

**RANGE-WIDE POPULATION SIZE OF THE
LESSER PRAIRIE-CHICKEN:
2012 TO 2022**



**Prepared for:
Western Association of Fish and Wildlife Agencies**

**Prepared by:
Kristen Nasman, Troy Rintz, Guy DiDonato, and Faith Kulzer**

Western EcoSystems Technology, Inc.
2121 Midpoint Drive, Suite 201
Fort Collins, Colorado 80525

October 20, 2022



EXECUTIVE SUMMARY

- We estimated lesser prairie-chicken (LPC) population sizes annually from 2012 to 2018, and 2020 to 2022 in the 2011 estimated occupied range of the LPC, as defined by the LPC Interstate Working Group in Kansas, Colorado, New Mexico, Oklahoma, and Texas. In 2022, a redefined area of the estimated occupied range was used in Colorado, New Mexico, and Texas.
- We estimated LPC population sizes and abundance of leks in four ecoregions of the estimated occupied range.
- In 2022, the sampling frame was reduced by nine cells in the Shinnery Oak Prairie Region and increased by 21 cells in the Sand Sagebrush Prairie Region and 19 cells in the Short Grass Conservation Reserve Program (CRP) Region. The estimates in this report account for the change in the study area.
- Sample cells were selected by an equal probability procedure and 308 cells were surveyed in 2022. A rotating panel design was implemented 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 2022 where two transects were surveyed in each grid cell and the two transects covered 8% of the grid cell.
- On estimated parameters, 90% confidence intervals (CI) were computed to account for variation in the estimates due to unsampled grid cells, detection probability, and surveying two transects in each sampled grid cell.
- From 2012 to 2022, 1,447 prairie-chicken clusters were detected and used to estimate the probability of detection.
- Probability of detection increased as the size of prairie-chicken cluster increased and decreased as distance from the transect line increased. We adjusted counts of LPC and greater prairie-chicken by covariate-specific, scaled probabilities of detection to estimate population sizes in ecoregions and the total study area.
- We estimated the probability of detection of clusters of all prairie-chickens using 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 estimated the total population sizes of LPC to be:
 - 30,682 (90% CI: 20,938, 39,385) LPC in 2012;
 - 16,724 (90% CI: 10,420, 23,538) in 2013;
 - 20,378 (90% CI: 13,563, 27,410) in 2014;
 - 24,678 (90% CI: 17,500, 32,915) in 2015;
 - 22,278 (90% CI: 15,437, 28,600) in 2016;
 - 28,600 (90% CI: 19,565, 37,745) in 2017;

- 36,278 (90% CI: 25,471, 47,559) in 2018;
 - 36,077 (90% CI: 25,345, 46,688) in 2020;
 - 33,504 (90% CI: 22,262, 45,111) in 2021; and
 - 26,591 (90% CI: 16,321, 38,259) in 2022.
- An estimated total population decrease of 6,913 LPC was observed from 2021 to 2022 (20.6% decrease); however, this decrease was not statistically significant at the 90% confidence level (90% CI: -22,205, 6,328).
 - We observed a stable to increasing population of LPC from 2015 to 2020 and a decrease in the population from 2020 to 2022 in the Shinnery Oak Prairie Region of eastern New Mexico and western panhandle of Texas. Note that the survey was designed to measure trends in the range-wide population of LPC over time, and estimates can be variable in low-density ecoregions, such as the Shinnery Oak Prairie Region.
 - We observed a stable to increasing population of LPC 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 LPC population from 2019 to 2020, and a slight increase in the population from 2020 to 2022. Note that the survey was designed to measure trends in the range-wide population of LPC over time, and estimates can be variable in low-density ecoregions such as the Sand Sage Prairie Region.
 - We observed an increasing population of LPC 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 LPC in 2016, the population was stable in 2017 and 2018, a decrease in the population was observed from 2020 to 2021, and an increase in the population was observed from 2021 to 2022.
 - We observed a stable to increasing population of LPC from 2013 to 2021 in the Short Grass CRP Prairie Region of northwestern Kansas and east-central Colorado and a decrease in the population from 2021 to 2022.
 - To further evaluate trends in the LPC population, annual estimates of LPC were averaged over three years:
 - 22,595 (90% CI: 17,861, 27,267) estimated average annual LPC population from 2012 – 2014;
 - 20,593 (90% CI: 16,306, 24,929) from 2013 – 2015;
 - 22,445 (90% CI: 17,798, 26,903) from 2014 – 2016;
 - 25,185 (90% CI: 20,268, 29,927) from 2015 – 2017;
 - 29,052 (90% CI: 23,244, 34,650) from 2016 – 2018;
 - 32,439 (90% CI: 24,538, 39,741) from 2017 – 2018 (no surveys in 2019);
 - 36,178 (90% CI: 27,879, 43,934) from 2018 – 2020 (no surveys in 2019);
 - 34,791 (90% CI: 26,568, 43,099) from 2020 – 2021 (no surveys in 2019); and

- 32,058 (90% CI: 25,094, 38,525) from 2020 – 2022.
- The abundance of LPC leks in the total population were estimated to be:
 - 2,852 (90% CI: 1,729, 4,085) in 2012;
 - 1,815 (90% CI: 1,077, 2,666) in 2013;
 - 2,271 (90% CI: 1,463, 3,200) in 2014;
 - 1,445 (90% CI: 874, 2,106) in 2015;
 - 1,733 (90% CI: 887, 2,659) in 2016;
 - 2,602 (90% CI: 1,748, 3,569) in 2017;
 - 2,631 (90% CI: 1,702, 3,658) in 2018;
 - 4,745 (90% CI: 3,115, 6,365) in 2020;
 - 3,174 (90% CI: 2,059, 4,328) in 2021; and
 - 3,302 (90% CI: 2,016, 4,749) in 2022.
- We observed an increase in LPC leks from 2018 to 2020 and a decrease in LPC leks from 2020 to 2021. A slight increase in LPC leks was observed from 2021 to 2022.

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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 2022. To achieve this, we addressed issues of regional variation as well as the co-occurrence of greater prairie-chicken (*T. cupido*; GPC) in northwestern Kansas and east-central Colorado. We estimated LPC abundance for four ecoregions: 1) Shinnery Oak Prairie Region (SOPR), located in eastern New Mexico and the southwestern 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, northwestern Oklahoma, and south-central Kansas; and 4) Short Grass Conservation Reserve Program (CRP) Prairie Region (SGPR), located in northwestern Kansas and east-central Colorado (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; LPCIWG 2011, McDonald et al. 2012). In 2022, a redefined area of the EOR was used in Colorado, New Mexico, and Texas. We included habitats with a relatively high probability of lek occurrence in northwestern Kansas and east-central Colorado as measured by the Western Governors' Association Southern Great Plains Crucial Habitat Assessment Tool (WAFWA 2021). The study area for 2022 is illustrated in Figure 1, indicating the grid cells (cells) selected and not selected for surveys. In 2022, the sampling frame was reduced by nine cells in the SOPR, and increased by 21 cells in the SSPR and 19 cells in the SGPR. The EOR was further refined in June 2022, which reduced the southern extent of the SOPR (see LPCIWG 2022; WAFWA 2022).

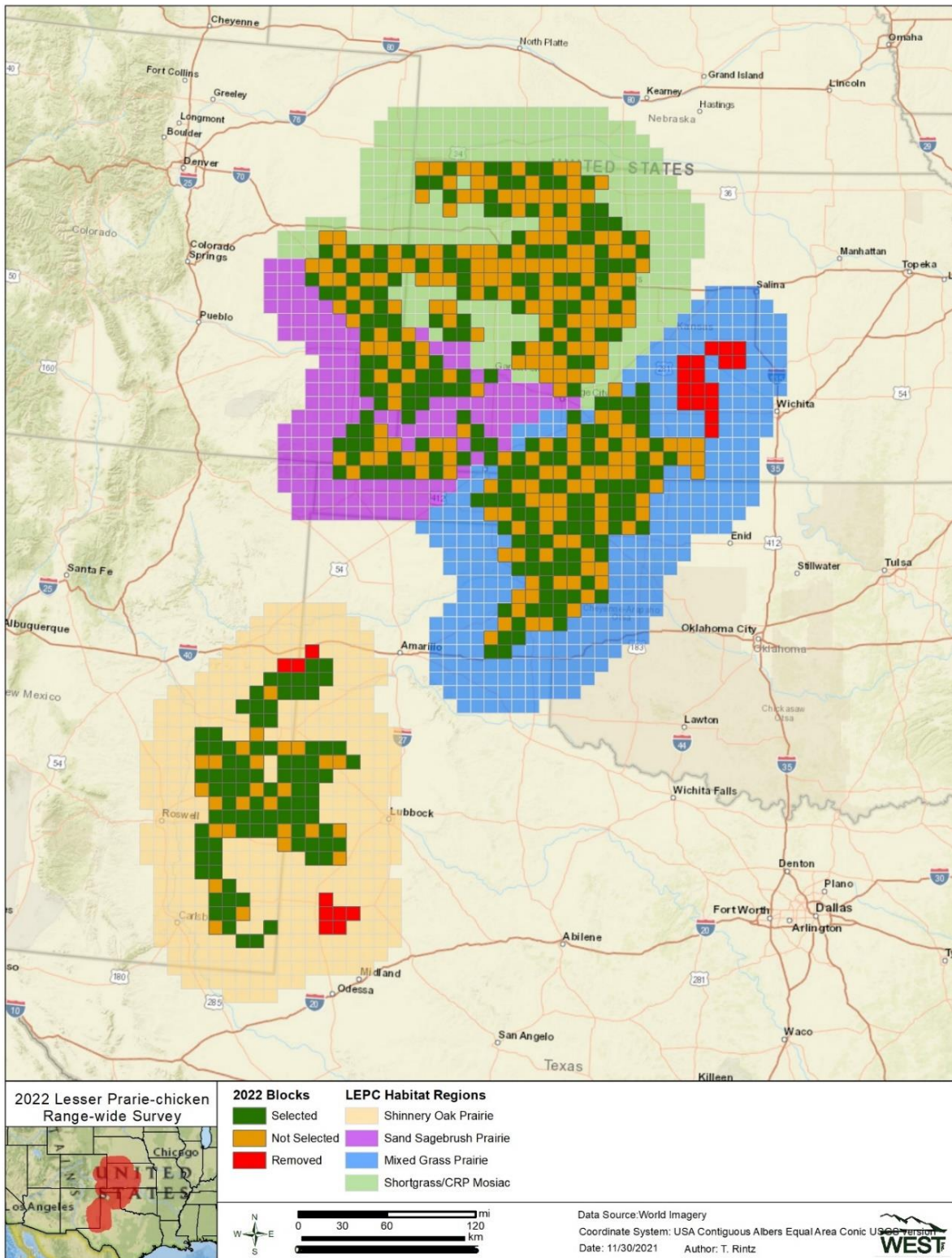


Figure 1. Study area for 2022 lesser prairie-chicken (LEPC) surveys, illustrated with grid cells selected for surveys. The colored areas surrounding the study area indicate an approximate 48.3-kilometer (30.0-mile) buffer, into which the survey may be expanded in the future.

