



Moose (*Alces alces*) population survey in Yukon-Charley Rivers National Preserve, November 2022

Natural Resource Report NPS/YUCH/NRR—2023/2589



ON THE COVER

Bull moose butting heads in Yukon-Charley Rivers National Preserve, November 2022.

Photograph by: Matt Cameron

Moose (*Alces alces*) population survey in Yukon-Charley Rivers National Preserve, November 2022

Natural Resource Report NPS/YUCH/NRR—2023/2589

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Executive Summary

- Overall survey dates: November 6-19, 2022 (10 days of survey, 3 weather days)
- Total survey area: 3,096 mi² (8,018 km²), 555 survey units
- Area surveyed: 614 mi² (1,590 km²), 110 survey units
- Total moose observed: 183 (101 cows, 21 calves [2 set of twins], 61 bulls)
- Average search effort: 5.9 minutes/mi² (3.5 minutes/km²)
- Population estimate: 738 moose (90% CI: 548-928; +/-26%); long-term average 848 moose
- Estimated density: 0.24 moose/mi² (0.62 moose/km²); long-term average 0.27 moose/mi²
- Estimated age/sex ratios: 19 calves:100 cows, 7 yearlings bulls:100 cows, 60 bulls:100 cows

Acknowledgments

This survey was funded by the U.S. National Park Service and Yukon-Charley Rivers National Preserve, Alaska, and was made possible by funding from the Inflation Reduction Act project “Enhancing Climate Change Resilience and Food Security Through Co-Stewardship Capacity Building.” Many safe flight hours and aircraft support were provided during the survey by pilots Don Welty, Nick Thompson, Paul Anderson, and Jake Combs. Jordan Pruszenski, Matt Cameron, Will Deacy, and Mat Sorum served as observers in aircraft, and we thank all observers for their help and dedication to the survey. We thank Jeff Wells and Mark Nelson for providing invaluable input on earlier versions of this report.

Introduction

Moose (*Alces alces*) are an integral component of the boreal ecosystem in Yukon-Charley Rivers National Preserve (YUCH). Moose are considered good indicators of long-term habitat change within the Preserve ecosystem because they require large quantities of resources from their habitat year-round, and populations have the potential to respond to long-term changes in resource conditions. In addition, moose are an important subsistence and sport hunting resource, and are named specifically in the founding legislation for the Preserve (ANILCA, 1980). The Central Alaska Network (CAKN) of the National Park Service (NPS) designated monitoring fauna distribution and abundance as 1 of the top 3 Vital Signs for the Network. Moose were identified as one such species to monitor as they are a common herbivore present in all 3 park units and indicate the health of lower elevational ecosystems (relative to the elevations within the Network). The CAKN is monitoring animal species across an elevational gradient as part of an effort to track long-term changes in ecosystems across 3 Alaskan park units (YUCH, Denali National Park and Preserve, and Wrangell-St. Elias National Park and Preserve). Moose surveys are scheduled for each park unit every 3 years.

YUCH conducted an aerial moose survey during November 6 - 19, 2022, in and around Yukon-Charley Rivers National Preserve (YUCH), Alaska (Figure 1). Moose surveys have been conducted within YUCH for 35 years (Appendix A) and 9 surveys have been conducted within the current survey area over the last 25 years.

The objectives of the 2022 moose survey were to: 1) estimate numbers of total moose in a 3,096 mi² survey area of the Preserve and 2) estimate sex and age ratios.

