Oregon Greater Sage-Grouse Population Monitoring: 2021 Annual Report

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Executive Summary

During the 2021 greater sage-grouse (*Centrocercus urophasianus*) breeding season, 1,854 aerial and ground lek surveys were conducted at 822 individual lek sites comprising 544 lek complexes. Surveys were conducted at 68.8% of known lek sites and 67.2% of known lek complexes in the state. Survey effort during 2021 increased 4.9%, 5.7%, and 7.1% from 2020 levels, in terms of number of surveys conducted, number of leks surveyed, and number of complexes surveyed, respectively. This constitutes the highest lek survey effort accomplished in Oregon to date for the proportion of known complexes surveyed and the second highest effort to date for the proportion of known leks surveyed. Results from these surveys indicate the sage-grouse spring breeding population in Oregon increased by 12.2% between 2020 and 2021, to 15,927 estimated individuals (95% CI: 15,345 – 16,510 individuals). These results indicate a second year of statewide population increase following three consecutive years of decline, 2017–19. However, the 2021 estimate is still the third lowest estimated sage-grouse population in Oregon during the analysis period of 1980 – 2021. Population increases occurred in the Burns, Lakeview, and Vale BLM Districts, ranging from 3.7% – 22.2%. Population decline occurred in the Prineville BLM District, at -13.6%. The estimated sage-grouse population in the Baker BLM Resource area increased by 42.6%, however, due to issues with population analysis methodology in this area, our confidence in trend estimates is lower than in other areas of the state.

Overview and Spring Population Monitoring Methods

Counts of male sage-grouse displaying on leks (communal breeding sites) during the spring breeding season have been used to generate indices of sage-grouse population trends since the 1940s (Patterson 1952) and remain the most widely used method to monitor sage-grouse populations range-wide (McCafferey et al. 2016). Monitoring of some sage-grouse leks in Oregon began in the 1940s, with survey efforts increasing in the state after 1980 (ODFW 2011). ODFW adopted a standardized lek survey methodology in 1996, ensuring consistent data quality and allowing data comparison across the state. ODFW has generated BLM District-specific spring sage-grouse population estimates since 2013. Prior to 2013, yearly population estimates were conducted at the scale of ODFW Wildlife Management Units (WMUs). While WMU-level estimates of fall sage-grouse populations are still developed to inform sage-grouse hunting permit allocation, the decision to generate spring estimates at the scale of BLM Districts was made because BLM is the primary land manager in much of Oregon sage-grouse range. Thus, BLM is the agency with the greatest ability to affect sage-grouse habitat quality and population trends in Oregon. Beginning in 2015, survey effort in Priority Areas for Conservation (PACs; synonymous with ODFW Core Areas) has increased to facilitate the implementation of PAC-level adaptive management population triggers required under the BLM Greater Sage-Grouse Approved Resource Management Plan Amendment (ARMPA). This increased survey effort is supported by a Cooperative Funding Agreement between the BLM and ODFW, which supports additional seasonal lek survey positions, as well as increased aerial lek survey and telemetry effort. ODFW provides lek survey results to the BLM following the lek survey period, from which the BLM generates estimates of sage-grouse population trend at the PAC-level and reports on PAC-level population trends and adaptive management triggers. Survey effort and trend in male lek attendance are reported at the PAC-level in Appendix I. However, due to slight differences in trend estimation methodology, the PAC-level information presented here should

not be conflated with BLM-generated estimates of PAC population trend, or adaptive management trigger analysis, as required by the ARMPA. The data regarding PAC-specific trends are presented here for informational purposes only.

Sage-grouse leks and lek complexes (a group of allied leks within 1 mile of each other, between which a set of males may move; ODFW 2011) are monitored between 15 March and 30 April to obtain counts of breeding male sage-grouse. In a collaborative effort, biologists with ODFW, BLM, USFWS, Burns Paiute Tribe, Pheasants Forever, and Oregon State University, as well as volunteers under the ODFW Adopt-a-Lek Program (Appendix II), visit leks from approximately 30 minutes before sunrise until approximately 2 hours after sunrise and count all male sage-grouse visible on a lek. Same day counts of all individual leks comprising a complex are summed and treated as a single unit during analysis. Hereafter, lek complex will be used to refer to the sample unit in this report, whether a single lek or multiple leks compose a complex. Due to variability in male lek attendance throughout the breeding season, a subset of lek complexes is counted up to 4 times per season, with individual counts separated by 7-10 days. Using this methodology, a subset of lek complexes is counted in each BLM District containing extant sage-grouse populations, with minimum spring population estimates generated by ODFW at the scale of BLM District (Table 1, Figure 1). In the case of the Vale District, population estimates are generated separately for the Baker Resource Area and the remainder of the District, due to the small size of the Baker Resource Area (RA) population and its isolation from the other sage-grouse populations in the District.

Minimum spring population estimates are generated from maximum counts of males at each lek complex using a stratified random estimator (Krebs 1994). Lek complexes are assigned to one of five strata, based on the 8-year average of maximum male attendance: inactive (0 males), small (1-10 males), medium (11-25 males), large (26-50 Males), and XL (>50 males; ODFW 2011). To assign lek complexes not counted during the current year to the appropriate stratum, lek complex attendance is estimated by adjusting the most recent male count by the average proportional change in lek complex size for counted leks, in the relevant BLM District, between the count year and the current year (ODFW 2011). Mean lek complex attendance per stratum is then calculated based solely on actual counts and adjusted by 0.75 to obtain an estimate of the actual mean number of males per lek complex per stratum, based on the assumption that only 75% of males reliably attend leks in a given year (Jenni and Hartzler 1978, Emmons and Braun 1984, Walsh et al. 2004, ODFW 2011). The adjusted estimate of mean males per lek complex per stratum is then multiplied by the 5-year statewide average sex ratio, estimated from hunter-harvested wings (Appendix IV), to generate an estimate of the mean number of females per lek complex per stratum. The sum of females and males per lek complex per stratum is then generated and an estimate of individuals per lek complex is calculated, weighted based on the proportion of lek complexes composing each stratum. The final spring population estimate for each BLM District/RA is calculated as the total number of known active lek complexes in a given BLM District multiplied by the weighted average lek complex size in that District (Krebs 2004). Confidence limits on these estimates are generated based on variability in counts per stratum and number of lek complexes surveyed within each stratum (Krebs 2004).

Methods for projecting sage-grouse population estimates back in time contain multiple assumptions regarding lek formation and extinction rates (ODFW 2011). Thus, no attempt is

made in this report to back project estimated sage-grouse populations by BLM District to those years prior to 2013, when population estimates were conducted at the scale of WMUs. Rather, trends in population at the scale of BLM Districts between 1980 and 2021 are reported following the methodology of Schroeder et al. (2000). An index of population trend by BLM District, between 1980 and 2021, is reported as the percentage of 2021 male attendance during Year *t*, solely at leks counted during both 2021 and Year *t*. For example, if a set of leks is counted in both 2021 and Year *t*, and the count totals are 100 males during 2021, and 120 males during Year *t*, the population index during Year *t* = 120%.

Throughout this report, change in lek size over time is depicted using the average number of males counted per active lek in a given analysis unit. While this metric is generally reliable, caution should be taken when examining these graphs during the 1980 – 1996 period. In many areas, few leks were counted prior to 1996 (Figure 2) and the leks counted were often large. As knowledge of lek distribution across the state has increased, many relatively small leks have been identified and surveys of those leks have increased in recent years. The recent routine counting of these smaller leks has likely corrected bias in the males/active lek metric, reducing the average size of counted leks, and thus, potentially indicating an artificial decline in lek size in some areas.

While ODFW generates point estimates of the sage-grouse population in Oregon and confidence intervals around those estimates using the statistical methods described above, caution should be used when making inference based on these estimates. Lek counts are an index of population size and the true relationship between the index and the population size is unknown (Walsh et al. 2004, ODFW 2011). Due to the high proportion of leks surveyed each year, and consistency in monitoring and analysis methodologies over the previous 25 years, ODFW is confident that the long-term population trends reported herein are accurate and scientifically supported. However, the actual number of sage-grouse in a given BLM District remains unknown.

Table 1. BLM Districts/Resource Areas containing current sage-grouse populations, and the percent of the 2021 spring sage-grouse population contained in each analysis unit.

BLM District/ Resource Area	% Of 2021 Population
Baker Resource Area[a]	4.4
Burns District	18.1
Lakeview District	28.5
Vale District[a]	40.4
Prineville District	8.6

[a]The Baker Resource Area is analyzed separately from the remainder of the Vale BLM District, due to dissimilarity in population size and trajectory.

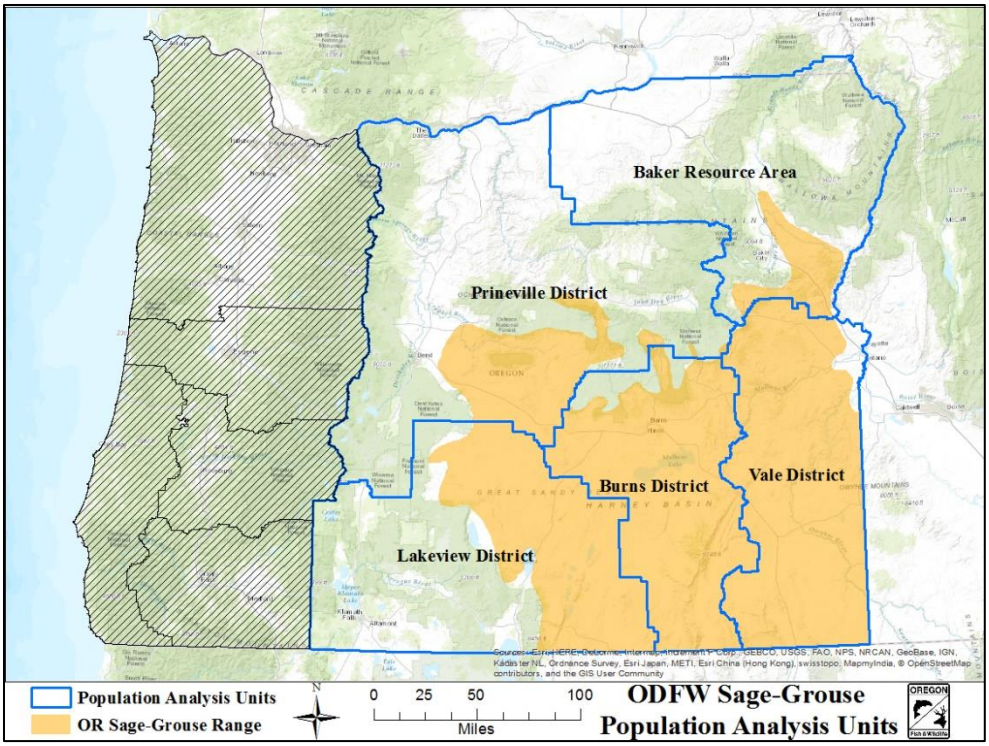

Figure 1. Oregon BLM Districts/Resource Areas containing current sage-grouse populations and functioning as analysis units for spring population estimation in Oregon. The Baker Resource Area is analyzed separately from the remainder of the Vale BLM District, due to dissimilarity in population size and trajectory.

Lek Monitoring Effort and Population Estimates

Statewide

Statewide lek survey effort during 2021 was the highest accomplished to date in Oregon for the proportion of known complexes surveyed and the second highest effort to date for the proportion of known leks surveyed (Figure 2; Table 2). Weather conditions were mild through March and April, increasing the number of days available to count leks. ODFW and partners completed 1,854 ground counts and 186 aerial counts. Surveys were conducted at 822 leks comprising 544 lek complexes. Of the 1,195 individual leks, and 809 lek complexes known to exist or have existed in the state, 68.8% and 67.2%, respectively, were surveyed during 2021. On average, each lek was surveyed 2.3 times. Dedicated aerial surveys (Appendix III) and incidental observations during ground surveys help expand knowledge of sage-grouse distribution. ODFW contracted aerial services for lek searches by helicopter and lek counts by aerial infrared surveys during spring 2021. Ten new leks were located by helicopter and confirmed by ground surveyors; 6 new leks in the Soldier Creek PAC and 4 new leks in adjacent low-density habitat. Several potential new leks were located by helicopter in spring 2021 and still need to be confirmed on the ground during the spring 2022 sage-grouse breeding season before they can be added to the statewide lek database.

The estimated spring greater sage-grouse population in Oregon during 2021 was 15,927 individuals (95% CI: 15,345 – 16,510 individuals), a 12.2% increase from 2020 (2020 estimate = 14,201 individuals [95% CI: 13,030 – 15,372 individuals]). This represents the second year of statewide population increase following three consecutive years of decline, 2017–19. However, the 2021 estimate is still the third lowest estimated sage-grouse population in Oregon during the analysis period of 1980 – 2021. The population during 2021 was 46.0% below the 2003 baseline population estimate of 29,327 individuals (Figure 3). Data collected since the 2011 Oregon Greater Sage-Grouse Conservation Assessment and Strategy (hereafter: 2011 Conservation Assessment), suggests a statistically significant decline in the annual average number of males counted per active complex of -0.22 birds per year since 1980 (Multiple $R^2 = 0.22$, p-value < 0.01; Figure 3).

Baker Resource Area

Lek survey effort in the Baker Resource Area during 2021 increased slightly compared to 2020 and was the second highest survey effort accomplished in the area for the proportion of known leks surveyed (Figure 4; Table 3). Due to limited private land access, survey effort in the Baker Resource Area is unlikely to increase substantially in future years. During 2021, 147 ground surveys and 2 aerial surveys were conducted at 54 leks comprising 36 complexes. This constitutes 62.8% of the 86 leks, and 60.0% of the 60 complexes known to exist or have existed in the Resource Area. Survey effort per lek was high, with each lek receiving, on average, 2.76 surveys during the monitoring season. No new leks or complexes were discovered in the area during 2021.

The estimated spring sage-grouse population in the Baker Resource Area during 2021 was 704 individuals (95% CI: 547 – 862 individuals), a 42.6% increase from 494 estimated individuals in 2020. The apparent large increase in estimated population during 2021 was likely a result of the analysis methodology used to generate population estimates. The Krebs random stratified estimator used to generate population estimates does not perform well with small populations, such as the existing sage-grouse population in the Baker Resource Area. Observed male attendance at lek complexes counted during both 2021 and 2020 was 99, a 17.9% increase from observed male attendance of 84 recorded at these same leks in 2020. While the sage-grouse population in the Baker Resource Area remains above 2014 levels ($n_{2014} = 402$ individuals), this area has experienced a long-term population decline and has remained stagnant in recent years. The five-year average annual change in male lek complex attendance between 2016 and 2021 is estimated at 1.7%. Since 2005, a -81.0% decline in male lek complex attendance has been observed at complexes counted during both 2005 and 2021 ($n_{2005} = 179$, $n_{2021} = 34$). Male attendance at complexes monitored in both 2003 and 2021 indicates that the population in the Baker Resource Area is currently -82.4% below the 2003 baseline level ($n_{2003} = 193$, $n_{2021} = 34$). Data collected since the 2011 Conservation Assessment suggests a significant reduction in the average size of lek complexes since 1996, with average males per active complex declining by -0.49 individuals per year over this period (Multiple $R^2 = 0.51$, p-value < 0.01; Figure 5).

Table 2. **Oregon statewide** greater sage-grouse lek complex survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1980 – 2021.

	1980-84		1985-89		1990-94		1995-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	140.00	*6.32*	220.40	*20.60*	326.00	*16.41*	486.00	*21.23*	605.60	*13.51*	690.00	*8.04*	734.00	*6.44*	786.40	*7.18*	800.00	-	809.00	-
Complexes Counted	52.00	*6.02*	67.60	*10.36*	94.00	*12.09*	164.20	*8.75*	200.80	*11.05*	266.60	*16.05*	295.00	*26.69*	486.60	*19.51*	508.00	-	544.00	-
Proportion Counted*	0.38	*0.06*	0.30	*0.03*	0.28	*0.02*	0.34	*0.02*	0.33	*0.01*	0.39	*0.02*	0.40	*0.03*	0.62	*0.02*	0.64	-	0.67	-
Active Complexes	27.20	*3.40*	48.20	*7.27*	73.00	*12.68*	129.20	*4.12*	144.60	*7.75*	178.80	*6.92*	178.60	*10.32*	249.20	*4.27*	249.00	-	275.00	-
Males Per Complex	13.39	*2.46*	19.13	*2.06*	19.19	*1.96*	12.34	*0.54*	17.03	*0.92*	15.24	*2.61*	11.83	*1.61*	9.07	*0.90*	7.03	-	7.37	-
Males Per Active Complex	23.44	*1.79*	26.61	*2.28*	25.28	*2.42*	15.61	*0.59*	23.78	*1.82*	22.40	*3.59*	18.89	*1.72*	17.64	*1.54*	14.34	-	14.57	-
Proportion Change - Male Attendance	0.01	*0.10*	0.08	*0.08*	-0.08	*0.07*	-0.05	*0.07*	0.09	*0.02*	-0.09	*0.10*	0.00	*0.11*	-0.01	*0.11*	0.02	-	0.03	-

*Proportion complexes counted during the designated timeframe.

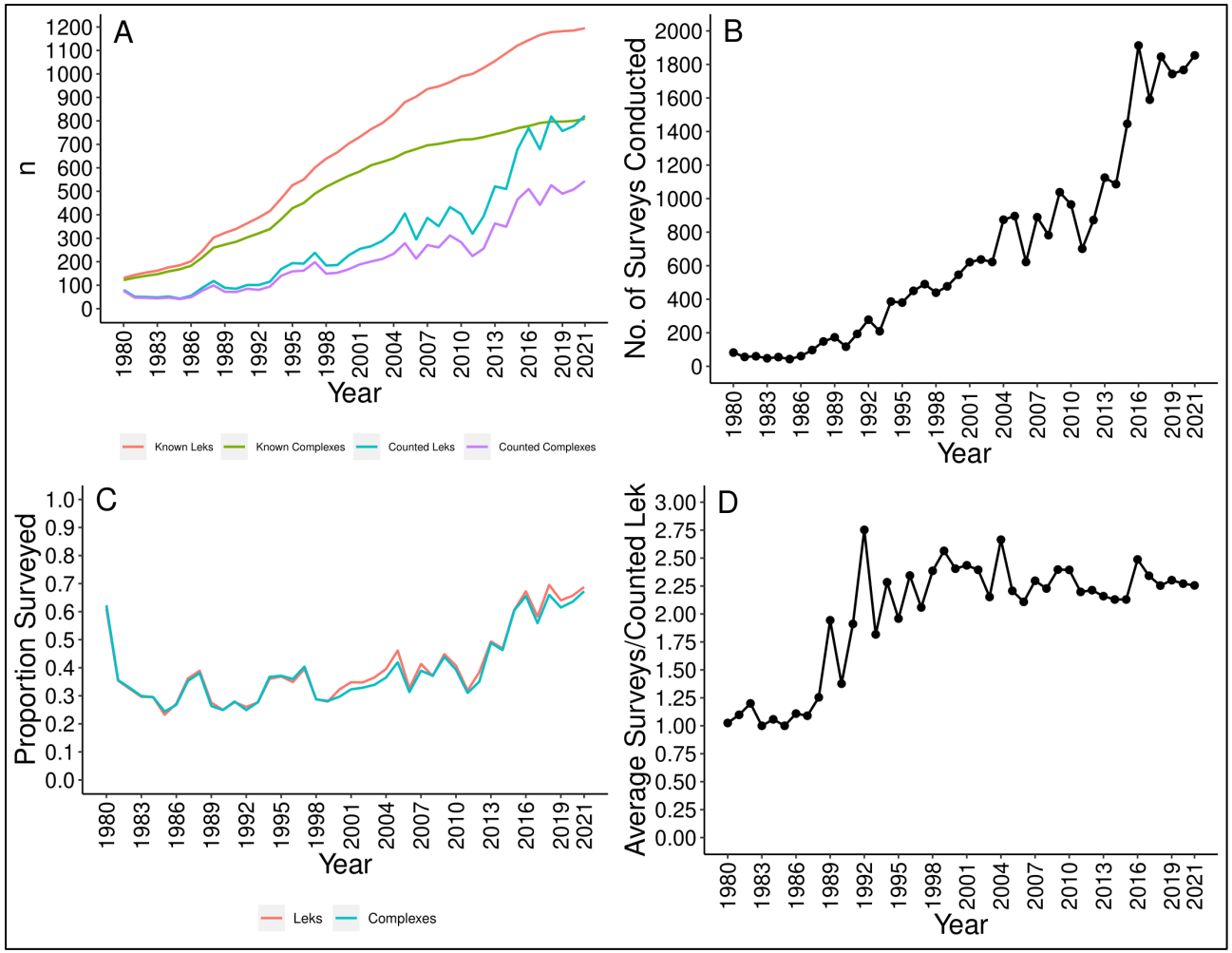

Figure 2. Oregon statewide greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

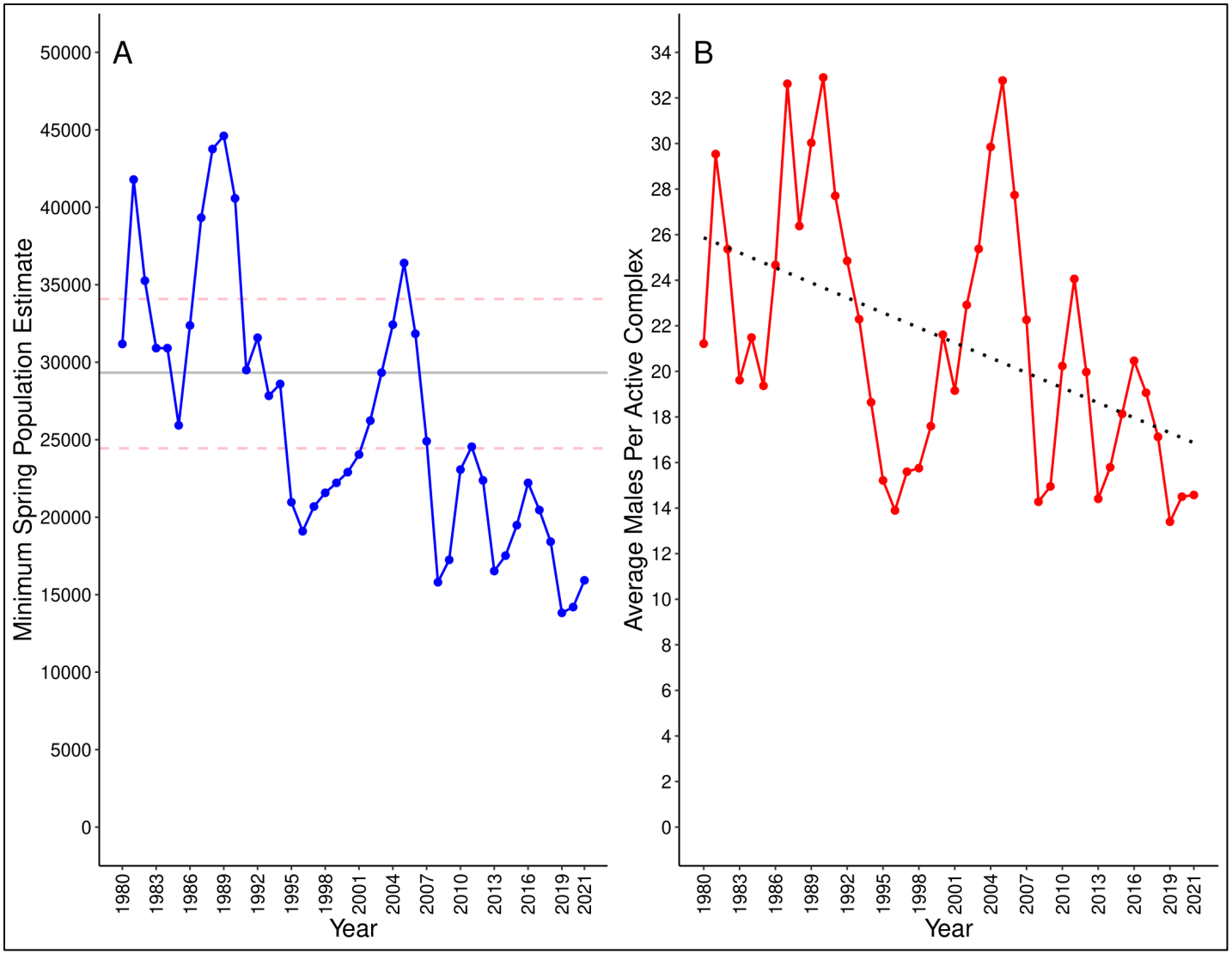

Figure 3. Greater sage-grouse population trends in Oregon, 1980 – 2021. A - Estimated spring breeding population of greater sage-grouse, gray line indicates 2003 baseline population level of 29,327 individuals, pink dotted lines indicate the 95% confidence interval around the 2003 baseline estimate. B - Change in average lek complex size (males per active lek complex).

Table 3. **Baker BLM Resource Area** greater sage-grouse lek complex survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1996 – 2021.

	1996-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	24.00	*3.39*	40.60	*1.17*	44.20	*0.80*	52.40	*0.40*	58.40	*1.76*	60.00	-	60.00	-
Complexes Counted	12.25	*1.49*	15.00	*2.61*	18.80	*4.14*	16.40	*1.69*	32.80	*5.20*	37.00	-	36.00	-
Proportion Complexes Counted	0.52	*0.04*	0.37	*0.07*	0.42	*0.08*	0.31	*0.03*	0.56	*0.08*	0.62	-	0.60	-
Active Complexes	8.00	*0.82*	12.40	*2.73*	13.40	*0.75*	10.40	*1.17*	9.80	*1.03*	10.00	-	9.00	-
Males Per Complex	13.61	*1.21*	15.22	*2.02*	12.03	*2.71*	6.64	*0.96*	3.58	*0.78*	2.83	-	2.84	-
Males Per Active Complex	20.46	*1.11*	18.99	*2.39*	14.56	*2.51*	10.26	*1.01*	11.32	*0.95*	10.20	-	11.67	-
Proportion Change - Male Attendance	0.08	*0.05*	0.02	*0.12*	-0.16	*0.05*	-0.10	*0.12*	0.02	*0.13*	0.01	-	0.03	-

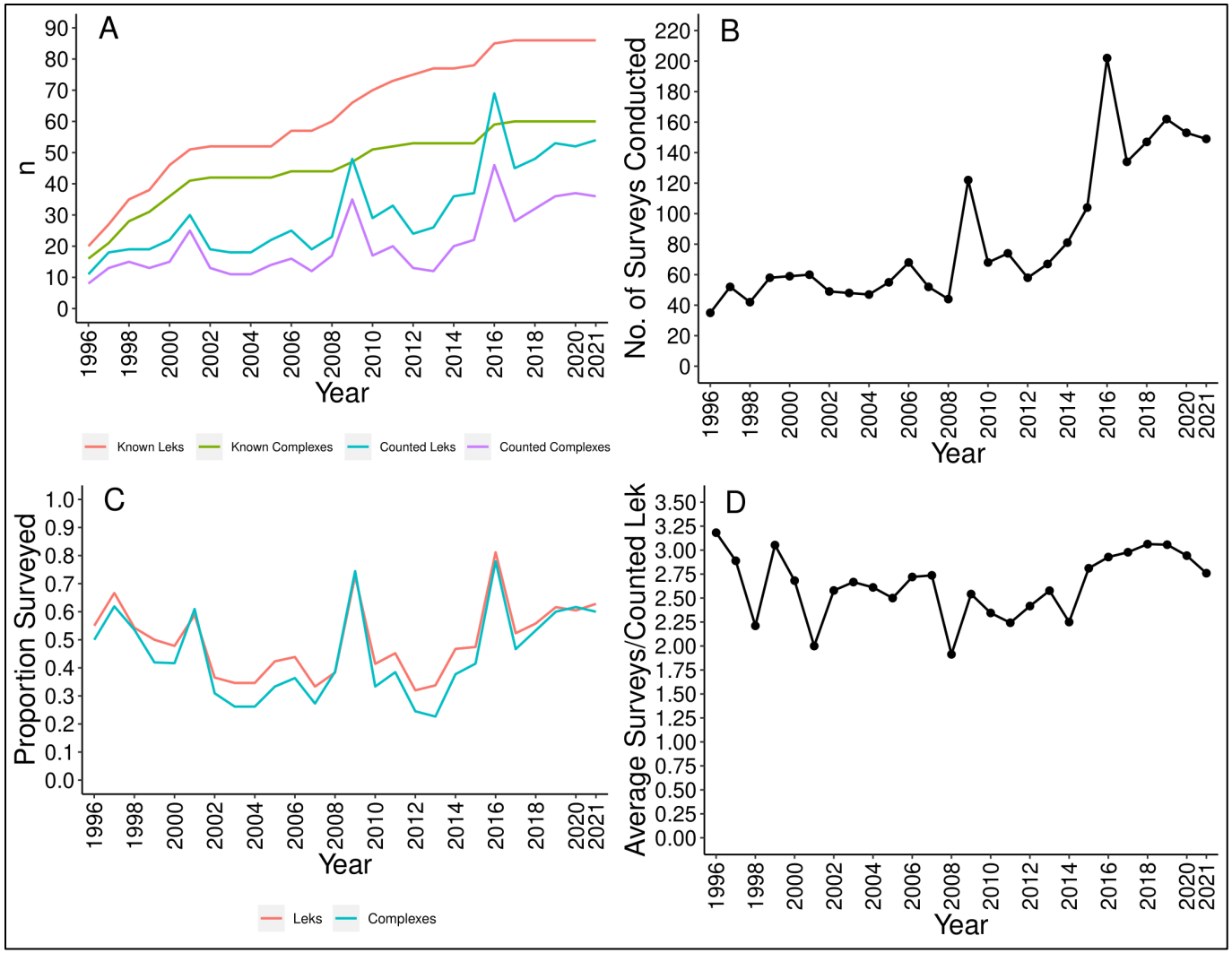

Figure 4. Baker BLM Resource Area greater sage-grouse survey effort statistics, 1996 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

Figure 5. Greater sage-grouse population trend in the Baker BLM Resource Area, 1996 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Burns District

Overall survey effort for the Burns District decreased during 2021 but remained above survey effort goals for the District (Table 4; Figure 6). During 2021, 272 ground surveys were conducted, and 1 aerial survey was conducted at 126 leks comprising 86 complexes. This constitutes 58.6% of the 215 leks, and 59.7% of the 144 complexes known to exist or have existed in the District. Survey effort in 2021 was 2.17 surveys per lek, similar to 2.18 surveys per lek in 2020. No new leks or complexes were discovered in the District during 2021.

The estimated spring sage-grouse population in the Burns District during 2021 was 2,885 individuals (95% CI: 2,823 – 2,947 individuals), a 3.7% increase from 2,783 individuals in 2020. Observed male attendance at lek complexes counted during both 2021 and 2020 was 671, a 9.5% increase from observed male attendance of 613 recorded at those same leks in 2020. This represents the second year of population increase following three consecutive years of population decline (2017–19) in the District (Figure 7). The 5-year average population trend in the District has been negative at -7.9%. Observed male attendance during 2021 is -63.6% below the 2003 baseline level (n_{2003} = 610, n_{2021} = 222), at complexes counted during both 2003 and 2021 (Figure 7). Data collected since the 2011 Conservation Assessment suggests a significant reduction in average lek complex size since 1981, with the number of males per active complex declining by -0.54 individuals per year over this period (Multiple R^2 = 0.36, p-value <0.01; Figure 7).

Lakeview District

Overall survey effort in the Lakeview District decreased slightly during 2021 but remained above goals for the District (Table 5; Figure 8). During 2021, 398 ground surveys and 29 aerial surveys were conducted at 186 leks comprising 111 complexes. This constitutes 60.6% of the 307 leks, and 54.7% of the 203 complexes known to exist or have existed in the District. Survey effort in 2021 was 2.30 surveys per lek, a slight decrease from 2.33 surveys per lek in 2020. No new leks or complexes were discovered in the area during 2021.

The estimated spring sage-grouse population in the Lakeview District was 4,540 individuals (95% CI: 4,428 – 4,652 individuals), a 11.3% increase from 4,078 individuals in 2020. Observed male attendance at lek complexes counted during both 2021 and 2020 was 740, an 8.5% increase from observed male attendance of 682 recorded at those same leks in 2020. This represents the second year of population increase following three consecutive years of population decline (2017–19) in the District (Figure 9). The 5-year average population trend in the District has been negative at -6.9%. Observed male attendance was -51.0% below the 2003 baseline level (n_{2003} = 1,326, n_{2021} = 650), at complexes counted during both 2003 and 2021 (Figure 9). Data collected since the 2011 Conservation Assessment suggest a small, non-significant reduction in average lek complex size since 1980, with average males per lek complex declining by -0.19 males per year over this period (Multiple R^2 = 0.06, p-value = 0.10; Figure 9).

Table 4. **Burns BLM District** greater sage-grouse lek complex survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1981 – 2021.

	1981-84		1985-89		1990-94		1995-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	30.75	*1.44*	54.40	*6.68*	75.80	*1.16*	83.00	*1.87*	95.20	*3.75*	120.00	*3.77*	131.80	*1.39*	143.00	*0.58*	144.00	-	144.00	-
Complexes Counted	15.00	*0.82*	21.60	*4.32*	18.80	*0.92*	25.20	*4.14*	30.20	*3.43*	39.80	*7.32*	48.00	*3.99*	102.40	*6.01*	95.00	-	86.00	-
Proportion Counted*	0.49	*0.05*	0.41	*0.07*	0.25	*0.02*	0.30	*0.05*	0.31	*0.03*	0.33	*0.05*	0.36	*0.03*	0.72	*0.04*	0.66	-	0.60	-
Active Complexes	11.50	*1.32*	14.40	*0.40*	16.80	*0.58*	20.00	*1.76*	24.40	*2.54*	29.00	*4.00*	31.60	*1.69*	57.00	*2.16*	60.00	-	60.00	-
Males Per Complex	22.70	*1.67*	26.86	*5.44*	32.76	*2.18*	12.97	*1.49*	19.10	*1.89*	19.59	*5.47*	13.09	*2.03*	9.69	*1.85*	7.72	-	8.36	-
Males Per Active Complex	30.19	*2.65*	36.70	*5.64*	36.86	*3.49*	15.35	*0.88*	23.20	*1.46*	24.95	*5.81*	19.22	*2.25*	17.00	*2.29*	12.22	-	12.19	-
Proportion Change - Male Attendance	-0.07	*0.02*	0.12	*0.12*	-0.04	*0.08*	-0.06	*0.13*	0.12	*0.10*	-0.10	*0.14*	0.00	*0.13*	-0.04	*0.14*	0.11	-	0.09	-

*Proportion complexes counted during the designated timeframe.

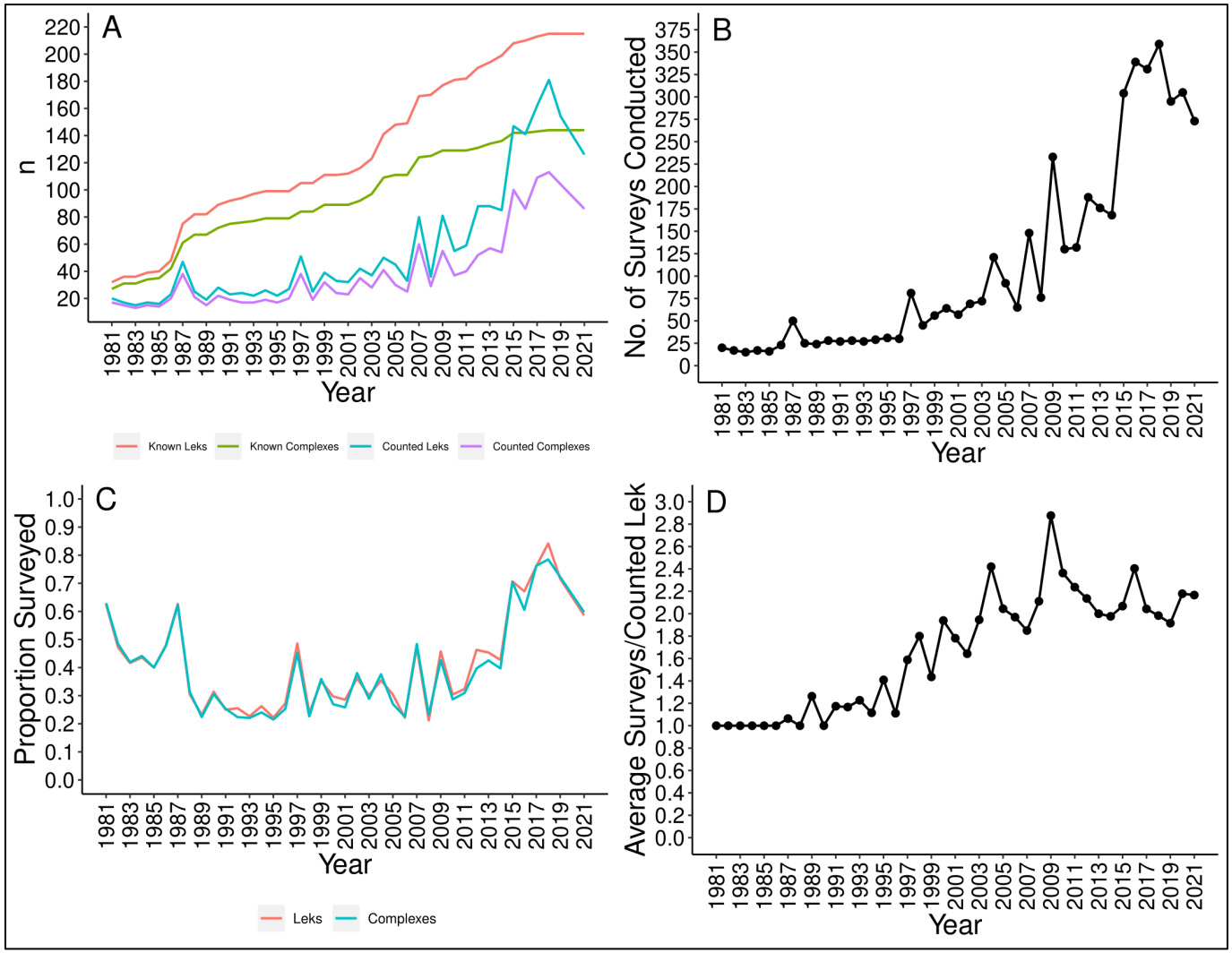

Figure 6. Burns BLM District greater sage-grouse survey effort statistics, 1981 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

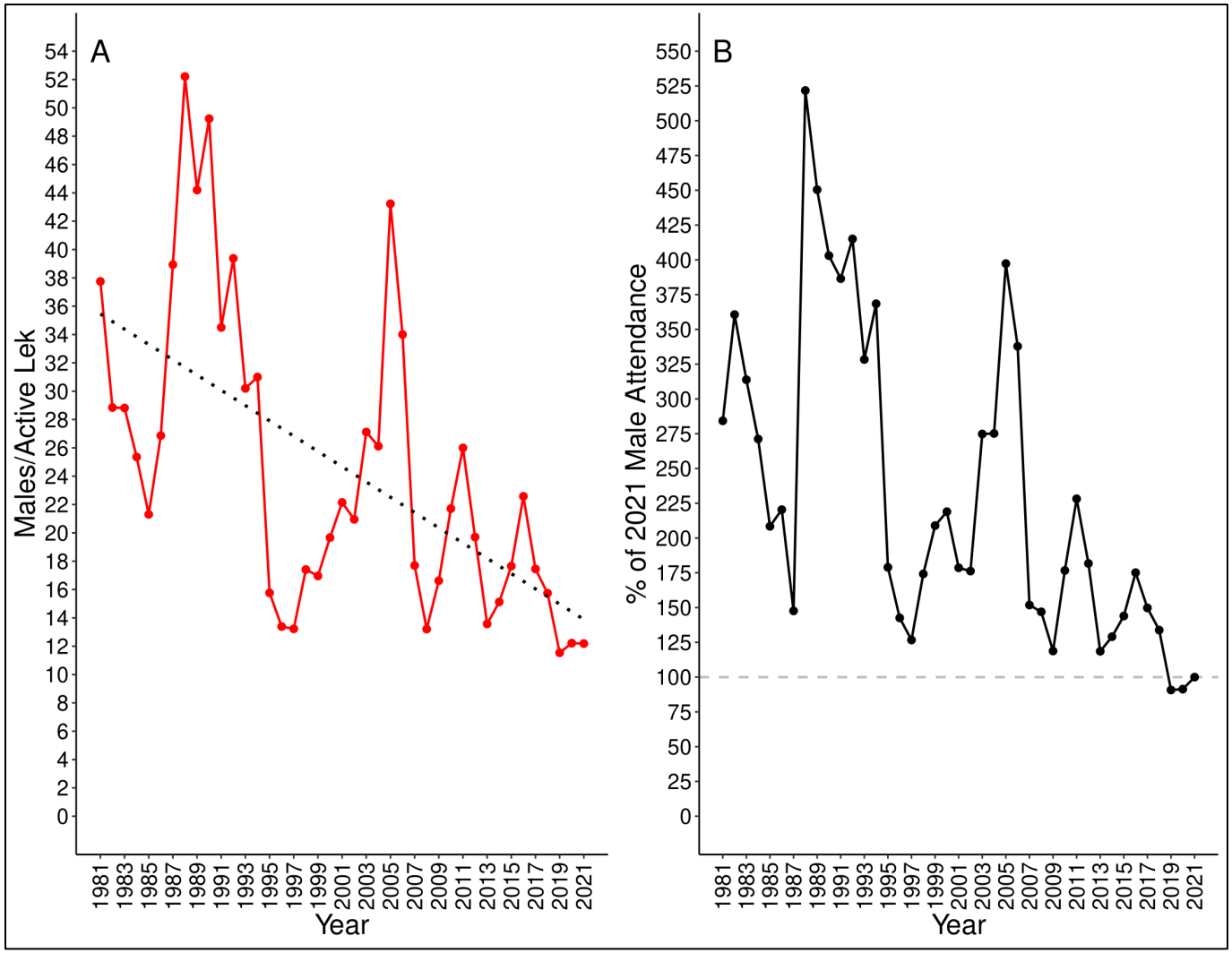

Figure 7. Greater sage-grouse population trend in the **Burns BLM District,** 1981 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year t, and 2021.