METHODS

In general, sampling, analysis, and data collection was consistent among survey years. The number of cells selected for surveys and included in the sampling frame varied but the selection methodology was consistent (Table 1). Following the cell selection, aerial surveys using a helicopter were conducted across the species range within each cell. Lastly, analytical methods included an estimate of probability of detecting LPC during aerial surveys which were used to estimate population size. In addition, in 2022 we developed new estimates the proportion of LPC and GPC in the SGPR.

Probabilistic Samples for Trend

We ranked 15.0- × 15.0-kilometer (km; 9.3- × 9.3-mile [mi]) cells in the study area from one to 536 by an equal probability sampling procedure known as the Generalized Random Tessellation Stratified (GRTS) sampling (Stevens and Olsen 2004; McDonald et al. 2012, 2014). Ranked cells were then selected by the GRTS sampling 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 2022, 308 cells were selected for survey and the number of cells surveyed from 2012 to 2022 by ecoregion can be found in Table 1. A rotating panel design was implemented within each ecoregion. A panel of approximately 20% of the top-ranked cells on the GRTS list were dropped and a panel of equal size cells next on the GRTS list were added from each ecoregion.

Aerial Survey Methods

Surveys were conducted from a Raven II (R-44; Robinson Helicopter Company, Torrance, California) helicopter able to accommodate three observers; two observers in the rear left and right seats, and a third observer in the front left seat. Three helicopters and survey crews conducted surveys simultaneously within the study area each year. Transects were flown north-to-south or south-to-north at a speed of 60 km/hour (37 mi/hour) and at a 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 to May 15.

Two 15-km north-to-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 (984 ft) on each side of the transect lines. The area surveyed in each grid cell was 8% of the total 225 square km (87 square mi). Survey methods were the same for all ten years of surveys. For more information regarding the survey methods, please see McDonald et al. (2012).

Table 1. Total number of grid cells surveyed by year and region for survey years 2012 to 2018, and 2020 to 2022.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	75	29	72	80	256
2013	77	55	78	73	283
2014	77	55	78	73	283
2015	77	55	78	78 ⁵	285
2016	77	55	78	78 ⁵	285
2017	87	55	88	78 ⁵	308
2018	87	55	88 ¹	78 ⁵	308
2020	86 ²	55	88 ¹	78 ⁵	307
2021	87	55	88 ¹	78 ⁵	308
2022	87 ³	55 ⁴	88 ¹	78 ⁵	308

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 (northwestern Kansas and east-central Colorado).

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

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

³ The total number of grid cells in the sampling frame in the SOPR was reduced from 123 grid cells in 2012 to 2021, to 114 grid cells in 2022.

⁴ The total number of grid cells in the sampling frame in the SSPR increased from 71 grid cells in 2012 to 2021, to 92 grid cells in 2022.

⁵ The total number of grid cells in the SGPR was increased from 166 grid cells in 2012 to 2014, to 177 grid cells from 2015 to 2021, to 196 grid cells in 2022.

Statistical Methods

Probability of Detection - Mark-Recapture Models

We use the observations of all prairie-chickens by the front left and back left observers in “mark-recapture” models. For example, groups of prairie-chickens seen by the back left observer were “marked” and some of those groups were independently “recaptured” by the front left observer. These models were used to estimate the probability that at least one of the two observers detected a group given that it was in the field of view of the back left observer (i.e., greater than 6.8 m [22.3 ft] from the transect line). The data were pooled across the 10 survey years to estimate the probability that at least one of the two observers detected a group. Logistic regression models were fit using perpendicular distance from the transect line to the group (distance) as a covariate and a model with no covariates was fit. The best model was selected as the most parsimonious model within two corrected Akaike Information Criterion (AICc) units of the model with the lowest AICc value (Burnham and Anderson 2002).

Probability of Detection – Distance Sampling Analysis

We fit multiple covariate distance sampling detection models and conventional distance sampling detection models for the estimated probability of detection of groups of prairie-chickens. We used the package “Rdistance” in the R language and environment (R version 4.2.1; R Development

Core Team 2022) to estimate the detection models. Data were grouped into 15 intervals for fitting models for probability of detection, with the “all intervals” encompassing 20 m (66 ft). 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. Perpendicular distance from the transect line to the group (distance) were included in all models and covariates used in the models for probability of detection group size (size, i.e., number of prairie-chickens in an observation) and the categorical variable habitat type (habitat). The negative exponential, hazard rate, and half normal distributions were considered as key distributions. The best model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value. The estimates of probability of detection were then scaled by the probability of detection on the transect line to obtain overall probabilities of detections. The estimates account for the change in the study area.

Estimation of Population Parameters in the Short Grass Prairie Region

In the SGPR, an attempt is made to ground truth all observations to identify the observations as LPC or GPC. However, for observations that cannot be ground truthed, the number of LPC and GPC observed must be estimated. An estimated proportion of LPC and GPC for each cell was obtained using ground and aerial survey data collected from 2012 through 2021. All ground survey data were collected and processed by the Kansas Department of Wildlife, Parks and Tourism (KDWPT), and Colorado Parks and Wildlife (CPW). In addition, data collected during the aerial range-wide LPC surveys from 2012 to 2018, 2020, and 2021 were used.

A Dirichlet regression model was used to model the proportion of LPC and GPC for each grid cell in the SGPR. The Dirichlet regression model was selected as the proportion of LPC and GPC in each grid cell must sum to 1. We used the package “DirichletReg” in the R language and environment (R Version 4.2.1; R Development Core Team 2022) to estimate the models for proportions. Models for Kansas and Colorado were fit separately due to differences in data collection methods. Grid cells with five or fewer LPC or GPC counts were removed from the modeling as outliers. For Kansas, we considered latitude, longitude, and a regional covariate (based on occurrence of LPC and GPC distributions on the northern and eastern extents of the LPC range; i.e., south of Interstate 70 [I-70] and west of Highway 183, and north of I-70 and east of Highway 183), and pairwise interactions as covariates in the model. In addition, weights for the total LPC and GPC observed in each grid cell were considered. The model for Colorado represented a smaller area, and therefore, only latitude and longitude and the interaction between the two were considered as covariates. The best model was selected as the most parsimonious model within two AIC units of the model with the lowest AIC value.

Estimation of Precision of Estimated Population Parameters

Estimates of LPC population size were calculated for 2022. Counts of observed LPC were adjusted for LPC missed in the 600-m (1,969-ft) wide 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 from 2012 to 2018, 2020, and 2021.

Using the calculated probability of detection and the counts of LPC observed from the surveys, bootstrapping techniques (Manly 2006) were conducted to estimate confidence intervals (CIs) for density and population totals of LPC 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 90% of the bootstrap distribution (the percentile method) for each estimated parameter.

RESULTS

We detected 135 groups of prairie-chicken during the 2022 survey (Table 2). From 2012 to 2022, a total of 1,447 groups prairie-chickens were detected (Table 2) and 58.5% were in short-grass grassland, 22.9% were in cropland, 10.2% were in tall-grass grassland including CRP grassland (with little or no shrubs), 5.2% were in sand-sage prairie, 2.5% were in shinnery oak (*Quercus havardii*) including other shrub dominated land, and 0.7% were on bare ground (Table 2). There were 306 LPC detected on transect during the 2022 survey (Table 3) which was a decrease from 2021.

Table 2. Trends in the numbers and percent of detections of leks and non-lekking groups of lesser and greater prairie-chickens by habitat type in the data sets for survey years 2012 to 2018, and 2020 to 2022.

Year	Habitat						Total
	Bare Ground	Cropland	Short-Grass Grassland	Shinnery Oak	Sand-Sage Prairie	Tall-Grass Grassland Including CRP ¹ (with little or no shrubs)	
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%)	66 (71.7%)	2 (2.2%)	2 (2.2%)	11 (12.0%)	92
2015	0 (0%)	24 (17.5%)	85 (62.0%)	1 (0.7%)	10 (7.3%)	17 (12.4%)	137
2016	1 (0.7%)	34 (25.4%)	66 (49.3%)	1 (0.7%)	17 (12.7%)	15 (11.2%)	134
2017	2 (1.1%)	52 (29.1%)	96 (53.6%)	5 (2.8%)	4 (2.2%)	20 (11.2%)	179
2018	3 (1.7%)	39 (22.2%)	94 (53.4%)	8 (4.5%)	3 (1.7%)	29 (16.5%)	176
2020	1 (0.5%)	47 (23.3%)	109 (54.0%)	1 (0.5%)	23 (11.4%)	21 (10.4%)	202
2021	0 (0%)	52 (29.2%)	105 (59.0%)	9 (5.1%)	3 (1.7%)	9 (5.1%)	178
2022	3 (2.2%)	32 (23.7%)	86 (63.7%)	1 (0.07%)	3 (2.2%)	10 (7.4%)	135
Total	10 (0.7%)	332 (22.9%)	847 (58.5%)	36 (2.5%)	75 (5.2%)	147 (10.2%)	1,447

¹ CRP = Conservation Reserve Program.

Table 3. Trends in the numbers of lesser prairie-chicken detected by ecoregion (estimated number detected in SGPR) and overall for survey years 2012 to 2018, and 2020 to 2022.