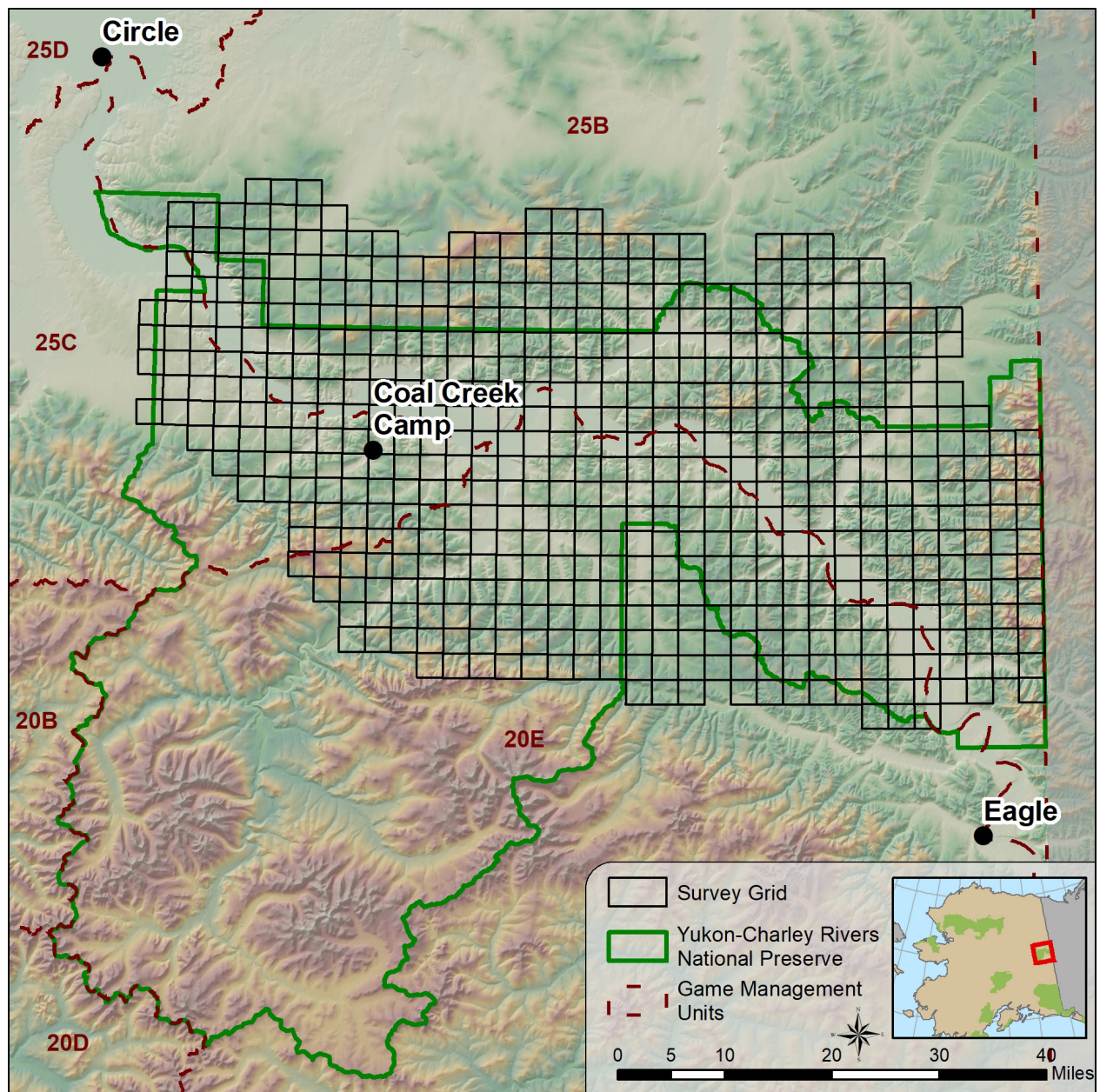


Figure 1 Location of moose survey units within and around Yukon-Charley Rivers National Preserve (YUCH), Alaska. State of Alaska Game Management Unit (GMU) boundaries are indicated in maroon.

Study Area

The moose survey was conducted along a 30-40 mile- (48-64 km) wide corridor of the Yukon River drainage within and around YUCH, between Eagle and Circle, Alaska (Figure 1). The topography of the area consists mainly of rolling hills and river bluffs (Figure 2). Isolated rugged terrain occurs on several eroded mountains, with peaks generally under 6000 feet (1800 meters). Vegetation is dominated by black spruce (*Picea mariana*) and several species of deciduous hardwoods including aspen (*Populus tremuloides*) and birch (*Betula papyrifera*). Ponds, sloughs, and large areas of tussock tundra are common in the flats along the Yukon River and lower parts of large tributaries such as the Charley and Kandik rivers. Wildfire burns of varying sizes and ages are present throughout the study area including the more recent large fires from the summers of 1999 and 2004 along the Yukon, Nation and Kandik rivers.



Figure 2. Typical topography and vegetation of the survey area. Foothills of the confluence of the Charley River and Yukon River, photo by Matt Cameron.

Methods

Moose population surveys were conducted using the GeoSpatial Population Estimator (GSPE) method (Ver Hoef 2008), a modification of a technique initially developed by Gasaway et al. (1986). The GSPE method is widely used in Alaska, which allows comparison between survey areas. The publications, “GeoSpatial Survey Operations Manual” (Kellie and DeLong 2006) and “GeoSpatial Population Estimator Software User’s Guide” (DeLong 2006) provide guidelines for sample unit design and selection, navigation, and data analysis.