Table 5. **Lakeview BLM District** greater sage-grouse lek complex survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1980 – 2021.

	1980-84		1985-89		1990-94		1995-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	74.00	*0.95*	90.20	*5.85*	117.60	*1.12*	130.80	*0.20*	162.00	*8.58*	184.00	*0.84*	191.00	*1.30*	198.40	*1.94*	203.00	-	203.00	-
Complexes Counted	23.80	*7.83*	21.00	*3.45*	25.20	*1.56*	30.20	*2.60*	81.80	*9.83*	79.00	*3.96*	80.20	*6.67*	116.80	*7.59*	133.00	-	111.00	-
Proportion Counted*	0.33	*0.11*	0.23	*0.03*	0.21	*0.01*	0.23	*0.02*	0.50	*0.04*	0.43	*0.02*	0.42	*0.03*	0.59	*0.04*	0.66	-	0.55	-
Active Complexes	10.60	*1.54*	14.00	*1.58*	16.60	*2.20*	23.80	*2.15*	52.80	*6.08*	48.20	*2.29*	49.20	*3.02*	59.40	*4.39*	62.00	-	60.00	-
Males Per Complex	14.50	*3.52*	22.94	*3.18*	20.18	*2.52*	15.93	*1.62*	20.10	*1.38*	20.14	*3.59*	14.56	*2.06*	10.39	*1.71*	7.56	-	8.32	-
Males Per Active Complex	22.65	*2.49*	33.21	*3.91*	30.98	*2.28*	20.02	*1.76*	31.39	*3.01*	33.33	*6.56*	23.19	*2.61*	20.08	*2.61*	16.23	-	15.38	-
Proportion Change - Male Attendance	0.16	*0.17*	0.04	*0.08*	-0.10	*0.11*	-0.02	*0.12*	0.17	*0.04*	-0.13	*0.09*	-0.02	*0.11*	-0.04	*0.13*	0.14	-	0.09	-

*Proportion complexes counted during the designated timeframe.

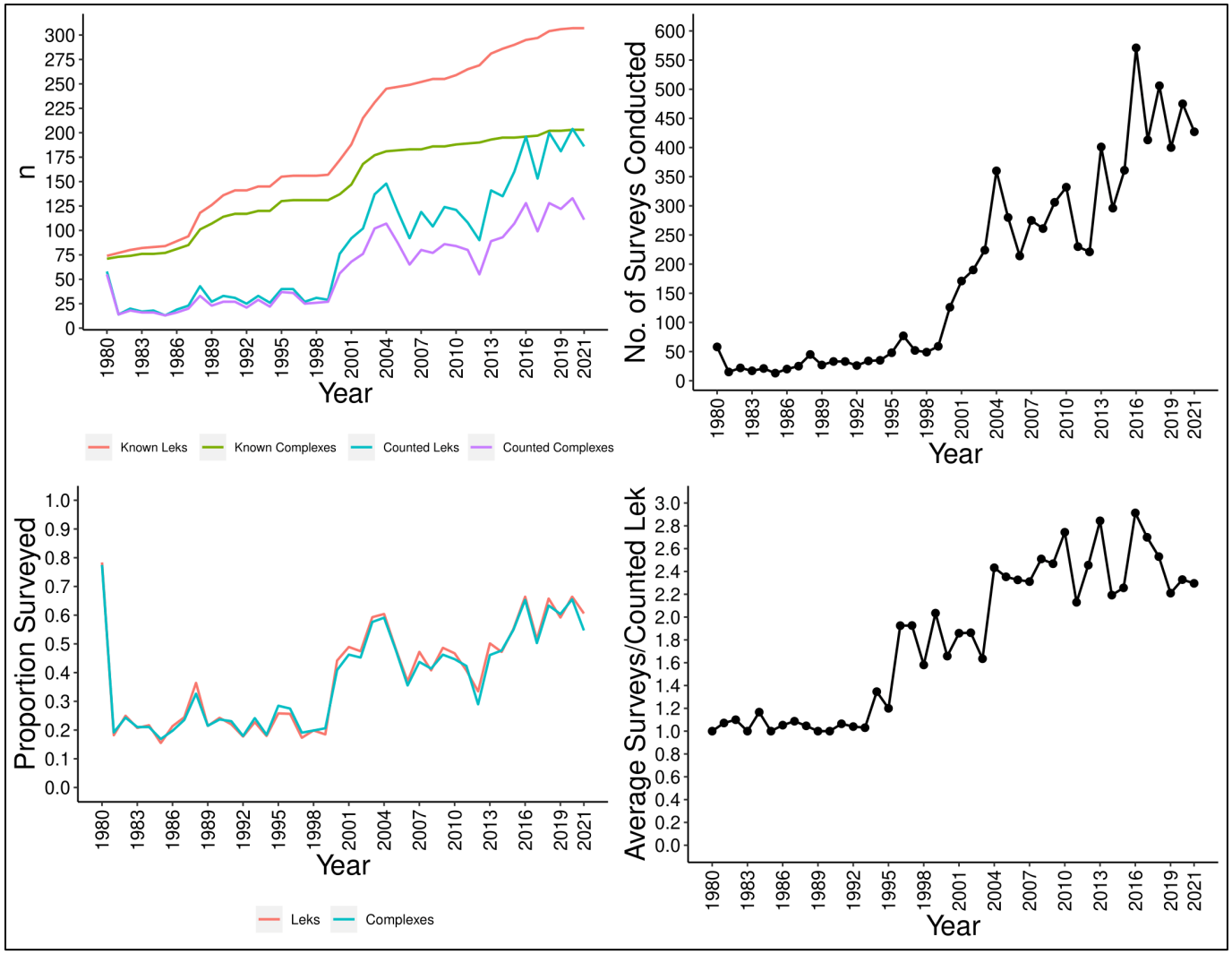

Figure 8. Lakeview BLM District greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

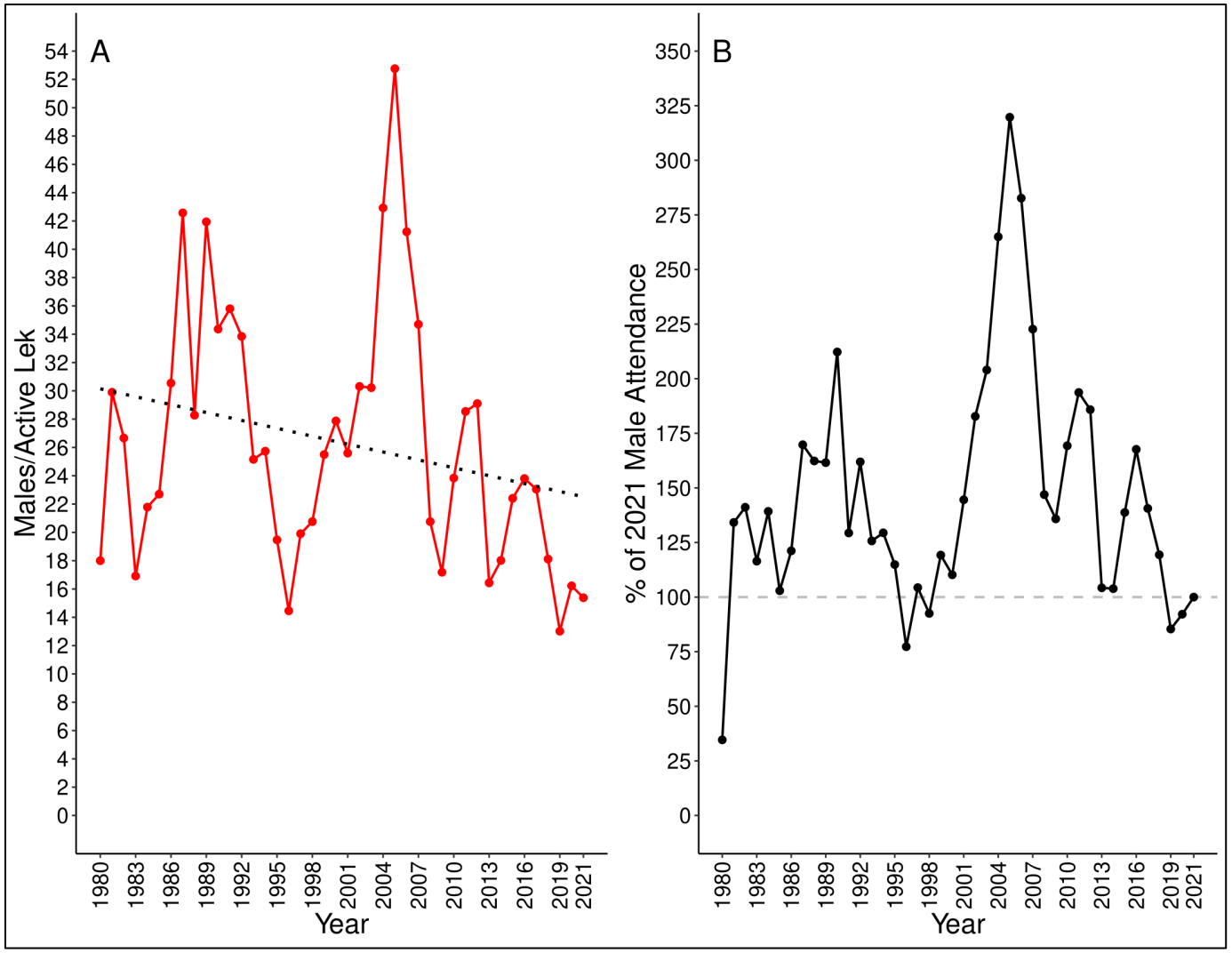

Figure 9. Greater sage-grouse population trend in the Lakeview BLM District, 1980 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Prineville District

Overall survey effort in the Prineville District increased slightly during 2021 and remained above survey goals for the District (Table 6; Figure 10). During 2021, 234 ground surveys were conducted at 81 leks comprising 37 complexes. This constitutes 63.3% of the 128 leks, and 58.7% of the 63 complexes, known to exist or have existed in the District. Survey effort per lek during 2021 was 2.89 surveys per lek, an increase from 2020 survey effort of 2.49 surveys per lek. No new leks or complexes were discovered in the District during 2021.

The estimated 2021 spring sage-grouse population in the Prineville District was 1,365 individuals (95% CI: 1,241 – 1,488 individuals), a -13.6% decrease from 1,580 individuals estimated in 2020. Observed male attendance at lek complexes counted during both 2021 and 2020 was 302, a -17.3% decrease from observed male attendance of 365 recorded at those same leks in 2020. The 5-year average population trend in the District has been negative at -4.6%. Observed male attendance is -29.3% below the 2003 baseline level ($n_{2003} = 441$, $n_{2021} = 312$), at complexes observed during both 2003 and 2021 (Figure 11). Data collected since the 2011 Conservation Assessment suggest a small, but significant decline in average lek complex size since 1980, with average males per lek complex declining by -0.06 males per year over this period (Multiple $R^2 = 0.09$, p-value = 0.05; Figure 11). However, it appears that this relationship may be driven by 2 years of high observed lek attendance during the early 1980s, when the number of leks counted was low.

Vale District

Survey effort in the Vale District (excluding the Baker Resource Area) during 2021 represented the greatest survey effort achieved in the District, mostly due to the high number of aerial surveys conducted this year (Table 7; Figure 12). During 2021, 617 ground surveys and 154 aerial surveys were conducted at 375 leks comprising 274 complexes. This constitutes 82.1% of the 457, and 81.3% of the 337 complexes, known to exist or have existed in the District. Surveys conducted per lek decreased slightly from 2020, with each lek receiving on average 2.06 surveys during the monitoring season. Ten new leks were located by helicopter and confirmed by ground surveyors; 6 new leks in the Soldier Creek PAC and 4 new leks in adjacent low-density habitat. In addition, 2 leks previously discovered by biologists on the ground were confirmed in the Vale District during 2021 lek surveys and added to the statewide lek database.

The estimated spring sage-grouse population in the Vale District in 2021 was 6,433 individuals (95% CI; 6,306 – 6,561 individuals), a 22.2% increase from 5,266 estimated individuals in 2020. This was the first year of population increase following three consecutive years of population decline in the District. However, this estimate does include the 10 new leks located by aerial surveys and confirmed on the ground, which contributed 12.0% of the 22.2% overall population increase. Observed male attendance at lek complexes counted during both 2021 and 2020 was 1,388, a 4.1% increase from observed male attendance of 1,334 recorded at those same leks in 2020. The five-year average population trend in the District was -7.4% between 2016 and 2021. Observed male attendance remains -46.8% below the 2003 baseline level ($n_{2003} = 481$, $n_{2021} = 256$) at complexes counted during both 2003 and 2021 (Figure 13). Data collected since the 2011 Conservation Assessment suggests a stable trend in average complex size since 1993 (Multiple $R^2 = 0.00$, p-value = 0.98; Figure 13).

Table 6. **Prineville BLM District** greater sage-grouse lek complex ground survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1980 – 2021.

	1980-84		1985-89		1990-94		1995-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	15.60	*0.98*	22.00	*2.61*	35.60	*0.40*	41.40	*0.60*	52.60	*2.52*	56.40	*0.24*	57.80	*0.02*	63.00	*0.00*	63.00	-	63.00	-
Complexes Counted	12.20	*1.39*	12.60	*4.61*	24.60	*1.33*	37.40	*0.98*	49.20	*2.40*	52.40	*0.81*	38.00	*1.84*	38.20	*1.44*	37.00	-	37.00	-
Proportion Counted*	0.80	*0.10*	0.52	*0.13*	0.69	*0.04*	0.90	*0.02*	0.94	*0.01*	0.93	*0.02*	0.66	*0.03*	0.61	*0.02*	0.59	-	0.59	-
Active Complexes	6.80	*1.39*	15.20	*4.91*	21.40	*1.69*	32.80	*0.86*	37.20	*0.73*	31.20	*2.48*	30.20	*0.92*	29.80	*2.25*	30.00	-	26.00	-
Males Per Complex	10.22	*1.67*	13.26	*0.83*	13.32	*0.83*	12.50	*0.19*	10.56	*0.34*	9.95	*1.12*	11.36	*0.53*	11.90	*0.63*	10.14	-	9.68	-
Males Per Active Complex	16.72	*2.53*	15.77	*0.73*	15.92	*0.67*	14.65	*0.38*	14.82	*0.51*	15.35	*1.82*	14.91	*0.41*	14.98	*0.88*	12.50	-	13.77	-
Proportion Change - Male Attendance	-0.24	*0.13*	0.11	*0.17*	-0.02	*0.09*	-0.04	*0.02*	-0.04	*0.04*	-0.07	*0.09*	0.10	*0.13*	-0.03	*0.05*	0.13	-	-0.17	-

*Proportion complexes counted during the designated timeframe.

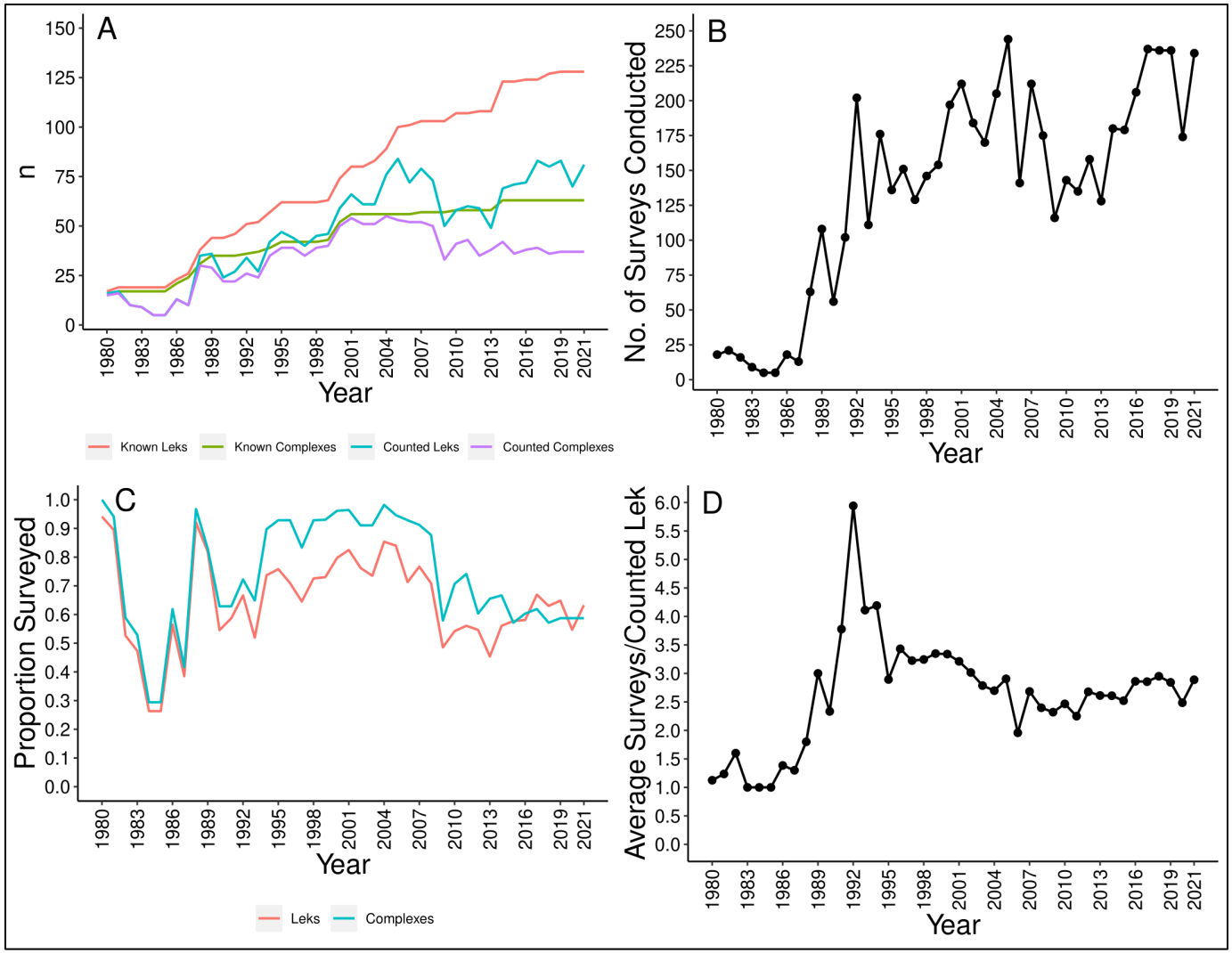

Figure 10. Prineville BLM District greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

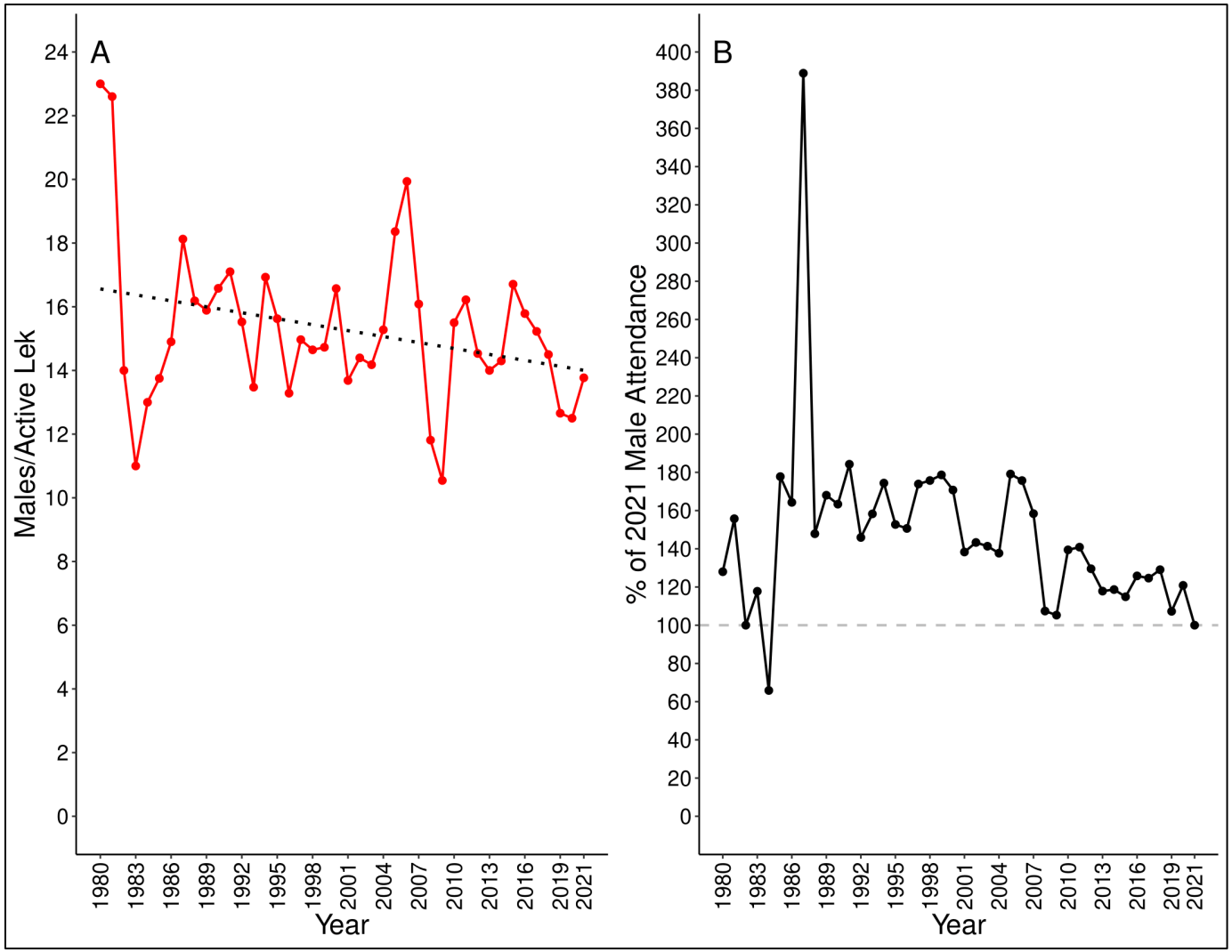

Figure 11. Greater sage-grouse population trend in the **Prineville BLM District**, 1980 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Table 7. **Vale BLM District** (Excluding the Baker Resource Area) greater sage-grouse lek complex ground survey effort, and trend in maximum male lek complex attendance summarized over 5-year periods, 1993 – 2021.

	1993-94		1995-99		2000-04		2005-09		2010-14		2015-19		2020		2021	
Variable	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Known Complexes	110.50	*18.50*	206.40	*15.65*	250.60	*0.24*	284.00	*3.16*	297.80	*2.71*	321.60	*3.50*	328.00	-	337.00	-
Complexes Counted	39.00	*19.00*	59.80	*7.73*	21.60	*1.29*	81.60	*8.94*	110.60	*21.24*	197.40	*11.44*	206.00	-	274.00	-
Proportion Counted*	0.33	*0.12*	0.30	*0.05*	0.09	*0.01*	0.29	*0.03*	0.37	*0.07*	0.61	*0.04*	0.63	-	0.81	-
Active Complexes	36.50	*16.50*	46.80	*4.45*	19.00	*0.55*	58.40	*4.86*	59.80	*8.75*	95.40	*2.90*	88.00	-	117.00	-
Males Per Complex	17.61	*6.19*	10.45	*0.64*	21.30	*2.12*	13.13	*1.89*	11.05	*2.00*	8.62	*0.61*	6.56	-	6.74	-
Males Per Active Complex	18.15	*5.65*	13.14	*0.65*	23.94	*1.97*	17.87	*2.11*	18.84	*2.31*	17.75	*1.07*	15.36	-	15.78	-
Proportion Change - Male Attendance	0.51	*0.83*	-0.06	*0.08*	0.11	*0.05*	-0.05	*0.12*	0.00	*0.11*	0.03	*0.11*	-0.10	-	0.04	-

*Proportion complexes counted during the designated timeframe.

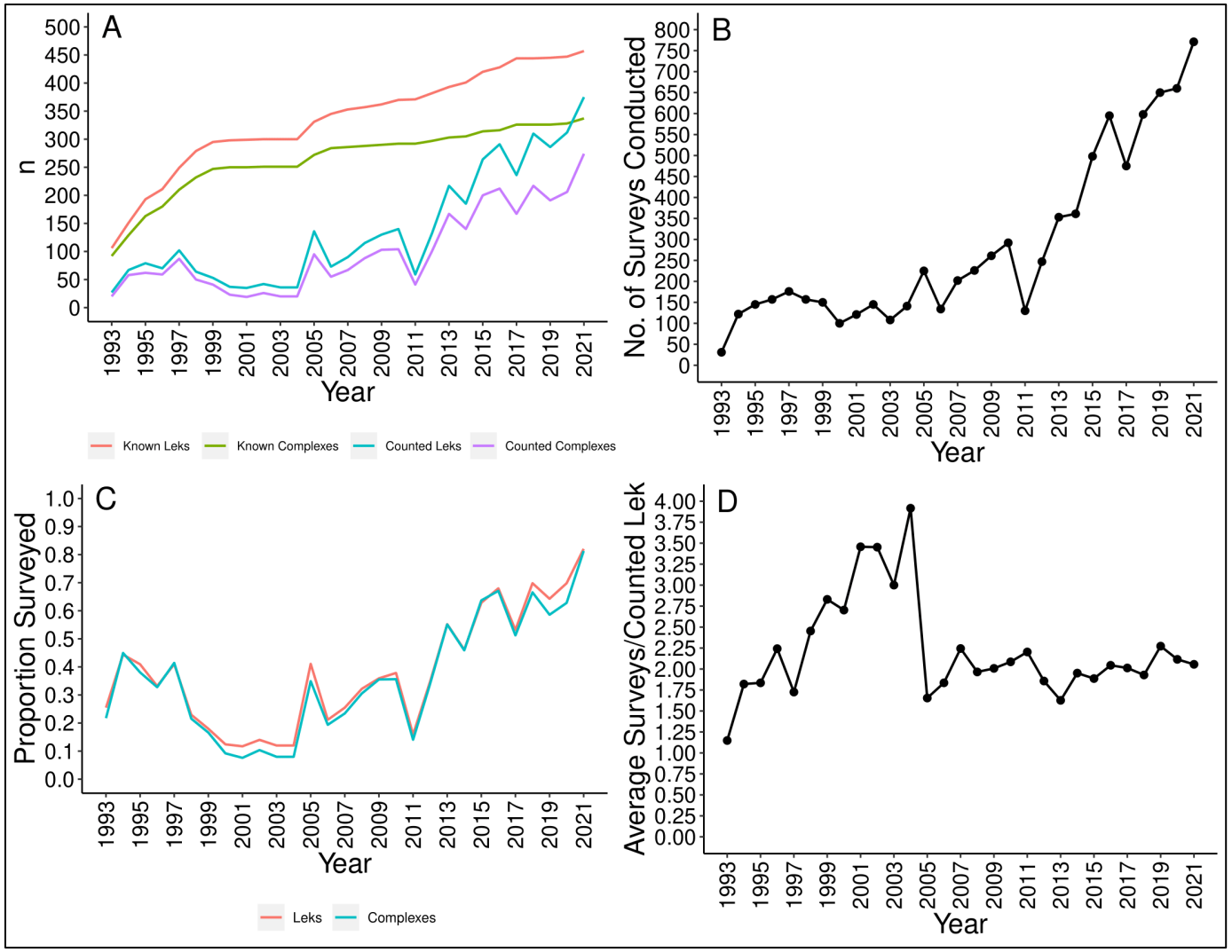

Figure 12. Vale BLM District (excluding the Baker Resource Area) greater sage-grouse survey effort statistics, 1993 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

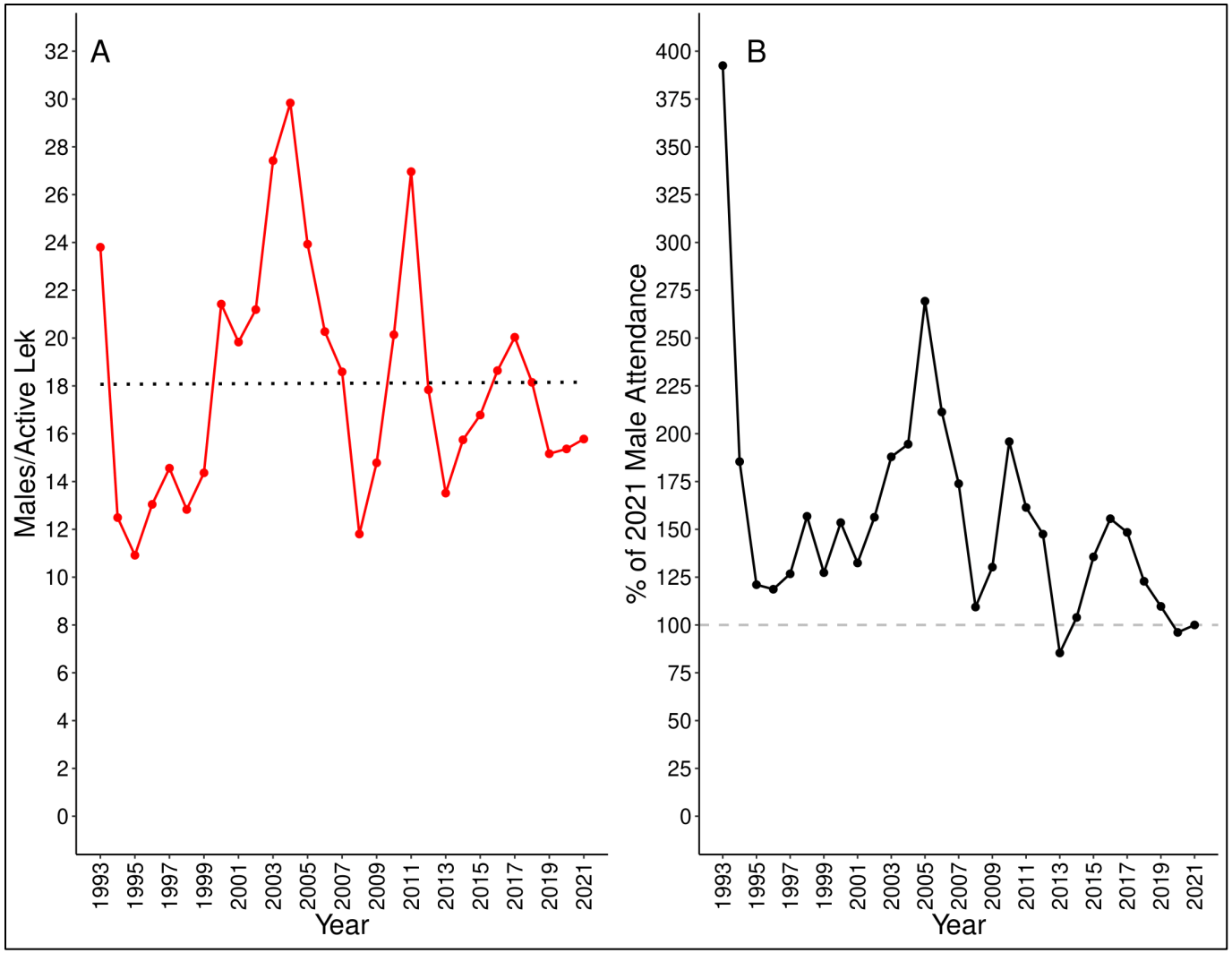

Figure 13. Greater sage-grouse population trend in the Vale BLM District (excluding the Baker Resource Area), 1993 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Summary and Conclusions

The sage-grouse population in Oregon experienced a moderate increase during 2021 following a slight population increase in 2020. The statewide population increased by 12.2% from 2020, to an estimated 15,927 individuals. Observed increases occurred in the Burns, Lakeview, and Vale BLM Districts, ranging from 3.7% – 22.2%. Population decline occurred in the Prineville BLM District, at -13.6%. The estimated sage-grouse population in the Baker BLM Resource area increased by 42.6%, however, due to issues with population analysis methodology in this area, our confidence in the trend estimates is lower than in other areas of the state. Population trends at the statewide level are primarily driven by the Burns, Lakeview, and Vale Districts, which contain approximately 90% of the statewide population. Typically, further variation in population trend exists within the state at the scale of individual PACs. During 2021, population increases were observed in 13 PACs and decreases were observed in 6 PACs where sufficient data was collected to analyze trends (Appendix I).

Sage-grouse populations exhibit density dependent fluctuations over time (Garton et al. 2011). In recent decades, sage-grouse populations in Oregon have cycled on an approximately 6–7-year period. The estimated population over the past couple years followed this pattern, with a slight increase during 2020 and a moderate population increase during 2021, following 3 years of population decline from 2017–19. Despite these consecutive increases, Oregon's statewide population is at the third lowest estimate observed during the 1980 – 2021 analysis period and is currently 46% below the 2003 statewide baseline population of approximately 29,000 individuals. Population trend in 2021 was more variable at the scale of individual PACs, than has typically been observed (Appendix I), ranging between a -46% decline in the Cow Valley PAC, and a 104% increase in the Soldier Creek PAC. However, the apparent population decline in Cow Valley PAC and the apparent population increase in Soldier Creek PAC were a result of increased aerial survey effort. Most of the leks within the Cow Valley PAC are located on private lands and surveyors do not have access to count these leks by ground. During the 2021 lek survey season, ODFW contracted Owyhee Air Research to count leks in the Cow Valley PAC using aerial infrared surveys. Many of these leks had previously been occupied during the last survey several years ago and were found unoccupied during the 2021 survey season, resulting in the large apparent population decline in this PAC. ODFW is still assessing the efficacy of aerial infrared surveys and has less confidence in the trend estimates in the Cow Valley PAC as compared to PACs primarily surveyed using ground observers. Lek searches were conducted by helicopter in the Soldier Creek PAC during March 2021. The helicopter surveys discovered several previously unknown leks, which were subsequently verified on the ground. Addition of these new leks to the database resulted in the large apparent population increase in this PAC and in the Vale BLM District.

Much of the state followed trend and continued to exhibit the population increase we expected, but several PACs saw noticeable declines. Brothers PAC and Paulina PAC both saw population declines, reflecting the overall decline in the Prineville BLM district population estimate during 2021. Additionally, the Trout Creeks PAC declined noticeably from the 2020 population estimate. Explanations for these sharp localized declines are not immediately apparent, but below average moisture conditions in this area during 2020 may have impacted sage-grouse chick production. Sage-grouse production during 2020, estimated from hunter-harvested birds, was

1.12 chicks/female, below the long-term average of 1.50 chicks/female (Figure A4.2, Table A4.5). No major habitat alterations occurred in 2020 which may have caused the localized declines in 2021. Other localized factors may have been at play in this pattern, such as West Nile Virus, or changes in predator populations, however, monitoring of these threats is notoriously difficult.

Oregon's 2019 statewide sage-grouse population estimate was the lowest recorded in the state's history during the monitoring timeframe. The slight population increase in 2020 and moderate increase in 2021 suggests that 2019 was the trough in the most recent population cycle (Figure 3). However, lack of a sharp rebound following the 2019 historic low population estimate warrants serious concern for the sage-grouse population in Oregon. Continued dedicated effort conducting sage-grouse lek surveys and searches over the next few years will be necessary to closely monitor the current population trend. Multiple years of moderate increase in the current population cycle may help ensure the next trough is not another historic low population estimate. Oregon has an excellent framework for sage-grouse conservation in place, however, active habitat management and restoration should be accelerated to the greatest extent possible. This will help maintain sage-grouse range at its current extent and support population rebound over the long-term.

Estimating sage-grouse populations from lek counts is a complicated process, containing multiple assumptions (Beck and Braun 1980, Walsh et al. 2004). Standardized count procedures, in place in Oregon since 1996, have improved the reliability of sage-grouse population estimates; however, multiple potential sources of uncertainty remain. These include assumptions regarding the lek attendance rate of male sage-grouse, knowledge of the distribution of leks in an area, bias in the selection of leks to be monitored in a given year, and uncertainty regarding the rate of new lek formation. Due to these sources of uncertainty all estimates of sage-grouse population size in Oregon should be considered indices only, with the relationship between these indices and the true population size remaining unknown (Walsh et al. 2004, ODFW 2011).

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Appendix I – PAC Scale Survey Effort and Population Trend

ODFW delineated the breeding habitat, based on lek size and distribution, of approximately 90% of the state's sage-grouse population, and grouped this area into 20 "Sage-Grouse Core Areas" during 2011 – 2012 (ODFW 2011; Figure A1.1). Since the initial delineation of these core areas, they have been incorporated into multiple assessments and regulatory documents, including the 2015 USFWS "Not-Warranted" decision (USFWS 2015), the BLM Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment (ARMPA; BLM 2015), and the Oregon Sage-Grouse Action Plan (SageCon 2015). The term Priority Area of Conservation (PAC) corresponds directly with ODFW's core areas, and the term Priority Habitat Management Area (PHMA) describes the portions of each core area under BLM administration. Annual PAC-scale population assessments are integral to the adaptive management approach outlined in the ARMPA. Concurrent with their adoption in various regulatory documents, information regarding population trends at the scale of individual PACs has received heightened attention; the PAC has become the de facto scale of interest for much of the landscape-scale sage-grouse habitat assessment and conservation currently ongoing. As such, it is appropriate to report sage-grouse survey effort and population trend information at the PAC scale. Presented below is information at the scale of individual PACs regarding survey effort during the 1980 – 2021 period, as well as population trend information reported in terms of males per active lek, and proportional change in male lek attendance following the methodology used in the main body of this document (Tables A1.1, A1.2; Figures A1.2 – A1.43). The information presented below was derived from the same base data used to make ARMPA "trigger" determinations, however it has been analyzed using slightly different methods than those used to make ARMPA trigger decisions. As such, no effort is made to pre-project BLM trigger decisions, and all information presented below should be used for informational purposes only.