Year	Ecoregion									
	SOPR		SSPR		MGPR		SGPR (estimated ¹)		Total	
	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	225	41	377	54
2013	24	12	35	5	39	4	112	2	210	23
2014	17	10	8	7	70	2	141	14	236	33
2015	10	7	14	13	87	19	175	10	286	49
2016	42	12	22	0	61	0	141	0	266	12
2017	35	18	23	1	80	0	214	1	352	20
2018	90	1	57	3	95	4	259	19	501	27
2020	81	6	3	12	61	2	304	57	449	77
2021	26	30	8	0	41	0	331	142	406	172
2022	9	19	26	0	63	4	208	46	306	69

¹ Estimated to account for greater prairie-chicken in the Short Grass Conservation Reserve Program Prairie Region (SGPR).

SORP = Shinnery Oak Prairie Region; SSPR = Sand Sagebrush Prairie Region; MGPR = Mixed-grass Prairie Region.

Note: "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 meters from the transect. In 2012, 256 cells were surveyed, 283 cells were surveyed in 2013 and 2014, 285 cells were surveyed in 2015 and 2016, 308 cells were surveyed in 2017, 2018, 2021, and 2022, and 307 cells were surveyed in 2020.

Mark-recapture Models

The observations from each observer were 511 and 544, for the back left and front left observers, respectively (Table 4). The top model for both the back left and front left observer included distance as a covariate (Table 5).

Table 4. Sample sizes recorded and used for logistic regression models in order to estimate the probability at least one of the two observers would detect a cluster for survey year 2012 to 2018, and for 2020 to 2022.

Year	Back Left	Front Left
2012	50	57
2013	28	24
2014	40	33
2015	46	49
2016	47	54
2017	52	66
2018	61	55
2020	69	79
2021	70	78
2022	48	49
Total	511	544

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 and front left observers.

Back Left Observer Model		Front Left Observer Model	
Covariates	AICc	Covariates	AICc
Distance*	679.39	Distance*	732.98
None	683.67	None	743.12

AICc = corrected Akaike Information Criterion.

Distance = perpendicular distance to detected clusters.

None = no covariates.

*Selected model.

Probability of Detection – Distance Sampling Analysis

We dropped 25 (1.7%) observations from the distance sampling analysis that were greater than 300 m from the transect line as these observations were outside the viewshed (i.e., off transect) 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 collected from surveys from 2012 to 2022 were used to estimate the detection function. Probability of detection was estimated as a function of distance from the transect (Appendix A).

In addition, group size and habitat were considered as covariates in the distance sampling model. Group size of prairie-chickens detected varied by year and ecoregion (Table 6). The average

group size of prairie-chickens detected remained similar between 2021 and 2022 at 4.0 and 3.9 prairie-chickens per group, respectively (Table 6). From 2021 to 2022, an increase in average group size was observed in the SSPR and MGPR, and a decrease in average group size was observed from the SOPR and SGPR.

Table 6. Trends in average group sizes of prairie-chicken detected by ecoregion and overall for survey years 2012 to 2018, and 2020 to 2022.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	3.4	7.3	6.6	5.2	5.2
2013	2.4	5.8	5.6	5.1	4.8
2014	2.4	4.0	4.4	4.2	4.1
2015	1.4	1.8	3.0	4.2	3.7
2016	2.5	2.8	3.8	4.6	4.1
2017	2.7	3.3	3.5	4.2	3.9
2018	3.5	3.8	3.8	5.7	4.9
2020	2.6	1.0	2.4	4.2	3.7
2021	2.6	2.0	1.7	4.6	4.0
2022	1.3	3.2	2.9	4.4	3.9

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 (northwestern Kansas and east-central Colorado).

We pooled data collected from 2012 to 2022 to estimate the probability of detection of groups 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 groups of prairie-chickens was estimated as a function of distance from transect and the top model included the size covariate with a negative exponential key function (Figure 2, Table 7).

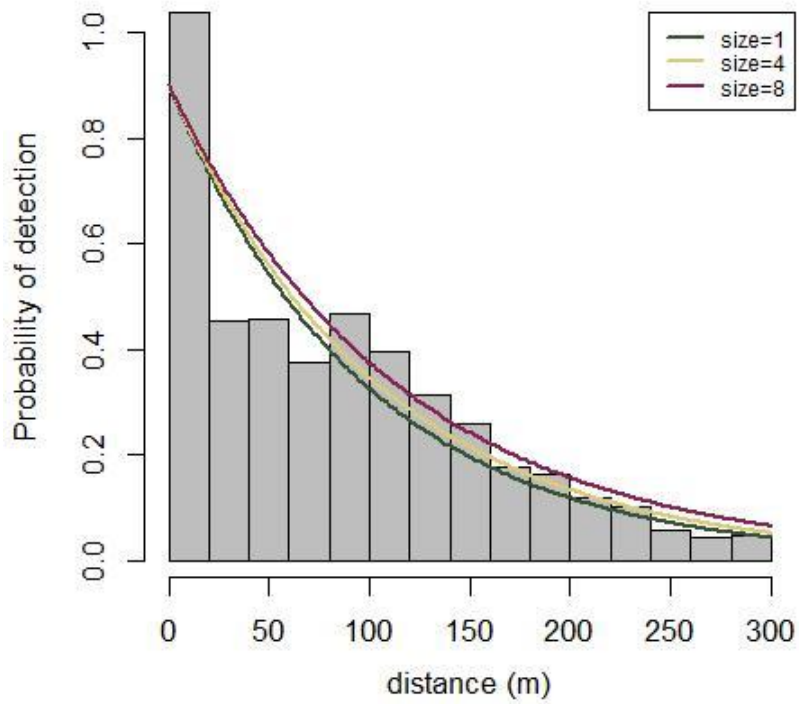


Figure 2. Probability of detection for groups of one, four, and eight prairie-chickens (size), plotted by distance from transect line.

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
Size	ne	15,618.52*
None	ne	15,621.63
Habitat	ne	15,625.81
Size	hn	15,644.01
Size + Habitat	hn	15,647.34
None	hn	15,651.98
Habitat	hn	15,654.49
Size	hr	15,669.42
Habitat	hr	15,674.52
Size + Habitat	hr	15,675.07
None	hr	15,678.63

AICc = corrected Akaike Information Criterion.

Size = size of group (observation).

Habitat = habitat occupied by detected clusters.

None = no covariates.

Pooled data from 2012 to 2022 were used to fit the distance sampling models.

Key Functions were ne = negative exponential model, hr = hazard rate, hn = half normal.

*Selected Model.

Estimation of Population Parameters in the Short Grass Prairie Region

The top model for the Kansas in the SGPR included latitude, longitude, and the regional covariate, and the top model for Colorado in the SGPR included latitude as a covariate (Table 8). The estimated proportion of LPC in the SPGR are shown in Figure 3.

Table 8. Dirichlet regression models used to estimate the proportion of lesser and greater prairie-chickens in the Short Grass Prairie Region in Kansas and Colorado.

Kansas		
Model Covariates	Weight	AIC
latitude + longitude + region	No	-702.00*
latitude + longitude + latitude*longitude + region	No	-717.30
latitude	No	-688.30
latitude + longitude + region	Yes	-76,222.00
latitude + longitude + latitude*longitude + region	Yes	Did not converge
latitude	Yes	-72,938.00
Colorado		
Model Covariates	Weight	AIC
latitude	No	1.52*
latitude + longitude	No	-27.56
latitude + longitude + lat*longitude	No	Did not converge

AICc = corrected Akaike Information Criterion.

Region = south of Interstate-70 (I-70) and west of Highway 183, or north of I-70 and east of Highway 183

*Selected Model.

Weight = total number lesser and greater prairie-chickens observed

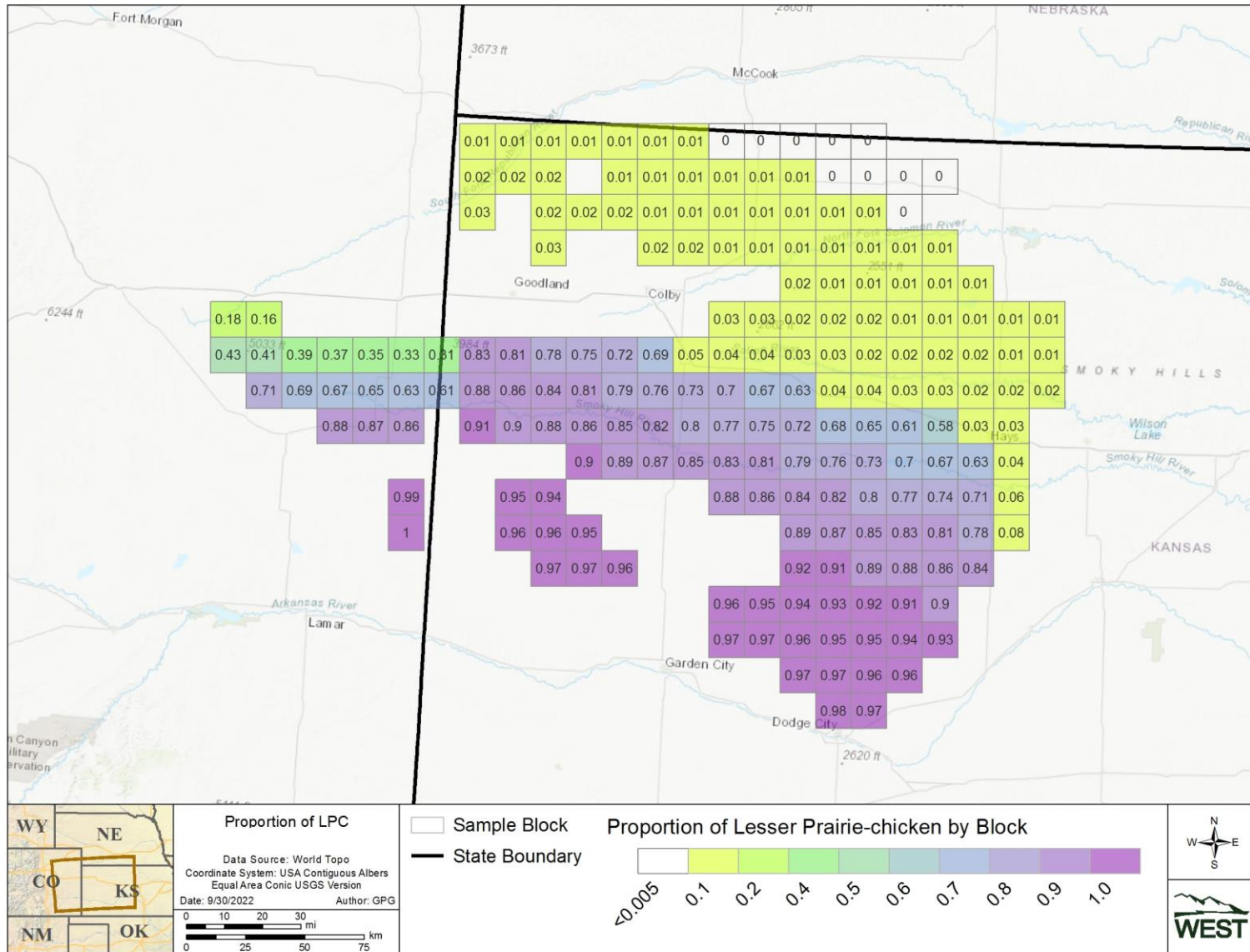


Figure 3. Proportion of lesser prairie-chicken in the Short Grass Prairie Region in Kansas and Colorado, as estimated using a Dirichlet regression model.