For the 2022 survey, we modified the 2019 aerial stratification. The aerial stratification was flown in November 2019 and followed the protocol described in Kellie and DeLong (2006). In either a Cessna 185 or a Found Bush Hawk, 3 observers with the pilot followed centerline transects through all the survey units at speeds ranging from 100-140 knots and at an altitude of 800-1500 ft above ground level. The presence of moose, moose sign, and predominant habitat were recorded. If any moose were detected, a unit was classified as a high stratum. If no moose were detected, presence of tracks and predominant habitat were used to determine strata, with deciduous shrub habitat (such as burned areas, high elevation shrub lines, and riparian corridors) characterizing high stratum (Schwartz and Franzmann, 1989, MacCracken et al. 1997). For units which were of questionable stratum and were surveyed previously, we used information from the last 3 surveys to help inform stratum classification (Kellie and DeLong 2006). To update the aerial survey for 2022, we changed units from low to high strata if they had 3 or more moose during the 2019 survey. This resulted in 208 high units and 347 low units (Table 1 and Figure 3).

Sample units to survey were randomly selected from each density strata following Kellie and DeLong (2006). We withheld 20% of the units from the random selection and subjectively used them to fill in-between blocks of units because the GSPE has a spatial component whose results are improved if there are no large gaps (> 50 km) among surveyed units. Because observations are more variable in the high stratum than the low stratum, we allocated greater sample effort to the high-density units to reduce overall variance (Kellie and DeLong 2006). We selected 120 units to survey out of the 555 total units, with a goal to sample approximately 35% and 10% of the high and low stratum units, respectively.

For the survey, four tandem seat fixed-winged aircraft (Piper PA-18 and Top Cub CC-18) were used to survey ~ 5.6 mi² units that were delineated by 2 minutes of latitude by 5 minutes of longitude. Aircrafts used Global Positioning System (GPS) to navigate to and within assigned units and search intensity varied with habitat. The survey protocol required high search intensity in forested habitats (8-10 minutes per square mile) and lower intensity in open habitats or areas with significant water. Survey patterns varied according to terrain. Within lowland area, survey aircrafts generally flew transects about 300 to 800 feet AGL at 70 knots. Within mountainous terrain, survey aircrafts followed the contour of the mountains.