As described in the main body of this report, change in lek size over time is depicted using the average number of males counted per active lek in each PAC. This metric may be misleading for some of the PACs presented below. In many PACs, few leks were counted in the early years of the periods analyzed and the leks that were counted were often large. As knowledge of lek distribution within PACs and across the state has increased, many relatively small leks have been identified and surveys of those leks have increased in recent years. The recent routine counting of these smaller leks has likely corrected bias in the males/active lek metric, reducing the average size of counted leks, and thus potentially indicating an artificial decline in lek size in some areas.

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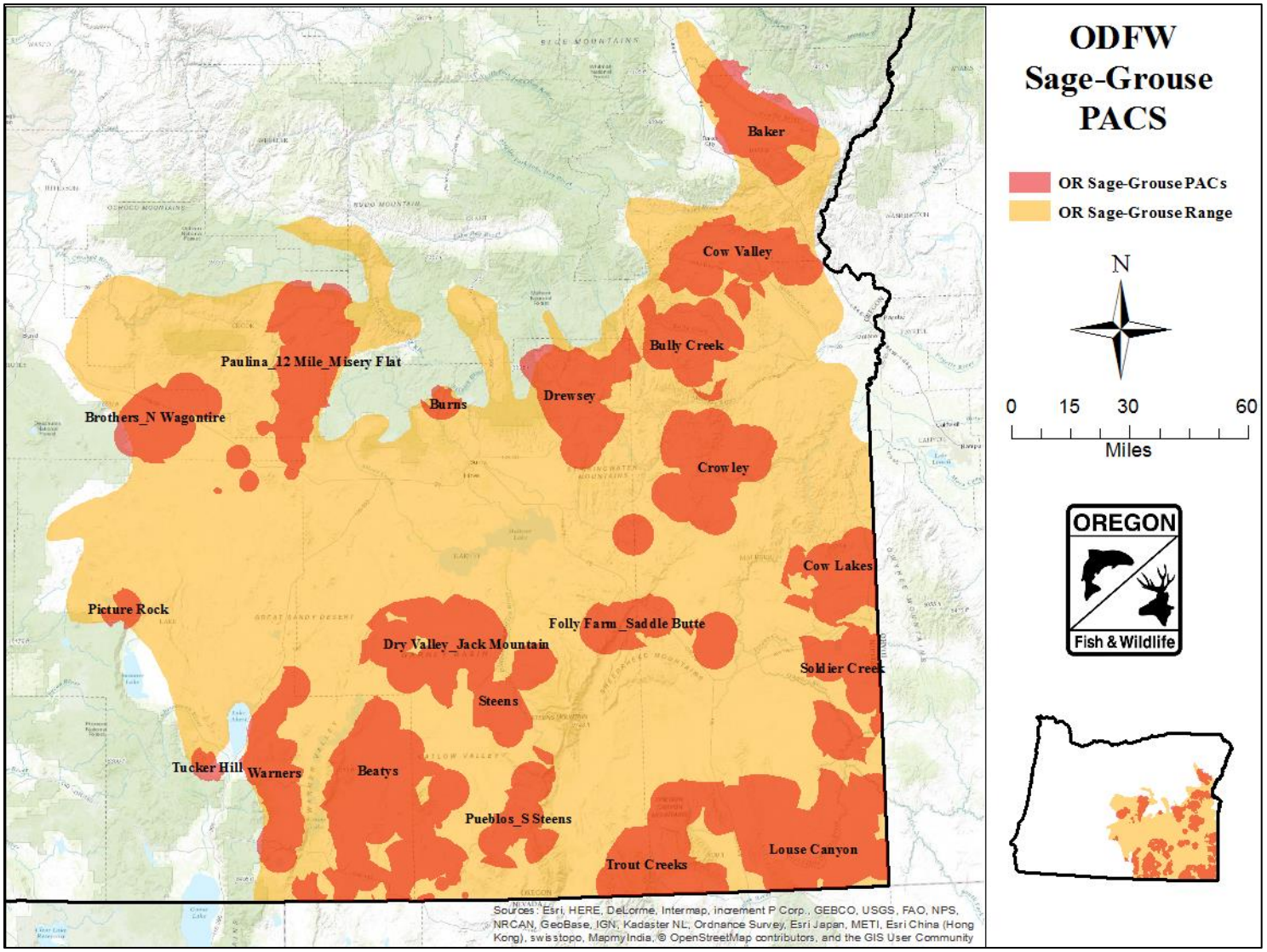


Figure A1. 1. Oregon greater sage-grouse Priority Areas for Conservation (PACs).

Table A1. 1. Survey effort statistics for the 20 Oregon greater sage-grouse PACs, and leks outside of PACs, 2021.

PAC	Total Known Leks	Total Known Complexes	Counts Conducted			Surveyed Sites		% Sites Surveyed		Surveys/Lek	Previously Unknown Sites Located	
			Total	Ground	Aerial	Leks	Complexes	Leks	Complexes		Leks	Complexes
Baker	66	46	127	127	0	44	28	66.7	60.9	2.89	0	0
Beatys	155	86	207	191	16	93	41	60.0	47.7	2.23	0	0
Brothers/N. Wagontire	45	18	114	114	0	37	13	82.2	72.2	3.08	0	0
Bully Creek	41	28	97	84	13	38	26	92.7	92.9	2.55	0	0
Burns	3	2	6	6	0	2	1	66.7	50.0	3.00	0	0
Cow Lakes	56	38	98	98	0	50	32	89.3	84.2	1.96	2	2
Cow Valley	56	44	116	46	70	54	42	96.4	95.5	2.15	0	0
Crowley	50	33	96	90	6	44	30	88.0	90.9	2.18	0	0
Drewsey	44	22	74	74	0	32	17	72.7	77.3	2.31	0	0
Dry Valley/Jack Mountain	26	18	32	32	0	19	14	61.5	66.7	2.00	0	0
Folly Farm/Saddle Butte	20	15	39	37	2	13	10	65.0	66.7	3.00	0	0
Louse Canyon	60	51	69	51	18	42	38	70.0	74.5	1.64	0	0
Paulina/12-Mile/Misery Flat	61	33	103	103	0	38	21	62.3	63.6	2.71	0	0
Picture Rock	7	4	15	15	0	5	3	71.4	75.0	3.00	0	0
Pueblos/S. Steens	30	19	25	25	0	12	9	40.0	47.4	2.08	0	0
Soldier Creek	53	37	103	86	17	45	29	84.9	78.4	2.29	6	5
Steens	15	10	30	30	0	10	7	66.7	70.0	3.00	0	0
Trout Creeks	96	55	136	136	0	63	34	65.6	61.8	2.16	0	0
Tucker Hill	6	4	13	13	0	5	3	83.3	75.0	2.60	0	0
Warner	57	42	85	72	13	34	25	59.6	59.5	2.50	0	0
Non-PAC	242	198	259	228	31	139	117	57.4	59.1	1.86	4	4

Table A1. 2. Population trend data for the 20 Oregon greater sage-grouse PACs, and leks outside of PACs, 2021.

PAC	Observed Males - Common Leks		% Change Male Attendance 2020 to 2021	2016 to 2021 - Average Annual Change in Male Lek Attendance	Observed Males - Common Leks		% Change Male Attendance 2003 to 2021	Lek Size Analysis Period	Annual Change in Lek Size (Males/Year)[a]
	2020	2021			2003	2021			
Baker	84	77	-8.3	-1.5	193	34	-82.4	1996 - 2021	-0.55*
Beatys	232	299	28.9	-3.8	605	328	-45.8	1980 - 2021	-0.13
Brothers/N. Wagontire	129	103	-20.2	4.4	94	106	12.8	1980 - 2021	-0.07
Bully Creek	227	247	8.8	2.6	124	92	-25.8	1996 - 2021	-1.68*
Burns	NA	6	NA	NA	NA	NA	NA	NA	-1.68*
Cow Lakes	148	156	5.4	-10.7	205	61	-70.2	1993 - 2021	-0.18
Cow Valley	123	127	3.3	5.8	64	73	14.1	1997 - 2021	0.10
Crowley	257	218	-15.2	-2.5	26	15	-42.3	1994 - 2021	0.09
Drewsey	117	163	0.39	-0.1	82	31	-62.2	1997 - 2021	-0.02
Dry Valley/Jack Mountain	71	72	1.4	-5.2	271	71	-73.4	1982 - 2021	-0.55*
Folly Farm/Saddle Butte	77	118	53.2	-2.1	18	4	-77.8	2005 - 2021	0.11
Louse Canyon	150	175	16.7	-5.9	NA	NA	NA	2012 - 2021	0.63
Paulina/12-Mile/Misery Flat	251	213	-15.1	-7.1	343	220	-35.9	1988 - 2021	-0.01
Picture Rock	2	4	100.0	-7.0	39	4	-89.7	1981 - 2021	-0.28*
Pueblos/S. Steens	87	97	11.5	-11.0	166	67	-59.6	1996 - 2021	-0.54
Soldier Creek	129	193	49.6	-8.6	62	15	-75.8	1993 - 2021	0.14
Steens	94	101	7.4	-9.1	181	59	-67.4	1982 - 2021	-1.67*
Trout Creeks	237	185	-21.9	-13.8	NA	NA	NA	2012 - 2021	0.11
Tucker Hill	45	49	8.9	-7.9	49	36	-26.5	1996 - 2021	-0.41
Warners	185	184	-0.1	-5.6	398	180	-54.8	1993 - 2021	-0.28
Non-PAC	424	413	-2.6	-8.0	137	77	-43.8	1980 - 2021	-0.12*

[a]Asterisk indicates significant change in lek size over the analyzed period at alpha value = 0.05.

Baker PAC

The Baker PAC is situated in eastern Baker County, with the north end of the PAC extending into southern Union County, and is completely contained within the Baker BLM Resource Area (Figure A1.1). Sixty-six leks, comprising 46 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1941, and lek counts during the 1940's were incorporated into one of the first scientific studies of sage-grouse in W.M. Batterson and W.B. Morse's "Oregon Sage Grouse", published by the Oregon State Game Commission. Following the work conducted by Batterson and Morse, sage-grouse leks were not surveyed consistently in the Baker PAC until 1996 (Figure A1.2).

Beatys PAC

The Beatys PAC is situated in southeastern Lake County, and southwestern Harney County, and is almost entirely contained within the Lakeview BLM District (Figure A1.1). One hundred fifty-five leks, comprising 86 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1941, with consistent surveys in the PAC beginning in 1980 (Figure A1.4).

Brothers/N. Wagontire PAC

The Brothers/N. Wagontire PAC (often referred to simply as the Brothers PAC) is situated in eastern Deschutes County and southern Crook County, and is almost entirely contained within the Prineville BLM District (Figure A1.1). Forty-five leks, comprising 18 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1948; consistent survey effort has occurred almost continuously in the PAC since leks were first recorded, although knowledge of existing leks increased substantially following dedicated aerial lek searches which occurred in the late 1980's (Figure A1.6).

Bully Creek PAC

The Bully Creek PAC is situated in northeastern Malheur County, and is entirely contained within the Vale BLM District (Figure A1.1). Forty-one leks, comprising 28 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1982. Surveys did not consistently occur at a significant portion of leks within the PAC until 2009, although at least two leks have been surveyed yearly in the PAC since 1994 (Figure A1.8). Population trend information is presented for the Bully Creek PAC from 1994 – 2021 (Figure A1.9); however, caution should be employed when interpreting this information due to the low proportion of leks consistently surveyed prior to 2009.

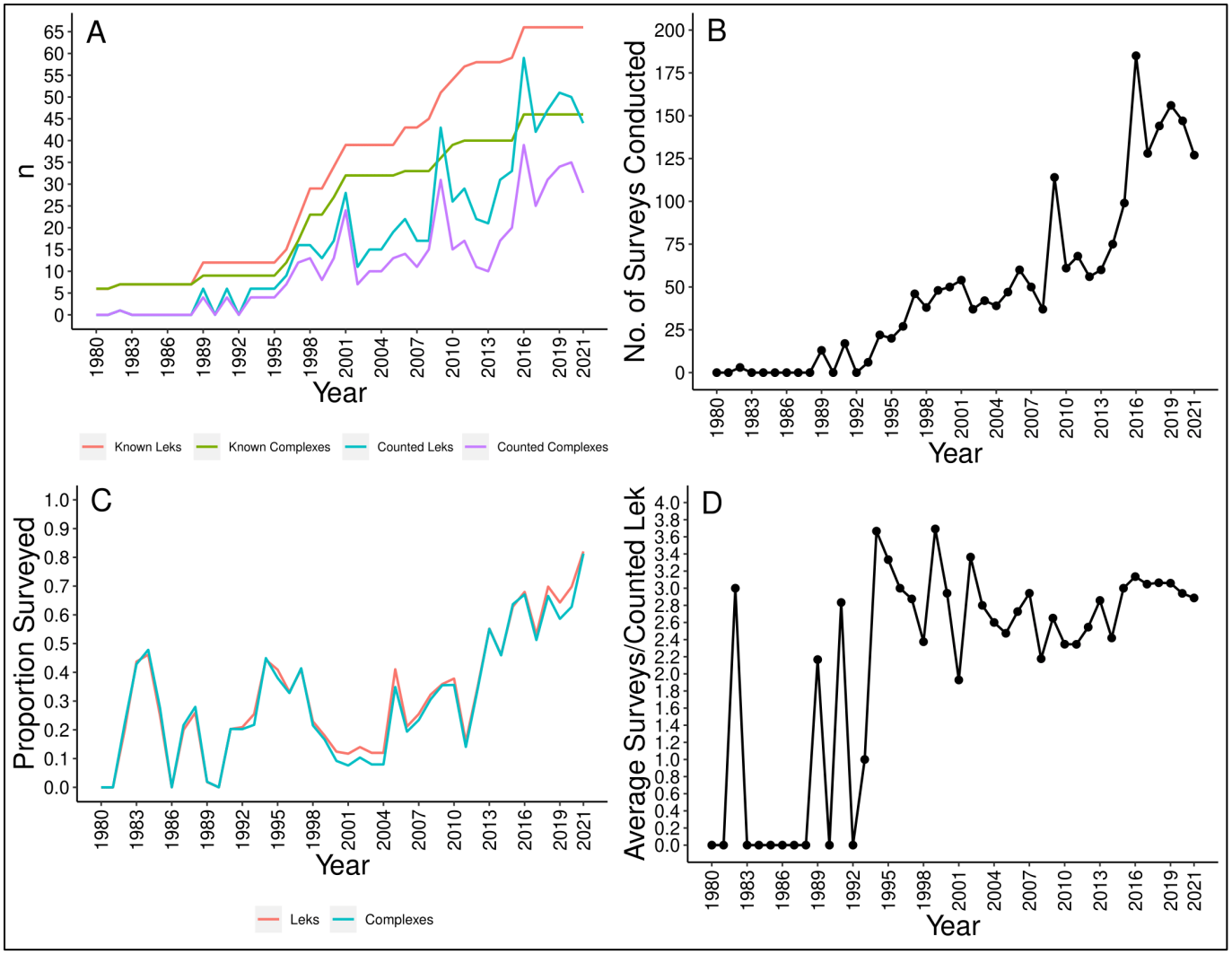


Figure A1. 2. Baker PAC greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

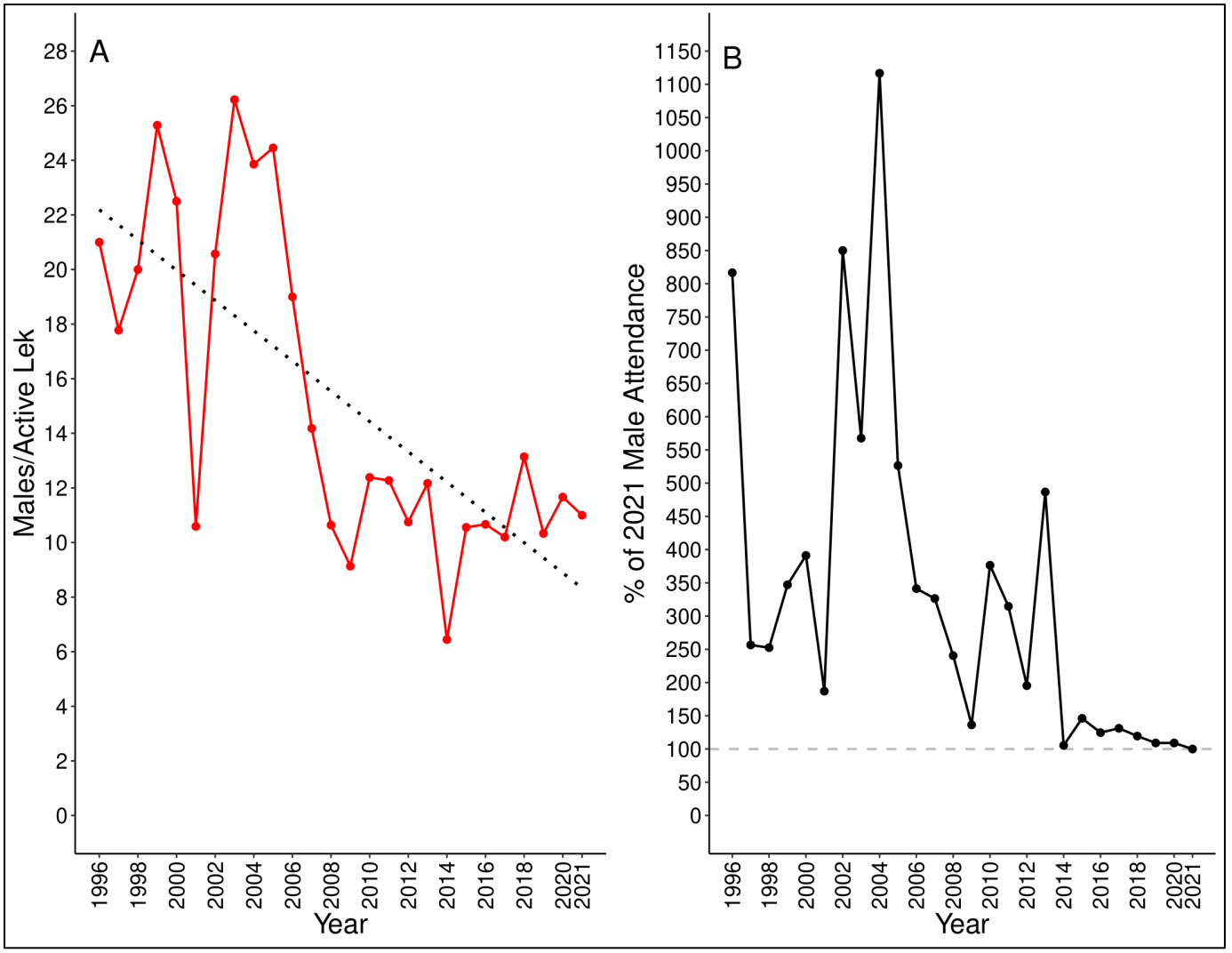


Figure A1. 3. Greater sage-grouse population trend in the Baker PAC, 1996 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

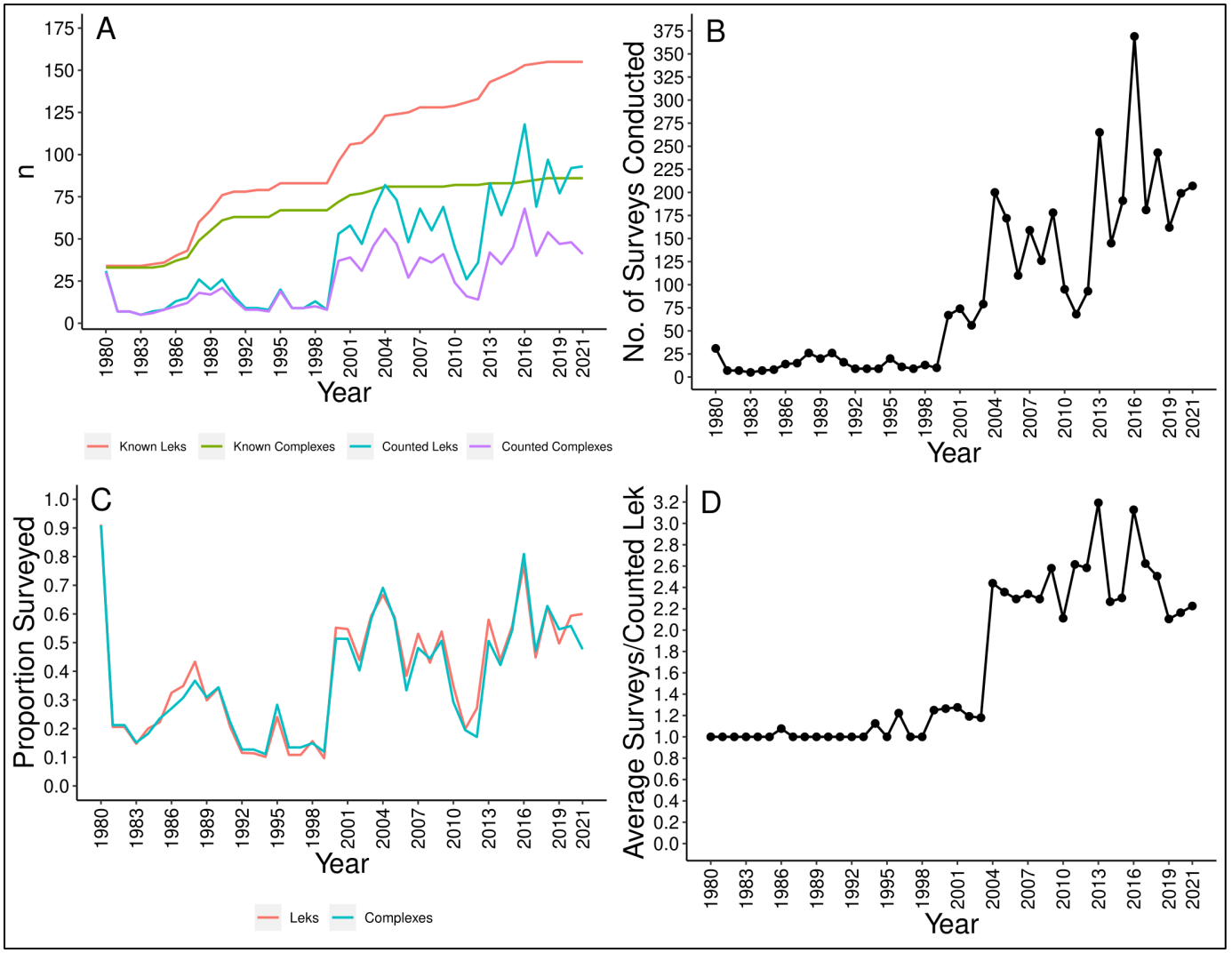


Figure A1. 4. Beatys PAC greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

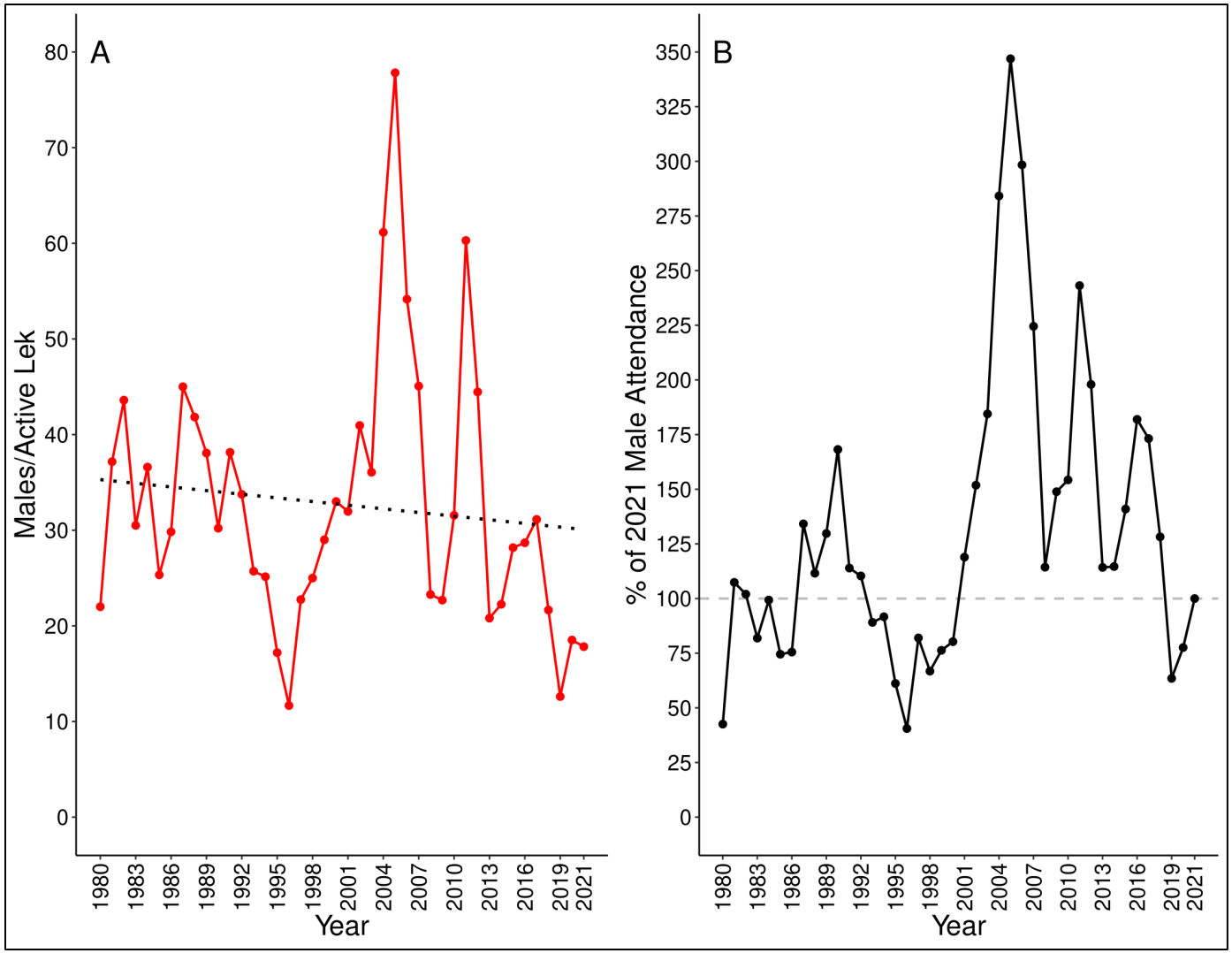


Figure A1. 5. Greater sage-grouse population trend in the Beatys PAC, 1980 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

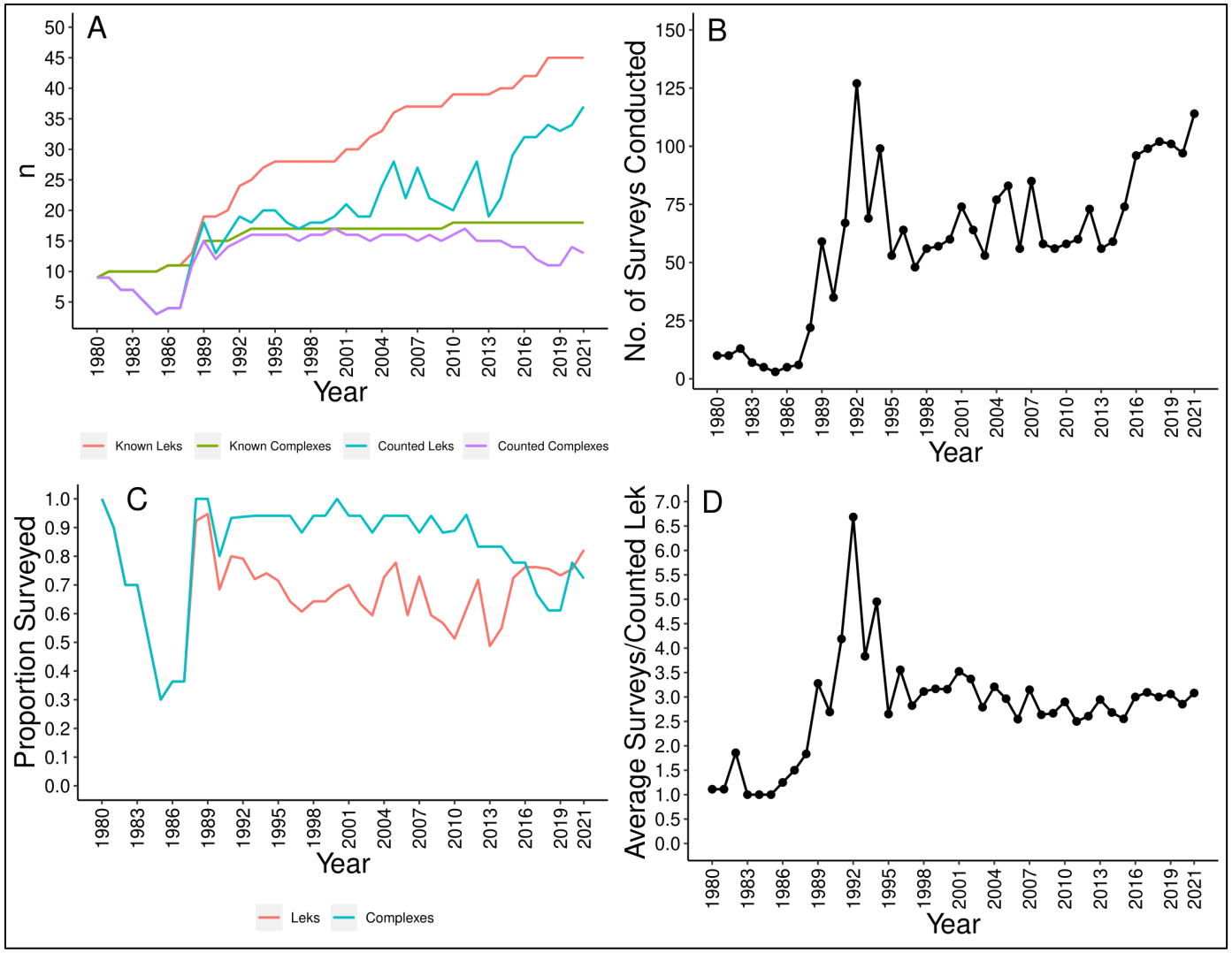


Figure A1. 6. Brothers/N. Wagontire PAC greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

Figure A1. 7. Greater sage-grouse population trend in the Brothers/N. Wagontire PAC, 1980 – 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

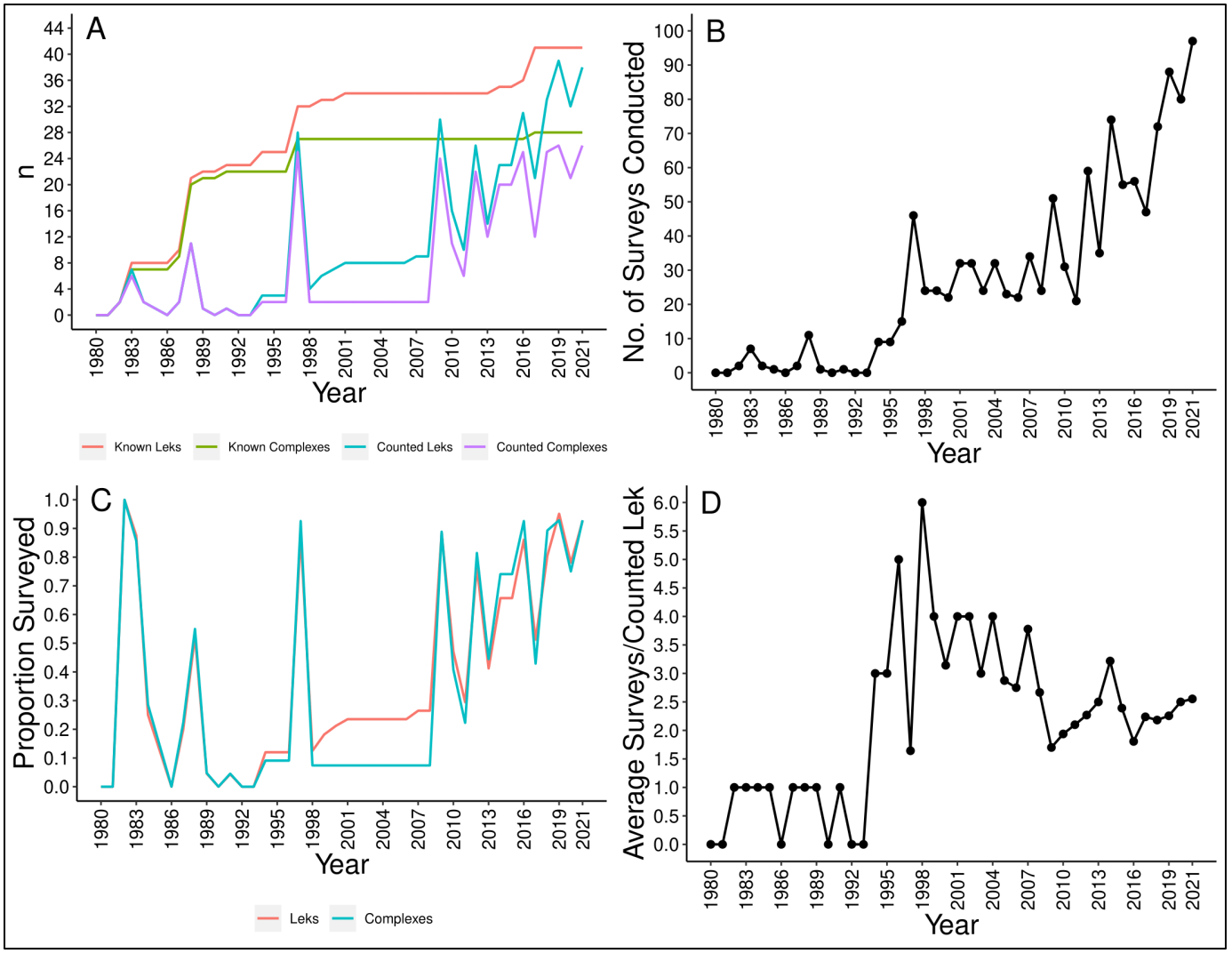


Figure A1. 8. Bully Creek PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

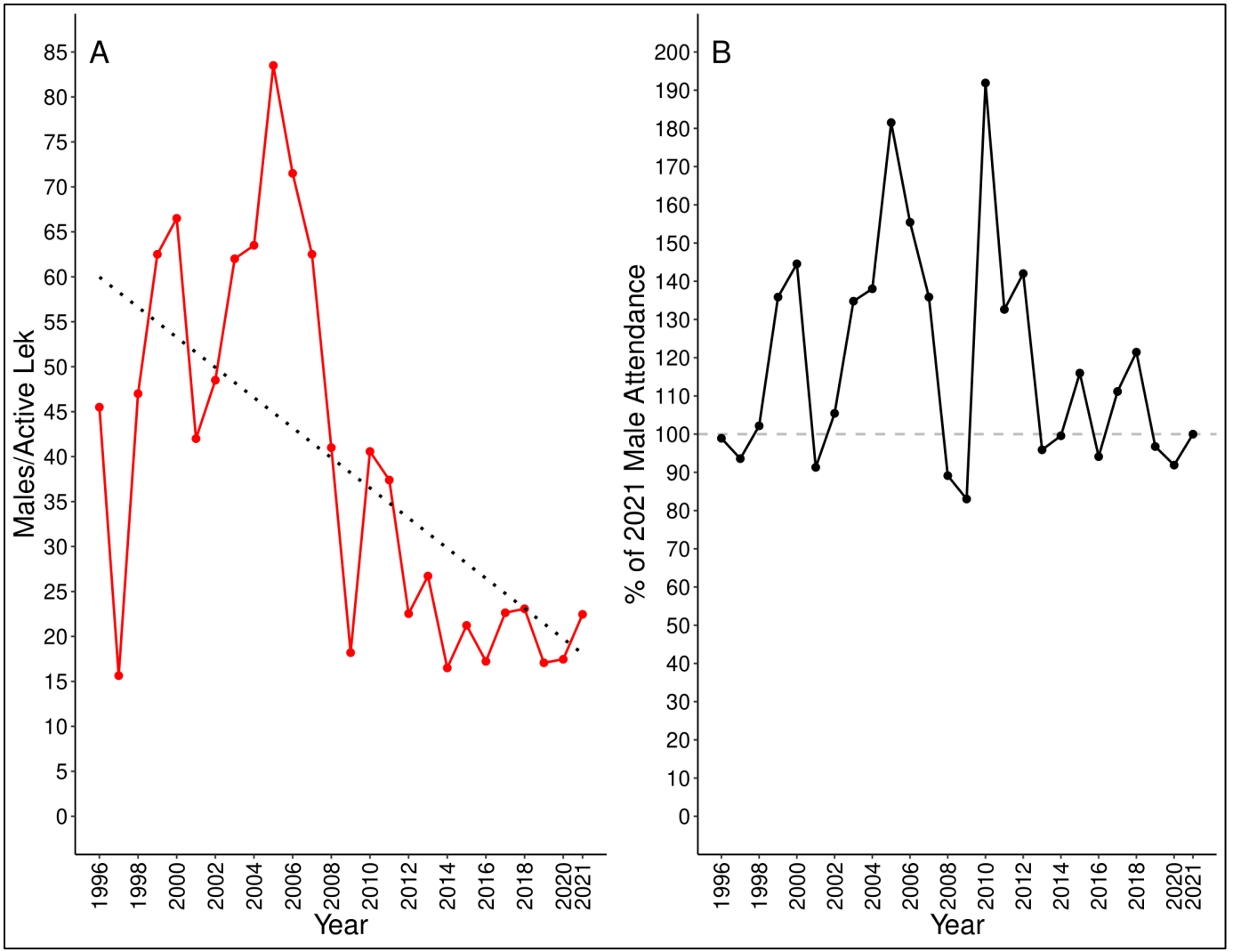


Figure A1. 9. Greater sage-grouse population trend in the Bully Creek PAC, 1996 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Burns PAC

The Burns PAC is situated in northern Harney County and is entirely contained within the Burns BLM District (Figure A1.1). Only three leks comprising two complexes are known to exist or have existed in the PAC (Table A1.1). During the delineation of core areas in Oregon, small polygons such as the Burns PAC were generally grouped with larger polygons and considered a single core area. However, the Burns PAC was not in proximity to any larger core area polygons and thus maintained as a separate PAC. Surveys were first recorded for leks within the PAC in in 1981, but surveys did not consistently occur in the PAC until 2013 (Figure A1.10).

Cow Lakes PAC

The Cow Lakes PAC is situated in eastern Malheur County, and is entirely contained within the Vale BLM District (Figure A1.1). Fifty-six leks, comprising 38 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1947, but surveys did not consistently occur at a significant portion of leks within the PAC until 1993 (Figure A1.12). The steep decline in annual rate of change in male lek complex attendance from 1993-95 (Figure A1.13B) is due to the limited sample of known leks counted during those years becoming largely inactive within the last 5 years. However, additional leks in the Cow Lakes PAC have been found since 1995. The decline in activity of most of the leks counted during 1993 and 1994 is concerning and informative; however, the total population of the PAC likely has not declined by 97% in the intervening years, as depicted by Figure A1.13B.

Cow Valley PAC

The Cow Valley PAC is situated in northern Malheur County and southern Baker County, and is split between the Baker BLM Resource area and the remainder of the Vale District (Figure A1.1). Fifty-six leks, comprising 44 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1941 and surveys have been conducted at leks within the PAC annually since 1997, although a significant portion of leks within the PAC were only consistently surveyed beginning in 2015 (Figure A1.14). The majority of the PAC is in private holding, so lek survey efforts in the PAC have been limited by land access issues. Population trend information is presented for the Cow Valley PAC from 1997 – 2021; however, caution should be employed when interpreting this information due to the low proportion of leks consistently surveyed prior to 2015 (Figure A1.15). Aerial infrared surveys were used to obtain lek counts at inaccessible leks during spring 2021; over 95% of known leks were surveyed the greatest survey effort in the Cow Valley PAC to date.