Estimated Trends in Densities and Abundance of Lesser Prairie-chicken

We estimated the total population size of LPC to be (Tables 9, Figures 4, 5a, and 5b):

- 30,682 (90% CI: 20,938, 39,385) LPC in 2012;
- 16,724 (90% CI: 10,420, 23,538) in 2013;
- 20,378 (90% CI: 13,563, 27,410) in 2014;
- 24,678 (90% CI: 17,500, 32,915) in 2015;
- 22,278 (90% CI: 15,437, 28,600) in 2016;
- 28,600 (90% CI: 19,565, 37,745) in 2017;
- 36,278 (90% CI: 25,471, 47,559) in 2018;
- 36,077 (90% CI: 25,345, 46,688) in 2020;
- 33,504 (90% CI: 22,262, 45,111) in 2021; and
- 26,591 (16,321, 38,259) in 2022.

An estimated total population decrease of 6,913 LPC was observed from 2021 to 2022 (20.6% decrease); however, this decrease was not statistically significant at the 90% confidence level (90% CI: -22,205, 6,328; Table 11).

Table 9. Trends in estimated densities of lesser prairie-chicken (LPC) per 100 km² (39 mi²) by ecoregion and overall for survey years 2012 to 2018, and 2020 to 2022. Bootstrapped 90% confidence intervals were reported on the densities of LPC per 100 km².

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	10.72 (4.05, 18.12)	13.13 (0.00, 26.27)	20.25 (8.16, 33.69)	47.12 (28.77, 66.30)	25.44 (17.36, 32.66)
2013	5.94 (2.61, 9.78)	11.21 (3.98, 19.53)	8.83 (2.97, 15.64)	26.22 (11.72, 42.52)	13.87 (8.64, 19.52)
2014	4.17 (1.22, 7.98)	2.73 (0.00, 5.86)	15.27 (5.13, 26.38)	34.11 (20.26, 49.65)	16.90 (11.25, 22.73)
2015	2.53 (0.74, 4.79)	4.84 (1.43, 9.32)	20.44 (12.22, 28.38)	37.94 (22.12, 57.44)	20.05 (14.22, 26.74)
2016	10.14 (4.39, 17.32)	7.43 (1.86, 13.36)	14.09 (7.45, 21.62)	31.9 (18.52, 45.17)	18.10 (12.54, 23.24)
2017	7.41 (2.80, 12.53)	7.75 (2.03, 15.15)	16.21 (7.74, 26.45)	47.44 (28.19, 67.96)	23.24 (15.9, 30.67)
2018	18.11 (6.72, 32.55)	18.29 (7.78, 30.56)	18.92 (9.87, 30.25)	54.71 (33.23, 78.18)	30.71 (21.56, 40.26)
2020	17.64 (7.95, 28.45)	1.08*	13.04 (5.54, 22.88)	66.56 (41.67, 90.88)	30.54 (21.46, 39.52)
2021	5.67 (2.16, 9.56)	2.75 (0.35, 6.33)	8.99 (4.62, 13.61)	71.26 (43.82, 100.27)	28.36 (18.85, 38.19)
2022	2.02 (0.70, 3.64)	8.28 (1.01, 17.78)	13.02 (6.49, 20.11)	45.00 (21.89, 70.86)	21.25 (13.05, 30.58)

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 (northwestern Kansas and east-central Colorado).

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

km² = square kilometers; mi² = square miles.

Table 10. Trends in estimated population sizes of lesser prairie-chicken (LPC) by ecoregion and overall for survey years 2012 to 2018, and 2020 to 2022. Bootstrapped 90% confidence intervals were reported on the population sizes of LPC.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	2,967 (1,119, 5,016)	2,097 (0, 4,196)	8,018 (3,232, 13,340)	17,599 (10,745, 24,763)	30,682 (20,938, 39,385)
2013	1,645 (723, 2,706)	1,791 (636, 3,119)	3,496 (1,177, 6,195)	9,792 (4,379, 15,881)	16,724 (10,420, 23,538)
2014	1,155 (337, 2,210)	436 (0, 937)	6,048 (2,030, 10,447)	12,740 (7,568, 1,8543)	20,378 (13,563, 27,410)
2015	701 (205, 1,327)	773 (228, 1,489)	8,095 (4,840, 11,238)	15,108 (8,811, 22,877)	24,678 (17,500, 32,915)
2016	2,808 (1,216, 4,793)	1,187 (298, 2,134)	5,578 (2,950, 8,563)	12,705 (7,376, 17,989)	22,278 (15,437, 28,600)
2017	2,050 (774, 3,468)	1,238 (325, 2,420)	6,421 (3,064, 10,475)	18,892 (11,226, 27,064)	28,600 (19,565, 37,745)
2018	5,012 (1,859, 9,007)	2,921 (1,243, 4,881)	6,554 (3,421, 10,481)	21,790 (13,234, 31,135)	36,278 (25,471, 47,559)
2020	4,881 (2,200, 7,873)	172*	4,517 (1,920, 7,927)	26,507 (16,596, 36,195)	36,077 (25,345, 46,688)
2021	1,569 (597, 2,644)	440 (56, 1,012)	3,116 (1,601, 4,716)	28,379 (17,451, 39,934)	33,504 (22,262, 45,111)
2022	519 (179, 934)	1,713 (209, 3,681)	4,512 (2,248, 6,968)	19,847 (9,653, 31,248)	26,591 (16,321, 38,259)

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 (northwestern Kansas and east-central Colorado).

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

Table 11. Estimated differences in population estimates for lesser prairie-chicken between years with bootstrapped 90% confidence intervals on the differences (Δ Year).

Δ Year	Ecoregion				Total
	SOPR	SSPR	MGPR	SGPR	
2013 minus 2012	-1,324 (-3,665, 799)	-177 (-2,715, 2,035)	-4,282 (-10,240, 637)	-7,782 (-16,944, 1,347)	-13,565 (-24,579, -2,666)
2014 minus 2013	-471 (-1,845, 969)	-1,373 (-2,774, -116)	2,469 (-2,113, 7,557)	2,967 (-5,087, 10,769)	3,592 (-5,564, 12,408)
2015 minus 2014	-474 (-1,613, 568)	360 (-437, 1,212)	2,034 (-3,850, 7,561)	2,495 (-5,888, 11,153)	4,415 (-5,110, 13,974)
2016 minus 2015	2,089 (421, 4,075)	370 (-732, 1,567)	-2,491 (-6,768, 1,743)	-2,546 (-11,094, 5,118)	-2,579 (-12,733, 6,737)
2017 minus 2016	-790 (-3,178, 1,364)	62 (-1,231, 1,489)	960 (-3,575, 5,693)	5,982 (-2,998, 15,593)	6,215 (-4,380, 17,721)
2018 minus 2017	2,943 (-410, 7,381)	1,616 (-414, 3,871)	72 (-4,681, 5,049)	2,852 (-8,693, 14,048)	7,484 (-6,067, 21,391)
2020 minus 2018	-243 (-4,969, 4,250)	-2,661*	-2,045 (-6,543, 2,796)	4,721 (-9,207, 17,097)	-229 (-16,610, 14,658)
2021 minus 2020	-3,131 (-6,410, -455)	272*	-1,445 (-5,159, 1,581)	1,742 (-12,395, 16,428)	-2,562 (-17,177, 12,596)
2022 minus 2021	-1,051 (-2,180, 2)	1,273 (-285, 3,216)	1,347 (-1,328, 4,429)	-8,532 (-24,014, 7,155)	-6,913 (-22,205, 9,328)

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 (northwestern Kansas and east-central Colorado).