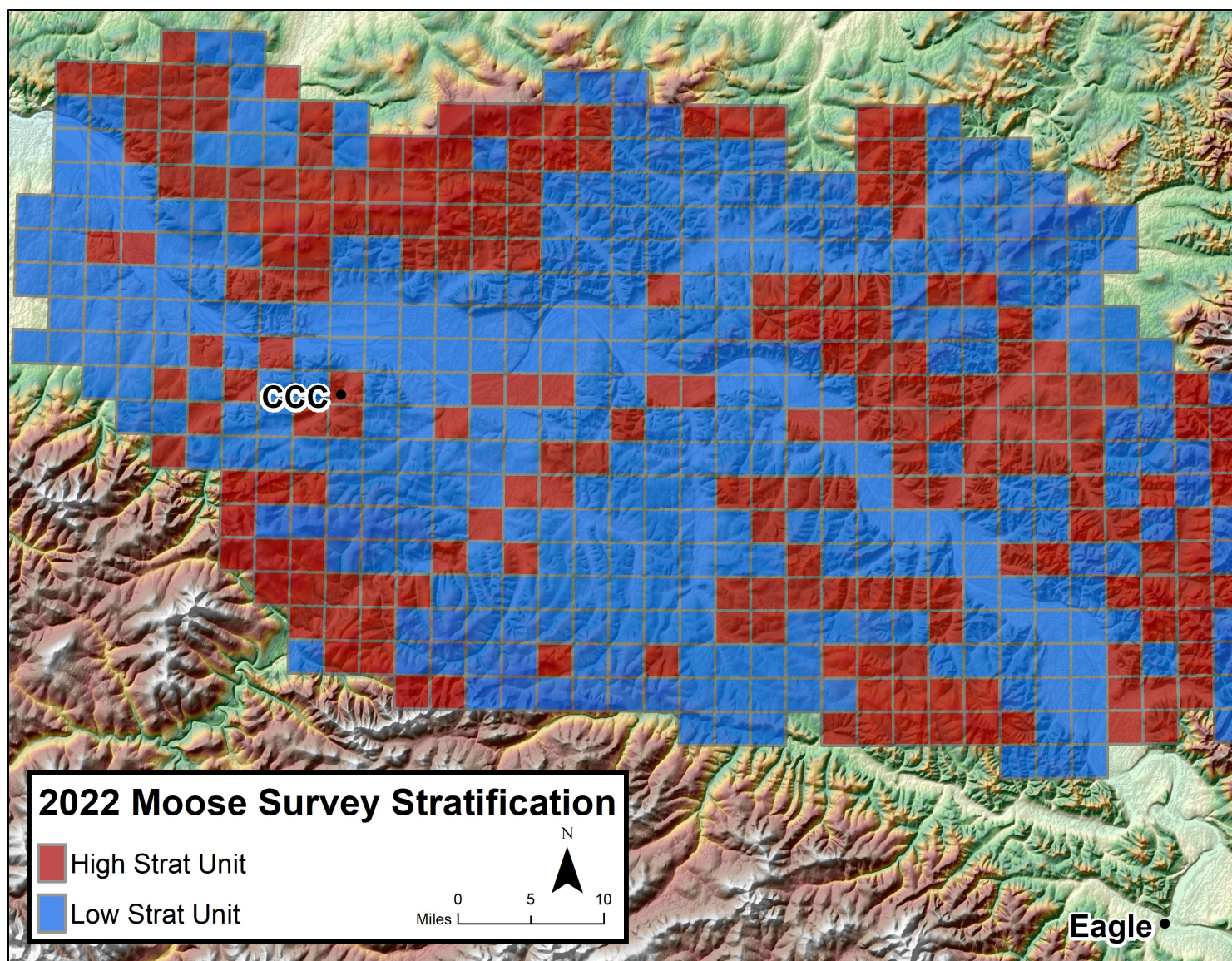


Figure 3. Map of stratification used during the 2022 fall moose survey in Yukon-Charley Rivers National Preserve, November 2022. High units are colored red, low units are colored blue, and “CCC” indicates Coal Creek Camp.

An observer was paired with each pilot, and the observer's job was to record data on an iPad using the NPS application, "Park Observer," (developed by the Alaska Regional GIS Team). iPads were loaded with base maps, the survey grid, and the remaining units to be surveyed each day. Using the Park Observer "Fall Moose Comp" (v1.1) protocol, the observer recorded the track log as well as moose group location and composition which were detected during the survey. Numbers of moose in each group were recorded and the sex and age classification of each moose was determined. Moose were classified as: cow, calf, yearling bull (spike or forked antlers), medium bull (antler spread > spike/fork, but < 50 inches [127 cm]), and large bull (antler spread $\geq$ 50 inches [127 cm]). Total moose, moose density and sex/age ratios were calculated using the GeoSpatial Population Estimator software (DeLong 2006, Kellie and DeLong 2006).

Results

Weather and Snow Conditions

Coal Creek weather station recorded 3.9" of snow depth at the beginning of the survey and 4.8" by the end (MesoWest). Snow cover throughout the study area was complete with some vegetation showing. Lighting most days was excellent. Temperatures ranged from 1°F to 42°F at the Eagle weather station during the project (MesoWest). Although snow depth was below recommended levels, recent snow fall, complete snow cover, and good weather were factors used to decide to initiate the survey. High winds gusting to 20-30 knots near Eagle caused the survey to be delayed for 3 days from Nov. 14 - 16 and created some patches of bare ground north of Eagle. The Yukon River was partially frozen-over during the survey, with the ice edge initially beginning approximately halfway across the study area and building upstream throughout the survey.

Survey Details

The survey was conducted between 6-19 November, completing 110 of 555 survey units which covered 20% of the survey area (Figure 3, Table 1). Seventy-five (36%) of the high-density units and 35 (9%) of the low-density units were surveyed (Table 1). A total of 60.0 hours of flight time was spent searching for moose for an average of 33.0 minutes per survey unit. Search intensity averaged 5.9 minutes per mi² (3.5 minutes/km², Table 2). Five high strata units and 5 low units were not completed north of Eagle because of windy conditions.

Aviation and project costs for the 2022 YUCH fall moose survey are found in Appendix B. Complete survey results for the entire 2022 survey are archived in, and can be retrieved from, the ADFG WINFONET database under the survey name "YUKON-CHARLEY, Fall, 2022" (<http://winfonet.alaska.gov/>; accessed 20 December 2022) as well as the NPS repository IRMA ("Moose (*Alces alces*) population survey in Yukon-Charley Rivers National Preserve, November 2022"; Code: 2301349).

Table 1. Summary of stratification and sampled units from GSPE moose population surveys in Yukon-Charley Rivers National Preserve, 2003 to 2022. Areas are presented as square miles and number of survey units are in parentheses.

