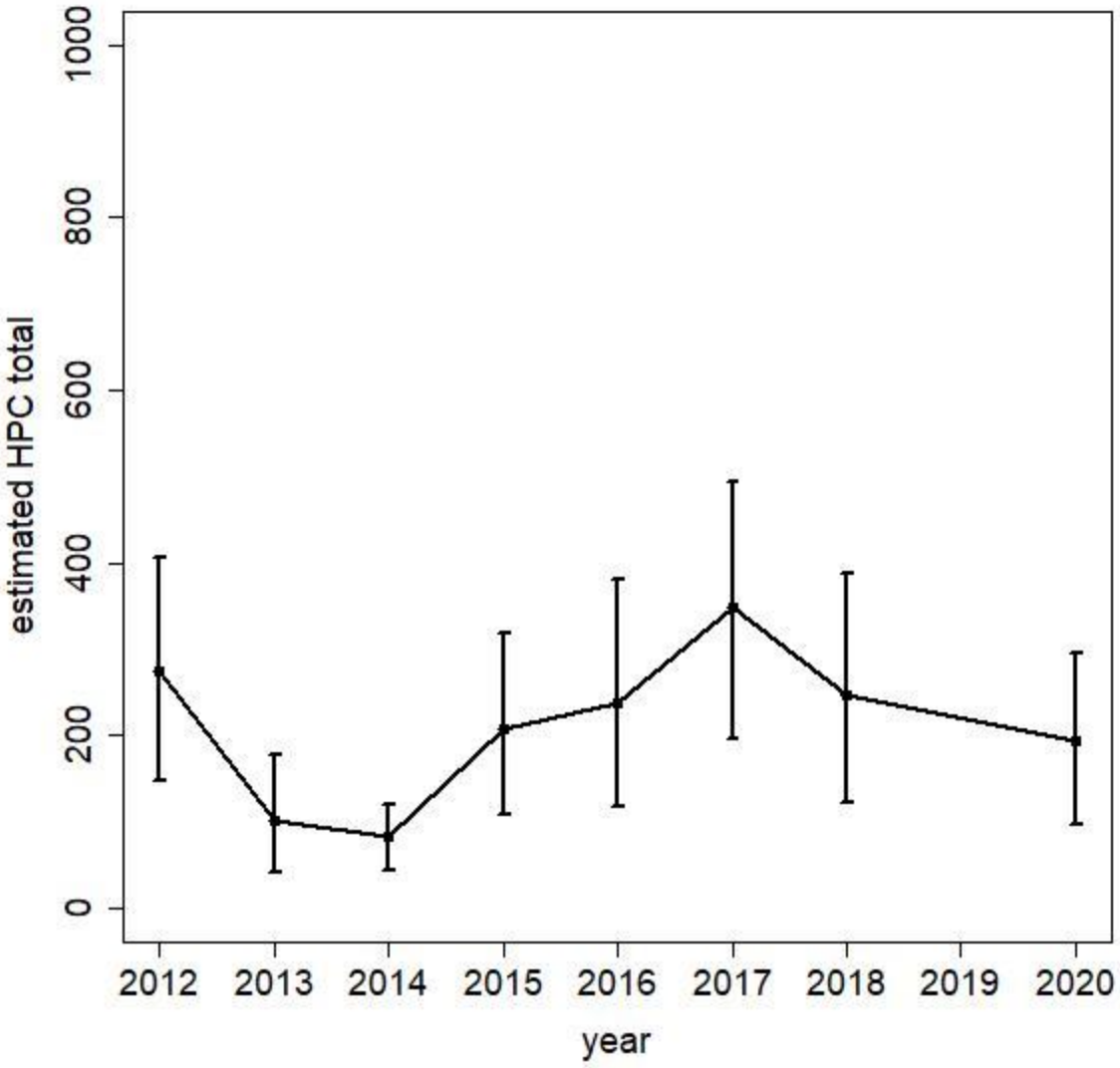

Figure B-2. Estimated population sizes of hybrid prairie-chickens (HPC) with 90% confidence intervals for survey years 2012 to 2018and 2020 in the Short Grass / Conservation Reserve Program Prairie Region (northwestern Kansas).