Crowley PAC

The Crowley PAC is situated in central Malheur County and is entirely contained within the Vale BLM District (Figure A1.1). Fifty leks, comprising 33 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1984 and surveys have been conducted at leks within the PAC annually since 1991, although a significant portion of leks within the PAC were only consistently surveyed beginning in 2006 (Figure A1.16). Population trend information is presented for the Crowley PAC from 1994 – 2021; however, caution should be employed when interpreting this information due to the low proportion of leks consistently surveyed prior to 2006 (Figure A1.17).

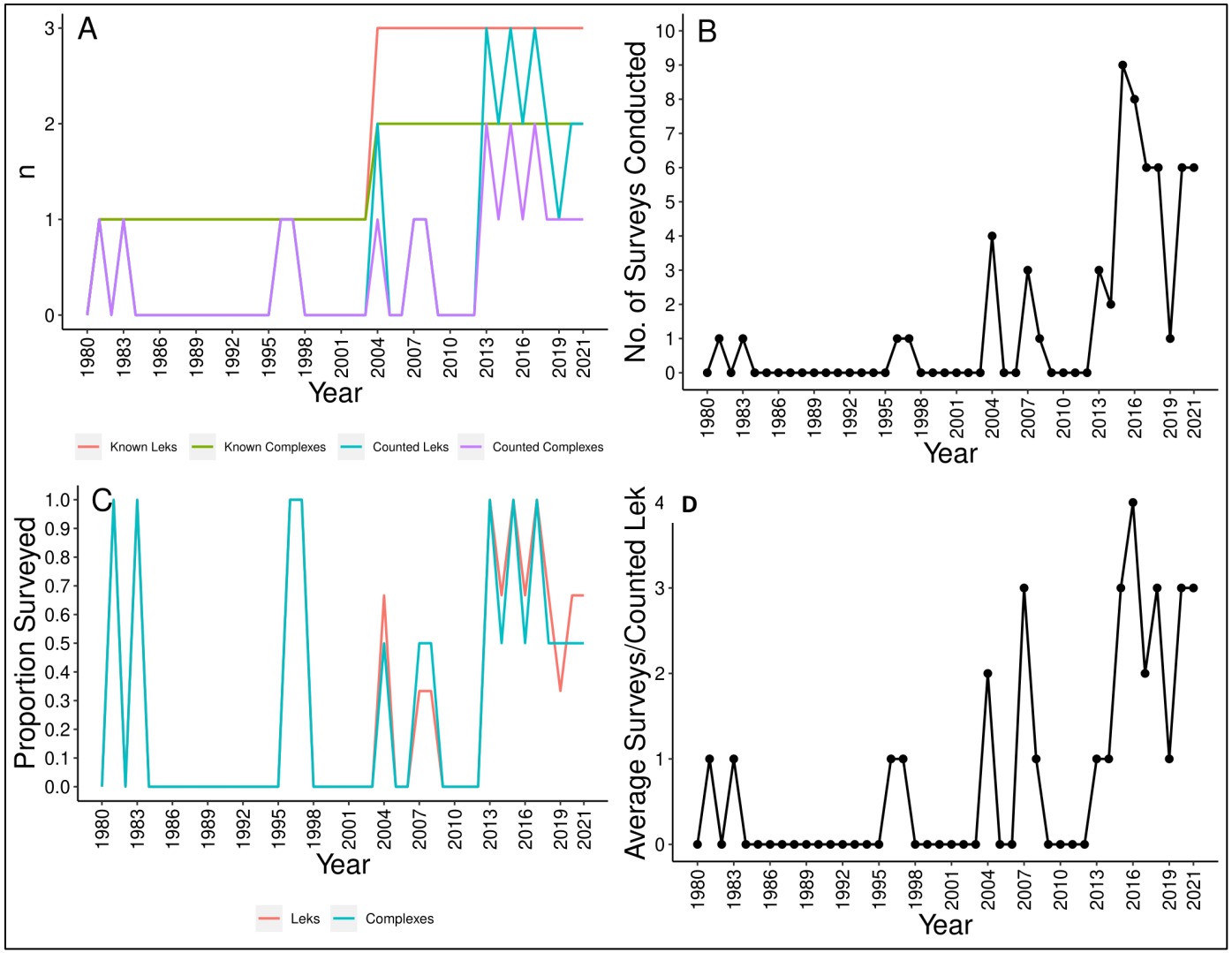


Figure A1. 10. Burns PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

Figure A1. 11. Greater sage-grouse population trend in the Burns PAC, 2013 - 2021. Change in average greater sage-grouse lek complex size (males per active lek). During 2019, only one lek was counted in the PAC, which was unoccupied. Thus, the number of males per active lek in 2019 was estimated based on the population trend and represented by an asterisk in the figure.

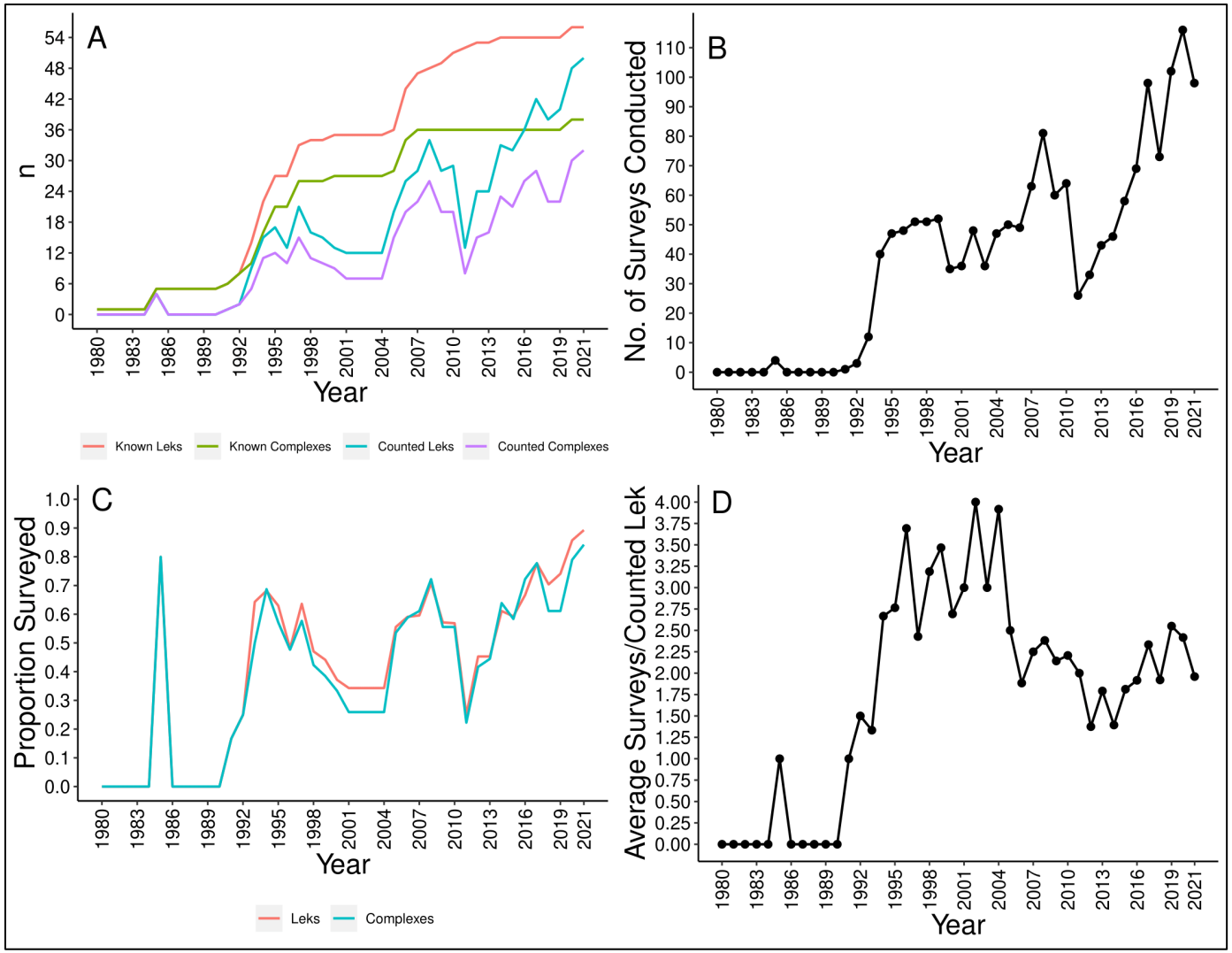


Figure A1. 12. Cow Lakes PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

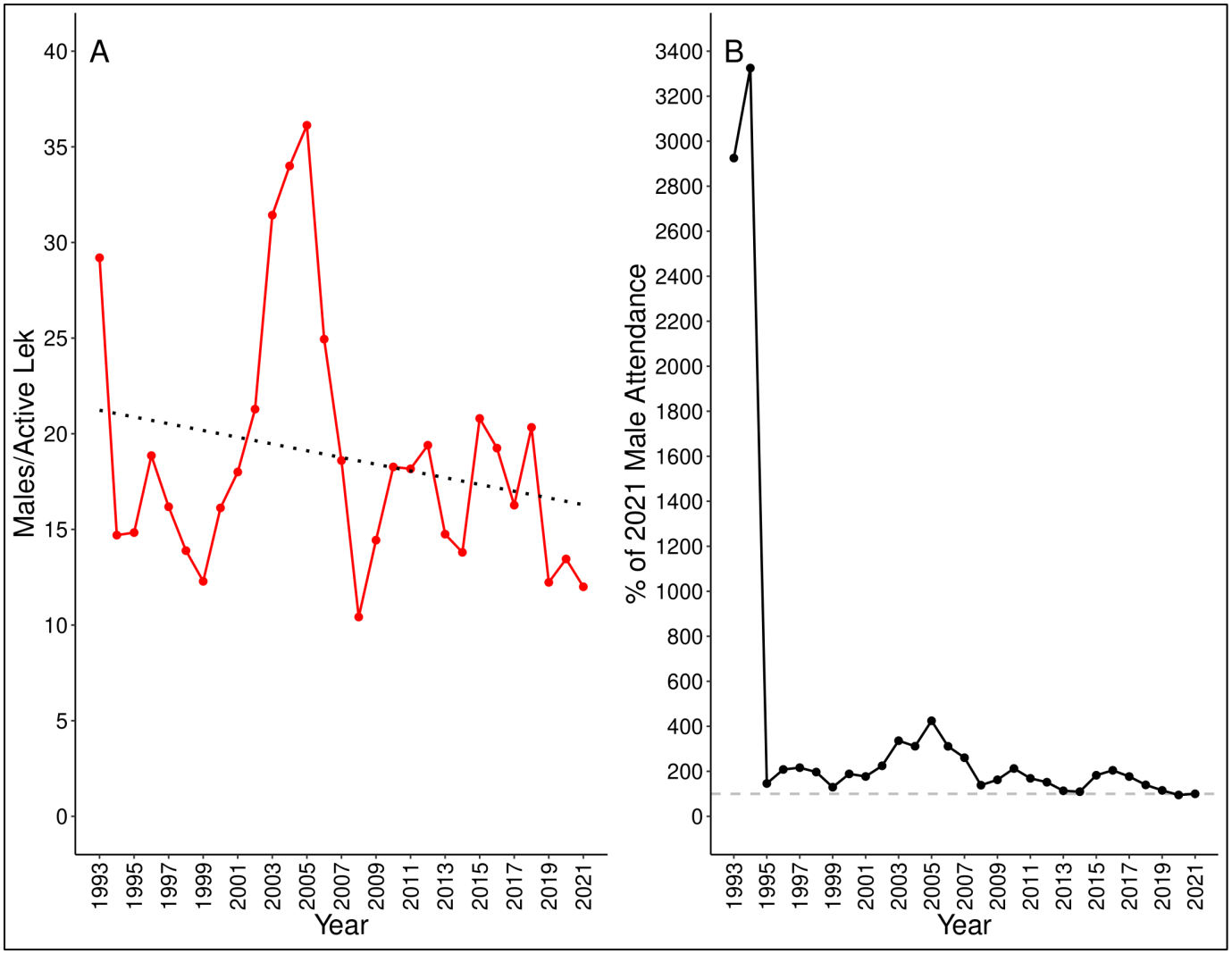


Figure A1. 13. Greater sage-grouse population trend in the Cow Lakes PAC, 1993 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

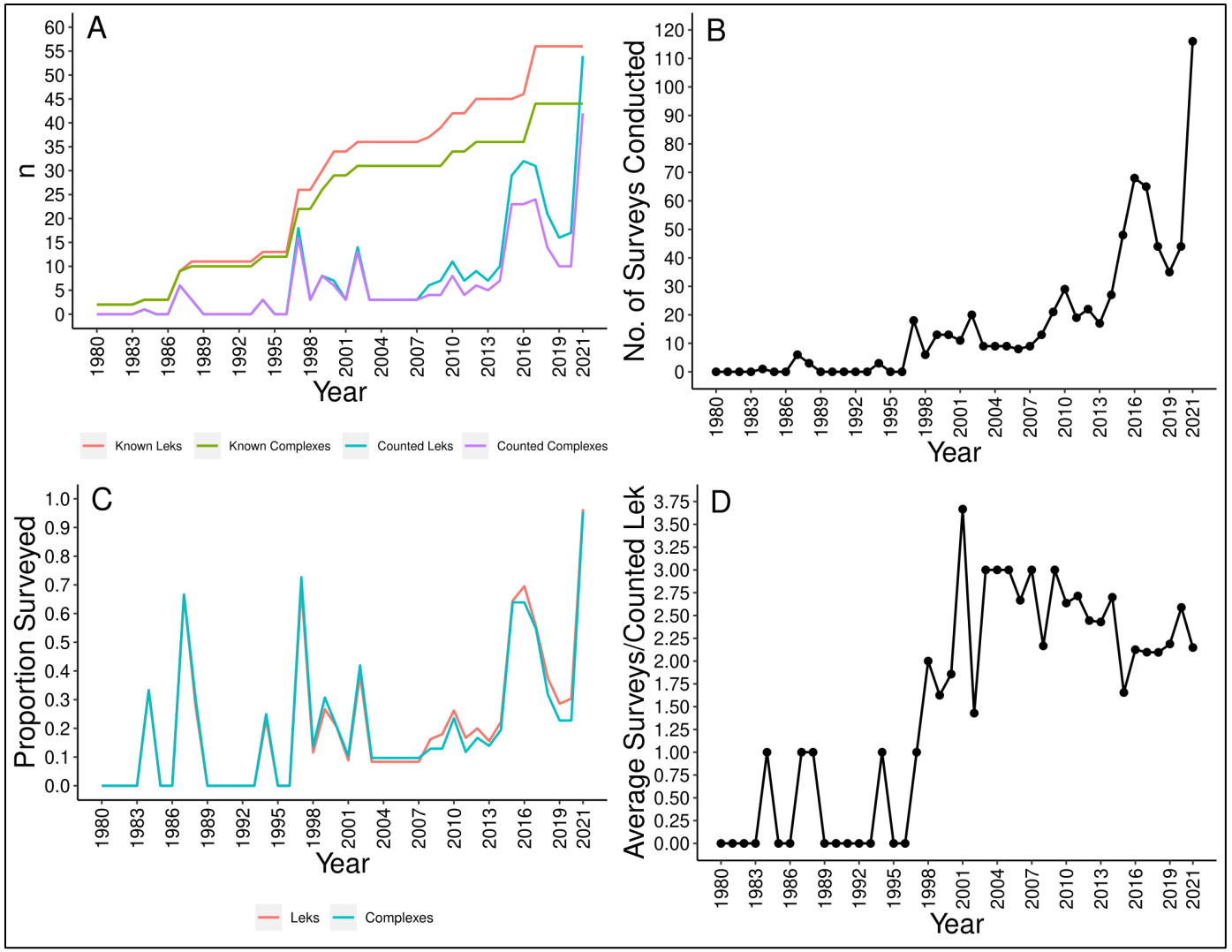


Figure A1. 14. Cow Valley PAC greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

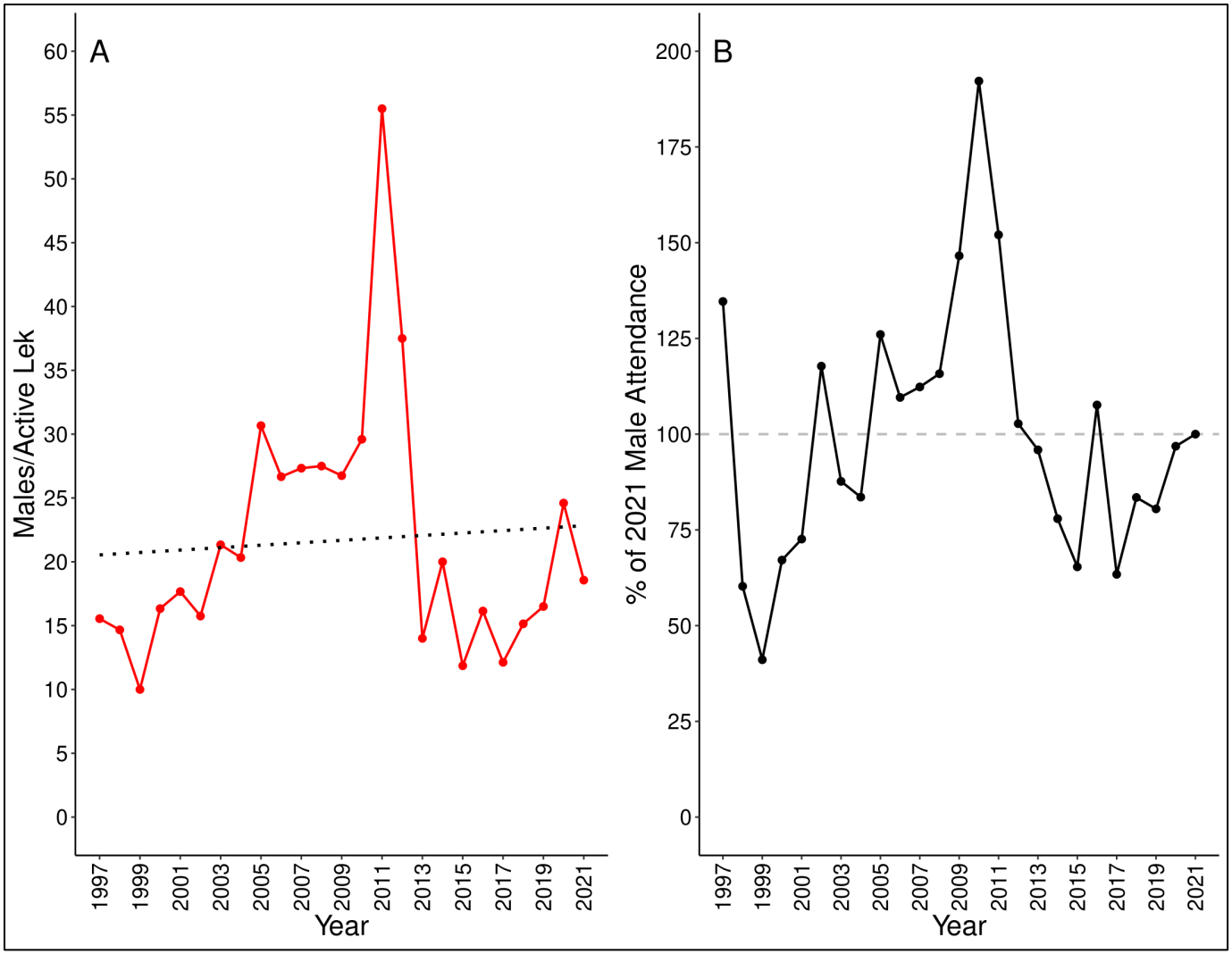


Figure A1. 15. Greater sage-grouse population trend in the Cow Valley PAC, 1997 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

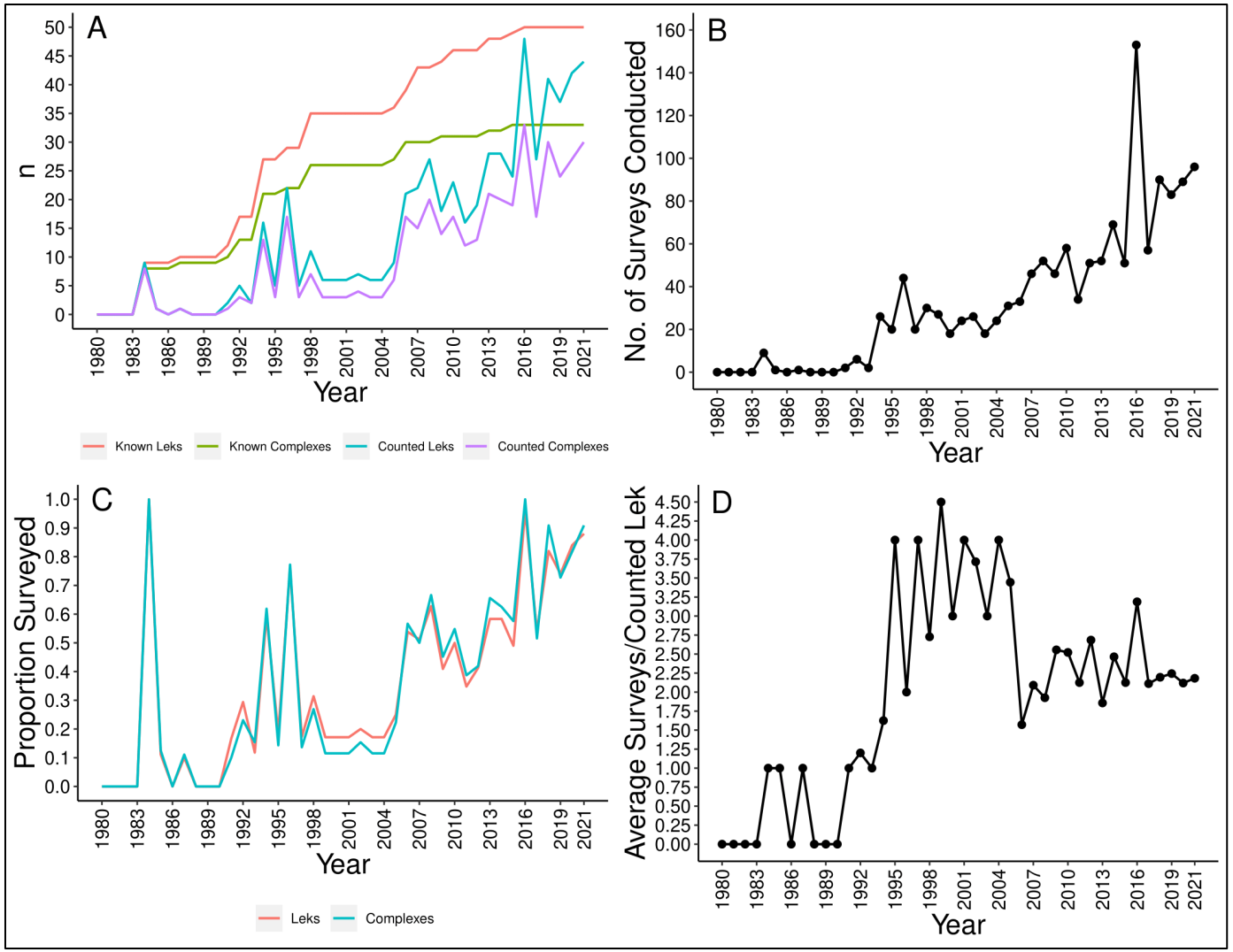


Figure A1. 16. Crowley PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

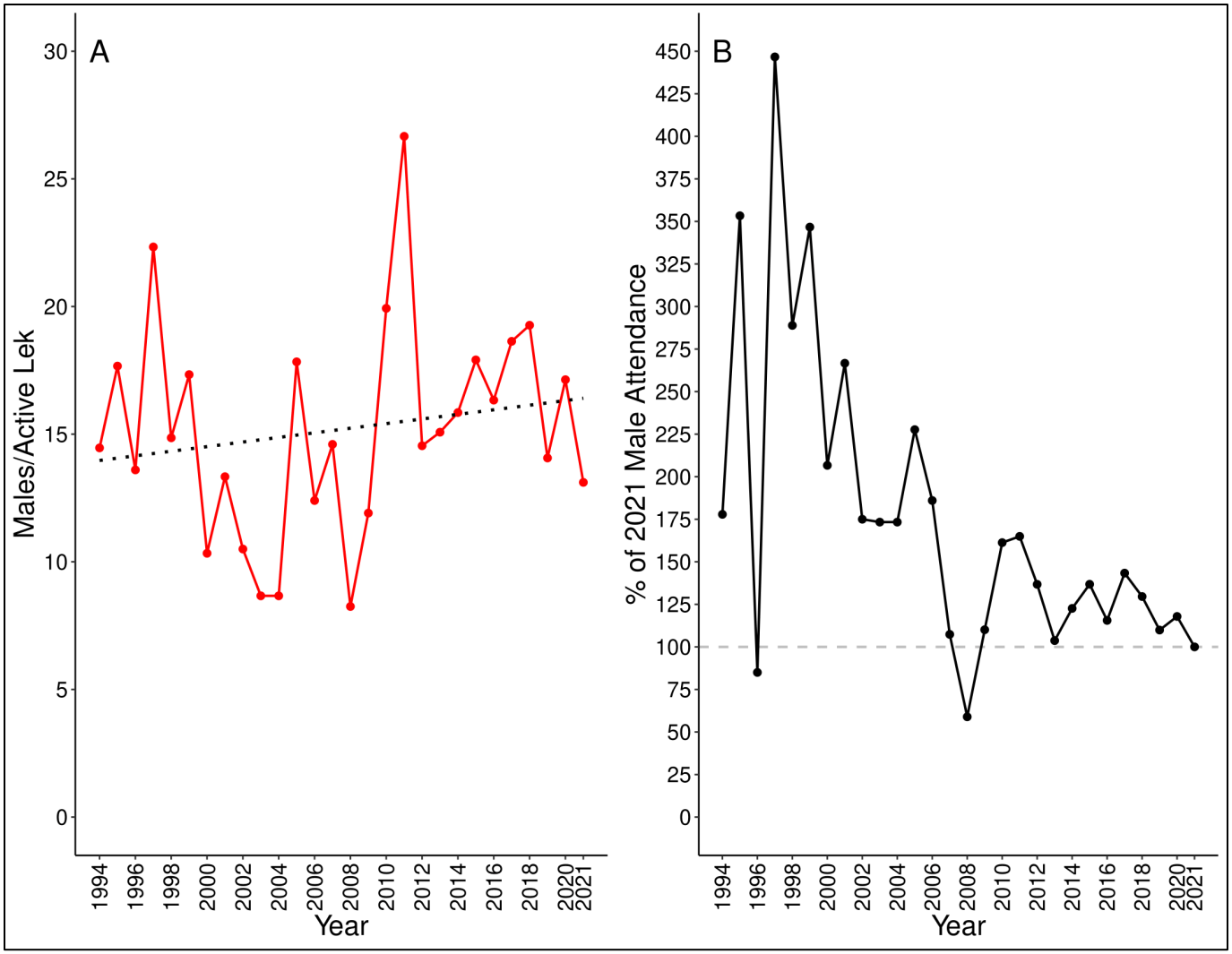


Figure A1. 17. Greater sage-grouse population trend in the Crowley PAC, 1994 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Drewsey PAC

The Drewsey PAC is situated in northwestern Harney County, with a small section extending into northeastern Malheur County. Similarly, the PAC is primarily contained within the Burns BLM District, although a small section does extend into the Vale BLM District (Figure A1.1). Forty-four leks, comprising 22 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1958 and leks have been surveyed annually in the PAC since 1981 (Figure A1.18). Population trend information is presented for the Drewsey PAC from 1997, when more than two complexes began to be surveyed annually, to 2021 (Figure A1.19). However, a significant portion of leks within the PAC were only consistently surveyed beginning in 2009, thus caution should be employed when interpreting population trend information prior to 2009 for this PAC.

Dry Valley/Jack Mountain PAC

The Dry Valley/Jack Mountain PAC (often simply referred to as the Dry Valley PAC) is situated in central Harney County and is split between the Burns and Lakeview BLM Districts (Figure A1.1). Twenty-six leks, comprising 18 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1970 and a significant portion of known leks within the PAC have been surveyed annually since 1981 (Figure A1.20). Knowledge of lek distribution in the PAC increased substantially following aerial lek searches conducted in 2003. The Dry Valley PAC was heavily impacted by the Miller Homestead Fire in 2012. Many of the historically surveyed leks within the PAC burned over during the fire, likely contributing to the significant population decline observed in the PAC since 2012 (Figure A1.21). Aerial lek searches were conducted in the PAC in 2018. No new leks were located during those searches, suggesting that the observed population decline is due to a true reduction in population as opposed to shifts in lek distribution following the fire.

Folly Farm/Saddle Butte PAC

The Folly Farm/Saddle Butte PAC (often simply referred to as the Folly Farm PAC) is situated in central Harney and Malheur Counties and is similarly split between the Burns and Vale BLM Districts (Figure A1.1). Twenty leks, comprising 15 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1982; however, prior to 2005, surveys were only consistently conducted at a single lek site (Figure A1.22). Survey effort in the PAC increased substantially in 2014, so caution should be employed when interpreting population trend data for the PAC during the 2005 – 2013 period (Figure A1.23).

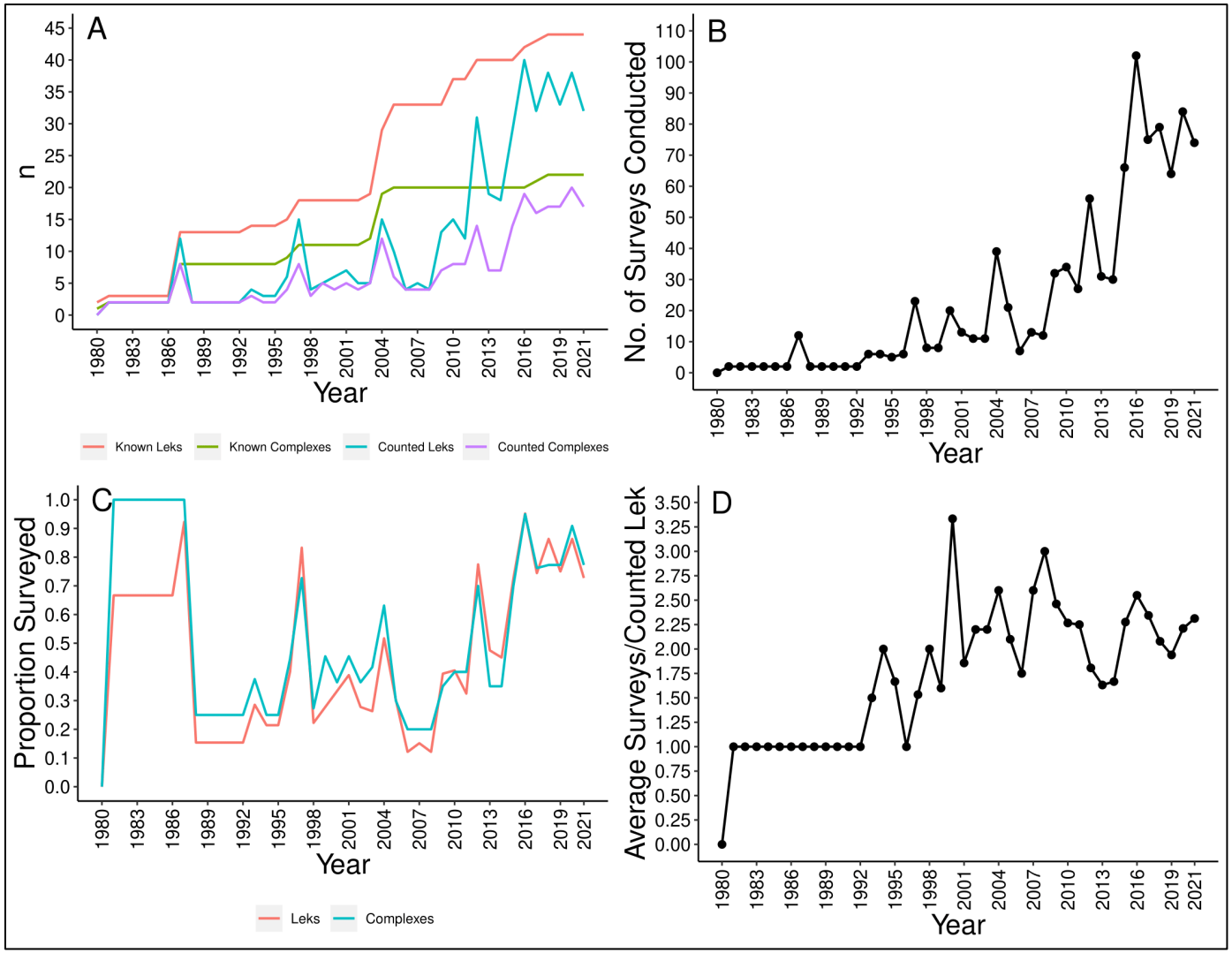


Figure A1. 18. Drewsey PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

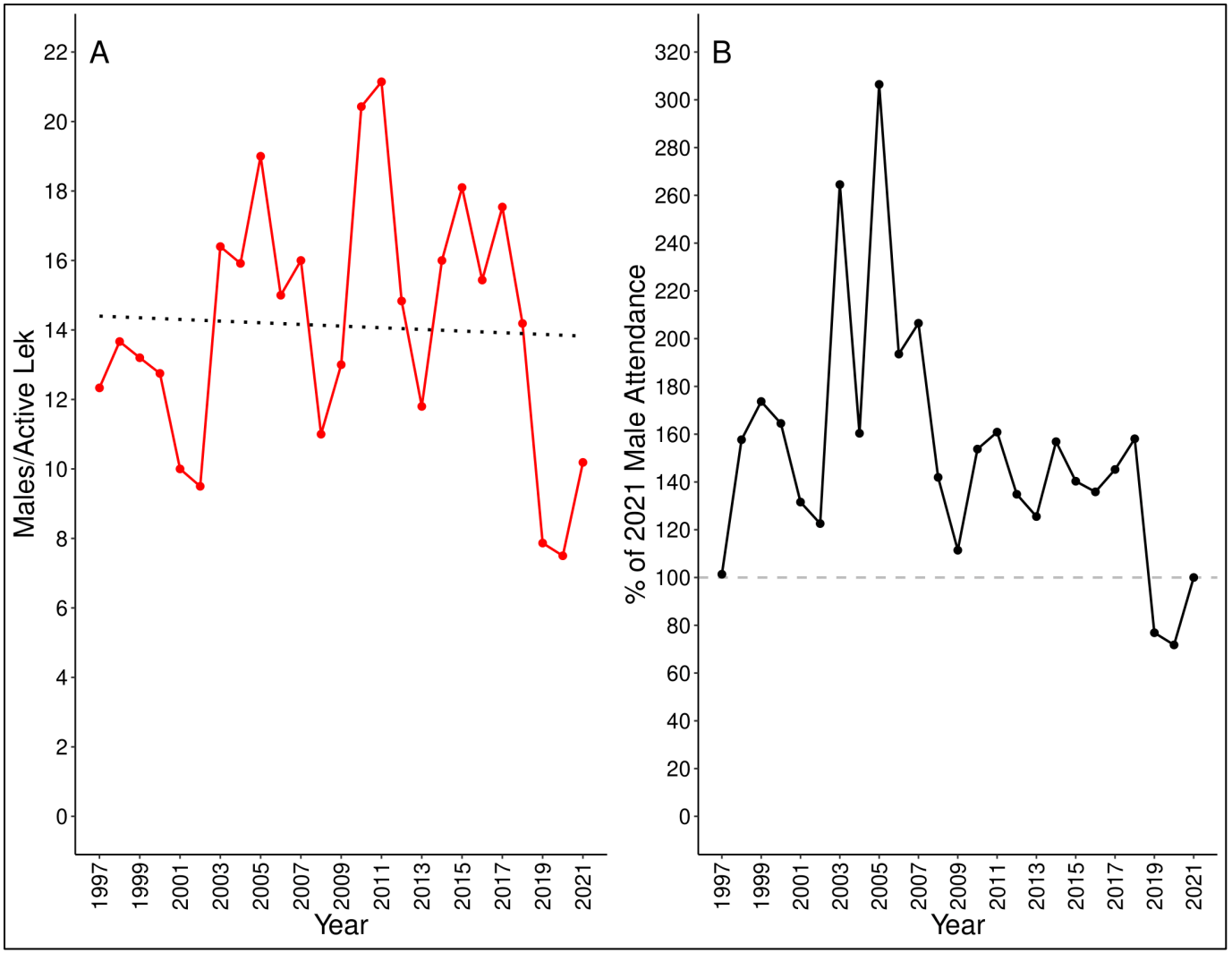


Figure A1. 19. Greater sage-grouse population trend in the Drewsey PAC, 1997 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

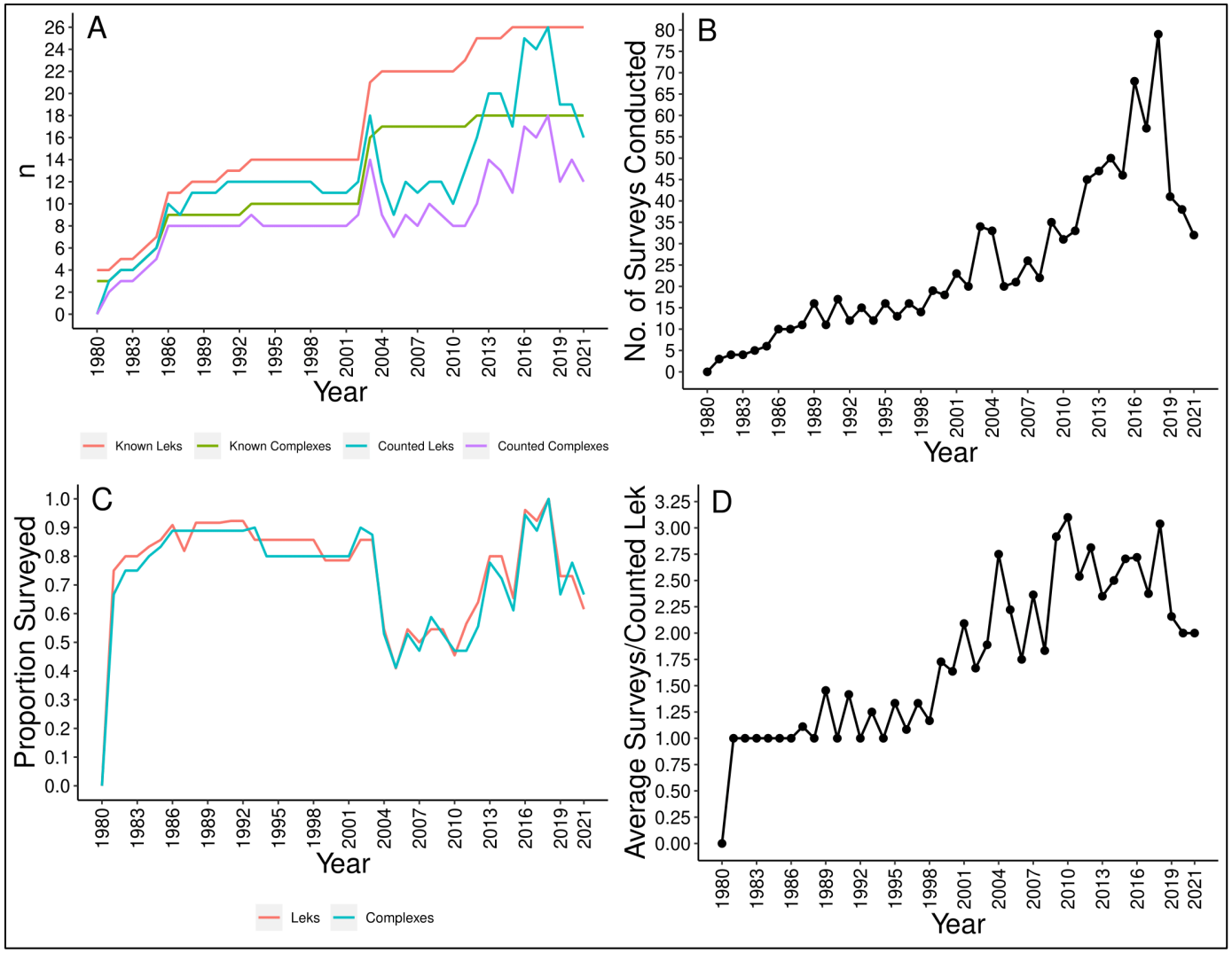


Figure A1. 20. Dry Valley/Jack Mountain PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