Survey Year	Survey Area	Sample Area	% Sampled	Stratification		Survey	
				High	Low	High	Low
2003	3157 (566)	591 (106)	18.7	1049 (188)	2108 (378)	340 (61)	251 (45)
2006	3096 (555)	841 (151)	27.2	899 (161)	2197 (394)	540 (97)	301 (54)
2009	3096 (555)	618 (111)	20.0	899 (161)	2197 (394)	329 (59)	289 (52)
2012	3096 (555)	664 (119)	21.4	899 (161)	2197 (394)	362 (65)	301 (54)
2015	3096 (555)	714 (128)	23.0	949 (170)	2147 (385)	458 (82)	256 (46)
2019	3096 (555)	670 (120)	21.6	1127 (202)	1969 (353)	447 (80)	223 (40)
2022	3096 (555)	614 (110)	19.8	1160 (208)	1936 (347)	419 (75)	195 (35)

Population Estimate

The GSPE population estimate for observable moose in YUCH was 738 moose (90% confidence interval [CI] = 548-928 [26% relative precision]) which yielded a density of 0.24 moose/mi² (0.09 moose/km²) (Figure 4) (Table 2).

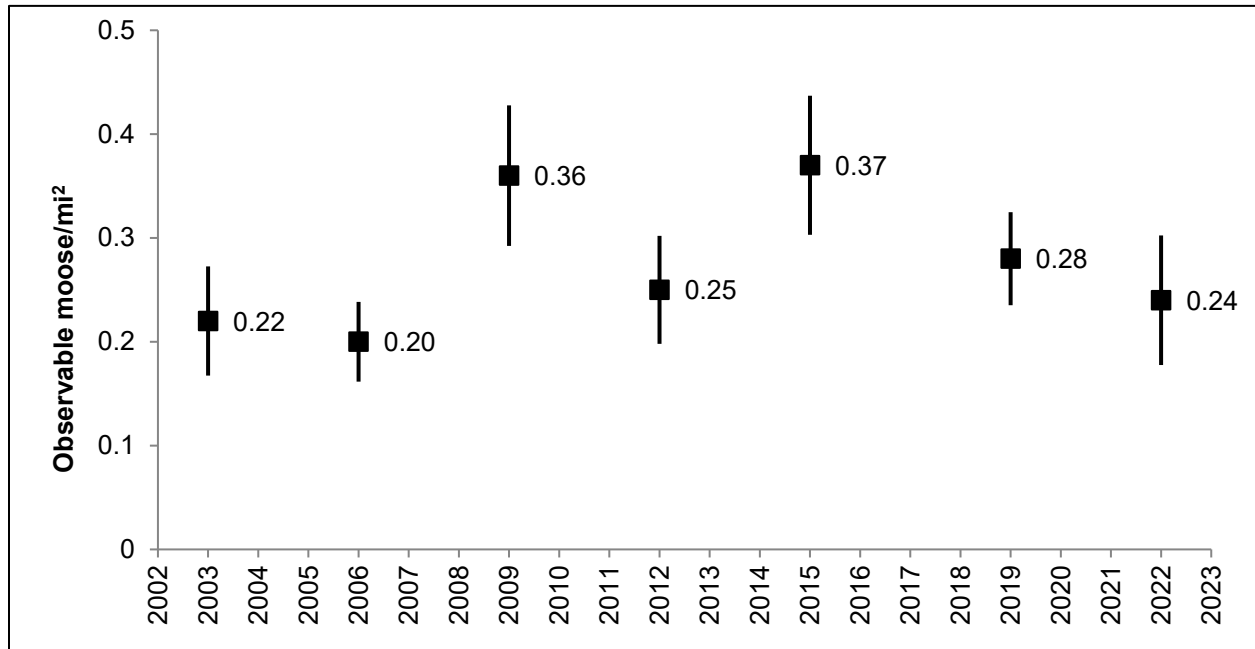


Figure 4. Moose densities (moose/mi²) with 90% confidence intervals for Yukon-Charley Rivers National Preserve from GSPE surveys from 2003-2022, Alaska.

Table 2. Summary of GSPE survey statistics and density estimates for moose population surveys in Yukon-Charley Rivers National Preserve, 2003 to 2022. Average at bottom row includes all surveys presented.