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

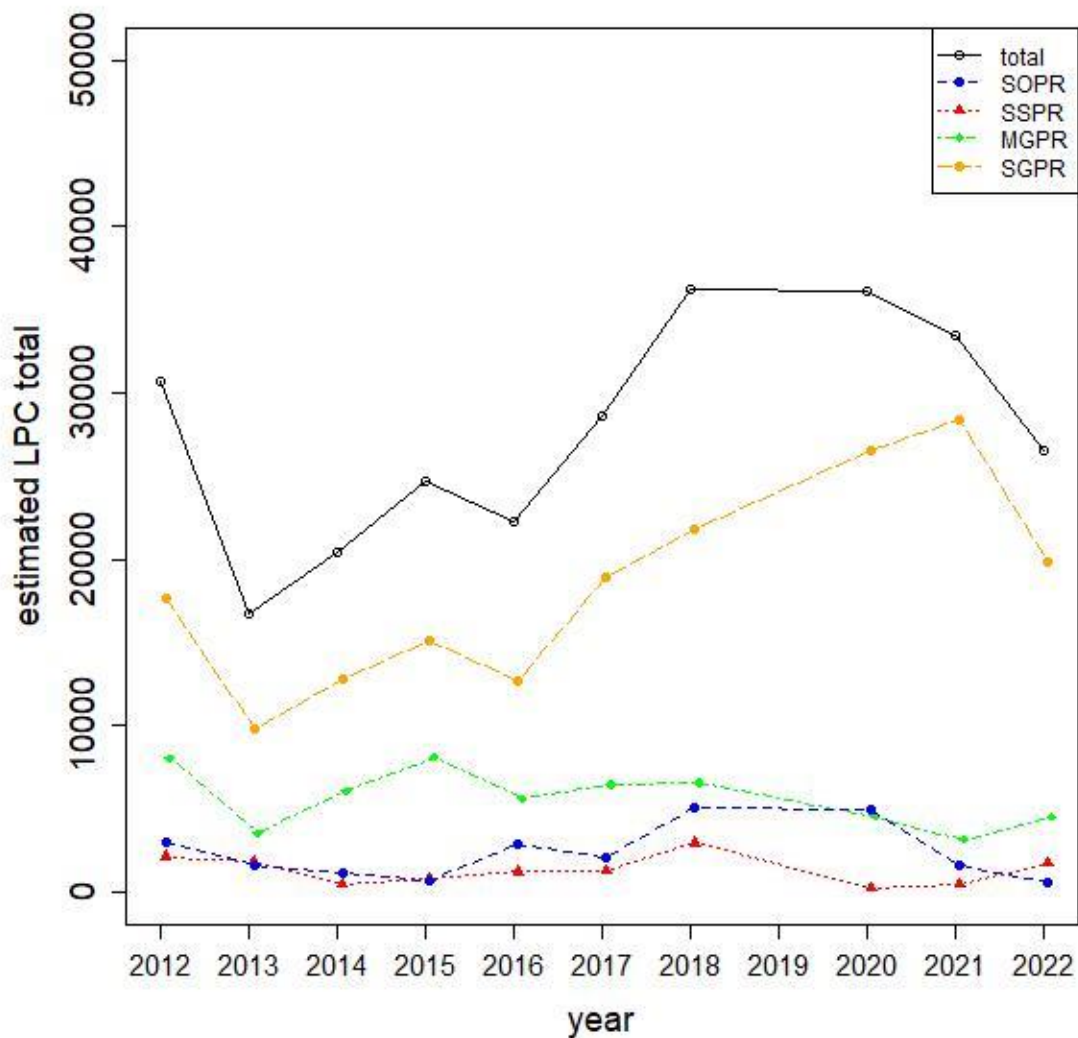


Figure 4. Trends in estimated total population sizes of lesser prairie-chicken for survey years 2012 to 2018, and 2020 to 2022.

Note: 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 (northwestern Kansas and east-central Colorado).

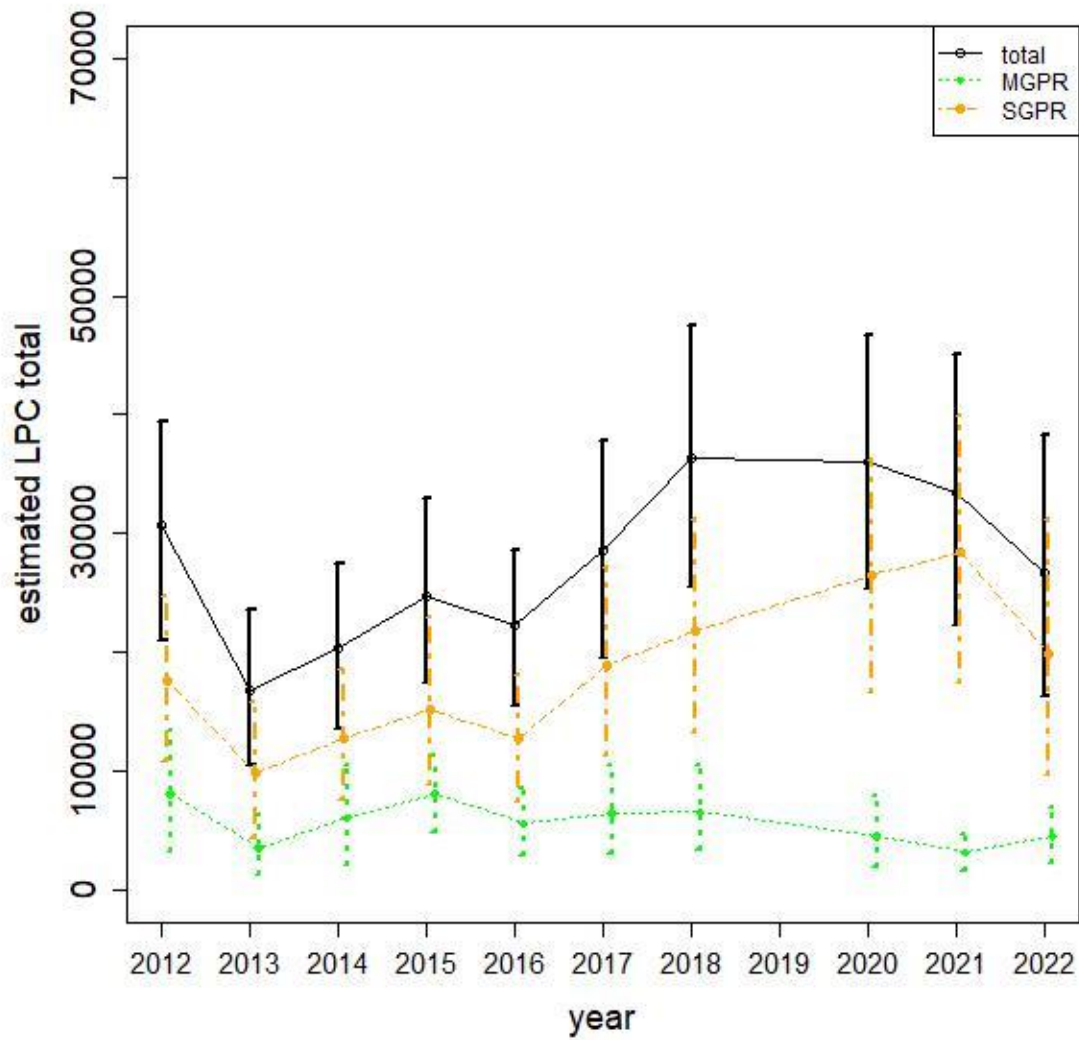


Figure 5a. Trends in estimated total population sizes of lesser prairie-chicken for survey years 2012 to 2018, and 2020 to 2022, with 90% confidence intervals for the original study area.

Note: MGPR = Mixed-grass Prairie Region (northeast Texas, northwestern Oklahoma, south-central Kansas), and SGPR = Short Grass Conservation Reserve Program Prairie Region (northwestern Kansas and east-central Colorado).

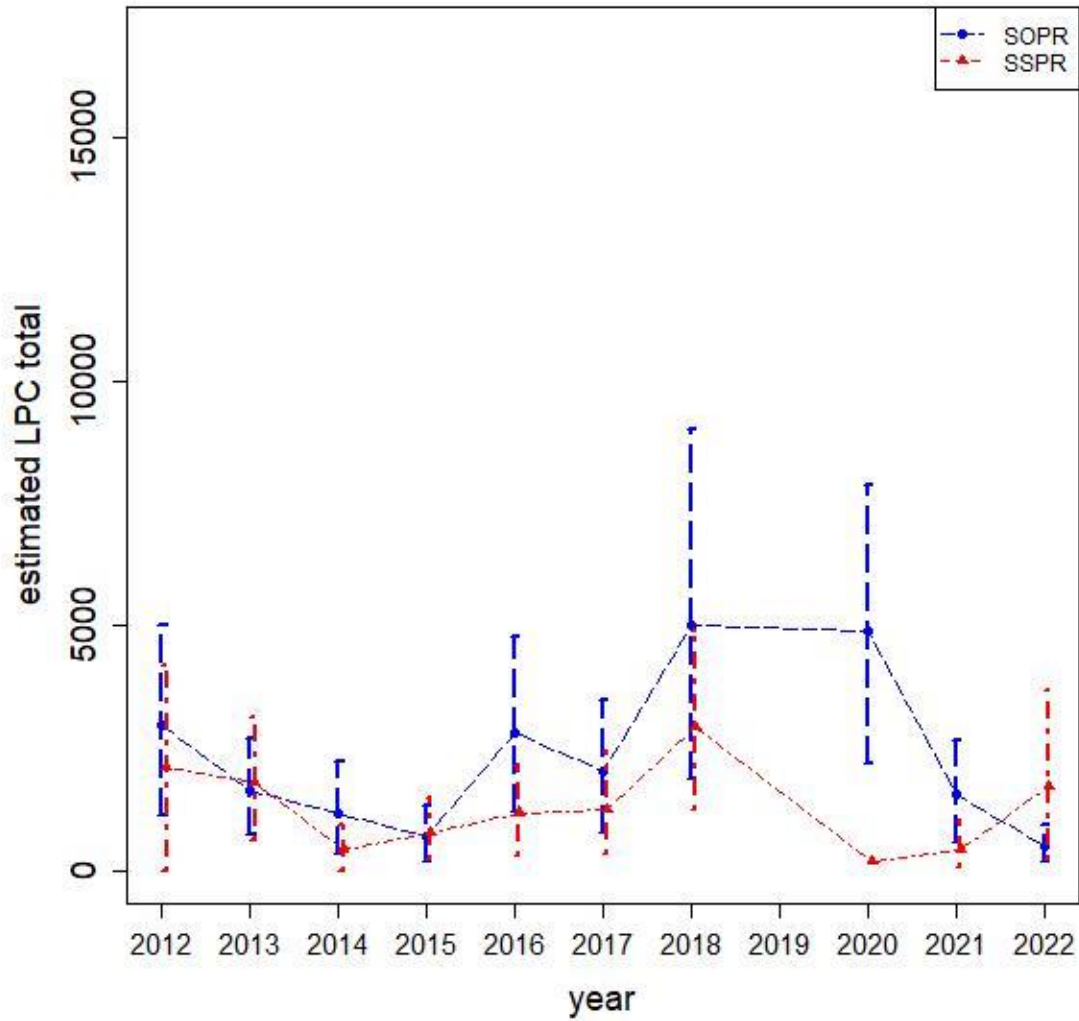


Figure 5b. Trends in estimated total population sizes of lesser prairie-chicken (LPC) for survey years 2012 to 2018, and 2020 to 2022, with 90% confidence intervals in the Shinnery Oak Prairie Region (SOPR; eastern New Mexico, western Texas) and Sand Sagebrush Prairie Region (SSPR; southeastern Colorado, southwestern Kansas, Oklahoma Panhandle).