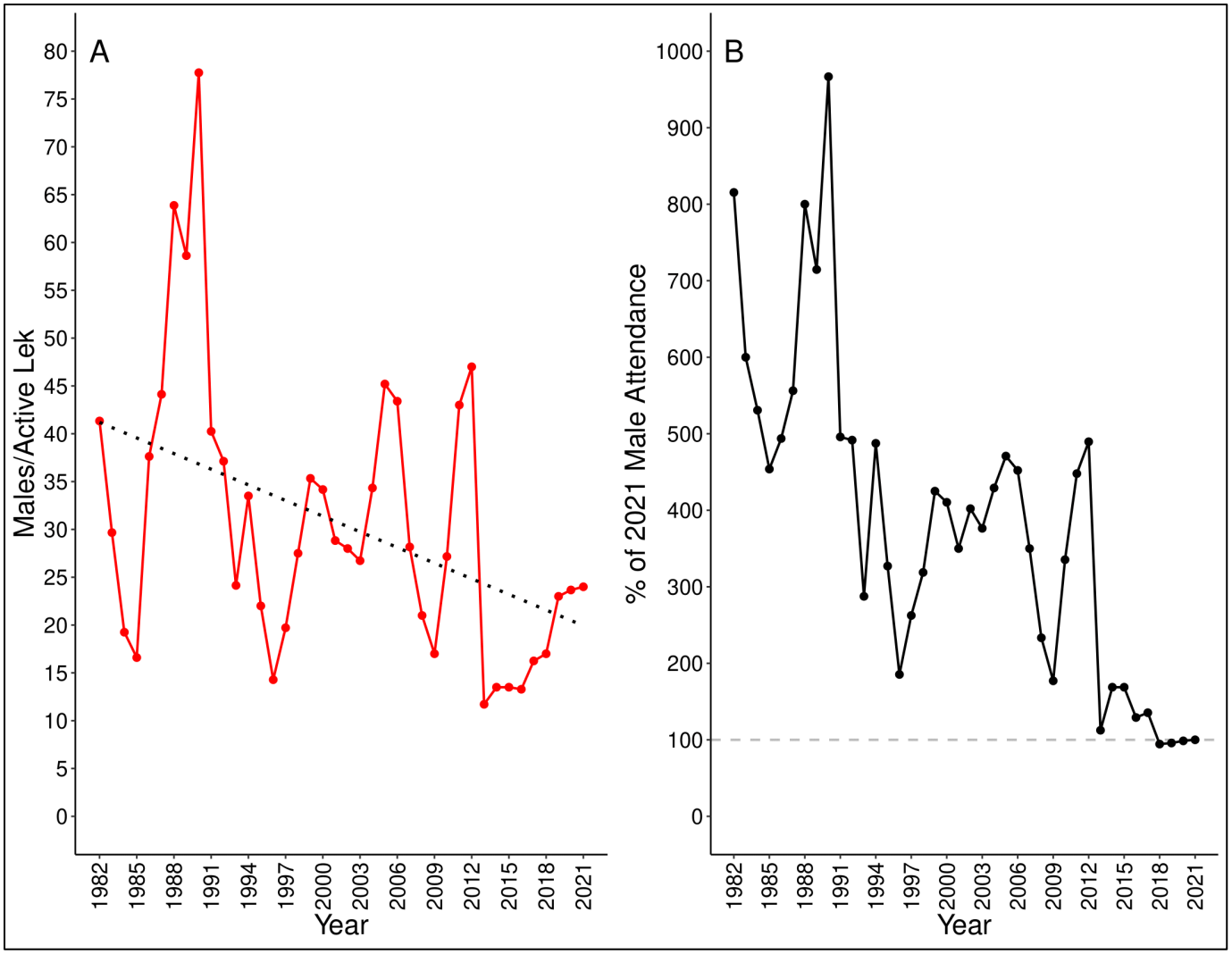


Figure A1. 21. Greater sage-grouse population trend in the Dry Valley/Jack Mountain PAC, 1981 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

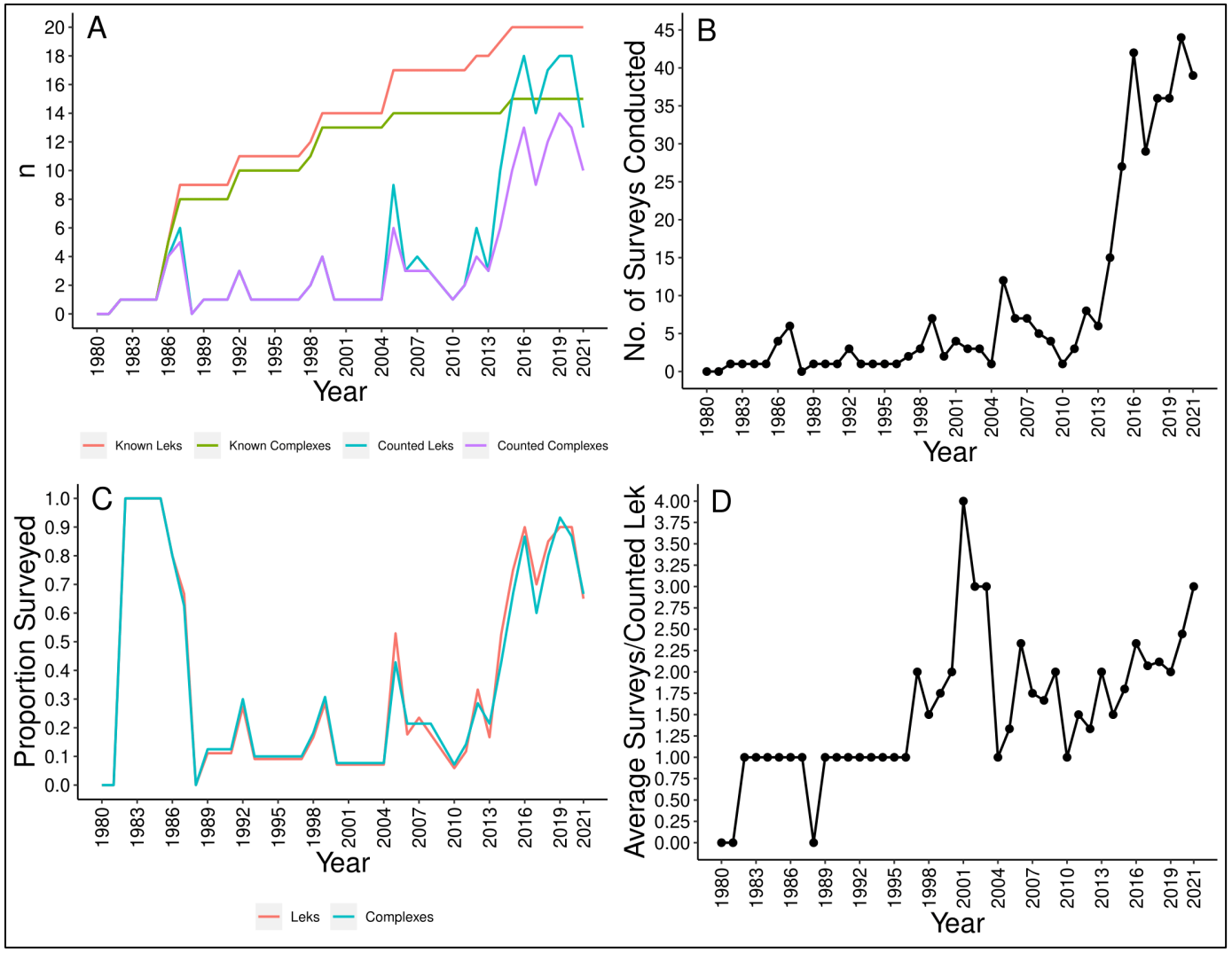


Figure A1. 22. Folly Farm/Saddle Butte PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

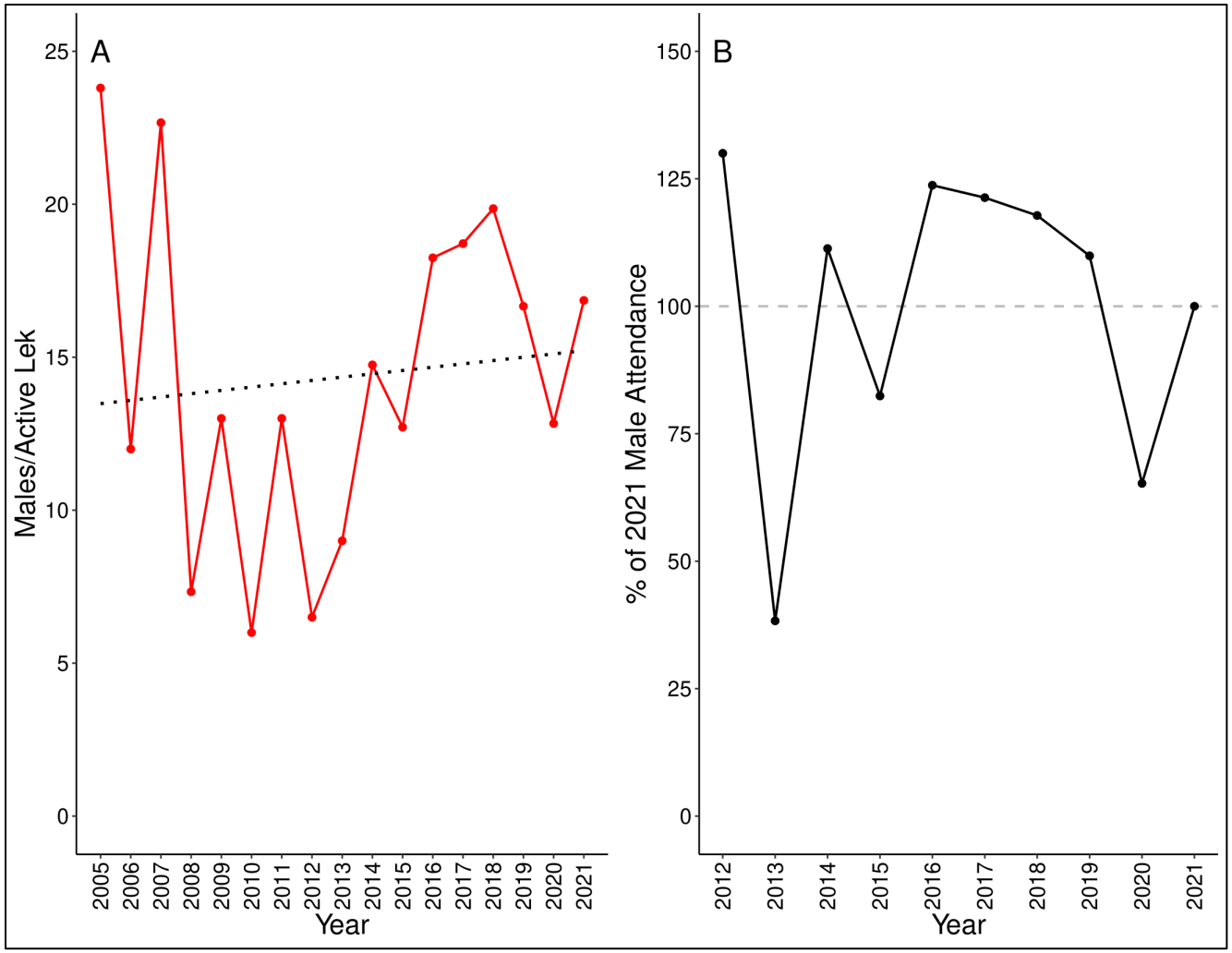


Figure A1. 23. Greater sage-grouse population trend in the Folly Farm/Saddle Butte PAC, 2005 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021. Difference in time period displayed is due to a lack of common leks counted during both 2021 and the 2005-2012 period.

Louse Canyon PAC

The Louse Canyon PAC is situated in southeastern Malheur County and is completely contained within the Vale BLM District (Figure A1.1). Sixty leks, comprising 51 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1963 (Figure A1.24); however, annual surveys were not consistently conducted in the PAC until 2012.

Paulina/12-Mile/Misery Flat PAC

The Paulina/12-Mile/Misery Flat PAC (often referred to simply as the Paulina PAC) is situated in eastern Crook County, with small portions extending into Grant, Harney, and Lake Counties; the PAC is contained almost entirely within the Prineville BLM District (Figure A1.1). Sixty-one leks, comprising 33 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1969; however, surveys were not conducted consistently at a significant portion of leks within the PAC until 1988 (Figure A1.26).

Picture Rock PAC

The Picture Rock PAC is situated in central Lake County and is completely contained within the Lakeview BLM District (Figure A1.1). Seven leks, comprising 4 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1958; however, annual surveys were not conducted consistently until 1981 (Figure A1.28).

Pueblo/S. Steens PAC

The Pueblo/S. Steens PAC (often referred to simply as the Pueblo PAC) is situated in southern Harney County and is completely contained within the Burns BLM District (Figure A1.1). Thirty leks, comprising 19 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded at leks within the PAC in 1959. Surveys have been conducted annually within the PAC since 1996, but a significant portion of leks within the PAC were not surveyed consistently until 2015 (Figure A1.30). Population trend data is presented for the Pueblo PAC from 1996 - 2021 (Figure A1.31); however, only a small proportion of leks were surveyed annually prior to 2015, so caution should be taken when interpreting this information.

Soldier Creek PAC

The Soldier Creek PAC is situated in southeastern Malheur County and is completely contained within the Vale BLM District (Figure A1.1). Fifty-three leks, comprising 37 complexes are known to exist or have existed in the PAC (Table A1.1). Six new leks, comprising 5 new complexes were located during 2021 aerial surveys. Surveys were first recorded for leks within the PAC in 1972 and annual surveys have been conducted at leks within the PAC since 1991 (Figure A1.32). A significant proportion of known leks within the PAC were first surveyed in 1993; however, from 1996 – 2005 only two complexes were consistently surveyed. Population trend data is presented for the Soldier Creek PAC from 1993 - 2021 (Figure A1.33). Due to the low proportion of leks surveyed annually prior to 2006, caution should be taken when interpreting this information.

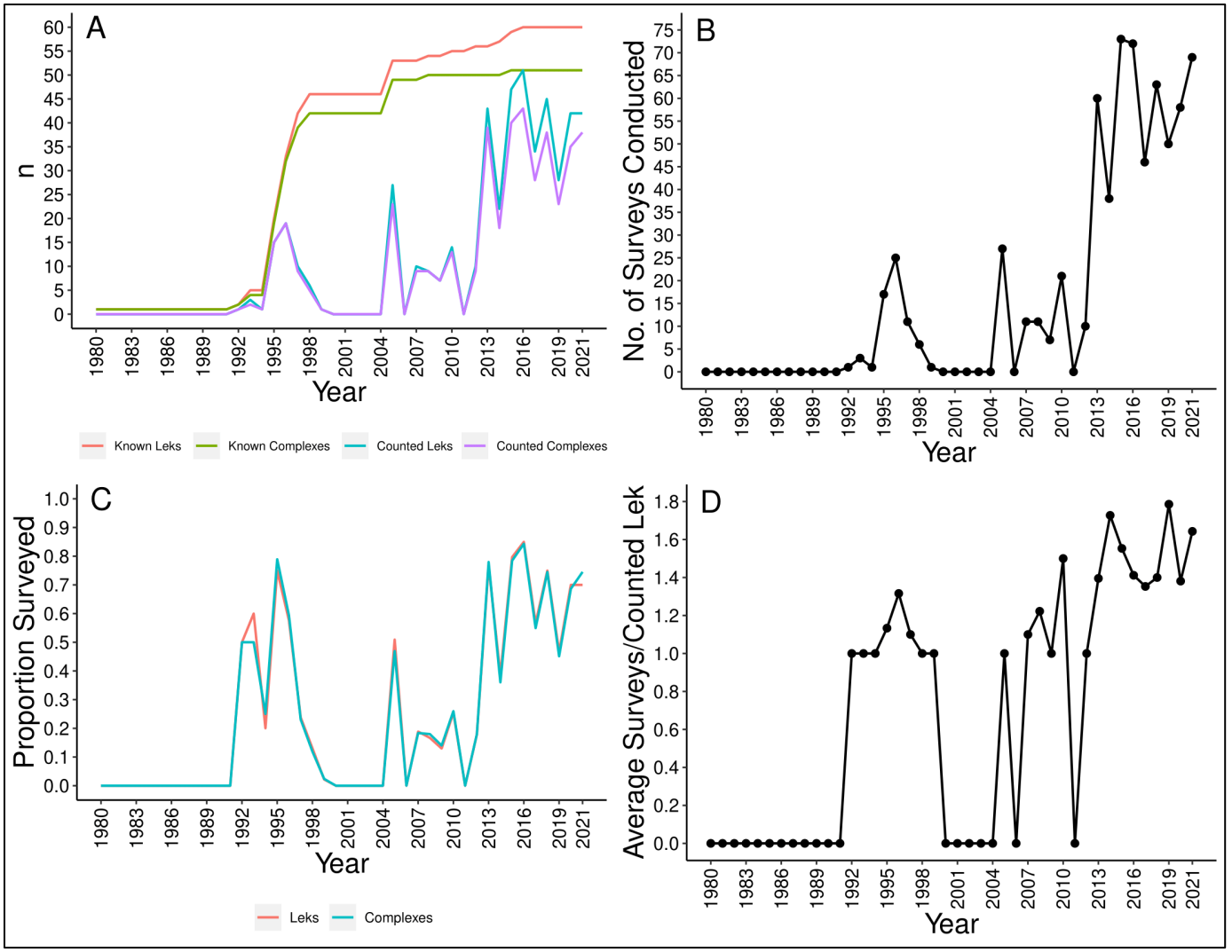


Figure A1. 24. Louse Canyon PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

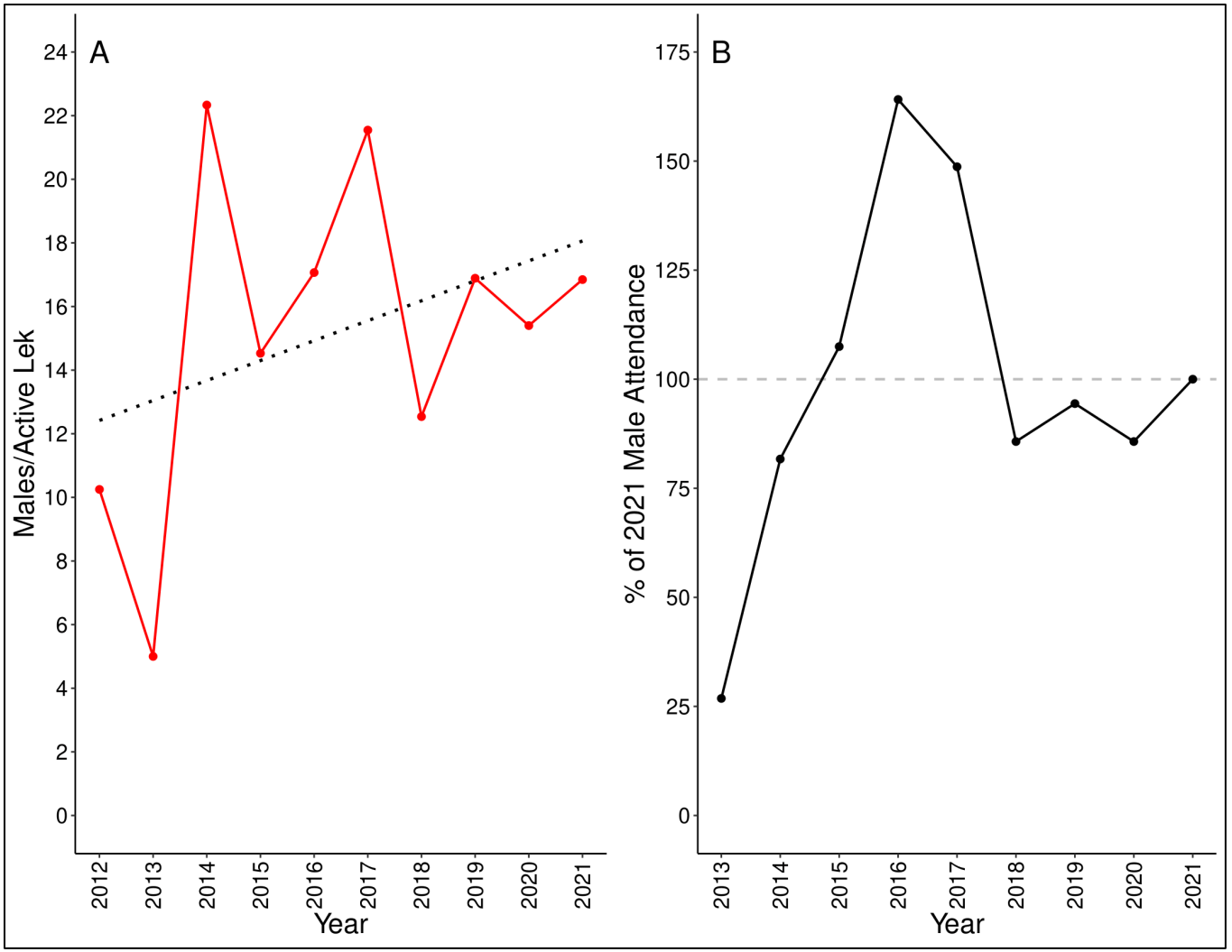


Figure A1. 25. Greater sage-grouse population trend in the Louse Canyon PAC, 2012 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

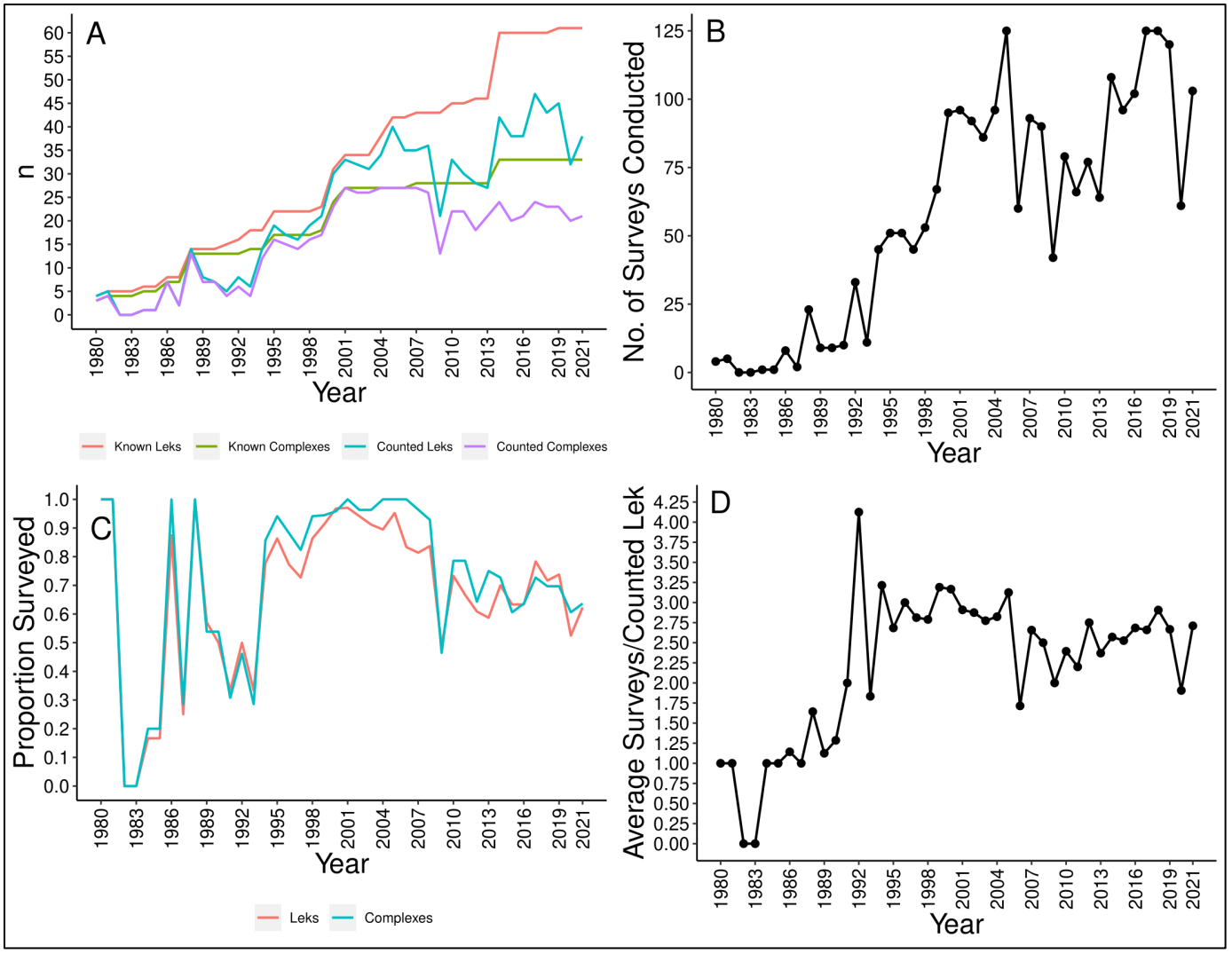


Figure A1. 26. Paulina/12-Mile/Misery Flat PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

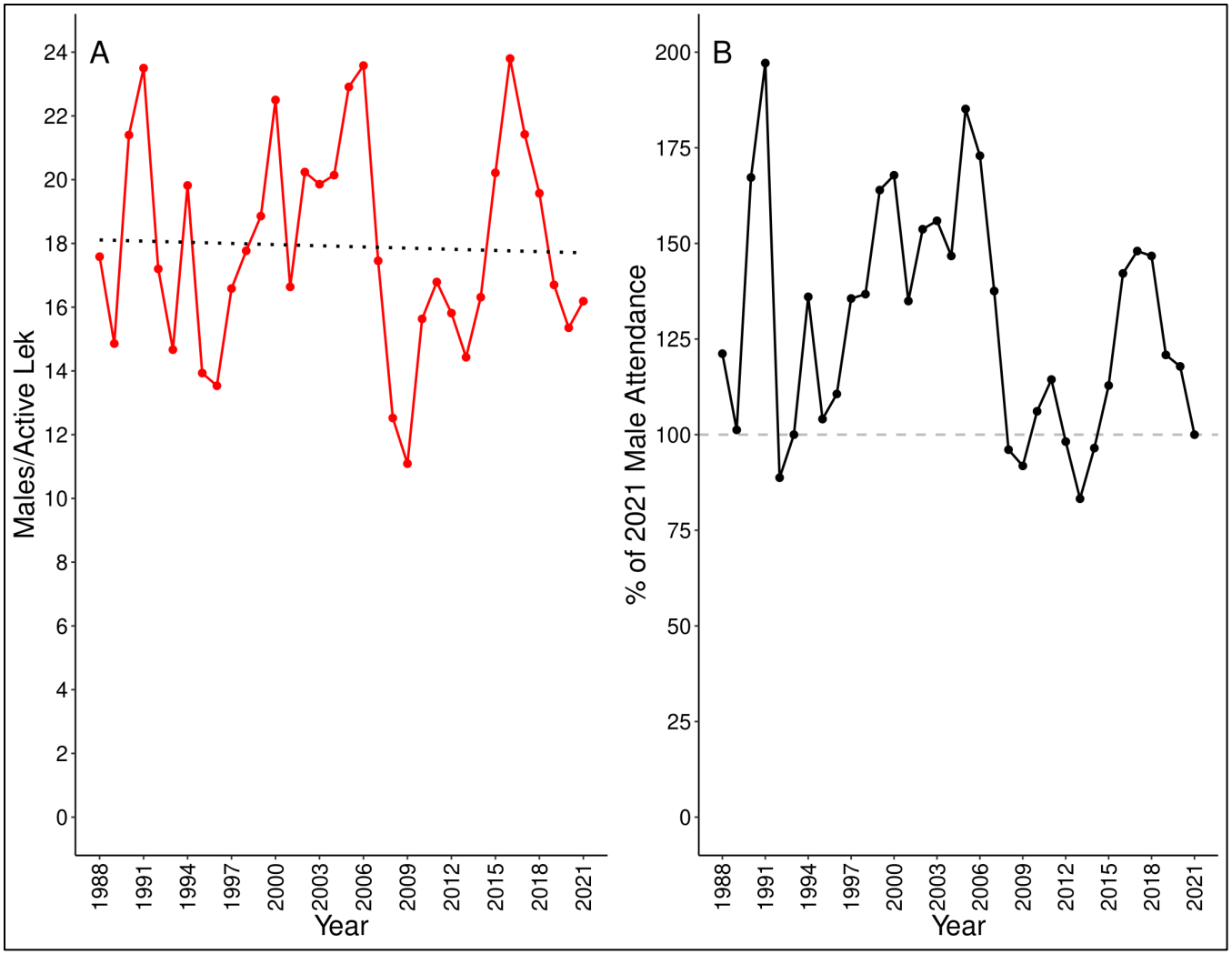


Figure A1. 27. Greater sage-grouse population trend in the Paulina/12-Mile/Misery Flat PAC, 1988 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

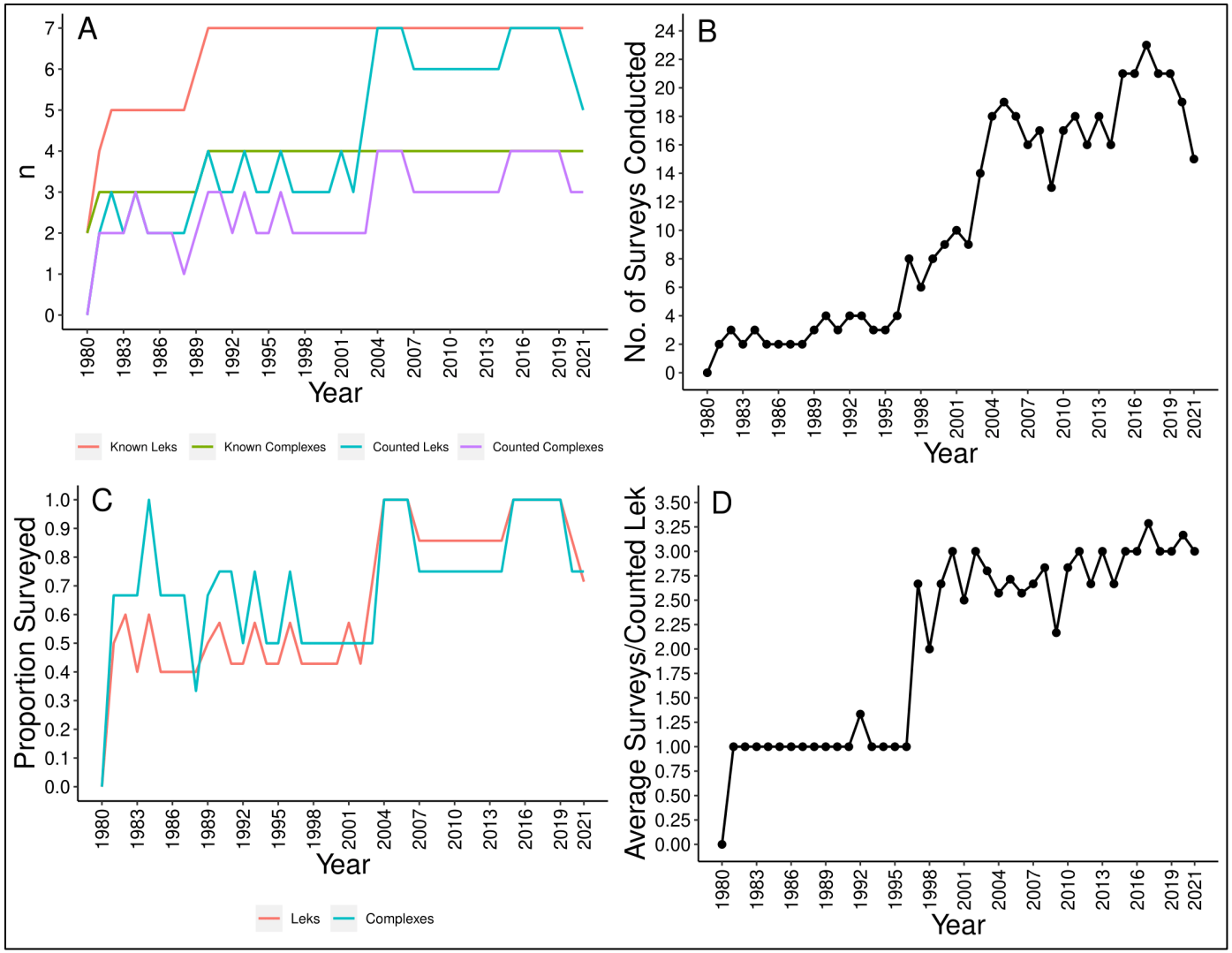


Figure A1. 28. Picture Rock PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

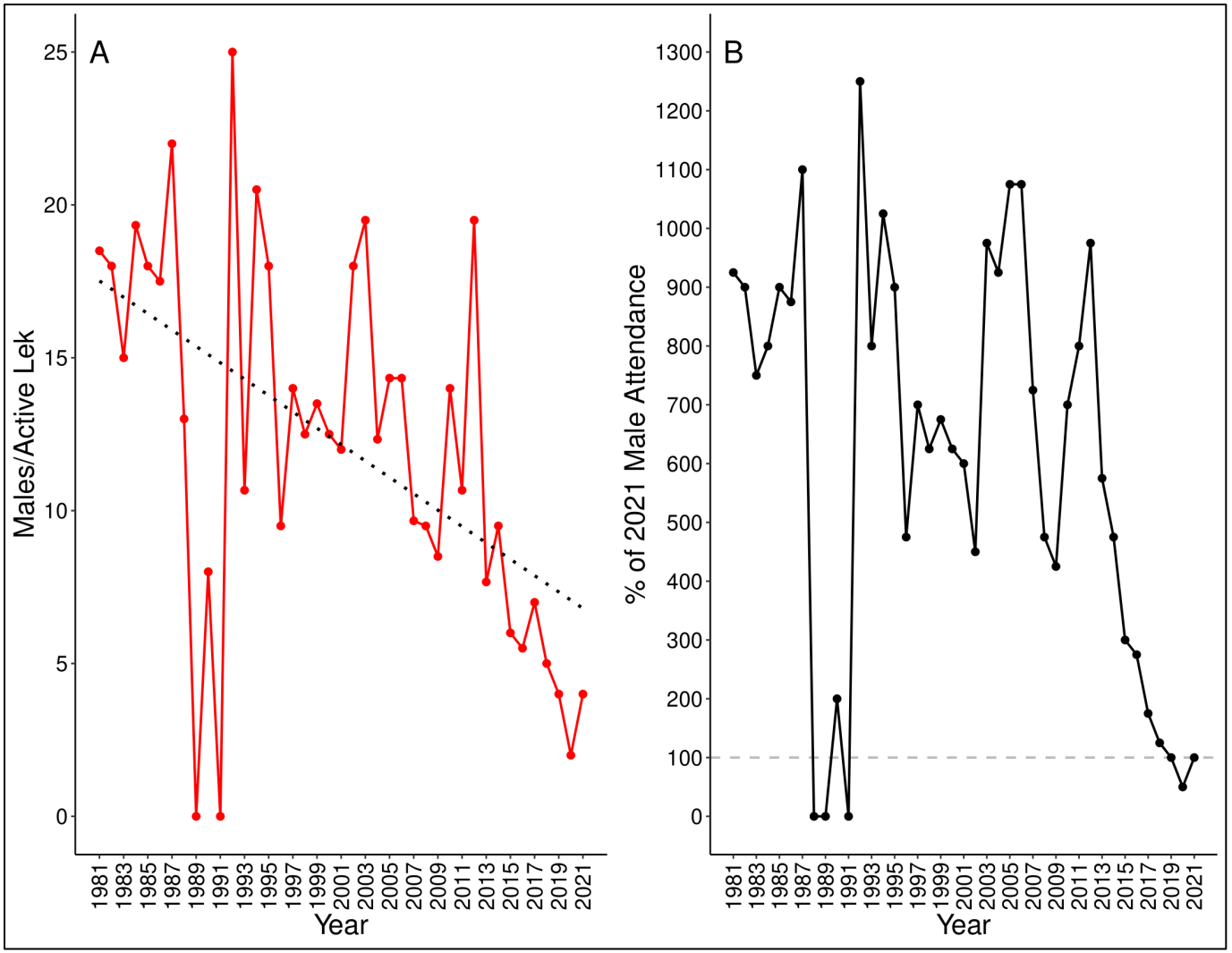


Figure A1. 29. Greater sage-grouse population trend in the Picture Rock PAC, 1981 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

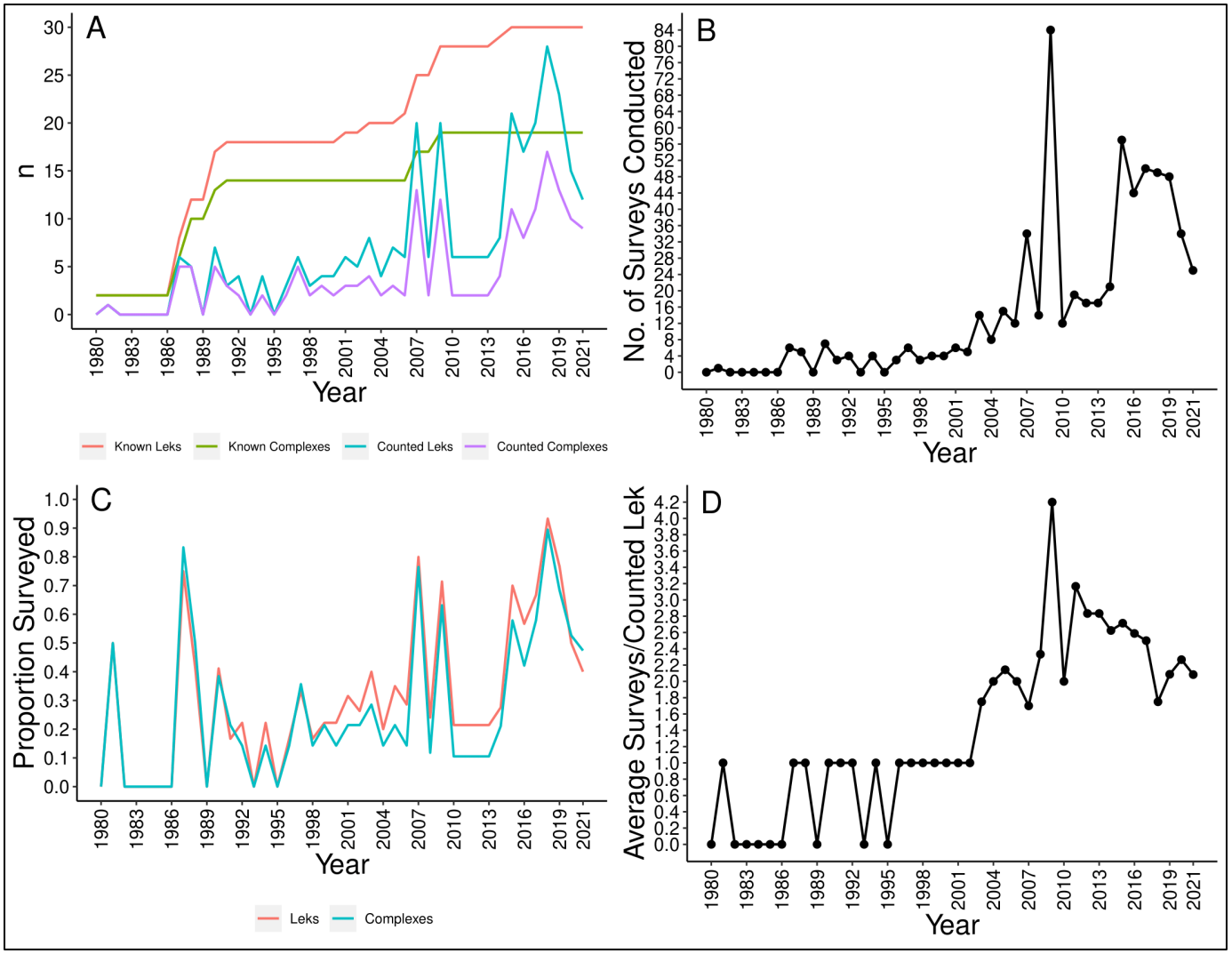


Figure A1. 30. Pueblos/S. Steens PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