Survey Year	Method	Survey Area mi ² (# units)	Sampled Area mi ² (# units)	Search Intensity (min/mi ²)	Population Estimate	Relative Precision	Density (moose/mi ²)
2003	GSPE	3157 (566)	591 (106)	6.6	696	0.24	0.22
2006	GSPE	3096 (555)	841 (151)	5.4	605	0.19	0.20
2009	GSPE	3096 (555)	618 (111)	6.7	1109	0.19	0.36
2012	GSPE	3096 (555)	664 (119)	6.0	780	0.21	0.25
2015	GSPE	3096 (555)	714 (128)	5.0	1138	0.18	0.37
2019	GSPE	3096 (555)	670 (120)	5.7	873	0.16	0.28
2022	GSPE	3096 (555)	614 (110)	5.9	738	0.26	0.24
Average	–	–	673 (121)	5.9	848	0.20	0.27

Sex and Age Composition

The sex and age composition of the 183 observed moose were as follows: 101 cows, 61 bulls, and 21 calves (Table 3). Composition of the observed bulls included 6 yearling bulls (spiked or forked antlers), 29 medium bulls, and 26 large bulls. No single-antlered bulls were observed, suggesting that antler shedding was not an issue for the survey. The estimated sex and age ratios of the population were 19 calves:100 cows (90% CI = 12-26), 7 yearling bulls (spike/fork):100 cows (90% CI = 3-11), and 60 bulls:100 cows (90% CI = 35-85; Table 3). Two sets of twins were observed in the survey (Table 3).

Table 3. Summary of observed moose during the surveys in Yukon-Charley Rivers National Preserve, 2003 to 2022. Sex and age ratios were calculated in WinfoNet for GSPE surveys and 90% confidence intervals for these are reported in parentheses. Average at bottom row includes all surveys presented.

Survey Year	Area (mi²)	Total Bulls	Total Cows	Total Calves	Total Moose	Bulls/ 100 Cows	YrIBulls/ 100 Cows	Calves/ 100 Cows	% Bulls	% Cows	% Calves	Sets of Twins
2003	591	55	87	17	159	60 (38-82)	6 (2-11)	25 (13-37)	35	55	11	1
2006	841	63	89	28	180	73 (53-94)	7 (2-11)	33 (21-46)	35	49	16	5
2009	618	102	164	42	308	60 (40-79)	13 (8-18)	27 (17-37)	33	53	14	4
2012	664	80	118	25	223	68 (46-89)	11 (5-17)	24 (15-33)	36	53	11	0
2015	718	105	165	44	314	72 (50-94)	4 (2-6)	25 (17-32)	33	53	14	4
2019	670	70	142	37	249	49 (34-65)	2 (0-3)	28 (19-36)	28	57	15	1
2022	648	61	101	21	183	60 (35-85)	7 (3-11)	19 (12-26)	33	55	12	2
Average	679	77	124	31	231	63	7	26	33	54	13	2

Discussion

Moose in Yukon-Charley Rivers National Preserve (Alaska GMU 20E, 25B, 25C, and 25D) have continued to occur at low densities over the past 30 years ranging from 0.20-0.37 moose/mi². The fall estimate of 738 observable moose resulted in a moose density of 0.24 moose/mi², or 0.09 moose/km². Continued conservative management of harvest is recommended including the conservation of cows.

The YUCH moose population trend over the last 20 years of GSPE surveys is suggestive of a generally stable but low-density population exhibiting fluctuations between survey periods. The 2022 moose population estimate represents 35% and 15% decreases from the most recent 2015 and 2019 survey estimates, respectively. Although the 2022 and 2019 estimates do not represent a significant decrease over the last 3 years, the 2022 estimate is significantly lower than the 2015 population estimate and below the long-term average (Table 2). Considered together, the high estimates recorded in 2009 and 2015 represented a 58% increase in moose density compared to the earlier estimates observed in the mid-2000s (2003, 2006; Figure 4). In a recent study of YUCH moose survey data, the YUCH population was found to be increasing at a rate of 2.3%/year and this increase was potentially driven by earlier wildfire extent that matured into high-quality moose habitat (i.e., 11-30 years old burns) within the Preserve (Schmidt et al. 2022). High-quality moose habitat should remain at relatively high levels as fires that occurred in 1999 and 2004 continue to mature into prime moose habitat. Yet the downward trend since 2015 suggests that a counter pressure is influencing the YUCH moose population. Multiple difficult winters characterized by deep snow and late springs have occurred since the 2015 moose survey, including the winters of 2019-20 and 2021-22 (Sousanes et al. 2022). These difficult winter conditions may have contributed to the significant decline in the moose population observed between 2015 and 2022. Similar declines in moose abundance have been reported across the region (Wells 2022, Carmello and Jamison 2023). We recommend that future analyses of moose population dynamics incorporate environmental conditions to disentangle these competing factors of habitat and the environment and that continued monitoring of the YUCH population be a priority.