Note that confidence intervals were not calculated for the SSPR due to a low sample size of observed LPC ($n < 5$).

To further evaluate trends in the LPC population, annual estimates of LPC were averaged over three years (Figure 6):

- 22,595 (90% CI: 17,861, 27,267) estimated average annual LPC population from 2012 – 2014;
- 20,593 (90% CI: 16,306, 24,929) from 2013 – 2015;
- 22,445 (90% CI: 17,798, 26,903) from 2014 – 2016;
- 25,185 (90% CI: 20,268, 29,927) from 2015 – 2017;
- 29,052 (90% CI: 23,244, 34,650) from 2016 – 2018;
- 32,439 (90% CI: 24,538, 39,741) from 2017 – 2018 (no surveys in 2019);
- 36,178 (90% CI: 27,879, 43,934) from 2018 – 2020 (no surveys in 2019);
- 34,791 (90% CI: 26,568, 43,099) from 2020 – 2021 (no surveys in 2019); and
- 32,058 (90% CI: 25,094, 38,525) from 2020 – 2022.

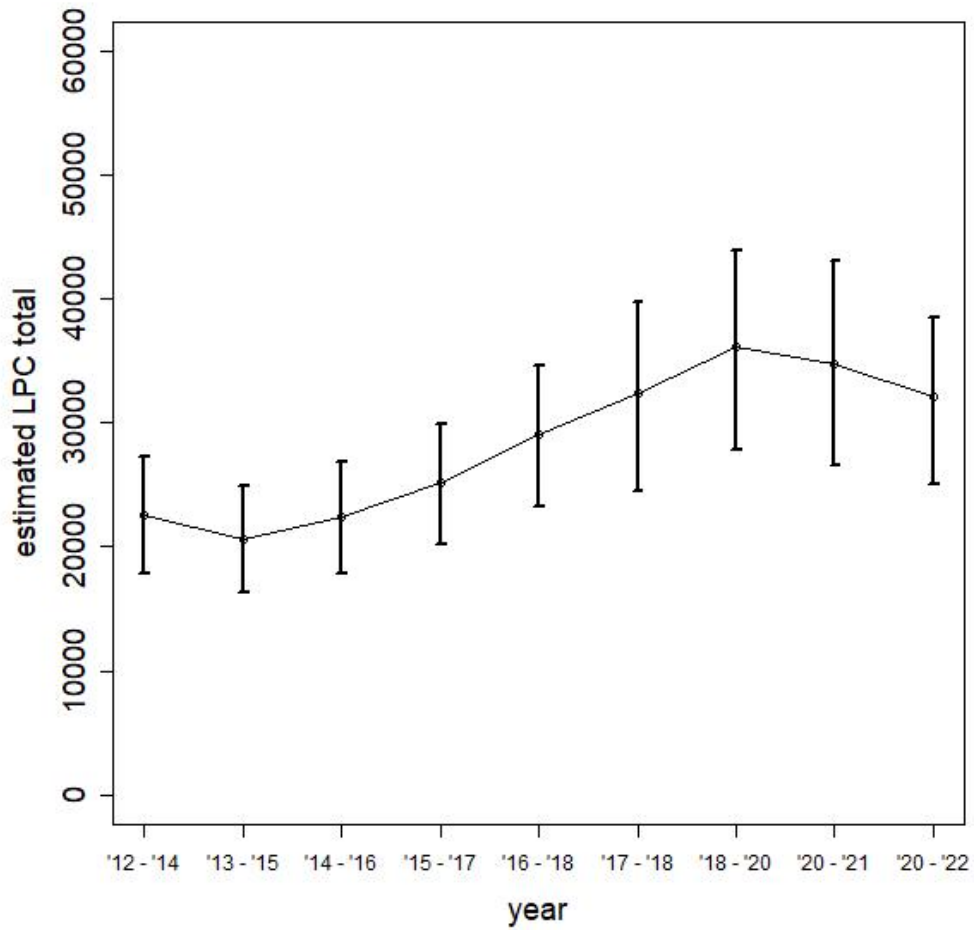


Figure 6. Estimated 3-year average annual population sizes of lesser prairie-chicken (LPC) with 90% confidence intervals for survey years from 2012 to 2022.

Estimated Trends in Lesser Prairie-chicken Leks

We estimated a slight increase in the density and abundance of LPC leks in 2022 relative to 2021 (Tables 12 and 13). The abundance of LPC leks was estimated to be:

- 2,852 (90% CI: 1,729, 4,085) in 2012;
- 1,815 (90% CI: 1,077, 2,666) in 2013;
- 2,271 (90% CI: 1,463, 3,200) in 2014;
- 1,445 (90% CI: 874, 2,106) in 2015;
- 1,733 (90% CI: 887, 2,659) in 2016;
- 2,602 (90% CI: 1,748, 3,569) in 2017;
- 2,631 (90% CI: 1,702, 3,658) in 2018;
- 4,745 (90% CI: 3,115, 6,365) in 2020;
- 3,174 (90% CI: 2,059, 4,328) in 2021; and
- 3,302 (90% CI: 2,016, 4,749) in 2022.

Table 12. Estimated trends in densities of lesser prairie-chicken (LPC) leks per 100 km² (39 mi²) by ecoregion and overall for survey years 2012 to 2018, and 2020 to 2022. Bootstrapped 90% confidence intervals were reported on the densities of LPC leks per 100 km².

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	1.22 (0.27, 2.13)	1.19 (0.00, 2.49)	2.06 (0.88, 3.29)	4.04 (1.66, 7.12)	2.36 (1.43, 3.39)
2013	0.5 (0.00, 1.22)	1.99 (0.70, 3.31)	0.89 (0.22, 1.64)	2.7 (1.00, 4.74)	1.50 (0.89, 2.21)
2014	0.74 (0.22, 1.50)	0.34 (0.00, 1.00)	1.82 (0.66, 3.06)	3.46 (1.68, 5.45)	1.88 (1.21, 2.65)
2015	0.26 (0.00, 0.78)	0.33 (0.00, 0.97)	1.84 (0.88, 2.94)	1.49 (0.57, 2.53)	1.17 (0.71, 1.71)
2016	0.71 (0.00, 1.45)	0.32 (0.00, 0.92)	1.37 (0.49, 2.23)	2.37 (0.69, 4.34)	1.41 (0.72, 2.16)
2017	0.86 (0.18, 1.74)	0.99 (0.31, 1.98)	1.9 (0.87, 3.08)	3.65 (1.93, 5.61)	2.11 (1.42, 2.9)
2018	1.85 (0.62, 3.31)	0.92 (0.00, 2.00)	2.47 (1.22, 3.85)	2.8 (1.20, 4.57)	2.23 (1.44, 3.1)
2020	1.71 (0.22, 3.42)	0.36*	1.94 (0.43, 3.88)	8.89 (5.40, 12.58)	4.02 (2.64, 5.39)
2021	0.89 (0.22, 1.72)	0.69 (0.00, 1.51)	0.88 (0.20, 1.81)	6.31 (3.76, 9.03)	2.69 (1.74, 3.66)
2022	0.68 (0.00, 1.61)	0.98 (0.27, 2.03)	1.46 (0.57, 2.47)	5.49 (2.74, 8.63)	2.64 (1.61, 3.80)

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 (northwestern Kansas and east-central Colorado).

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

km² = square kilometers; mi² = square miles.

Table 13. Estimated trends in abundance of lesser prairie-chicken (LPC) leks by ecoregion and overall for survey years 2012 to 2018, and 2020 to 2022. Bootstrapped 90% confidence intervals were reported on the abundance of LPC leks.

Year	Ecoregion				Overall
	SOPR	SSPR	MGPR	SGPR	
2012	337 (76, 591)	191 (0, 398)	815 (347, 1303)	1,509 (619, 26,601)	2,852 (1,729, 4,085)
2013	137 (0, 337)	317 (112, 529)	354 (86, 648)	1,007 (372, 1,771)	1,815 (1,077, 2,666)
2014	204 (61, 414)	54 (0, 160)	722 (26, 1210)	1,291 (629, 2,034)	2,271 (1,463, 3,200)
2015	71 (0, 216)	53 (0, 155)	729 (348, 1162)	592 (227, 1,008)	1,445 (874, 2,106)
2016	197 (0, 401)	51 (0, 146)	542 (194, 881)	943 (275, 1,727)	1,733 (887, 2,659)
2017	238 (48, 481)	159 (49, 316)	753 (346, 1220)	1,452 (770, ,2233)	2,602 (1,748, 3,569)
2018	513 (172, 916)	146 (0, 320)	856 (424, 1335)	1,116 (479, 1,820)	2,631 (1,702, 3,658)
2020	474 (60, 948)	57*	673 (149, 1344)	3,541 (2,151, 5,008)	4,745 (3,115, 6,365)
2021	245 (61, 477)	111 (0, 242)	306 (68, 628)	2,512 (1,497, 3,597)	3,174 (2,059, 4,328)
2022	175 (0, 413)	201 (57, 419)	506 (199, 855)	2,419 (1,208, 3,805)	3,302 (2,016, 4,749)

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 (northwestern Kansas and east-central Colorado)

*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 to 2022, in the 2011 EOR of the LPC in Kansas, Colorado, New Mexico, Oklahoma, and Texas, and a modified range in 2022 to evaluate trends in the population. In 2022, the sampling frame was reduced by nine cells in the SOPR and increased by 21 cells in the SSPR and 19 cells in the SGPR. The estimates in this report account for the change in the study area between each year of survey.

The objective of the study, to estimate the annual range-wide population size of LPC and evaluate trends through time of the range-wide population size of LPC, was met and we determined there was not a statistically significant decrease from 2021 to 2022 in the total population (decrease of 6,913 LPC 90% CI: -22,205, 6,328).

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. We observed a stable to increasing population of LPC from 2015 to 2020 and a decrease in the population from 2020 to 2022 in the SOPR. Ground surveys in New Mexico and Texas also reported a decrease in population from 2020 to 2022 in the SOPR; however, total counts were greater than the upper confidence interval of the 2022 aerial survey estimates (Beauprez 2022, Harryman 2022). In the SSPR, we observed a stable to increasing population of LPC from 2014 to 2018, with a decrease in the LPC population from 2019 to 2020, and a slight increase in the population from 2020 to 2022 (although in 2020, detections were insufficient to estimate confidence intervals). We observed an increasing population of LPC from 2013 to 2015 in the MGPR. There was a slight decrease in the population of LPC in 2016 in the MGPR, the population was stable in 2017 and 2018, a decrease in the population was observed from 2020 to 2021, and an increase in the population was observed from 2021 to 2022. We observed a stable to increasing population of LPC from 2013 to 2021 in the SGPR and a decrease in the population from 2021 to 2022.