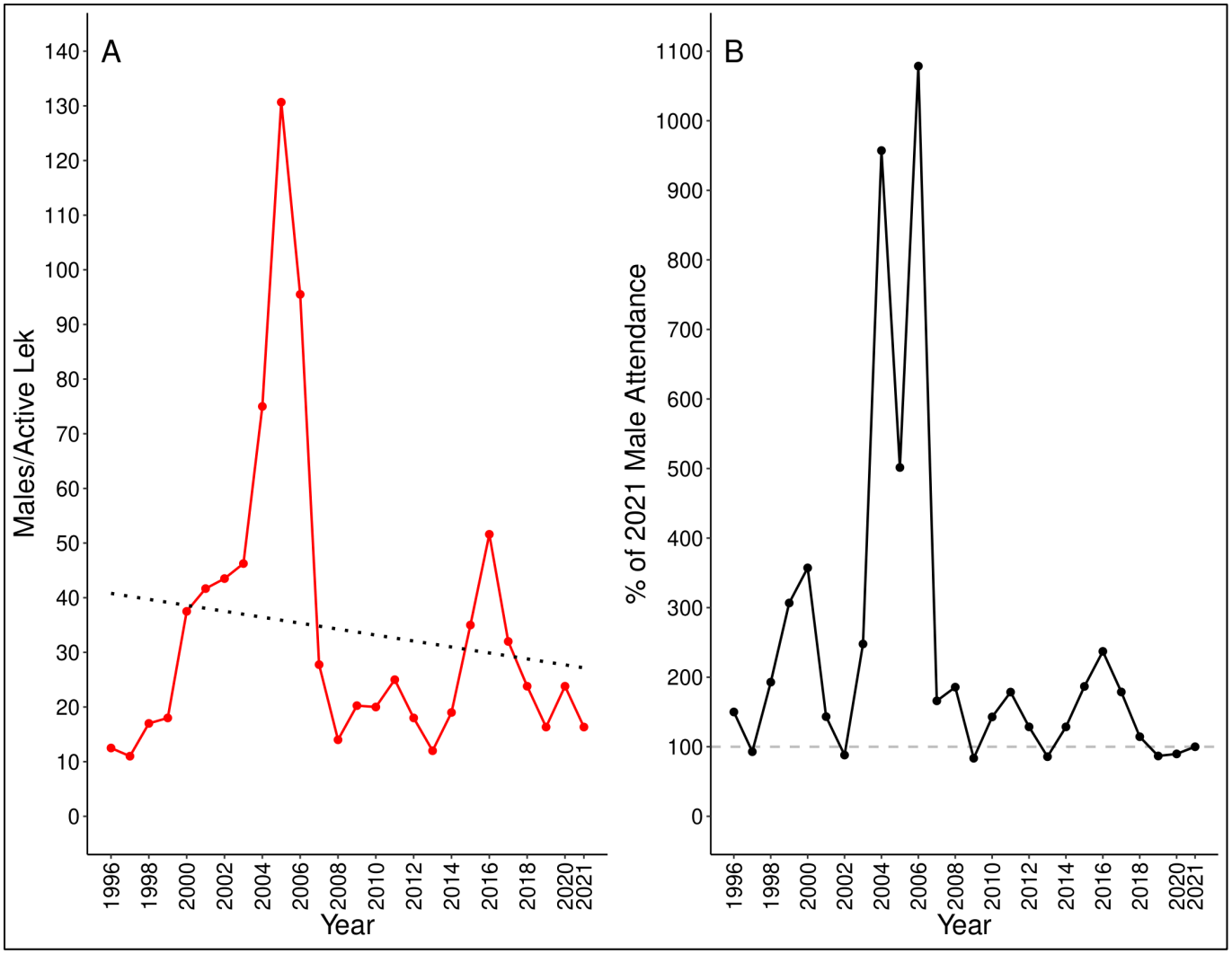


Figure A1. 31. Greater sage-grouse population trend in the Pueblos/S. Steens PAC, 1996 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

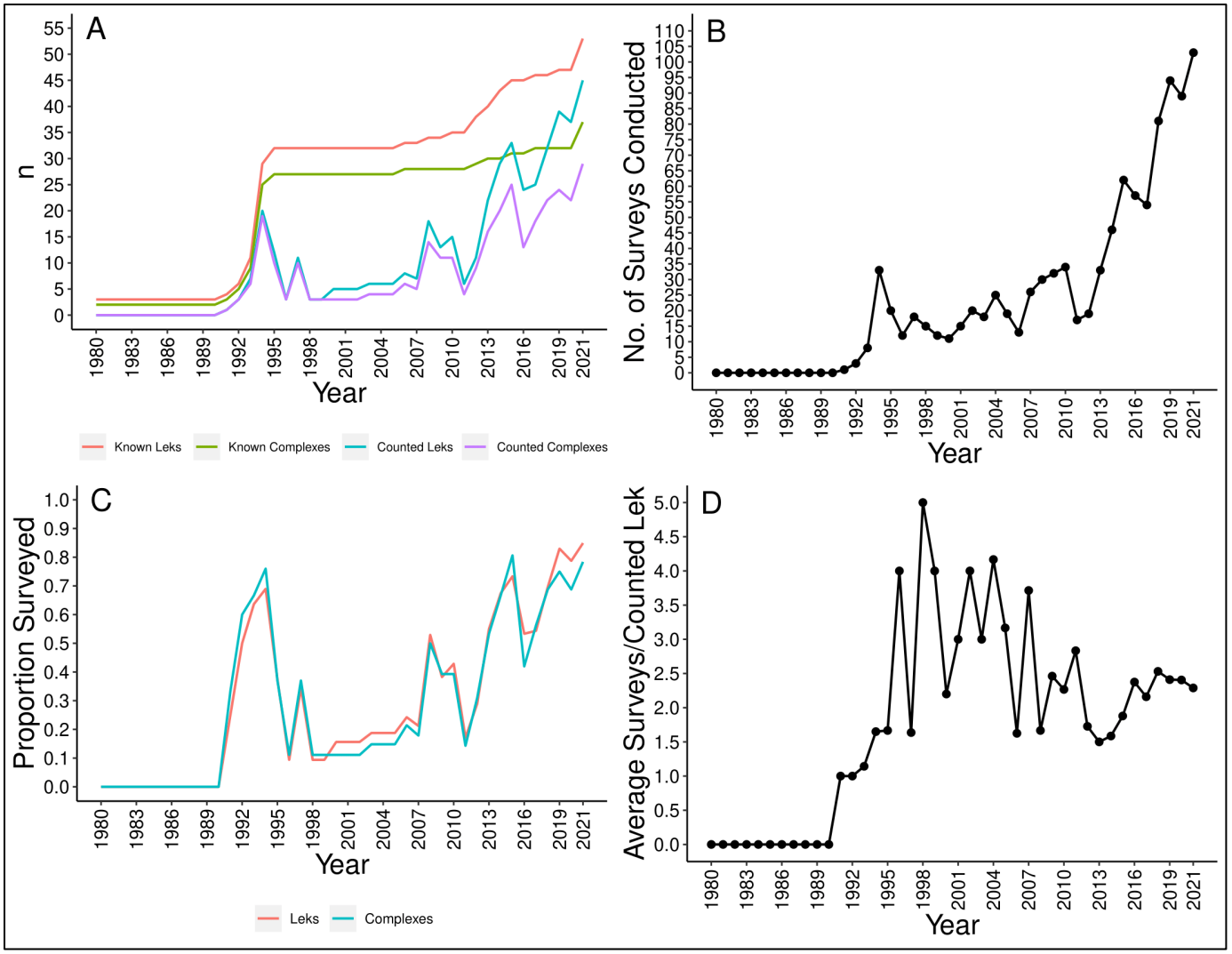


Figure A1. 32. Soldier Creek PAC greater sage-grouse survey effort statistics, 1980 – 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

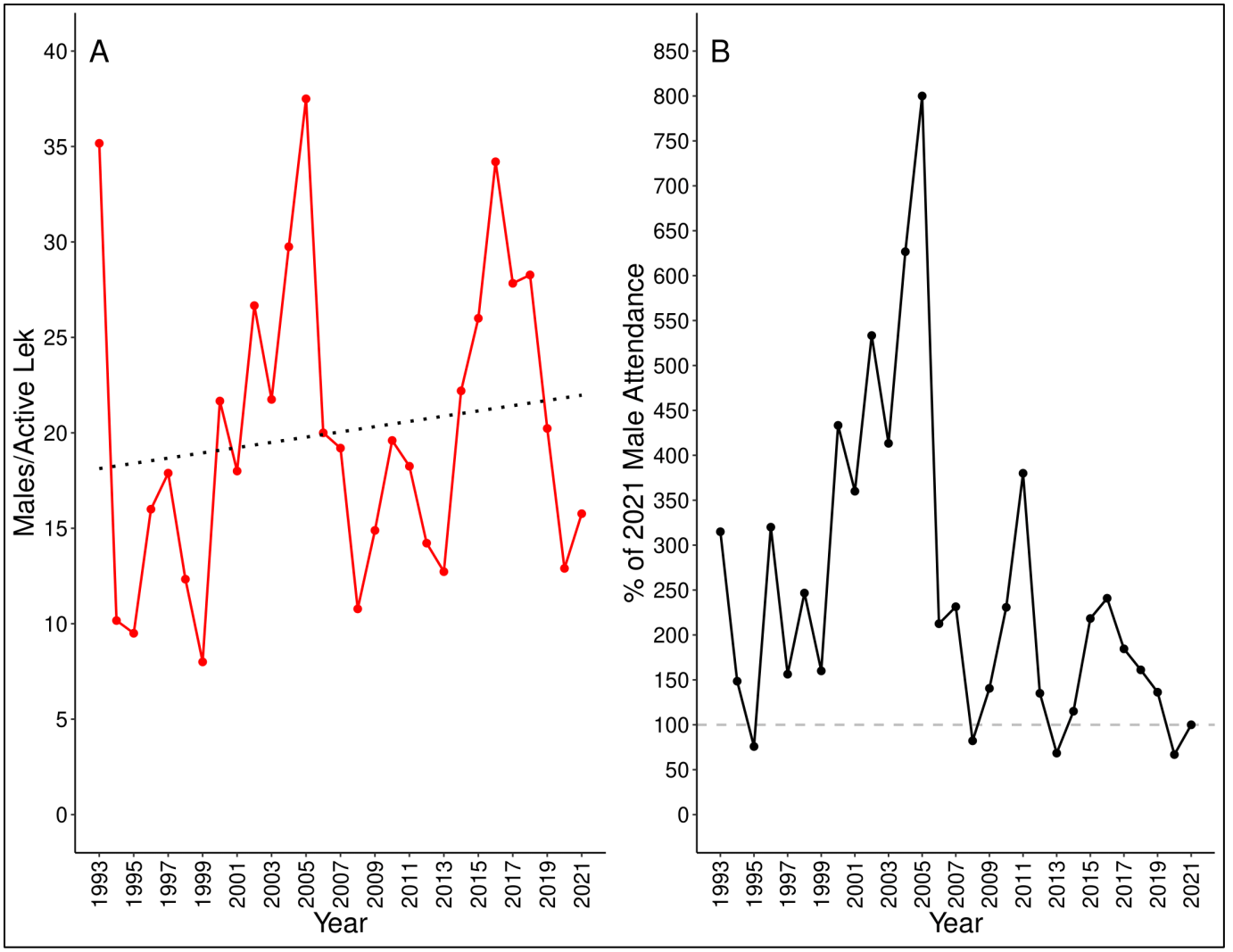


Figure A1. 33. Greater sage-grouse population trend in the Soldier Creek PAC, 1993 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Steens PAC

The Steens PAC is situated in central Harney County and is entirely contained within the Burns BLM District (Figure A1.1). Fifteen leks, comprising 10 complexes are known to exist or have existed within the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1947 and annual lek surveys have been conducted in the PAC since 1981. However, until 2005, only two complexes were consistently surveyed in the PAC (Figure A1.34), so caution should be taken when interpreting population trend data in the PAC prior to 2006 (Figure A1.35).

Trout Creeks PAC

The Trout Creeks PAC is situated in southeastern Harney County and southwestern Malheur County, and is split between the Burns and Vale BLM Districts (Figure A1.1). Ninety-six leks, comprising 55 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1970; however, annual lek surveys were not conducted consistently within the PAC until 2012 (Figure A1.36).

Tucker Hill PAC

The Tucker Hill PAC is situated in southern Lake County and is entirely contained within the Lakeview BLM District (Figure A1.1). Six leks, comprising four complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1977 and annual surveys have been conducted in the PAC consistently since 1996 (Figure A1.38).

Warners PAC

The Warners PAC is situated in eastern Lake County and is entirely contained within the Lakeview BLM District (Figure A1.1). Fifty-seven leks, comprising 42 complexes are known to exist or have existed in the PAC (Table A1.1). Surveys were first recorded for leks within the PAC in 1975 and annual surveys have been conducted in the PAC consistently since 1993 (Figure A1.40). The number of leks known to exist within the PAC increased substantially following aerial lek searches conducted in 2002.

Leks Outside of PACs

Leks occur outside of PACs throughout the range of sage-grouse in Oregon (Figure A1.1). Two hundred forty-two leks, comprising 198 complexes occur outside of mapped PACs in the state (Table A1.1). Surveys were first recorded for leks outside of mapped PACs in 1947 and surveys have been conducted annually from 1947 – 2021. Survey effort and knowledge of sage-grouse distribution in habitat not mapped as a PAC increased substantially following 1980 (Figure A1.42).

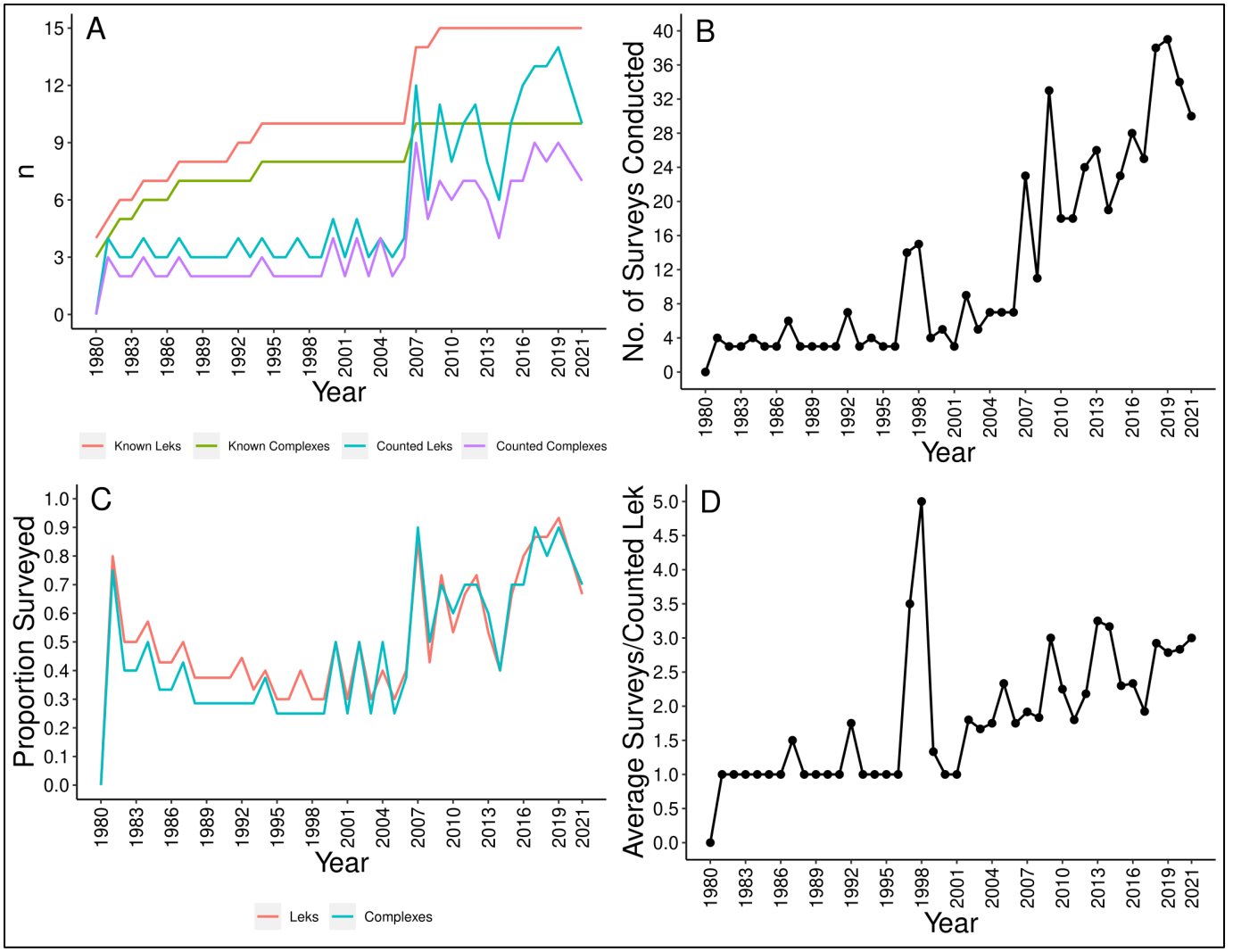


Figure A1. 34. Steens PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

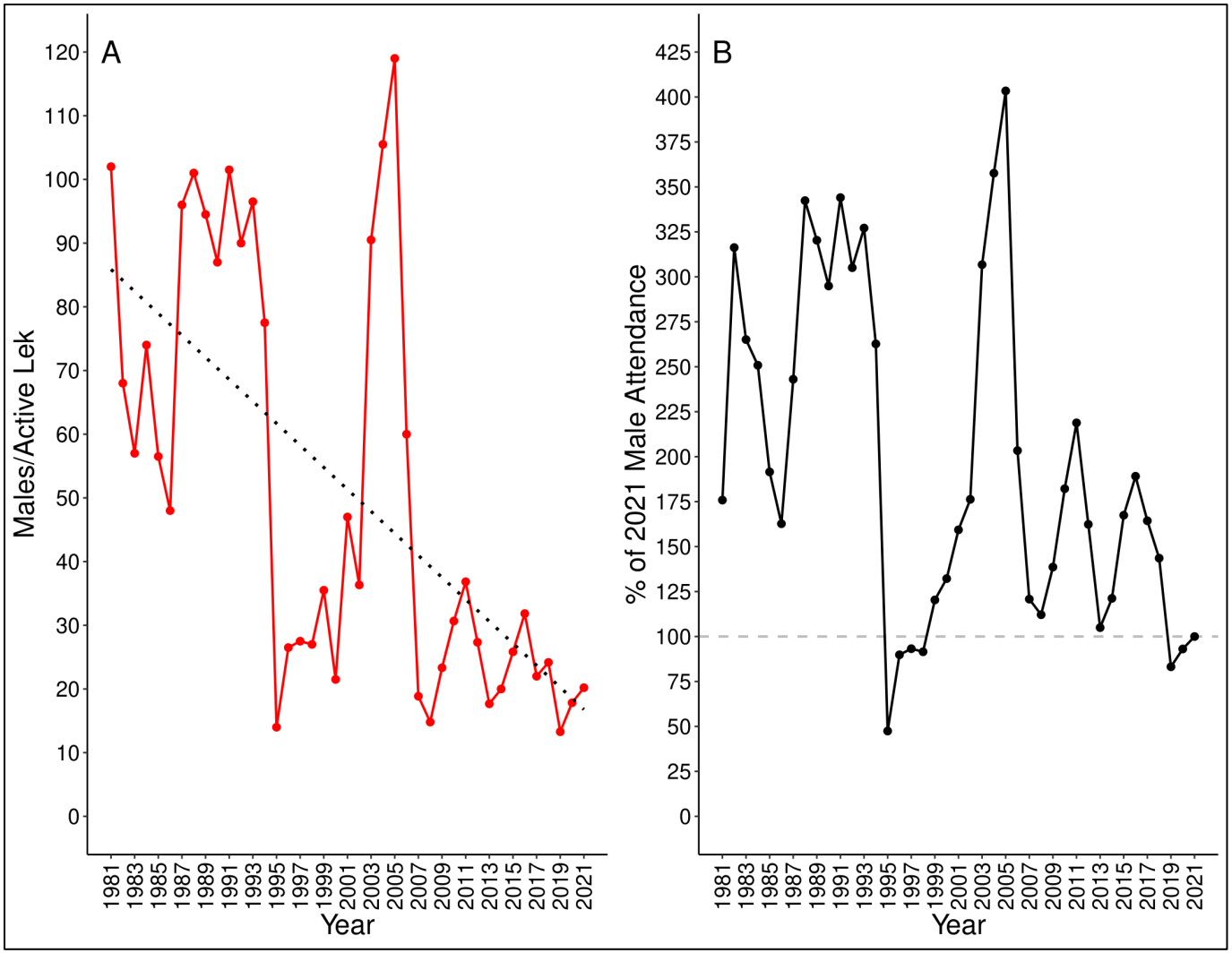


Figure A1. 35. Greater sage-grouse population trend in the Steens PAC, 1981 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

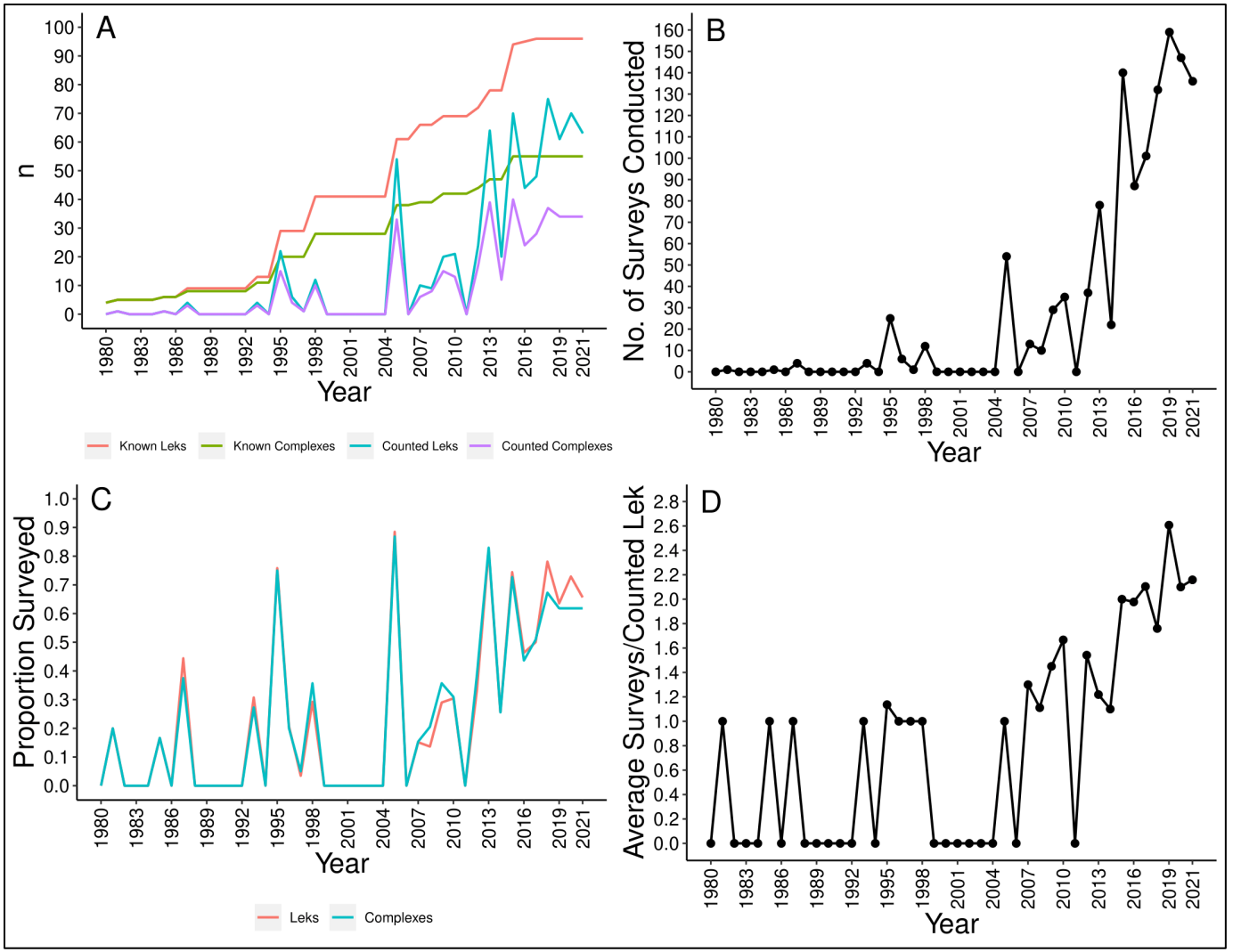


Figure A1. 36. Trout Creeks PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

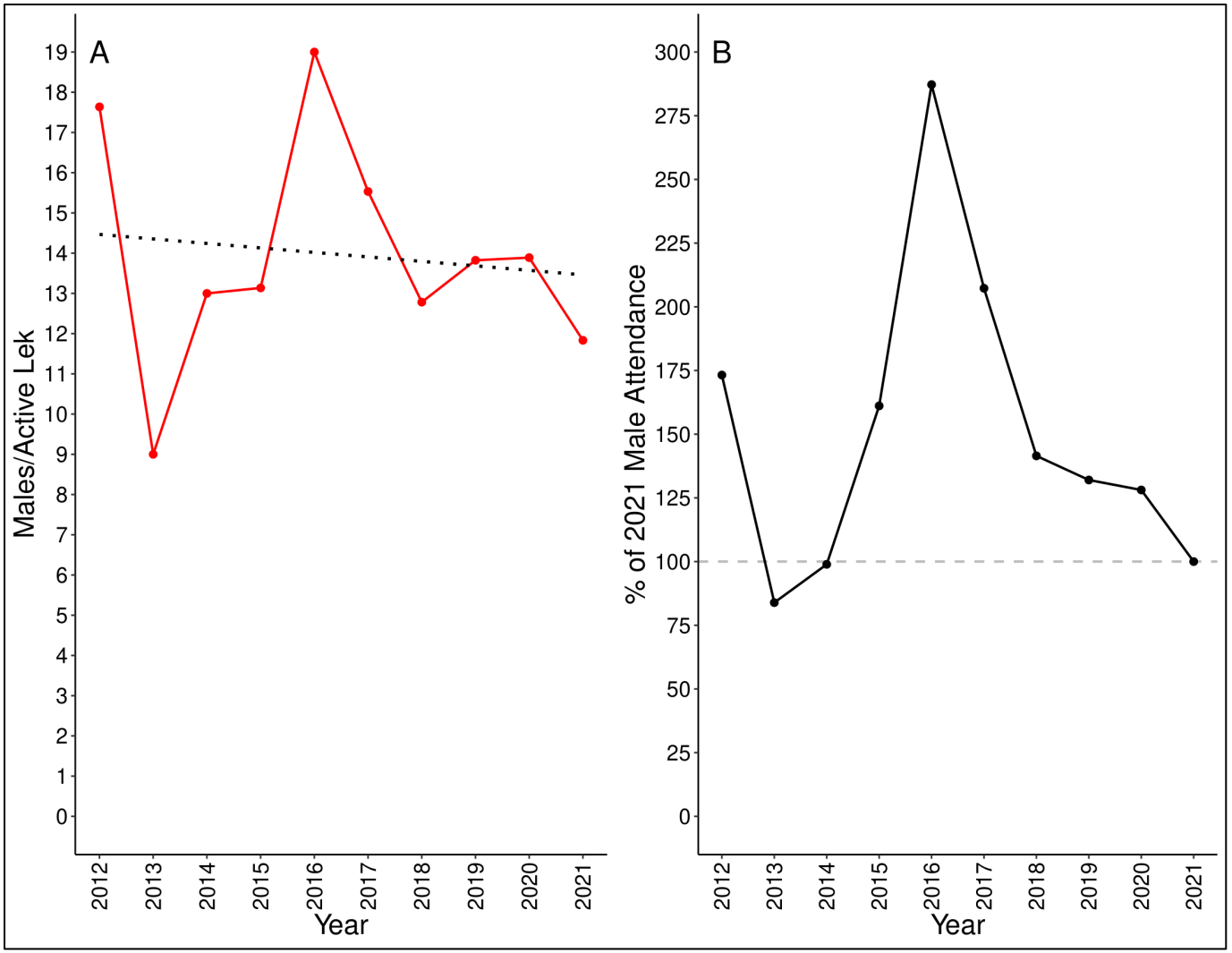


Figure A1. 37. Greater sage-grouse population trend in the Trout Creeks PAC, 2012 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

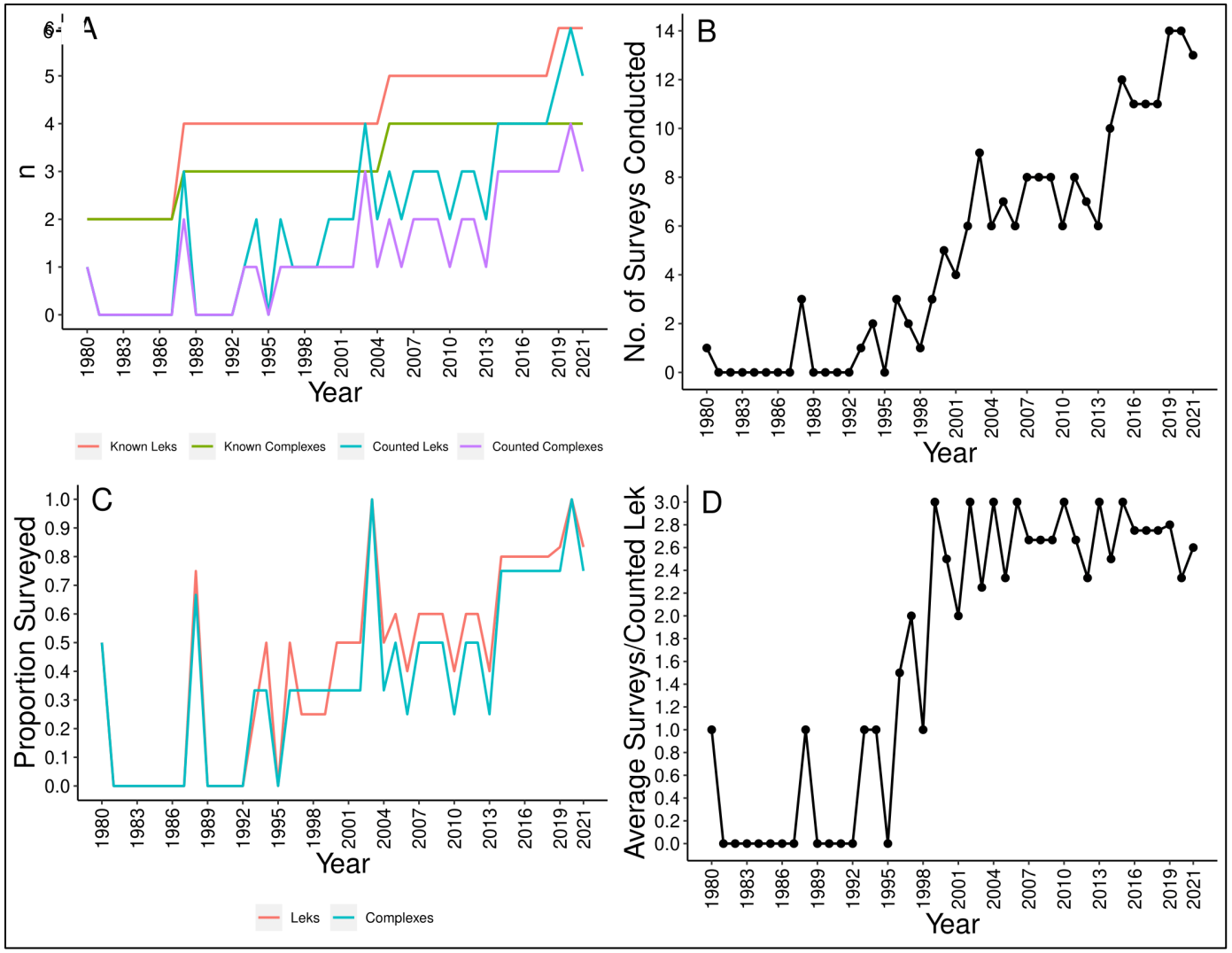


Figure A1. 38. Tucker Hill PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

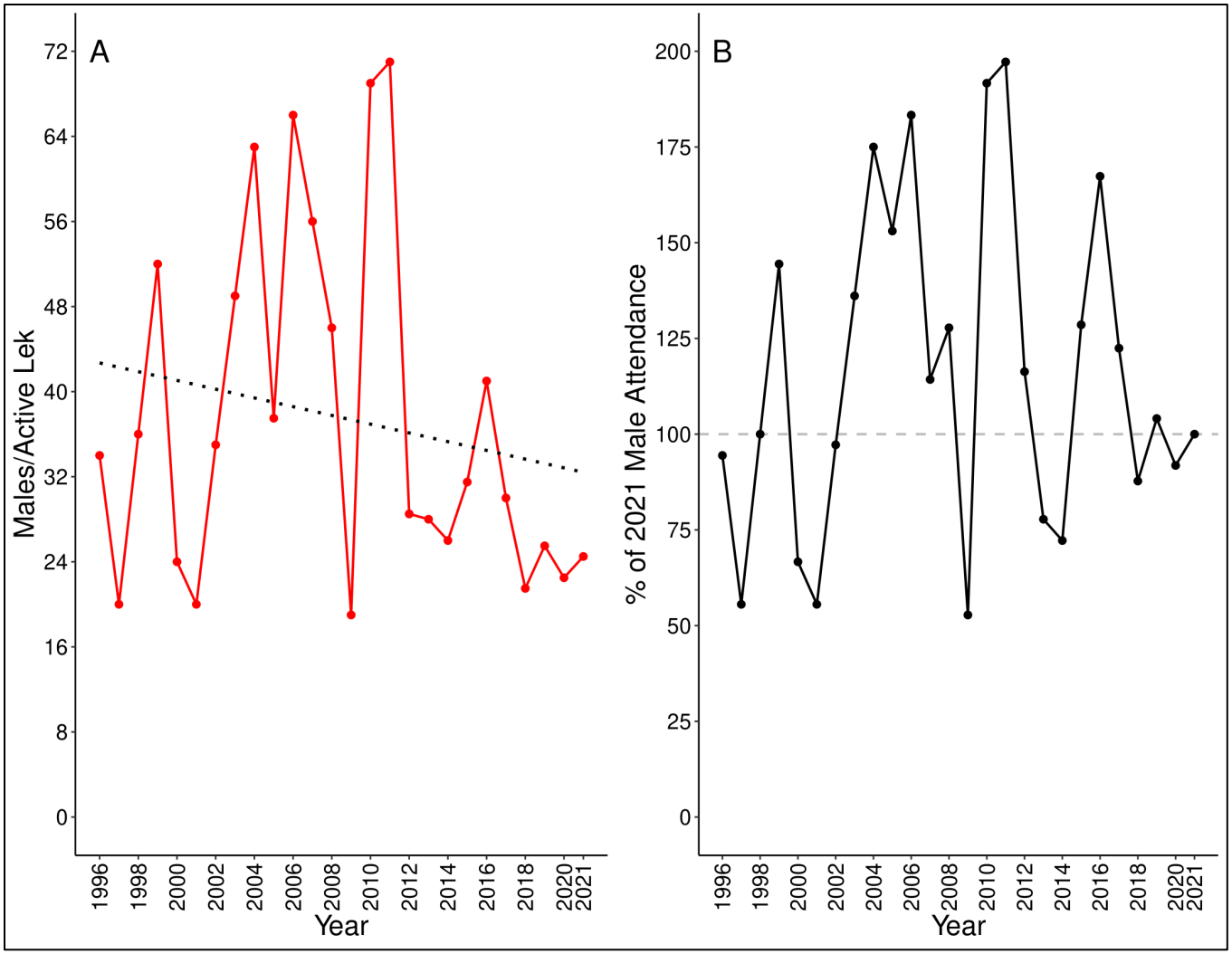


Figure A1. 39. Greater sage-grouse population trend in the Tucker Hill PAC, 1996 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