The calf:cow ratio was the lowest recorded in the last 30 years in YUCH. Extreme climate conditions, including deep snow and a late spring, characterized the winter of 2021-22 in YUCH (Sousanes et al. 2022) and across the region (U.S. Department of Agriculture 2022). Low calf:cow ratios were reported across upper Tanana and upper Yukon watersheds (Wells 2022, Carmello and Jamison 2023), suggesting fall calf recruitment may have been low across the region. With changing climate, long-term monitoring programs are increasingly important for understanding how environmental extremes can impact population dynamics.

The relative precision of the total moose estimate for this survey ($\pm 26\%$) was the lowest recorded for all moose surveys conducted within YUCH (note that the greater the $\pm$ percentage is, the lower the relative precision is) and above the goal of the sampling strategy of achieving less than a 20% relative precision at a 90% confidence interval used by the Arctic Inventory and Monitoring Network (Sorum et al. 2018). We believe that the relatively poor precision was driven by a high proportion of units with no observed moose in high strata as we observed a greater proportion of units with zero

observed moose (50%) compared to the long-term average (35%). This suggests that there were too many units in the high strata that moose were not selecting for in early winter at the density we measured in this survey. Therefore, we suggest critically reviewing the high stratum units and converting units/areas in the high strata that have a history of low moose abundance to low-strata units. Based on previous survey data, we recommend reducing the number of units in the high strata that occur 1) along major rivers (e.g., Yukon River, Charley River, Nation River, Kandik River, 70-mile River, Tatonduk River) since moose seem to avoid rivers in the early winter and 2) in uplands that have a history of low moose abundance. We also suggest changing units/areas from low to high that have a recent history of high moose abundance and/or are within new burned areas that have recently aged into high quality moose habitat (i.e., 11-30 years old). Snow cover may have influenced detection probability as well, thus decreasing our precision, with the approximately 4" of snow cover at Coal Creek being one of (if not the) lowest recorded values for a moose survey in YUCH. Similar challenges have been noted for past surveys and have resulted in postponed surveys (Cameron and Schertz 2020), and these challenges reflect the realities of organizing a survey in an environment undergoing rapid climate changes. We note, however, that new methods such as the Bayesian Spatial GAM (BSG) provide the opportunity to reduce the error of single survey point estimates by analyzing multiple surveys across time (Schmidt et al. 2022), and so we expect the precision of this survey to be improved with further analysis.

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Appendix A. Early Survey Details

Tables A-1 and A-2 show summaries of moose populations in YUCH.

Table A-1. Summary of area and results during early moose population surveys in Yukon-Charley Rivers National Preserve, 1987 to 1999. Methodology followed variations of those described in Gasaway et al. (1986). Areas are presented as square miles and number of survey units are in parentheses. Results presented here because they are not directly comparable to the GSPE.

Survey Year	Method	Survey Area	Sample Area	% Sampled	Search Intensity (min/mi ²)	Population Estimate	Relative Precision	Density (moose/mi ²)	Sightability Correction Factor
1987 ^a	Gasaway	3556	240	6.7	4.4	1116	–	0.31	–
1994 ^a	Gasaway	2790	1844	66.1	1.0	551	0.23	0.20	1.34
1997	Stratified Random	2758 (201)	1358 (98)	49.2	3.9	602	0.20	0.22	1.22
1999	Stratified Random	2745 (200)	1389 (100)	50.6	4.0	830	0.19	0.30	1.18

Table A-2. Summary of observed moose during early surveys in Yukon-Charley Rivers National Preserve, 1987 to 1999. Results presented here because they are not directly comparable to the GSPE

Survey Year	Area (mi ²)	Total Bulls	Total Cows	Total Calves	Total Moose	Bulls/ 100 Cows	Yr/Bulls/ 100 Cows	Calves/ 100 Cows	% Bulls	% Cows	% Calves	Sets of Twins
1987	3556	88	73	7	169	121	14	10	52	43	4	0
1994	2790	147	176	37	364	84	7	21	40	48	10	1
1997	1358	136	197	51	384	60	8	28	35	51	13	3
1999	1389	169	266	77	513	51	5	36	33	52	15	6

Appendix B. Survey Logistics

Tables B-1 and B-2 show the aviation usage and overall costs associated with sampling moose at YUCH during the 2019 field season. Figure B-1 shows the flight paths used.

Table B-1. Aviation usage and cost during the 2022 fall moose survey.