ACKNOWLEDGEMENTS

The 2012 survey and reports were accomplished by the financial support of the Great Plains Landscape Conservation Cooperative, the Bureau of Land Management, and the National Fish and Wildlife Foundation through grants to the WAFWA. Financial support for the 2013, 2014, 2015, 2016, 2017, 2018, 2020, 2021, and 2022 surveys and this report were provided by funding to the WAFWA from the wildlife agencies of the states of Colorado, Kansas, New Mexico, Oklahoma, and Texas, the Bureau of Land Management, the National Fish and Wildlife Foundation, US Department of Agriculture, US Fish and Wildlife Service, and various oil and gas companies and associations.

The recommended study design and methods were developed with the assistance of the following members of the LPCIWG: Bill Van Pelt, WAFWA Grassland Coordinator, Arizona Game and Fish

Department; Jim Pitman, WAFWA; Sean Kyle, WAFWA; David Klute, Colorado Division of Parks and Wildlife; Grant Beauprez, New Mexico Department of Game and Fish; and Doug Schoeling, Oklahoma Department of Wildlife Conservation.

We wish to acknowledge our use of the ground survey data collected by the KDWPT and CPW. Kent Fricke and Liza Rossi provided valuable feedback on the analysis of these data. We also wish to acknowledge the assistance of the aerial survey crew members and pilots.

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**Appendix A. Histograms of the Probability of Lesser Prairie-chicken Detection as a
Function of Distance**

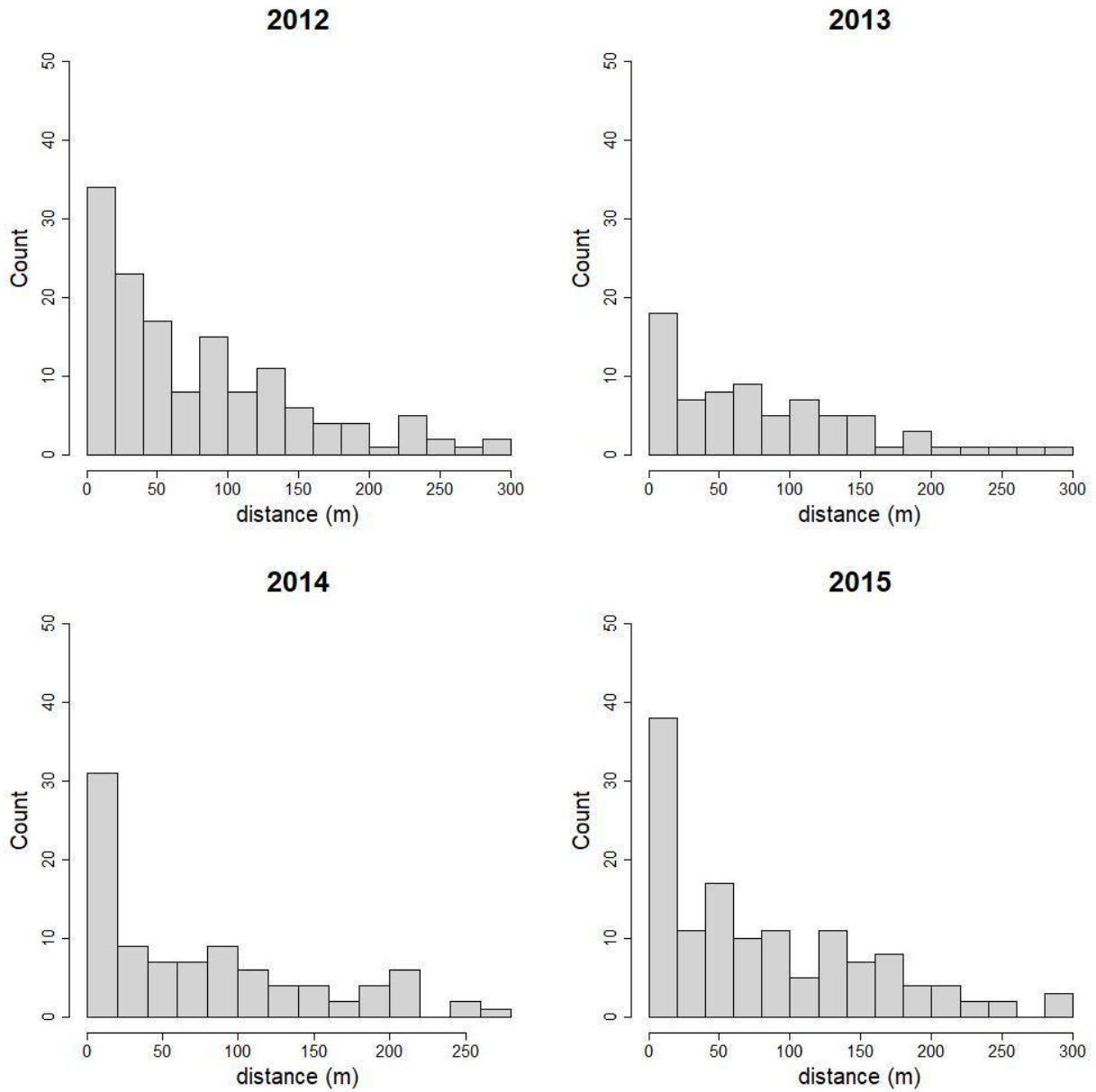


Figure A-1. Histograms showing the counts of observed distances of detected clusters of all prairie-chickens from the transect line to the center of the clusters (density of detections in 20-meter [m] bins) from 2012 to 2015.

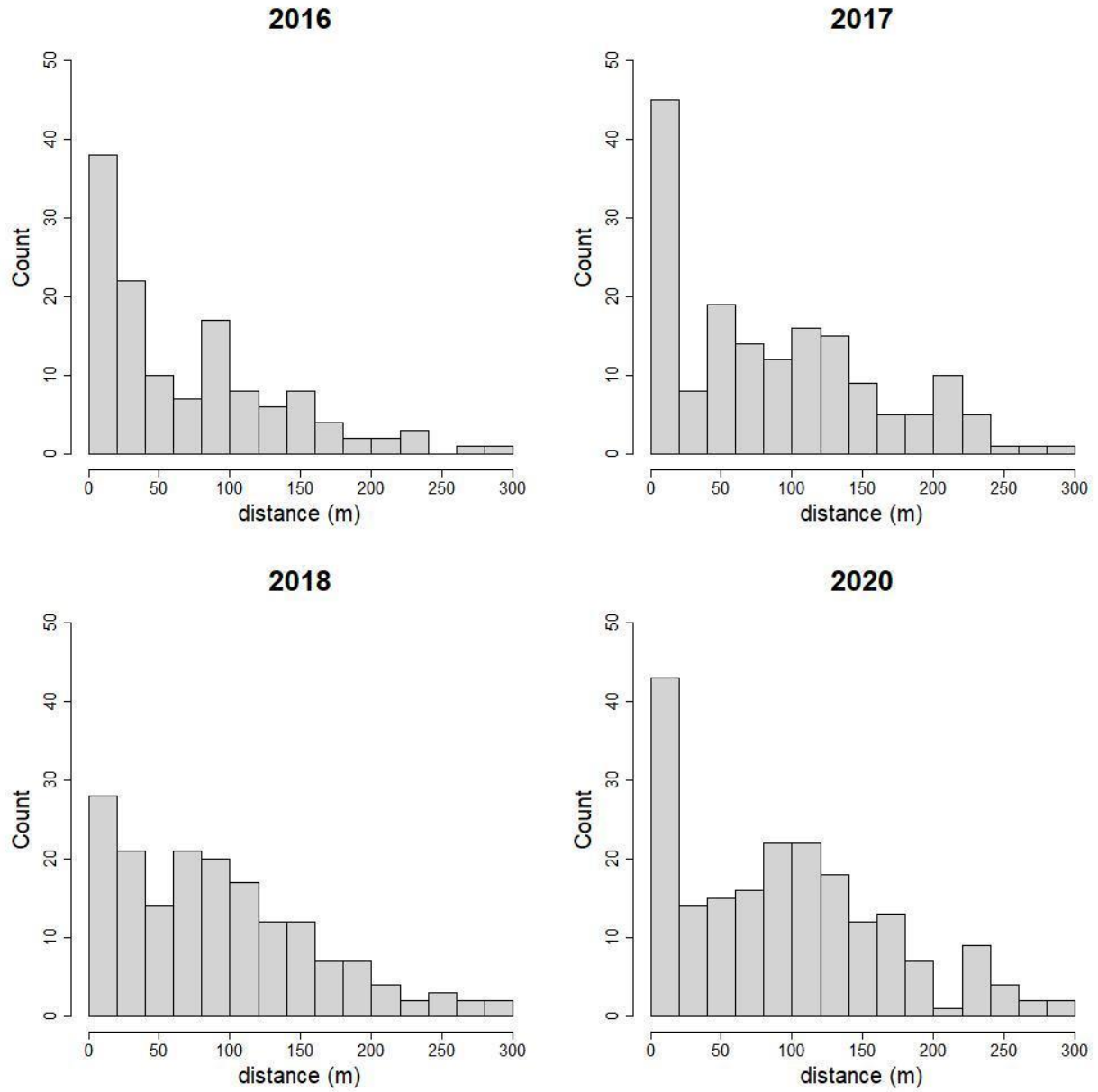


Figure A-2. Histograms showing the counts of observed distances of detected clusters of all prairie-chickens from the transect line to the center of the clusters (density of detections in 20-meter [m] bins) from 2016 to 2020.