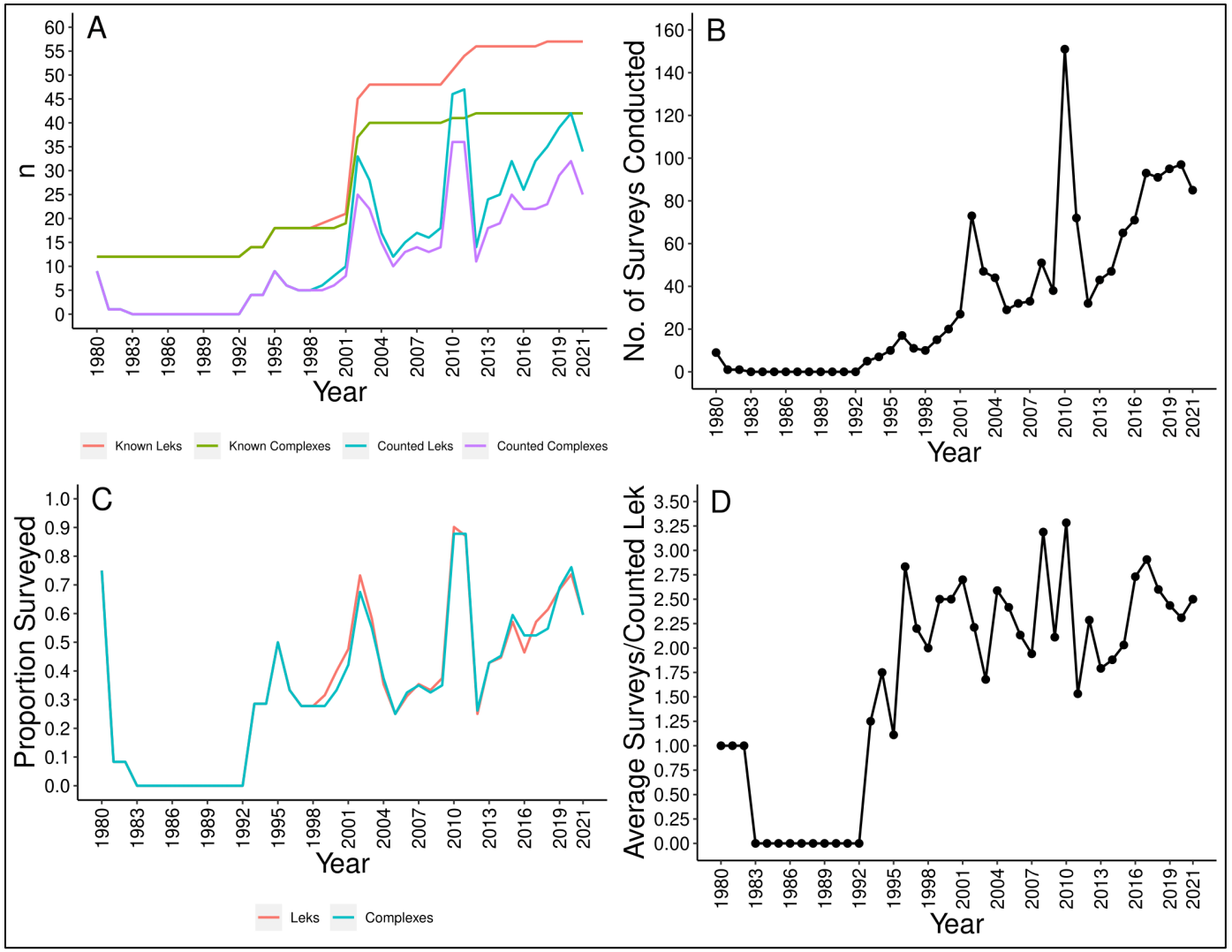


Figure A1. 40. Warners PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

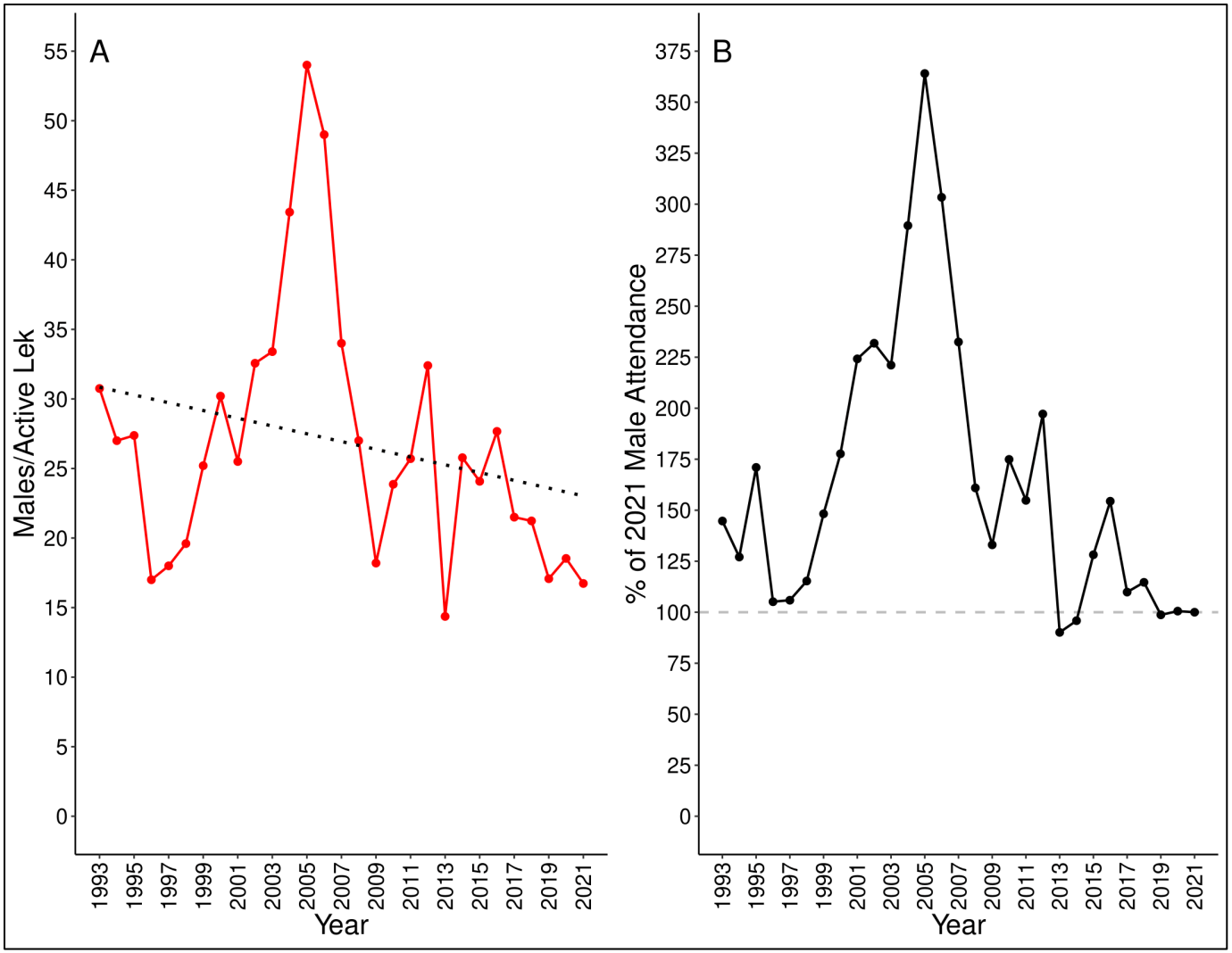


Figure A1. 41. Greater sage-grouse population trend in the Warners PAC, 1993 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

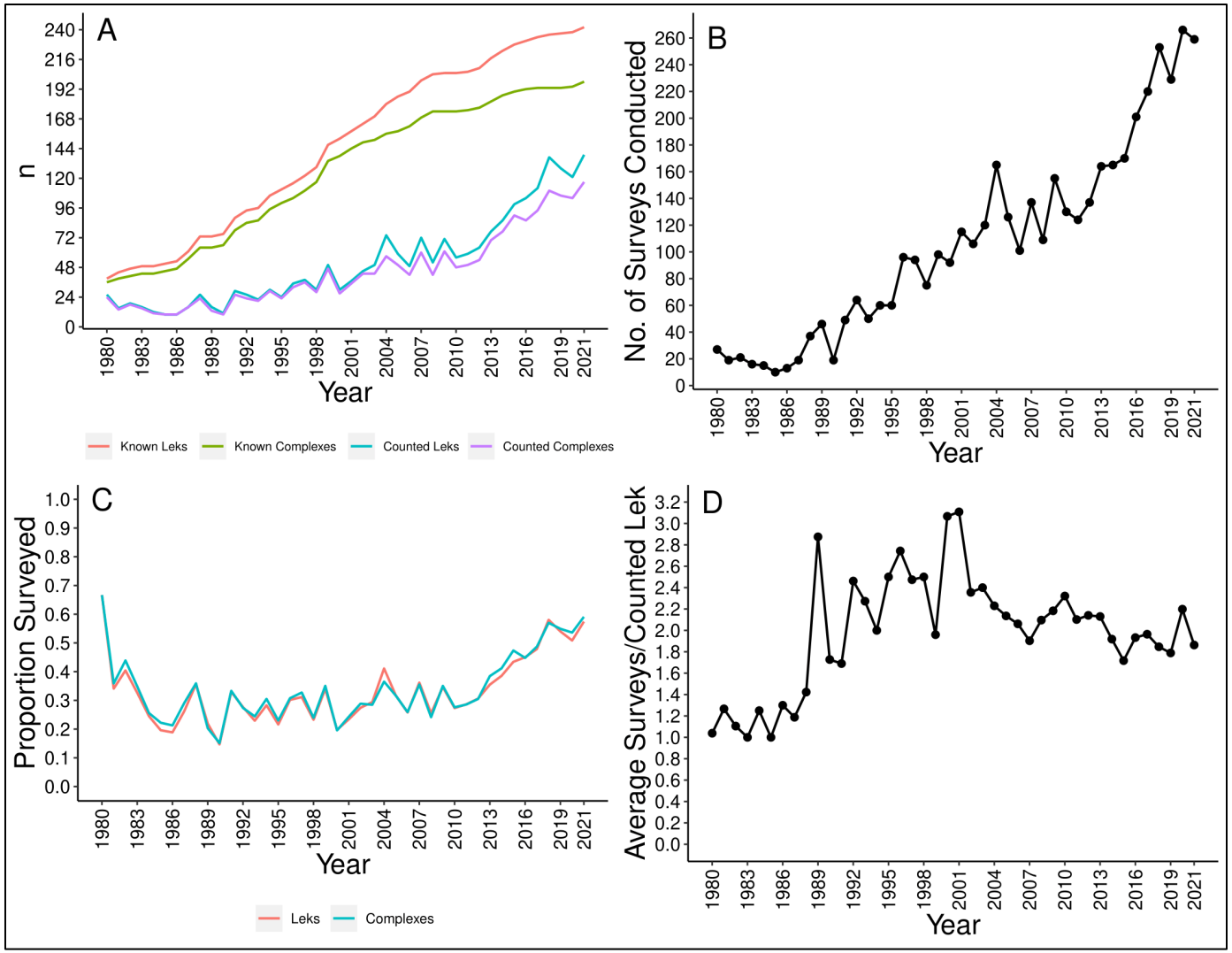


Figure A1. 42. Outside of PAC greater sage-grouse survey effort statistics, 1980 - 2021. A – Number of leks, and complexes known to exist or have existed, and number of leks and complexes actually surveyed, by year. B – Total number of ground and aerial surveys conducted, by year. C – Proportion of known leks and complex surveyed, by year. D – Average number of surveys conducted at each surveyed lek, by year.

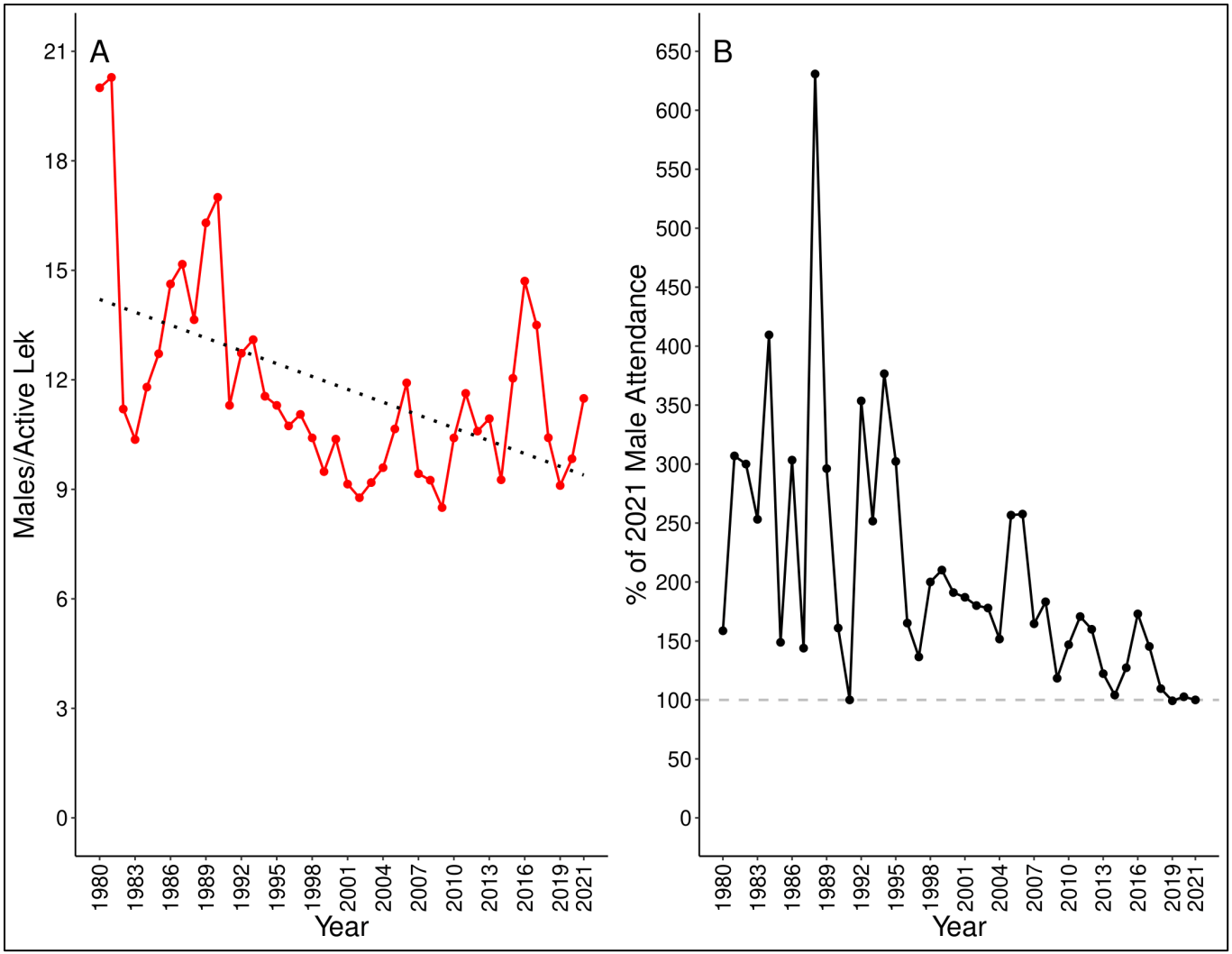


Figure A1. 43. Greater sage-grouse population trend outside of PACs, 1980 - 2021. A - Change in average greater sage-grouse lek complex size (males per active lek). B - Annual rate of change in male lek complex attendance reported as percentage of 2021 male attendance; annual rate of change in male lek complex attendance calculated only for lek complexes counted in both year *t*, and 2021.

Appendix II – 2021 ODFW Adopt-A-Lek Program Report

Photo by Patrick Lynch

2021 Volunteer Field Report

Southeast Oregon Greater Sage-Grouse Adopt-A-Lek Program

Oregon Department of Fish and Wildlife
Prepared by Damian Fagan

This year marked the 16th year of ODFW's Adopt-A-Lek (AAL) volunteer program. The program provides an opportunity for citizen scientists from Oregon, Washington, and Idaho to count greater sage-grouse (*Centrocercus urophasianus*) leks in remote portions of Malheur County. Data collected by the volunteers contribute to ODFW's annual population estimate for the species, which is essential to monitoring the health of the sage-grouse population in Oregon.

This year, 55 dedicated AAL volunteers braved rain, snow, and sunny weather, as well as the novel coronavirus COVID-19, to count greater sage-grouse displaying on leks. We welcomed new AAL volunteers to the program hailing from Bend, Eugene, Portland, Boise, and Caldwell.

The 2021 lek counting effort in Oregon continued to focus on key habitat areas know as Priority Areas for Conservation (PACs). These PACs contain high priority trend leks, which were counted three times between March 15 and April 30, with 7-10 days spaced between each count morning. The AAL program volunteers were assigned to count a total of 103 leks this year; some leks were added to the program due to the high number of volunteers. Three leks were not counted due to weather and road conditions.

This year, 100 individual sage-grouse leks were counted at least once during 243 count mornings, resulting in a total of 937 individual birds observed. Additional

sage-grouse were observed during mid-day lek checks or while observers were traveling to sites.

Even though weather and road conditions were extremely challenging at times, AAL volunteers persevered and documented new observation points, lek activity, and lek access. Many volunteers made special efforts to write detailed comments, observations, share photos, and make suggestions to improve the AAL program, which is always appreciated.

The AAL count data adds significantly to the statewide sage-grouse population database used by state biologists and federal land managers to manage this sagebrush-obligate species. Special thanks to the Oregon Wildlife Foundation and other partners for providing funding and assistance to the AAL program and a huge THANK YOU to all the AAL volunteers that contributed to this program and who share a deep commitment to the conservation and preservation of this unique and charismatic species.

2021 Volunteer Statistics

Note: this is not a year-to-year comparison of the exact same leks. Each year varies in terms of the number of leks assigned to the AAL program.

- **55 volunteers counted, checked, and surveyed leks**
- **100 individual leks were counted**
  (compared to 80 in 2020, 91 in 2019, 71 in 2018, 76 in 2017, 63 in 2016, 46 in 2015, 63 in 2014, and 81 in 2013)
- **45 individual leks were counted at least 3 times**
  (compared to 35 in 2020, 45 in 2019, 18 in 2018, 17 in 2017, 16 in 2016, 12 in 2015, 0 in 2014, and 0 in 2013)
- **243 count mornings were conducted**
  (compared to 185 in 2020, 236 in 2019, 171 in 2018, 171 in 2017, 116 in 2016, 89 in 2015, 67 in 2014, and 93 in 2013)
- **45% of the leks counted were active - had birds displaying during the count morning**
  (compared to 44% in 2020, 53% in 2019, 51% in 2018, 53% in 2017, 52% in 2016, 72% in 2015, 56% in 2014, and 49% in 2013)
- **55 leks were not active (no males displaying) on any count morning**
  (compared to 55 in 2020, 44 in 2019, and 35 in 2018)
- **45 leks were active (at least 1 male displaying) on a count morning**
  (compared to 35 in 2020, 47 in 2019, 36 in 2018, 40 in 2017, 33 in 2016, 33 in 2015, 35 in 2014, and 40 in 2013)
- **937 total birds were counted**
  (compared to 419 in 2020, 962 in 2019, 975 in 2017, 1052 in 2016, 871 in 2015, 453 in 2014, and 468 in 2013)

- **1 lek was checked but not counted**
  (compared to 0 in 2020, 9 in 2019, 5 in 2018, 2 in 2017, 10 in 2016, 14 in 2015, 34 in 2014, and 35 in 2013)
- **73% of the active leks counted had 1-10 males**
  (compared to 70% in 2020, 64% in 2019, 58% in 2018, 55% in 2017, 42% in 2016, 48% in 2015, and 44% in 2014)
- **13% of the active leks counted had 11-20 males**
  (compared to 12% in 2020, 19% in 2019, 33% in 2018, 18% in 2017, 21% in 2016, 18% in 2015, and 38% in 2014)
- **13% of the active leks counted had 21 or more males**
  (compared to 15% in 2020, 15% in 2019, 14% in 2018, 28% in 2017, 36% in 2016, 33% in 2015, and 15% in 2014)
- **The largest lek had 43 males (49 birds total)**
  (compared to 27 in 2020, 49 in 2019, 40 in 2018, 54 in 2017, 60 in 2016, 41 in 2015, and 37 in 2014)

Funding and support for the 2021 Volunteer Program was provided by Oregon Department of Fish and Wildlife, Oregon Wildlife Foundation, and the Bureau of Land Management.

Appendix III – 2021 Aerial Survey Summary

Oregon Department of Fish and Wildlife (ODFW) conducts annual aerial lek searches, with the goals of 1) locating previously undocumented leks, 2) documenting shifts in sage-grouse breeding distribution, and 3) monitoring activity of leks which are inaccessible from the ground. Results from our 2020 aerial lek surveys suggested that the efficacy of the aerial infrared survey methodology is questionable in regard to locating new leks, but this method performed well for counting males on known leks, compared to ground surveys. For this reason, ODFW contracted aerial services for lek searches by helicopter and lek counts by aerial infrared surveys during spring 2021. Funding for 2021 aerial lek surveys was provided by the BLM through the current ODFW/BLM Cooperative Funding Agreement and by the U.S. Fish and Wildlife Service.

Aerial Lek Searches

Aerial lek searches are conducted by helicopter from ½ hour before to 2 hours after sunrise, following fixed transects separated by ¼ - ½ mile. During searches, the helicopter maintains an altitude of 50 – 150 feet above ground level and a speed of approximately 60 mph. Helicopter searches and surveys are primarily directed towards the assessment of lek occupancy, as lekking sage-grouse are sensitive to aerial predators, and thus often limit their display behavior in presence of a helicopter. For this reason, following the discovery of previously unknown leks, ground observation of a site is required to confirm lek occupancy and attendance. Counts conducted from a helicopter are generally not used to estimate population trend in an analysis area. Rather, these counts act as presence-only assessments of lek activity and are used to assign leks to size strata. The exception to this rule is when male counts conducted from a helicopter are greater than follow up counts conducted by a ground observer. In these cases, the aerial counts are used to both assess population trend and assign leks to size strata.

During 2021, ODFW contracted JL Aviation, Inc. to conduct 52 hours of helicopter lek searches in the Soldier Creek PAC, Folly Farm/Saddle Butte PAC, Louse Canyon PAC, and in adjacent general and low-density sage-grouse habitat in Malheur County. Approximately 1,740 miles of transects were flown (Figure A3.1) over the course of 7 days utilizing 2 helicopters. Ten new leks were located by helicopter and confirmed by ground surveyors; 6 new leks in the Soldier Creek PAC and 4 new leks in adjacent low-density habitat. The combined maximum count at these leks by ground surveyors was 198 males. Several potential new leks were located by helicopter in spring 2021 and still need to be confirmed on the ground during the spring 2022 sage-grouse breeding season. Results from these lek searches may indicate that the large population decline observed in the Soldier Creek PAC since 2018 is partially due to lek movement, rather than a decline in the sage-grouse population in this area. Additionally, Soldier Creek PAC observed a 49.6% increase in estimated male attendance at common leks between 2020 and 2021, following a -16.2% decline, -15.4% decline, and -51.0% in 2018, 2019, and 2020, respectively. With the observed increase in 2021 and the addition of at least 6 new leks, the sage-grouse population in the Soldier Creek PAC appears stable. Consistent monitoring of the leks in Soldier Creek PAC over the next several years will be necessary to confirm stability in this sage-grouse population.

Aerial Infrared Lek Counts

During spring 2021, ODFW contracted Owyhee Air Research, Inc. (OAR) to conduct aerial infrared surveys at sage-grouse leks in Malheur County and eastern Harney County, Oregon. The non-invasive aerial infrared survey method is designed to detect heat signatures from sage-grouse at lek sites, potentially over 2 miles away, allowing surveyors to estimate the number of sage-grouse attending lek sites. Lek surveys were conducted by OAR in remote areas with difficult ground access or in areas with limited access due to private lands. The objectives of the 2021 aerial infrared surveys were to 1) survey known lek locations and opportunistically identify potential new lek locations, and 2) assess the efficacy of aerial infrared surveys to estimate counts of sage-grouse at known lek locations, compared to ground observers. Surveys were conducted from 30 minutes before to 90 minutes after sunrise in a fixed-wing aircraft equipped with an infrared imaging system. While counting sage-grouse at lek sites, the aircraft maintained an altitude of 1,000 – 1,500 feet above ground level and circled at a distance of > 0.5 miles to minimize stress to the birds. The aircraft circled the lek location while the sensor operator scanned the area, up to 0.75 miles in all directions, for sage-grouse activity. Each detection of sage-grouse was documented with real-time counts classified by sex when possible, geographical coordinates, and a video clip of the observed birds.

Aerial infrared surveys were conducted at 13 leks in the Bully Creek PAC, 19 leks in the Crowley PAC, 40 leks in the Cow Valley PAC, and 18 leks in the Louse Canyon PAC during April 2 – 16, 2021. Thirty-six of the leks in the Cow Valley PAC were surveyed twice, and all other leks were surveyed once. Surveys conducted in the Bully Creek PAC counted 16 sage-grouse males at 3 of the 13 surveyed leks. Surveys conducted in the Crowley PAC counted 38 sage-grouse males at 4 of the 19 surveyed leks. Surveys conducted in the Louse Canyon PAC counted 77 sage-grouse males at 6 of the 18 surveyed leks. The maximum number of males counted between the two visits in the Cow Valley PAC was 193 males at 11 of the 40 surveyed leks. In the Cow Valley PAC, the total number of males counted during the first visit was slightly lower than during the second visit, at 159 and 170 males, respectively [two-sample $t(35) = 0.46$, $p = 0.65$). No new leks were opportunistically discovered during aerial infrared surveys, but lek location shifts were documented at 12 of the 90 surveyed leks (range: 0.2 – 0.5 mi).

Twenty-five leks surveyed by OAR were also surveyed by an observer on the ground. Of these, at least one male was detected by either method at 15 leks. The average number of males detected at these 15 active leks was higher for ground surveys than aerial infrared surveys, at 9.73 and 7.27 males per lek, respectively [two-sample $t(14) = 1.60$, $p = 0.13$]. There were 3 leks where aerial infrared surveys detected ≥1 male (range: 1–8 males) and ground surveys at these same leks detected 0 males. Similarly, there were 4 leks were ground surveys detected ≥1 male (range: 4–10) and aerial infrared surveys detected 0 males. Note, only one aerial survey was conducted for each lek, where 1–3 ($\overline{x} = 1.67$) ground surveys were conducted at each of these same leks. Aerial infrared surveys were conducted during assumed peak lek attendance in the first two weeks of April.

Overall, aerial infrared surveys were useful for obtaining count data at inaccessible lek sites during spring 2021. This was especially apparent in the Cow Valley PAC, where over 95% of known leks were surveyed this year with aerial infrared surveys, the greatest survey effort in the Cow Valley PAC to date in terms of proportion known leks surveyed and number of lek surveys

conducted. Typically, only about 30% of known leks can be counted on the ground annually in the Cow Valley PAC. Many of the leks in the Cow Valley PAC had not been surveyed since the last aerial lek searches were conducted in 2016 and 2017. Eleven leks that were active in 2016 and/or 2017 were found inactive during 2021 aerial infrared surveys. As a result of these leks transitioning to inactive status, the Cow Valley PAC observed a large apparent population decline between 2020 and 2021. Lek searches in the Cow Valley PAC may be warranted to assess whether this apparent population decline is likely due to lek movement or a true decline in the sage-grouse population in the area.

For two consecutive years, the average number of males per active lek was higher for ground observers than for aerial infrared surveys at similar leks. However, these comparisons may have a positive bias toward ground observers, as the number of surveys conducted on the ground was >1 during both seasons, where the number of aerial infrared surveys conducted was limited to 1 survey. The discrepancy between the two survey methods may reflect the need to conduct >1 survey at lek sites during a given season, rather than the ability of aerial infrared surveys to effectively count sage-grouse males on leks. To evaluate this potential bias and provide a more valid comparison of the two methods, we used the aerial infrared and ground survey data from 2020 and 2021 and truncated the ground surveys to a single count (closest count to the aerial infrared survey), rather than using the maximum male count at these ground-surveyed leks. Sixty-five leks surveyed by OAR were also surveyed by an observer on the ground. Of these, at least one male was detected by either method at 35 leks. We found that the average number of males detected at these 35 leks during 2020 and 2021 was higher for ground surveys than aerial infrared surveys, at 8.40 and 7.17 males per active lek, respectively [two-sample $t(34) = 1.18$, $p = 0.25$]. These results indicate that the ground surveys may detect a larger number of sage-grouse males at active leks than aerial infrared surveys, but we did not find a significant difference in average males per active lek between the two methods. Aerial infrared surveys appear to perform adequately at counting sage-grouse males compared to observers on the ground. The similarity between lek counts conducted by both the aerial infrared platform and ground observers suggests that the method may continue to be valuable for surveying leks where access is limited by private land, terrain, or road conditions.

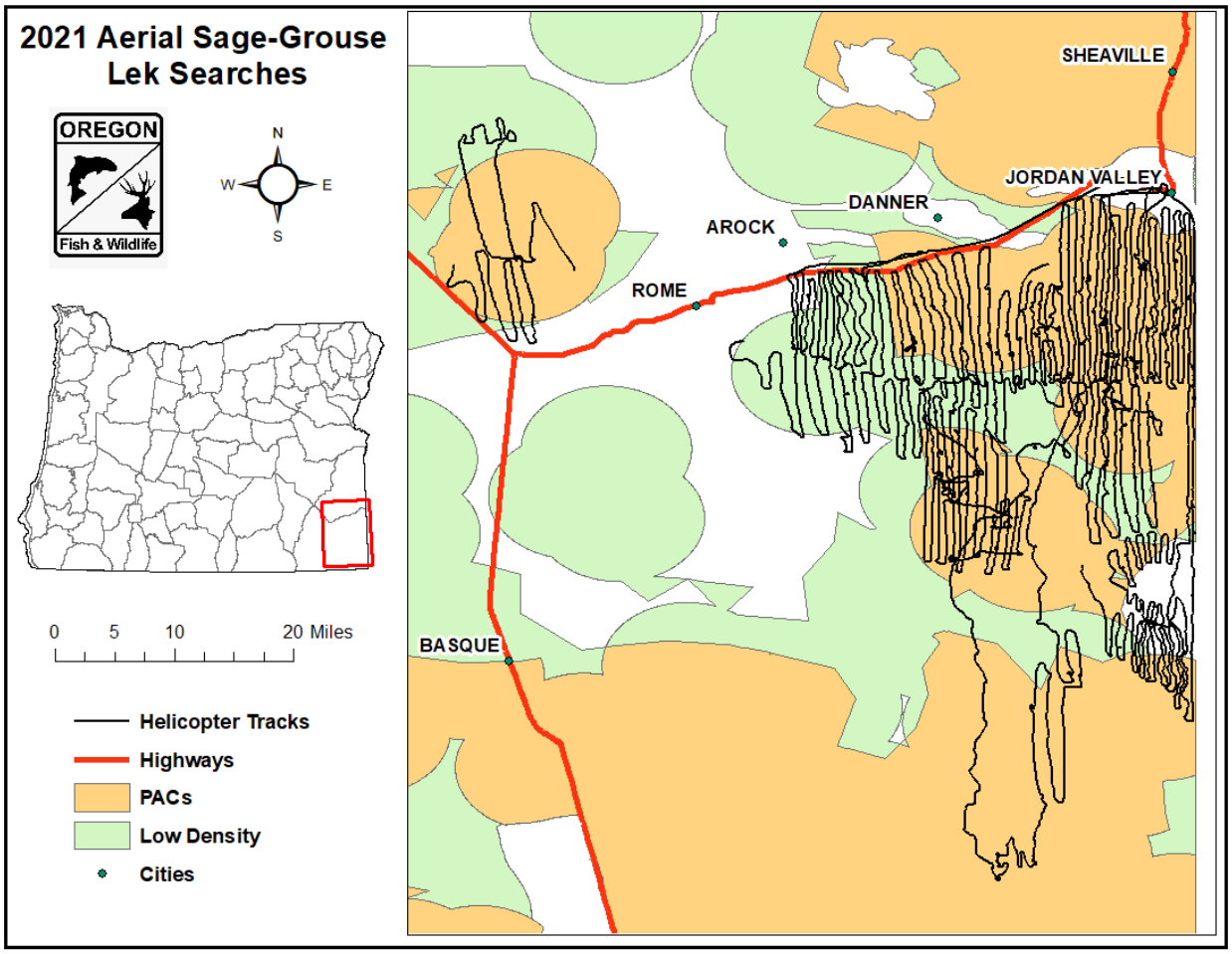


Figure A3. 1. Greater sage-grouse aerial lek search transects in southeastern Oregon, including portions of the Folly Farm/Saddle Butte PAC, Louse Canyon PAC, Soldier Creek PAC, and surrounding low density habitat, 2021.

Figure A3. 2. Screenshot from a wide-scale video collected by Owyhee Air Research, Inc. during greater sage-grouse aerial infrared leks surveys, 2021. The small white dots are lekking sage-grouse.

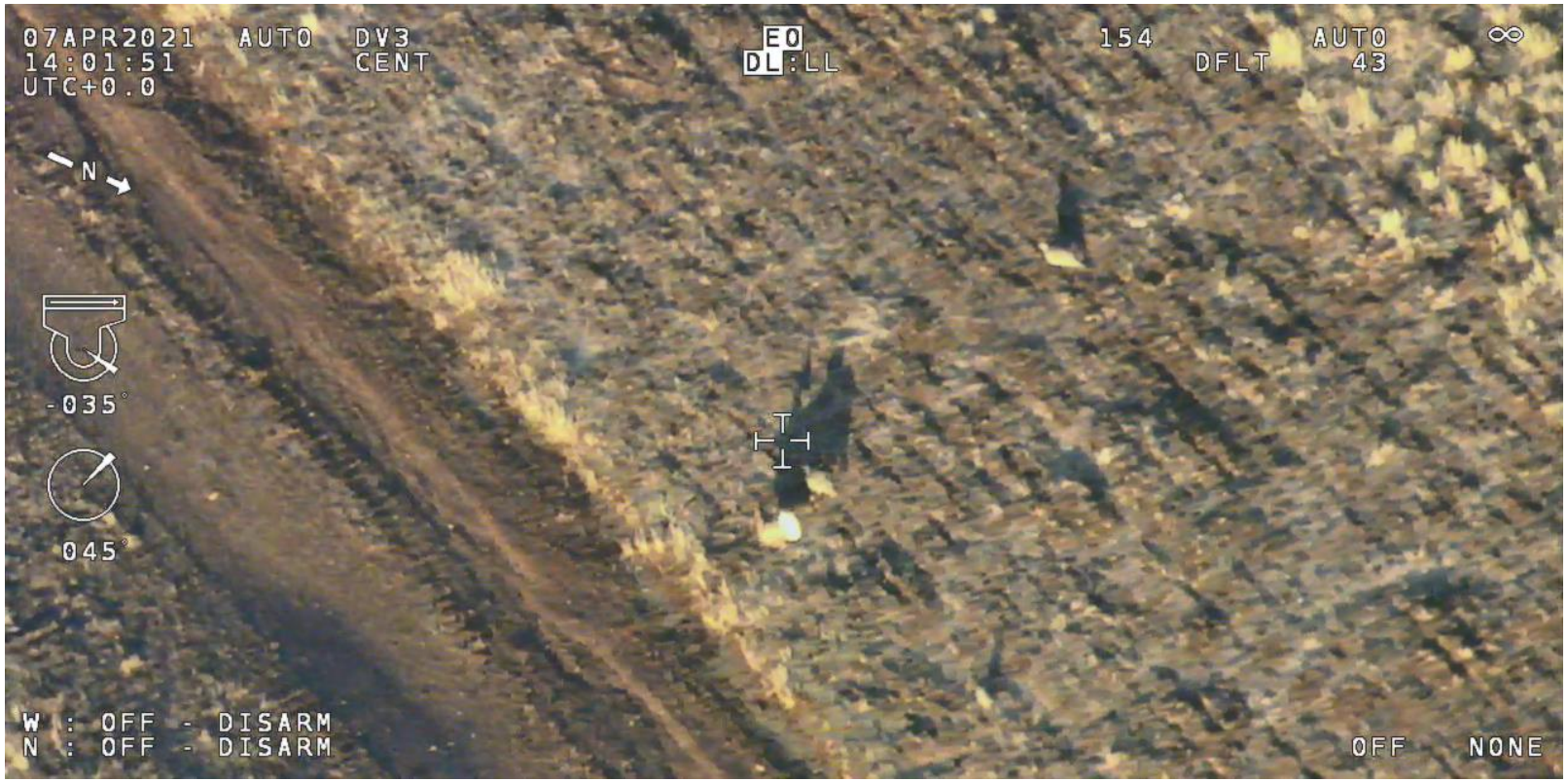


Figure A3. 3. Screenshot from a fine-scale video collected by Owyhee Air Research, Inc. during greater sage-grouse aerial infrared leks surveys, 2021. The photo shows one male sage-grouse displaying for two female sage-grouse.

Appendix IV – 2021 Sage-Grouse Wing-Bee Report (2020 Hunting Season Data)

Annual Report – Oregon Sage-Grouse Wing Analyses, 2021

Skyler Vold, Sage-Grouse Conservation Coordinator, Hines, OR

Lee Foster, Assistant District Biologist, Hines, OR

Executive Summary: Following the 2020 hunting season, 175 greater sage-grouse (*Centrocercus urophasianus*; hereafter: sage-grouse) wings were received from hunters. Production in 2020 (as measured by percent juveniles in the harvest) was 43%, similar to the long-term average of 47% (1993-2019). The number of chicks per hen was 1.1, lower than the 2019 production value of 1.4 chicks per hen and below the long-term (1993-2019) average of 1.5 chicks per hen. Apparent nest success in 2020 was below average, based on retention of primary 9 of harvested females (P9 Nest Success: 2020 = 33%, 1993 – 2019 Average = 43%). Production data collected from hunter-harvested wings in 2020 suggests that sage-grouse populations should be stable in 2021.

Overview

In 2020, the sage-grouse hunting season in Oregon was by permit for nine days (12 - 20 Sep), with a daily, and season bag limit of two birds. Season length in 2005-2020 was nine days, versus five days from 1995-2004, and two days in 1993 and 1994. There have not been any changes in daily bag and season limits from 1993-2020 (Braun et al. 2015; Table A4.1).

Plumage characteristics (e.g. those associated with wings) are used to assess age and sex of numerous game bird species. By assessing plumage characteristics from hunter-harvested wings, demographic parameters (e.g. age structure, sex ratio, and nest success) can be estimated for sage-grouse populations. Sage-grouse wings have been analyzed to gather information regarding population structure and demography in Oregon since 1982. However, methods used to determine age and sex from wing characteristics were refined in 1993. Due to this change in methodology, all long-term average rates are calculated only for the 1993 – 2020 period. As in previous years, all hunters who were successful in the controlled sage-grouse hunt drawing were provided envelopes for the return of sage-grouse wings to ODFW. Sage-grouse wings collected

during the 2020 hunting season were processed by personnel of Oregon Department of Fish and Wildlife and Pheasants Forever at an annual Wing Bee in February 2021.

Following the 2020 hunting season, 175 hunter-harvested wings were received from the nine wildlife management units (WMUs) where hunting was permitted (Table A4.2, Figure A4.1). This represents an increase in wing collection from the previous year (2019 = 145 wings), potentially due to suppresed wing return rates in 2019 from the late provision of wing envelopes to hunters. Wing collection remains below the 27-year (1993-2019) average of 487 wings (Table A4.3), due to continued reductions in the number of permits issued each sage-grouse hunting season. More than 75% of wings (n = 140) were received from only four WMUs (Beatys Butte, Beulah, Warners, and Whitehorse); fewer than 10 wings were received from the Malheur River, Owyhee, Silvies, and Steens Mountain WMUs (Table A4.4). No permits have been offered in the Sumpter or Lookout Mountain WMUs (WMUs 51 and 64 respectively) since 2014 due to concerns about decreasing population trends, and continued uncertainty about the impacts of wildfires (Kitten Complex) that occurred in the summer of 2014 (Figure A4.1). No permits have been offered in that portion of the Wagontire WMU south of the Christmas Valley Highway (South Wagontire, WMU 73B; Figure A4.1) since 2016 due to concerns about decreasing population trends. No permits have been offered in the Juniper WMU (WMU 71) since 2017 due to concerns about decreasing population trends. In 2019, permits were once again offered in that part of the Whitehorse WMU west of Highway 95 and south of the Whitehorse Ranch Road (Trout Creek Mountains, Sub-WMU 68A; Figure A4.1). No permits were offered in this area between 2012 and 2018 due to ongoing research investigating the impacts of the Holloway Fire on sage-grouse in the Trout Creek Mountains. In 2019, populations had sufficiently rebounded and initial research questions had been sufficiently addressed to make a conservative offering of 25 sage-grouse tags in the subunit. However, this tag draw was conducted seperately from the remainder of the Whitehorse WMU (E. Whitehorse, Sub-WMU 68B; Figure A4.1), to maintain a conservative harvest level in the Trout Creek Mountains sub-unit. In 2020, an additional 5 permits (30 total) were offered in the Trout Creek Mountains sub-unit.

Table A4. 1. Sage-grouse hunting season dates, lengths, daily and season bag limits, and permits authorized, Oregon, 1993-2020.