Planes	Pilots	Description	Hours	Total
C-185	Paul Anderson, Nick Thompson	Shuttle	12	\$2,310
PA-18, Top Cub	Jake Combs, Don Welty, Nick Thompson Brett Nigus	Survey	117	\$24,800
Total	n/a	n/a	n/a	\$27,110

Table B-2. Overall project cost during 2022 fall moose survey

Category	Description	Quantity	Cost/Unit	Total
Food	–	–	–	\$1,800
Fuel	CCC/Eagle 100LL	1,046 gal	\$12	\$12,552
	FAI Ferry 100LL	168 gal	\$8	\$1,344
Aviation	Detailed in Table A	–	–	\$27,110
Total Costs	n/a	n/a	n/a	\$42,806

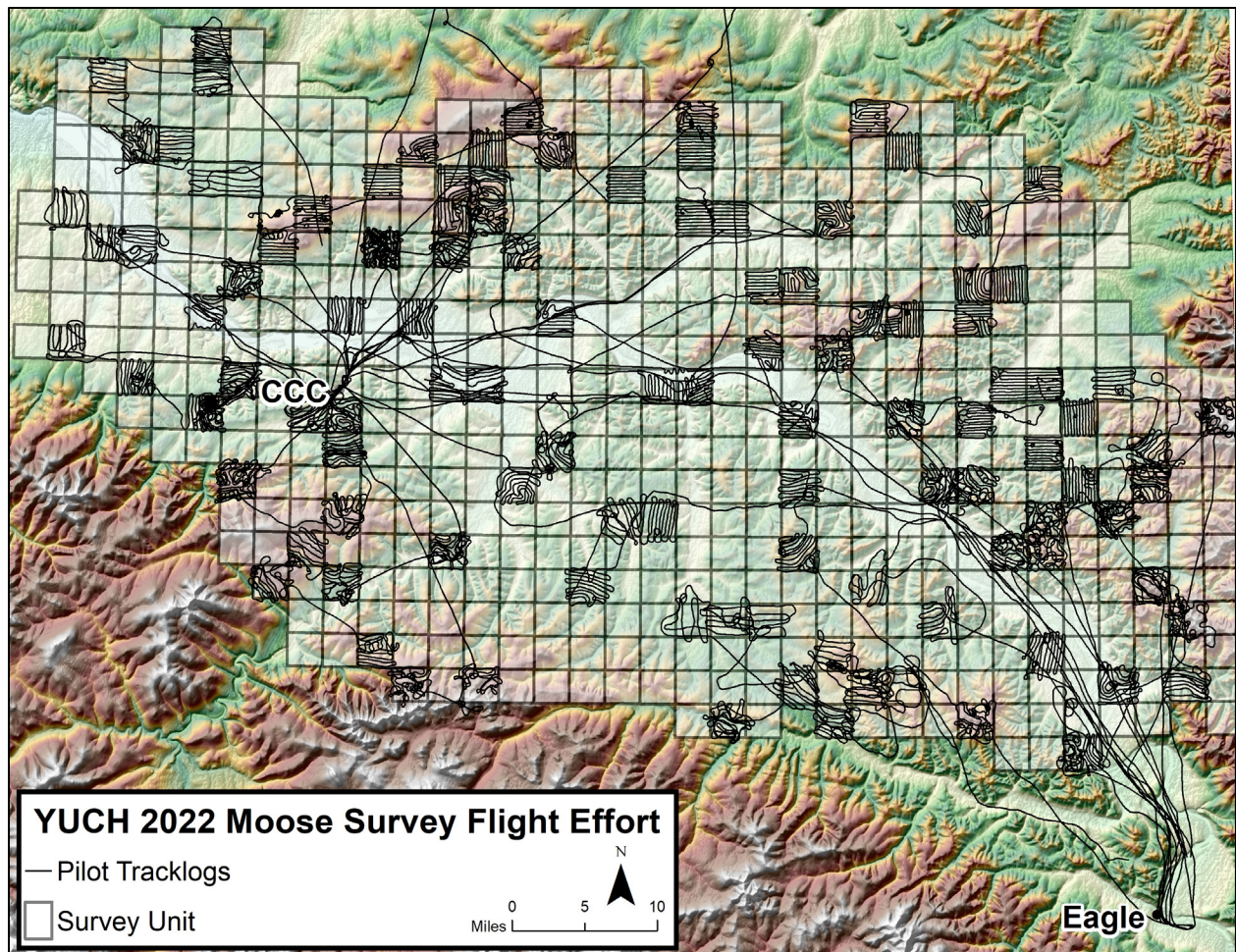


Figure B-1. Flight paths of the five planes that conducted the 2022 moose survey.

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