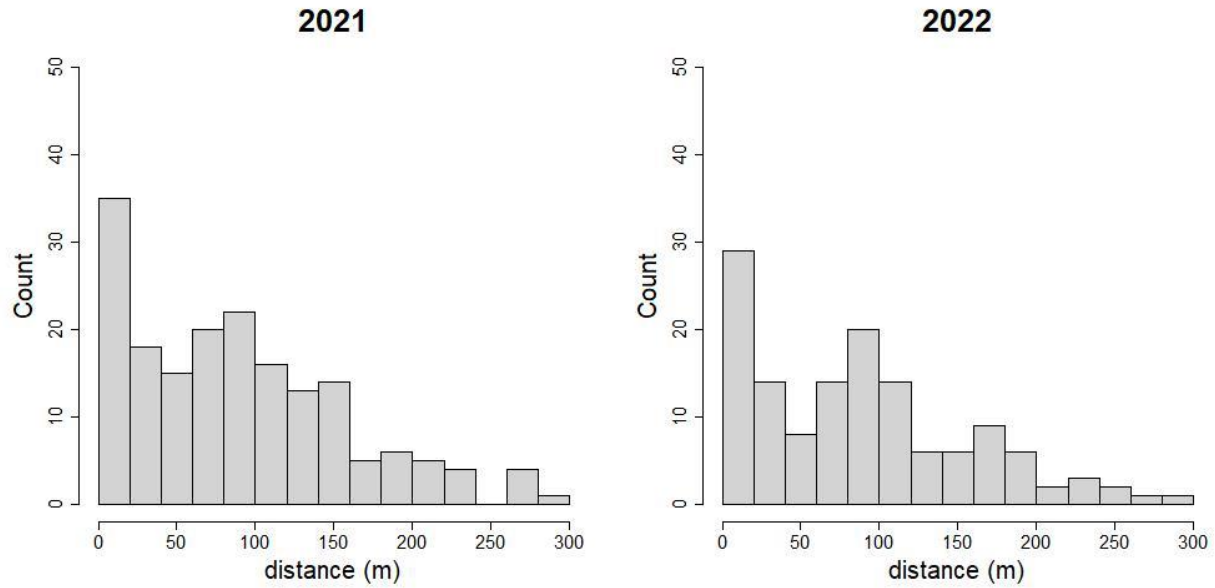


Figure A-3. Histograms showing the counts of observed distances of all detected clusters of prairie-chickens from the transect line to the center of the clusters (density of detections in 20-meter [m] bins) in 2021 and 2022.

Appendix B. Estimated Densities and Abundance of Greater Prairie-chicken

Densities (Table B-1 and Figure B-1) and abundance (Table B-2) of greater prairie-chicken (GPC) were estimated in the Short Grass Conservation Reserve Program Region (SGPR) of northwestern Kansas and east-central Colorado. The population sizes of the GPC in the SGPR were estimated to be:

- 27,571 (90% CI: 17,879, 37,286) in 2012;
- 12,776 (90% CI: 8,079, 18,224) in 2013;
- 13,171 (90% CI: 8,130, 18,123) in 2014;
- 17,563 (90% CI: 11,263, 23,753) in 2015;
- 23,867 (90% CI: 13,288, 29,599) in 2016;
- 29,028 (90% CI: 19,293, 35,547) in 2017;
- 30,291 (90% CI: 18,462, 41,893) in 2018;
- 26,068 (90% CI: 18,418, 34,000) in 2020;
- 28,460 (90% CI: 19,666, 36,888) in 2021; and
- 22,478 (90% CI: 14,902, 29,750) in 2022.

Table B-1. Estimates of greater prairie-chicken (GPC) densities per 100 kilometer² (km²; 39 miles²) and population size estimates for survey years 2012 to 2018, and 2020 to 2022 in the Short Grass Conservation Reserve Program Region of northwestern Kansas and east-central Colorado. Bootstrapped 90% confidence intervals were reported on the densities of GPC per 100 km².

Year	Density	Estimate
2012	73.82 (47.87, 99.83)	27,571 (17,879, 37,286)
2013	34.20 (21.63, 48.79)	12,776 (8,079, 18,224)
2014	35.26 (21.77, 48.73)	13,171 (8,130, 18,123)
2015	47.02 (30.15, 63.59)	17,563 (11,263, 23,753)
2016	63.90 (35.58, 79.25)	23,867 (13,288, 29,599)
2017	77.72 (51.62, 95.17)	29,028 (19,293, 35,547)
2018	76.06 (46.36, 105.19)	30,291 (18,462, 41,893)
2020	65.46 (46.25, 85.37)	26,068 (18,418, 34,000)
2021	71.46 (49.38, 92.63)	28,460 (19,666, 36,888)
2022	50.97 (33.79, 67.46)	22,478 (14,902, 29,750)

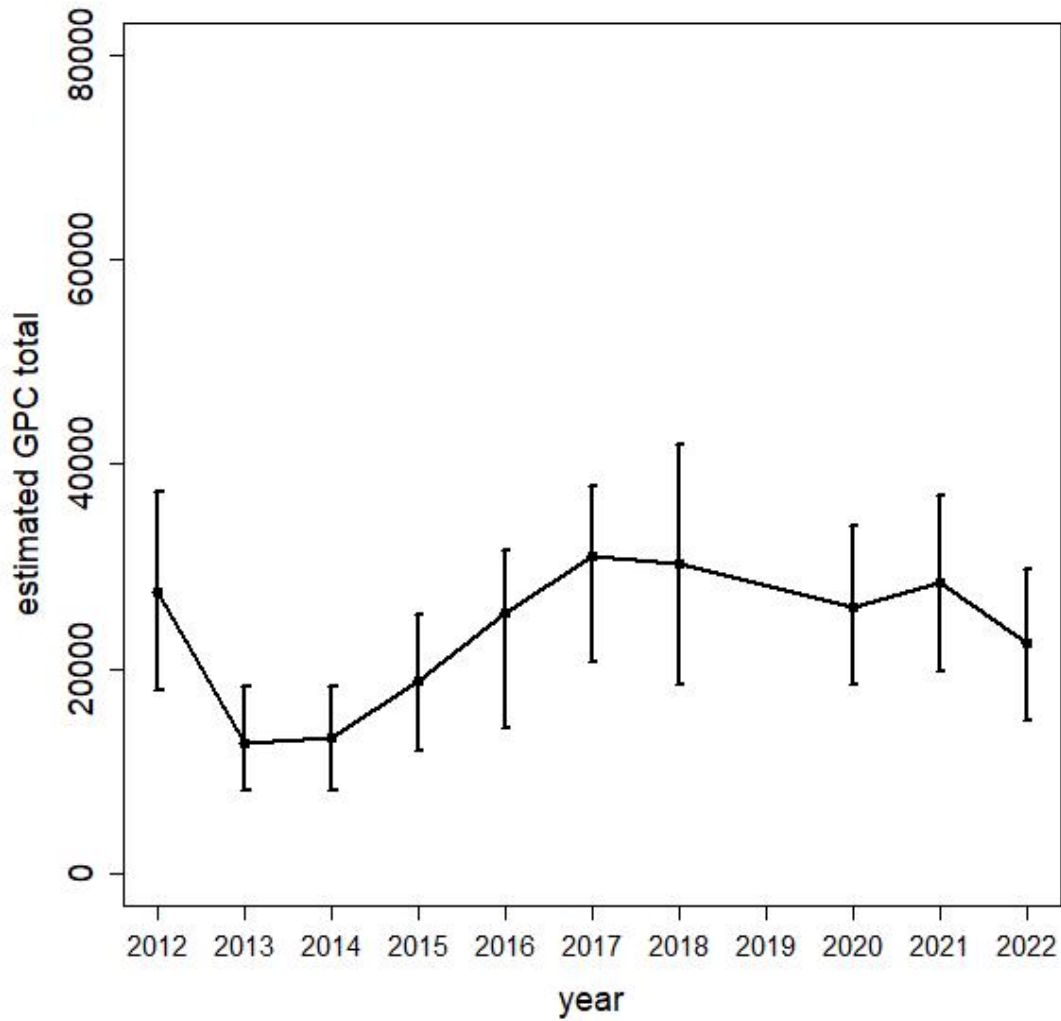


Figure B-1. Estimated population sizes of greater prairie-chicken (GPC) with 90% confidence intervals for survey years 2012 to 2018, and 2020 to 2022, in the Short Grass Conservation Reserve Program Prairie Region (northwestern Kansas and east-central Colorado).

Table B-2. Estimates of greater prairie-chicken (GPC) lek densities per 100 kilometer² (km²; 39 miles²) and abundance of GPC leks for survey years 2012 to 2018, and 2020 to 2022, in the Short Grass Conservation Reserve Program Prairie Region of northwestern Kansas and east-central Colorado. Bootstrapped 90% confidence intervals were reported on the population sizes of GPC and abundance of GPC leks per 100 km².

Year	Density	Abundance
2012	5.30 (3.25, 7.44)	1,978 (1,214, 2,780)
2013	3.77 (2.23, 5.55)	1,409 (8,32, 2,072)
2014	4.29 (2.55, 6.02)	1,601 (953, 2,248)
2015	3.21 (1.68, 4.83)	1,279 (671, 1,923)
2016	6.66 (3.49, 8.31)	2,654 (1,389, 3,308)
2017	5.37 (3.33, 6.94)	2,140 (1,326, 2,765)
2018	5.99 (3.57, 8.44)	2,387 (1,422, 3,360)
2020	9.93 (6.86, 12.92)	3,955 (2,733, 5,144)
2021	6.03 (3.91, 8.18)	2,403 (1,559, 3,259)
2022	7.84 (5.18, 10.92)	3,457 (2,283, 4,817)

A decrease of 5,981 GPC was observed from 2021 to 2022; however, this decrease was not statistically significant (90% CI: -16,633, 5,734; Table B-3).

Table B-3. Estimated differences in population estimates for greater prairie-chicken between years with bootstrapped 90% confidence intervals on the differences.

Δ Year	Estimate (90% Confidence Interval)
2013 minus 2012	-14,795 (-25,411, -4,329)
2014 minus 2013	396 (-6,685, 7,211)
2015 minus 2014	5,556 (-2,451, 13,592)
2016 minus 2015	6,721 (-6,137, 14,479)
2017 minus 2016	5,503 (-5,541, 17,338)
2018 minus 2017	-660 (-12,945, 15,109)
2020 minus 2018	-4,223 (-17,626, 9,182)
2021 minus 2020	2,392 (-9,222, 12,610)
2022 minus 2021	-5,981 (-16,633, 5,734)

Δ Year = change in year