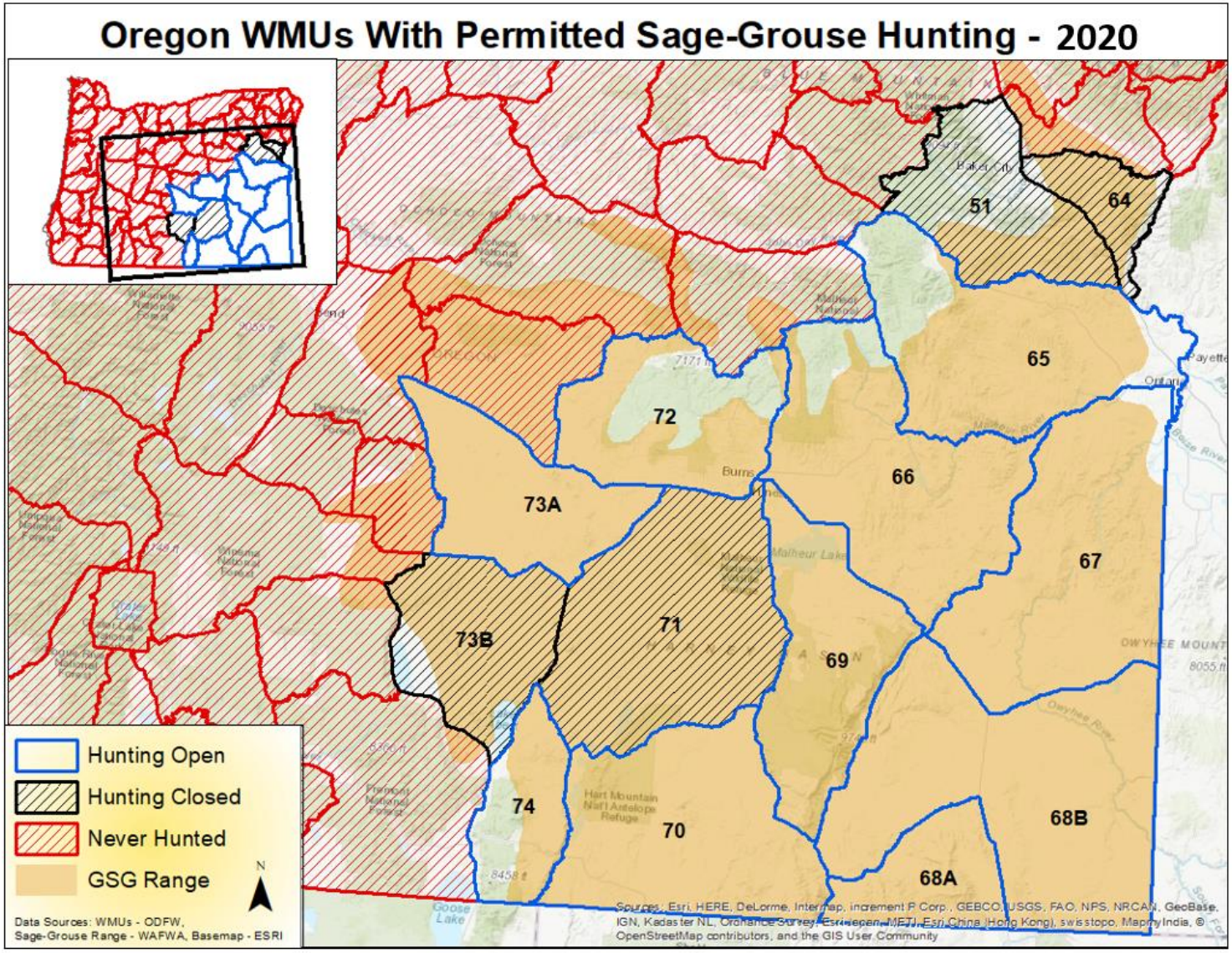
Year	Season Date	No. Days	Daily Bag	Season Limit	Permits Authorized
1993	18-19 Sep	2	2	2	865
1994	17-18 Sep	2	2	2	*No Data*
1995	9-13 Sep	5	2	2	1040
1996	7-11 Sep	5	2	2	1140
1997	6-10 Sep	5	2	2	1265
1998	12-16 Sep	5	2	2	1265
1999	11-15 Sep	5	2	2	1265
2000	9-13 Sep	5	2	2	1265
2001	8-12 Sep	5	2	2	1265
2002	7-11 Sep	5	2	2	1250
2003	6-10 Sep	5	2	2	1275
2004	11-15 Sep	5	2	2	1275
2005	10-18 Sep	9	2	2	1300
2006	9-17 Sep	9	2	2	1300
2007	8-16 Sep	9	2	2	1175
2008	6-14 Sep	9	2	2	1175
2009	12-20 Sep	9	2	2	1150
2010	11-19 Sep	9	2	2	1150
2011	10-18 Sep	9	2	2	1130
2012	8-16 Sep	9	2	2	885
2013	7-15 Sep	9	2	2	870
2014	6-14 Sep	9	2	2	845
2015	12-20 Sep	9	2	2	845
2016	10-18 Sep	9	2	2	845
2017	9-17 Sep	9	2	2	800
2018	8-16 Sep	9	2	2	740
2019	7-15 Sep	9	2	2	645
2020	12-20 Sep	9	2	2	630

Table A4. 2. Oregon wildlife management units with permitted sage-grouse harvest, 2020.

WMU #	WMU Name
65	Beulah
66	Malheur River
67	Owyhee
68A	Trout Creek Mtns.
68B	E. Whitehorse
69	Steens Mtn.
70	Beatys Butte
72	Silvies
73[a]	Wagontire
74	Warner

[a]Unit partially closed to hunting in 2020.

Figure A4. 1. Oregon wildlife management units with permitted greater sage-grouse hunting, and the distribution of greater sage-grouse in Oregon, 2020.



Age and Sex Composition

Sage-grouse wings were classified by age (juvenile = hatch year; yearling = second year; adult = after hatch year), based on characteristics of the outer primaries (P10 – P7), first secondary, tertials, and wing coverts (Braun and Schroeder 2015). In areas where the majority of breeding occurs in March and early April, such as Oregon, few yearling males will be identifiable in the harvest due to molt progression (Braun and Schroeder 2015). Additionally, if non-nesting or early nesting yearling females complete their wing molt before harvest, there is no reliable way to differentiate them from after second year adult females (Braun and Schroeder 2015). Therefore, in Oregon, after hatch year birds are classified as adults, unless they can be definitively identified as yearlings by the presence of juvenile P9 and/or P10 feathers (Braun et al. 2015). Sex classification was assigned based on the length of primary 10 and/or primary 9 depending on the condition of the wing (Braun and Schroeder 2015). Relatively few yearlings are identified in the harvest in Oregon (27 Year Average = 6% of harvest); 8% of the harvested birds were classified as yearlings in 2020, up slightly from the long-term average. Overall, the percent of juveniles in the harvest was 43%, representing a decrease from 2019 (48%) and was lower than the long-term average of 47%. Within individual WMUs, the percent of juveniles in the harvest was variable, likely because of small sample size for all WMUs. The number of wings received for individual WMUs ranged from 4 – 49 (Table A4.4). The greatest number of juveniles in the harvest was in the Silvies WMU (100%; 4 of 4 wings), followed by the Warners (66%; 23 of 35 wings), Owyhee (57%; 4 of 7 wings), and Trout Creek Mountains sub-WMUs (56%; 9 of 16 wings; Table A4.4). The sex ratio of juveniles in the 2020 harvest (44:56, males to females) was similar to the long-term average juvenile sex ratio (Table A4.5).

Table A4. 3. Sex composition by age class, and age composition of harvested sage-grouse, all wildlife management units open to harvest, Oregon, 1993-2020.

		Juvenile			Yearling			Adult		
Year	N	M (%)	F (%)	% Harvest	M (%)	F (%)	% Harvest	M (%)	F (%)	% Harvest
1993	439	51	49	47	26	74	4	40	60	49
1994	764	47	53	43	12	88	7	32	68	50
1995	456	42	58	36	5	95	5	32	68	60
1996	493	42	58	51	4	96	5	31	69	44
1997	586	47	53	54	16	84	4	39	61	39
1998	466	48	52	49	6	94	4	39	61	47
1999	671	46	54	56	14	86	5	41	59	39
2000	592	46	54	44	22	78	8	47	53	48
2001	670	50	50	54	10	90	7	44	56	38
2002	648	51	49	58	9	91	7	46	54	36
2003	655	46	54	48	12	88	5	47	53	47
2004	778	45	55	52	9	91	6	40	60	42
2005	829	46	54	45	5	95	5	46	54	50
2006	669	46	54	47	30	70	5	49	51	48
2007	485	44	56	28	10	90	6	38	62	66
2008	443	49	51	54	0	100	4	30	70	42
2009	493	47	53	57	0	100	5	49	51	38
2010	463	43	57	48	4	96	5	36	64	47
2011	422	43	57	42	10	90	5	48	52	53
2012	321	40	60	29	30	70	14	49	51	57
2013	254	50	50	58	11	89	7	36	64	35
2014	264	38	62	31	6	94	6	42	58	63
2015	290	43	57	58	14	86	2	40	60	40
2016	331	54	46	46	32	68	8	45	55	47
2017	270	42	58	39	5	95	7	37	63	53
2018	255	36	64	42	15	85	5	49	51	53
2019	145	44	56	48	0	100	5	38	62	47
27-yr Avg.	*487*	*45*	*55*	*47*	*12*	*88*	*6*	*41*	*59*	*47*
2020	175	44	56	43	7	93	8	37	63	49

Table A4. 4. Sex composition by age, and age composition of wings from harvested sage-grouse, all wildlife management units with potential sage-grouse harvest, Oregon, 2020. Total by percent in each age class represents the overall proportion of the given age class in the harvest.

		Juveniles						Yearlings						Adults					
		Male		Female		Totals		Male		Female		Totals		Male		Female		Totals	
WMU[a]	Sample Size	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
51[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	24	1	20	4	80	5	*21*	1	50	1	50	2	*8*	4	24	13	76	17	*71*
66	7	1	100	0	0	1	*14*	0	-	0	-	0	*0*	2	33	4	67	6	*86*
67	7	2	50	2	50	4	*57*	0	0	1	100	1	*14*	0	0	2	100	2	*29*
68A	16	3	33	6	67	9	*56*	0	0	3	100	3	*19*	0	0	4	100	4	*25*
68B	17	5	63	3	37	8	*47*	0	-	0	-	0	*0*	5	56	4	44	9	*53*
69	4	0	-	0	-	0	*0*	0	0	1	100	1	*25*	0	0	3	100	3	*75*
70	49	6	35	11	65	17	*35*	0	0	6	100	6	*12*	12	46	14	54	26	*53*
71[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	4	3	75	1	25	4	*100*	0	-	0	-	0	*0*	0	-	0	-	0	*0*
73[c]	12	2	50	2	50	4	*33*	0	0	1	100	1	*8*	3	43	4	57	7	*58*
74	35	10	63	13	38	23	*66*	0	-	0	-	0	*0*	6	50	6	50	12	*34*
All	*175*	*33*	*44*	*42*	*56*	*75*	*43*	*0*	*0*	*13*	*100*	*14*	*8*	*32*	*37*	*54*	*63*	*86*	*49*

[a]Wildlife Management Unit: 51 - Sumpter, 64 - Lookout Mtn., 65 - Beulah, 66 - Malheur River, 67 - Owyhee, 68A – Trout Creek Mtns, 68B – E. Whitehorse, 69 - Steens Mtn., 70 - Beatys Butte, 71 - Juniper, 72 - Silvies, 73 - Wagontire, 74 - Warner.
[b]WMU no hunting permits offered in 2020.
[c]WMU partially closed to hunting during 2020.

Table A4. 5. Sage-grouse production data as determined from hunter-harvested wings, Oregon, 1982 – 1984, 1989–1992, 1993–2019, and 2020. Data is divided into these periods due to the sage-grouse harvest closure during 1985–1988 and revised analysis methods in 1993.

Year	n	% Juvenile	Chicks/Female	Chicks M:F
1982	73	53	2.4	26:74
1983	291	38	0.9	53:47
1984	144	40	1	42:58
1985- 1988		Hunting Season Closed		
1989	326	41	1.1	46:54
1990	437	34	1	39:61
1991	295	31	0.8	37:63
1992	407	31	0.7	48:52
1982-1992 Mean	*282*	*38*	*1*	*48:58*
1993	439	47	1.4	51:49
1994	764	43	1.1	47:53
1995	456	36	0.8	42:58
1996	493	51	1.5	42:58
1997	586	54	1.8	47:53
1998	466	49	1.5	48:52
1999	671	56	2	46:54
2000	592	44	1.4	46:54
2001	670	54	1.9	50:50
2002	648	58	2.3	51:49
2003	655	48	1.6	46:54
2004	778	52	1.7	45:55
2005	829	45	1.4	46:54
2006	669	47	1.7	46:54
2007	485	28	0.6	44:56
2008	443	54	1.6	49:51
2009	493	57	2.3	47:53
2010	463	48	1.4	43:57
2011	422	53	1.3	43:57
2012	321	29	0.8	40:60
2013	254	58	2	50:50
2014	262	31	0.7	38:62
2015	290	58	2.3	43:57
2016	331	46	1.5	54:46
2017	270	39	1	42:58
2018	255	42	1.4	36:64
2019	145	48	1.4	44:56
1993-2019 Mean	*487*	*47*	*1.5*	*46:54*
2020	175	43	1.1	44:56

Nest Success and Production

Nest success was estimated based on wing molt patterns of adult and yearling females. Female sage-grouse replace primary feathers following completion of nesting activity (Braun and Schroeder 2015); thus, hens which nest successfully initiate their molt at a later date than hens with unsuccessful nests. Wings from hens harvested while they were in the process of growing new primaries through P9 likely had a successful hatch (Braun and Schroeder 2015). Conversely, hens with unsuccessful nests begin molting earlier and generally have a growing primary 10, or have completed their primary molt (Braun and Schroeder 2015). In Oregon, P9 is used to estimate apparent nest success, except in years of extraordinary snow or drought. Use of P9 will give a minimum estimate of nest success, but in some years may underestimate actual nest success. Overall, apparent nest success in 2020 was 33%, lower than apparent nest success in 2019 (45%) and lower than the long-term average (43%). It is unclear to what extent annual variability in apparent nest success is related to actual variability in nest success, due to the potential for variability in weather conditions and hatch dates to mask actual changes in nest success (Table A4.6). Apparent nest success was highest in the Malheur River WMU (75%, 3 of 4 total females), followed by the Beatys Butte WMU (55%; 11 of 20 total females; Table A4.7). Apparent nest success in the Beulah WMU was low (14%; 2 of 14 females), bringing down the overall apparent nest success estimate. However, this may reflect low sample size, as discussed above, and not representative of the true nest success in this WMU.

Connelly et al. (2000) suggested that a chick per hen ratio $\geq$ 2.25 indicates a healthy, stable or increasing population, but this ratio may be higher than required to maintain some populations and requires further study (Braun 2012). In Oregon, the long-term average chick per hen ratio is 1.5. Production in 2020 was below the long-term average, estimated at 1.12 chicks per hen (Figure A4.2). Within WMUs, nest success was not correlated with the proportion of juveniles in the harvest (Pearson's Correlation Coefficient = -0.27, p = 0.78; Figure A4.3) and nest success was not correlated with chicks per hen (Pearson's Correlation Coefficient = -0.11, p = 0.61; Figure A4.3). However, the decline in average production between 2019 and 2020 (average production 2019: 1.43 chicks/hen; 2020: 1.12 chicks/hen) was consistent with the decline in apparent nest success between 2019 and 2020 (apparent nest success 2019: 45%; 2020: 33%). Historically, apparent nest success and production in Oregon has not been well correlated, suggesting that nest success information derived from plumage patterns is unreliable.

The pattern of disagreement between estimated P9 nest success and production as measured by the ratio of chicks per hen is historically consistent, with no significant correlation between the two values at the statewide level since current data collection began in 1993. Long-term lack of correlation between these two values may suggest that variability in nesting and hatch dates due to climatological factors limits the utility of a single morphometric measure of nest success over time. Current methods for determining apparent nest success may be more useful as a measure of relative date of nesting between years than as a comparison of nest success between years. Further research is needed to develop accurate methods of determining nest success from wing data.

Table A4. 6. Sage-grouse nesting success as indicated by retention of at least primary feather P9, all wildlife management units with sage-grouse harvest, Oregon, 1993 – 2020.

Year	Nest Success (Retention of P9 and Lower)
1993	40
1994	40
1995	43
1996	51
1997	*No Data*
1998	30
1999	46
2000	45
2001	49
2002	47
2003	54
2004	35
2005	34
2006	49
2007	35
2008	48
2009	49
2010	37
2011	46
2012	63
2013	47
2014	52
2015	27
2016	30
2017	32
2018	46
2019	45
26-Year Average	*43*
2020	33

Table A4. 7. Sage-grouse nesting success as indicated by retention of at least primary feather P9, and production rates, all WMUs with sage-grouse harvest, Oregon, 2020.

WMU	Adults			Yearling			All Hens			Harvest Age Composition			Production	
	Successful Adult Females (n)	Total Adult Females (n)	Adult Nest Success (%)	Successful Yearling Females (n)	Total Yearling Females (n)	Yearling Nest Success (%)	Successful Females (n)	Total Females (n)	Nest Success (%)	Total Harvest (n)	Juveniles in Harvest (n)	Juveniles in Harvest (%)	Juveniles per Female	Juveniles per Successful Female
Beatys Butte	7	14	50	4	6	67	11	20	55	49	17	35	0.85	1.55
Beulah	1	13	8	1	1	100	2	14	14	24	5	21	0.36	2.50
E. Whitehorse	0	4	0	0	0	NA	0	4	0	17	8	47	2.00	NA
Malheur River	3	4	75	0	0	NA	3	4	75	7	1	14	0.25	0.33
Owyhee	1	2	50	0	1	0	1	3	33	7	4	57	1.33	4.00
Silvies	0	0	NA	0	0	NA	0	0	NA	4	4	100	NA	NA
Steens Mtn.	1	3	33	0	1	0	1	4	25	4	0	0	0.00	0.00
Trout Creek Mtns.	1	4	25	2	3	67	3	7	43	16	9	56	1.29	3.00
Wagontire[a]	0	4	0	0	1	0	0	5	0	12	4	33	0.80	NA
Warner	1	6	17	0	0	NA	1	6	17	35	23	66	3.83	23.00
All Areas (P9 or lower)	15	54	28	7	13	54	22	67	33	175	75	43	1.12	3.41
All Areas (P10 or lower)	23	54	43	13	13	100	36	67	54	175	75	43	1.12	2.08

[a]WMU partially closed to hunting.

Figure A4. 2. Oregon sage-grouse production values (chicks per hen) and 28-year average (dashed line; 1993 - 2020) estimated from hunter harvested wing analyses, 1993 – 2020.

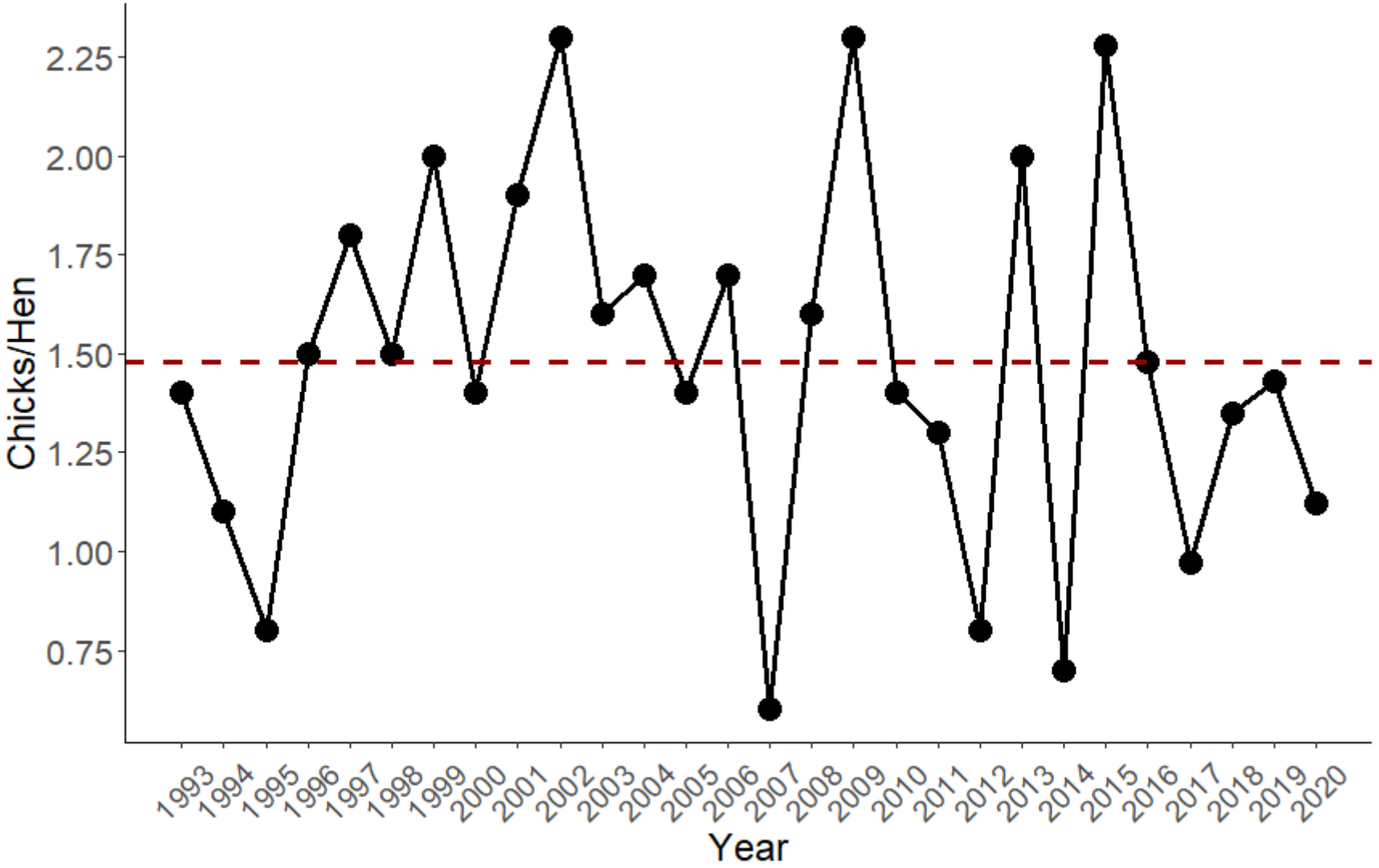
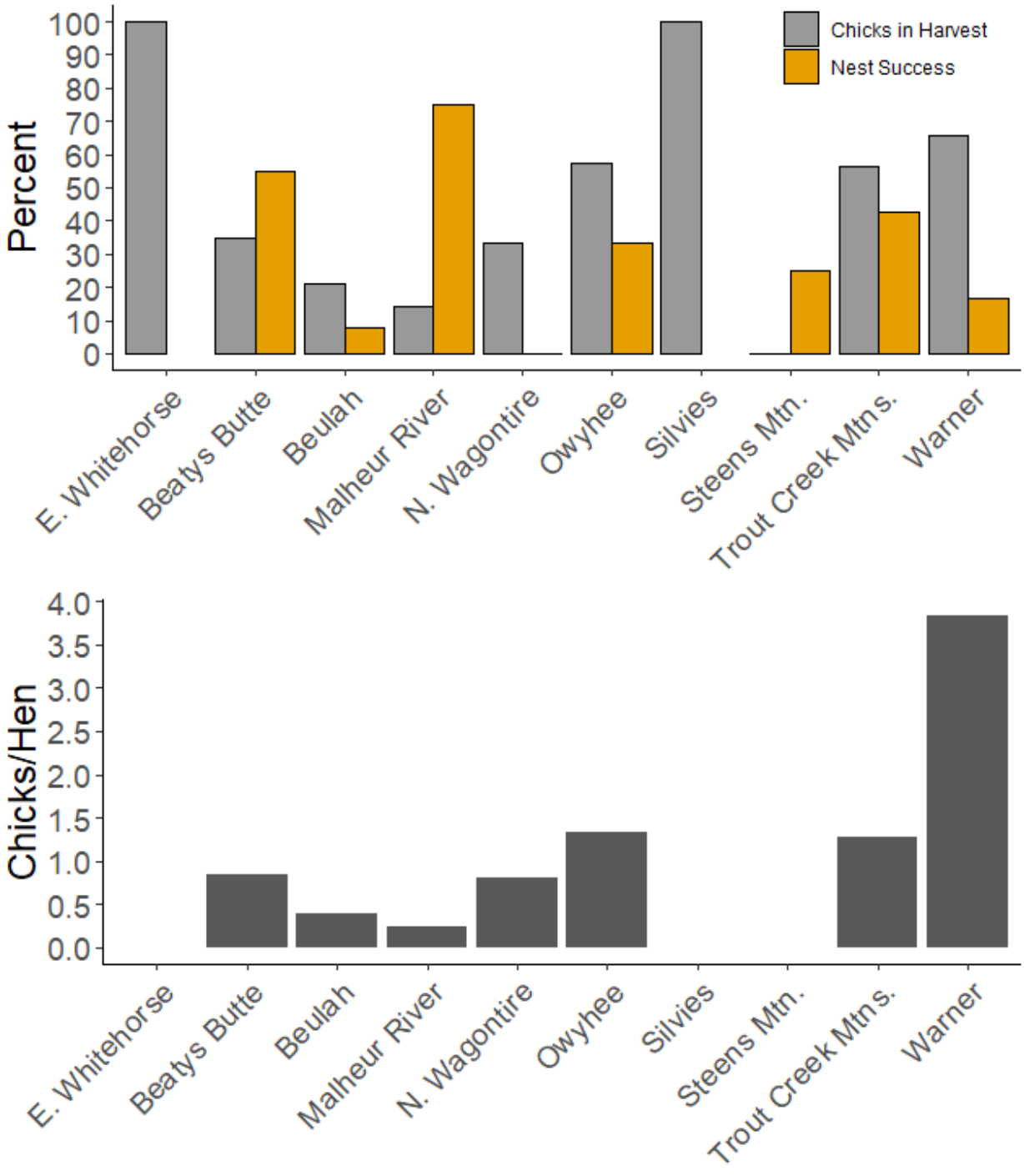


Figure A4. 3. Nest success, proportion juveniles in the harvest, and chicks per hen by WMU where sage-grouse harvest occurred, Oregon, 2020. Missing data in the Steens WMU reflects lack of harvested chicks in 2020. Missing data in the E. Whitehorse, N. Wagontire, and Silvies WMUs reflects apparent nest success of 0 for the hens harvested in these WMUs.



Hatching Chronology

Where possible, the length of the most recently replaced actively growing adult primary (usually P8 or P7) was recorded for juveniles. Ages of juveniles were calculated using growth data modified from captive-reared sage-grouse (Pyrah 1963). However, there is some evidence to suggest growth rates between wild and captive birds differ. Thus, the estimated hatch dates (Tables A4.8, A4.9) may be up to seven days earlier than the actual hatch date.

Hatching in 2020 began in late April and lasted through 27 June. Typically, hatching chronology estimates in Oregon have suggested that peak male hatching occurs approximately 1 week prior to peak female hatching, likely due to flaws in the primary growth curves used to estimate hatch date. However, hatching chronology estimates in 2020 were similar for male and female chicks, with peak hatching for both sexes occurring between May 15–21 (Figure A4.4). Notably, 22% of males were estimated to have hatched prior to May 8, where 0% of females were estimated to have hatched during this timeframe (Figure A4.4, Table A4.9).

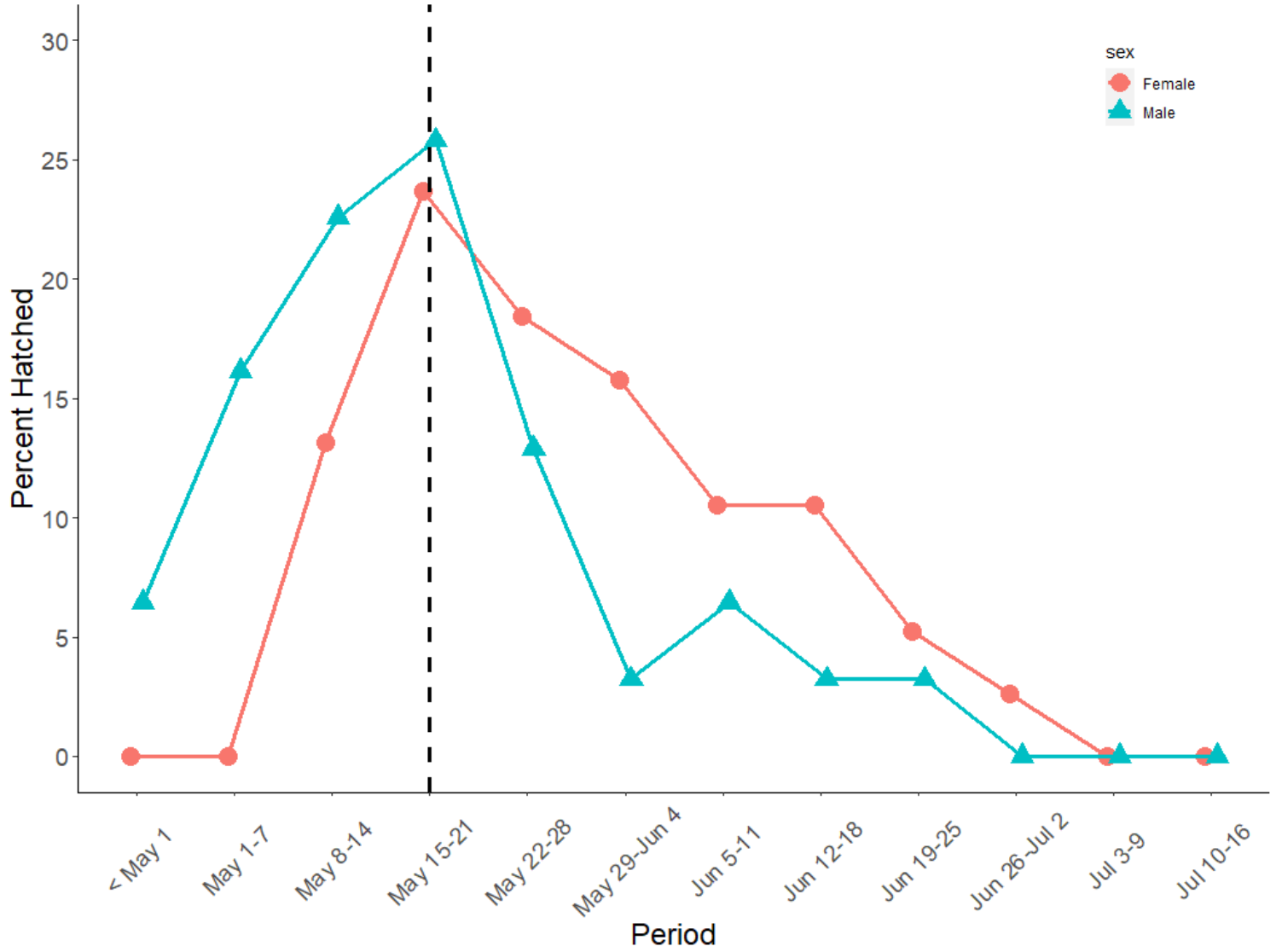
Table A4. 8. Estimated hatch dates for juvenile sage-grouse (% of total) from hunter-harvested wings, Oregon, 1993 – 2020.

		May					June				July		
Year	N	<1	1-7	8-14	15-21	22-28	29-4	5-11	12-18	19-25	26-2	3-9	10-16
1993	205		1	10	21	18	13	16	13	8	1	1	1
1994	327	1	9	22	18	16	11	12	8	3	1	1	-
1995	163	1	8	13	21	9	8	12	13	6	7	2	-
1996	253	2	9	15	12	14	11	17	10	4	2	3	1
1997	313	8	8	17	15	12	17	15	5	3	1	1	-
1998	229	2	10	13	15	18	14	10	3	7	2	4	1
1999	373	3	5	16	17	16	11	13	8	8	2	1	-
2000	260	7	7	17	18	16	15	14	4	2	1	-	-
2001	359	2	7	13	16	16	17	12	10	5	3	-	-
2002	373	5	6	17	13	21	13	13	4	4	3	1	-
2003	314	4	9	10	15	13	15	13	11	7	4	1	-
2004	398	3	10	24	24	14	11	8	5	2	1	-	-
2005	68	4	9	22	15	9	11	11	9	6	3	2	-
2006	323	1	3	10	12	12	18	21	15	7	1	1	-
2007	135	3	7	16	16	21	15	14	5	2	0	1	-
2008	241	3	7	10	12	15	15	15	8	8	7	-	-
2009	279	3	12	17	21	13	13	11	5	3	1	<1	-
2010	221	<2	6	9	18	13	15	14	13	4	4	<2	-
2011	178	-	<1	6	10	16	13	17	10	13	8	5	3
2012	94	3	5	25	14	16	11	10	11	5	-	-	-
2013	138	4	17	17	20	14	9	9	8	2	<1	-	-
2014	71	8	21	24	14	11	8	6	7	-	-	-	-
2015	152	3	17	28	15	9	14	8	6	1	1	-	-
2016	136	7	11	22	20	22	9	5	3	-	1	-	-
2017	96	6	6	17	21	20	9	11	6	2	1	-	-
2018	94	-	6	15	29	21	12	11	5	-	-	1	-
2019	67	15	6	12	13	16	10	15	7	3	1	-	-
2020	69	3	7	17	25	16	10	9	7	4	1	-	-

Table A4. 9. Estimated hatch dates, from hunter-harvested wings, for juvenile sage-grouse in Oregon, 2020.

	Males			Females			All Chicks		
Period	n	%	Cumulative %	n	%	Cumulative %	n	%	Cumulative %
< May 1	2	6	6	0	0	0	2	3	3
May 1-7	5	16	23	0	0	0	5	7	10
May 8-14	7	23	45	5	13	13	12	17	28
May 15-21	8	26	71	9	24	37	17	25	52
May 22-28	4	13	84	7	18	55	11	16	68
May 29-Jun 4	1	3	87	6	16	71	7	10	78
Jun 5-11	2	6	94	4	11	82	6	9	87
Jun 12-18	1	3	97	4	11	92	5	7	94
Jun 19-25	1	3	100	2	5	97	3	4	99
Jun 26-Jul 2	0	0	100	1	3	100	1	1	100
Jul 3-9	0	0	100	0	0	100	0	0	100
Jul 10-16	0	0	100	0	0	100	0	0	100

Figure A4. 4. Estimated hatch dates of male and female juvenile sage-grouse (% hatched during period), from hunter-harvested wings, Oregon, 2020.



Annual Turnover

Analysis of annual turnover provides a rough estimate of adult mortality, assuming population stability. As during previous years, the data for annual turnover, when based on the proportion of yearlings in the fall harvest, were too marginal for analysis. Few yearlings were identifiable in 2020 (N = 14; 1 male, 13 females), likely due to typically early nesting in Oregon, corresponding to an early start of the primary molt. Generally, the timing of breeding and nesting in Oregon is earlier than in populations which occur in the eastern portion of the sage-grouse distribution and in populations occupying higher elevations (Connelly et al. 2011), leading to a comparatively earlier molt in Oregon. Thus, the proportion of juveniles in the fall harvest of each sex was compared to the proportion of adults and yearlings (combined) of each sex to examine annual turnover (Table A4.10). This method is valid if one assumes the proportion of juveniles equals the annual loss of yearlings and adults. If the population was stable, annual mortality of adult and yearling males, and adult and yearling females would be 52%, and 44%, respectively (based on the 27-year average; Table A4.10).

Table A4. 10. Estimated annual turnover (%) of adult sage-grouse, assuming population stability, Oregon, 1993-2020.

	Males		Females	
Year	Young	Adults/Yearling	Young	Adults/Yearling
1993	54	46	41	59
1994	54	46	36	64
1995	44	56	31	69
1996	60	40	46	54
1997	61	39	49	51
1998	56	44	44	56
1999	60	40	52	48
2000	45	55	43	57
2001	61	39	49	51
2002	64	36	52	48
2003	50	50	47	53
2004	57	43	47	52
2005	47	53	43	57
2006	47	53	48	52
2007	33	67	25	75
2008	68	32	46	54
2009	58	42	55	45
2010	55	45	44	46
2011	42	58	43	57
2012	27	73	31	69
2013	69	31	50	50
2014	31	69	31	69
2015	61	39	56	44
2016	51	49	41	59
2017	45	55	36	64
2018	37	63	46	53
2019	54	46	44	56
27-yr Avg	*52*	*48*	*44*	*56*
2020	50	50	39	61

Conclusions

Oregon's sage-grouse hunting seasons are based on a long history of population monitoring and research. The current permit system allows ODFW to closely control legal harvest of sage-grouse. Each year, ODFW projects the fall population of sage-grouse based on lek counts. In 2020, ODFW estimated there were 11,650 sage-grouse in the fall population in the 9 WMUs where sage-grouse hunting is permitted. ODFW offered 630 permits, of which 378 tags were issued, and an estimated 301 individuals chose to hunt (Table A4.11). This was a slight reduction in the number of authorized permits from 2019 levels (645 permits).

In 2019, the methodology to estimate the fall sage-grouse population was updated to reflect the best available science. In the place of brood route-derived estimates of chicks per hen, a conservative estimate of summer production (0.50 chicks/hen) was used to estimate fall population size in all units. Historically, fall population estimates were generated using an estimate of chick production derived from summer brood route observations. However, analysis of brood route data revealed no long-term correlation between the chicks per hen ratios derived from brood routes and those derived from the wing analysis. Given this lack of correlation, brood route chick production estimates for sage-grouse in Oregon are likely unreliable and, thus, inappropriate to use during the harvest tag allocation process. The updated methodology reduced the estimated fall population size in all units and the numbers of permits offered were reduced in 2019 in the Beatys Butte, Steens Mountain, and Warner WMUs. Permits in the other 5 WMUs were not reduced, due to harvest allocation in those units already existing well under the level needed to maintain harvest at <5% of fall population size. This updated methodology was used in 2020 to estimate the fall sage-grouse population and will be used in future years as well.

ODFW has a self-imposed policy not to harvest more than 5% of the fall population, with harvest usually estimated at around 3% of the fall population. This harvest strategy is well within the guidelines suggested by the Western Association of Fish and Wildlife Agencies (Connelly et al. 2000). In addition, it is well below the <11% harvest rate identified as unlikely to influence sage-grouse populations in Nevada and Colorado (Sedinger et al. 2010).

Compared to other states that offer a sage-grouse hunting season, Oregon's hunting season is likely the most conservative:

- Oregon's sage-grouse season is limited-entry for each WMU.

- Sage-grouse are not hunted range-wide in Oregon. Hunting is permitted in only 9 of 21 WMUs where sage-grouse occur (Figure A4.1).
- Permit numbers are allocated to take no more than 5% of the fall population in hunted WMUs (typically 3% or less in practice).
- Each permit holder is allowed to harvest only 2 sage-grouse per season.
- In 2020, estimated harvest of sage-grouse was 273 birds, 2.3% of the estimated 11,650 sage-grouse in potential hunt areas.

Through the collection of hunter-harvested wings, Oregon's sage-grouse hunting season provides crucial demographic data regarding the structure of sage-grouse populations in Oregon. This data would be costly or unfeasible to collect through other means.

Table A4. 11. Estimated fall sage-grouse population, maximum allowable harvest, hunter statistics, and permit allocation in Oregon wildlife management units where sage-grouse harvest is permitted, 2020.

WMU	Estimated Fall Population	Harvest Limit (5%)	Birds/Hunter[a]	Hunter Participation Rate[a]	2020 Permits
Silvies	884	44	0.62	0.58	20
North Wagontire	708	35	0.62	0.58	20
Beatys Butte	1566	78	1.12	0.72	80
Steens Mtn.	754	38	1.12	0.72	30
Warner	1052	53	1.12	0.72	60
Beulah	1502	75	0.72	0.31	150
Malheur River	1447	72	0.72	0.31	100
Owyhee	874	44	1.27	0.47	70
Trout Creek Mtn.	1325	66	1.34	0.45	30
East Whitehorse	1538	77	1.34	0.45	70
Total	11,650	582	-	-	630

[a]Hunter statistics based on average from hunter harvest survey by Data Analysis Unit (DAU) for years 2014 – 2019.

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