



Moose (*Alces alces*) Population Survey in and around Gates of the Arctic National Park and Preserve, March 2022

Natural Resource Report NPS/GAAR/NRR—2022/2467



ON THE COVER

Adult and calf moose standing in river bottom in Gates of the Arctic National Park and Preserve, March 2022.

NPS / JORDAN PRUSZENSKI

Moose (*Alces alces*) Population Survey in and around Gates of the Arctic National Park and Preserve, March 2022

Natural Resource Report NPS/GAAR/NRR—2022/2467

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U.S. Department of the Interior
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Executive Summary

Moose (*Alces alces*) are an integral component of the boreal ecosystem in Gates of the Arctic National Park and Preserve (hereafter “Park” or “GAAR”) and are considered good indicators of long-term habitat change within the Park’s ecosystem. From March 25 to 28, 2022, the National Park Service (NPS) surveyed moose in a 6,118mi² (15,846 km²) area in and around GAAR, which included the Alatna and John Rivers, as well as the North and Middle Forks of the Koyukuk River. We used the Geo-Spatial Population Estimator (GSPE) technique to estimate moose abundance for the entire survey area as well as three subareas of management interest. The population estimate for the entire survey area was 1,308 moose (90% confidence interval [CI] = 1,062–1,554) which yielded a density of 0.21 moose/mi² (0.08 moose/km²), and the calf ratio estimate was 10 calves:100 adults. The estimate for the GAAR subarea was 1,129 moose (90% CI = 915–1,342) and a density of 0.22 moose/mi². Our results suggest that there may have been a slight increase in moose abundance within GAAR since the previous population estimate in 2015, but deeper snow conditions this year compared to 2015 may have had an influence on our estimate.

Acknowledgments

This project was a multi-agency collaboration, and we are indebted to our colleagues with the US Fish and Wildlife (FWS) and the Bureau of Land Management (BLM) in supporting this important monitoring work. Many safe flight hours and aircraft support were provided by pilots Brett Nigus and Ed Mallek of FWS, Don Welty of NPS, Andy Greenblatt of Shadow Aviation, and Seth McMillan of BLM. Logistical support from NPS staff Chad Billock and Judd Manual, as well as Eric Burroughs of FWS, were instrumental in our operations out of Bettles. We thank Erin Julianus of BLM for logistical support in providing 400 gallons of fuel and Kanuti Refuge for the support in housing and hanger facilities in Bettles. We thank Mat Sorum, Kyle Joly, Erin Julianus (BLM) and Graham Frye (Alaska Department of Fish and Game) for providing invaluable input on earlier versions of this report. This survey was funded by NPS Gates of the Arctic National Park and Preserve and BLM.

Data Summary

Entire Survey Area

- March population estimate: 1,308 (90% confidence interval [CI] = 1,062–1,554 or $\pm 19\%$) moose
- Total area covered by survey: 6,118 mi² (15,846 km²)
- Estimated total density: 0.21 moose/mi² (0.08 moose km²)
- Estimated ratios: 10.2 calves:100 adults
- Total moose observed: 238 moose (216 adults and 22 calves)
- Survey Dates: 25–28 March, 2022

Gates of the Arctic National Park and Preserve (GAAR) Subarea

- March population estimate: 1,129 (90% CI = 915–1,342 or $\pm 19\%$) moose
- Total area covered by survey: 5,106 mi² (13,225 km²)
- Estimated total density: 0.22 moose/mi² (0.09 moose km²)
- Estimated ratios: 9.4 calves:100 adults
- Total moose observed: 198 moose (181 adults and 17 calves)

Middle and North Fork Koyukuk River Drainage (KRD) Subarea

- March population estimate: 637 (90% CI = 519–755 or $\pm 18\%$) moose
- Total area covered by survey: 2,147 mi² (5,561 km²)
- Estimated total density: 0.30 moose/mi² (0.11 moose/km²)
- Estimated ratios: 9.2 calves:100 adults
- Total moose observed: 130 (119 adults and 11 calves)

Ambler Road Area (ARA) Subarea

- March population estimate: 179 (90% CI = 121–237 or $\pm 32\%$) moose
- Total area covered by survey: 1,011 mi² (2,618 km²)
- Estimated total density: 0.18 moose/mi² (0.07 moose km²)
- Estimated ratios: 14.3 calves:100 adults
- Total moose observed: 40 moose (35 adults and 5 calves)

Introduction

Moose (*Alces alces*) are an integral component of the boreal ecosystem in Gates of the Arctic National Park and Preserve (hereafter “Park” or “GAAR”). Moose are considered good indicators of long-term habitat change within the Park’s ecosystem because they require large quantities of resources from their habitat year-round and populations have the potential to respond dramatically to long-term changes in resource conditions. In addition, moose are an important subsistence resource for the Park’s neighboring subsistence communities of Bettles, Evansville, Wiseman, Alatna, and Allakaket.

From March 25 to 28, 2022, the National Park Service (NPS) surveyed moose in a 6,118mi² (15,846 km²) area in and around GAAR, which included the Alatna and John Rivers, as well as the North and Middle Forks of the Koyukuk River. Surveys within this area were previously conducted in the fall of 2004 and the spring of 2015 using the GeoSpatial Population Estimator (GSPE; Ver Hoef 2002) to estimate moose abundance, density, and calf:adult ratio of the greater survey area and subareas. Results from these surveys indicated that the moose population is generally characterized as low-density (0.18 moose/mi² in 2004 and 0.16 moose/mi² in 2015; Lawler et al. 2006, Sorum et al. 2015).

The objectives of the 2022 moose survey were to: 1) continue monitoring the moose population in and around GAAR for management decision purposes using the GSPE method and 2) estimate moose abundance on lands that are adjacent to GAAR that have been proposed for industrial road development.

Study Area

The survey area is bounded by the Brooks Range to the north ($67^{\circ} 58'N$), the Alatna River ($155^{\circ} 26'W$) to the west, the Dalton Highway ($150^{\circ} 20'W$) to the east, and by the Alatna Hills or northern boundary of the Kanuti National Wildlife Refuge (NWR) to the south ($67^{\circ} 00' N$). Principal land managers in this area are the State of Alaska, Bureau of Land Management (BLM), NPS, and Native corporations and villages. Vegetation types that characterize the boreal, shrubland, and alpine communities across the survey area include spruce and deciduous forest and woodland, tall shrub, low shrub, prostrate shrub, mesic herbaceous, sparsely vegetated areas, and aquatic habitat. Survey units that were entirely alpine or water were intentionally excluded from the survey because those habitats are not typically utilized by moose.

The survey area was analyzed in its entirety as well as 3 subareas: GAAR ($5,106 \text{ mi}^2$ [$13,225 \text{ km}^2$]), the Koyukuk River Drainage (KRD; $2,147 \text{ mi}^2$ [$5,561 \text{ km}^2$]), and the proposed Ambler Road Area (ARA; $1,011 \text{ mi}^2$ [$2,618 \text{ km}^2$]; Figure 1). The GAAR subarea was differentiated so that estimates from the 2004 and 2015 surveys could be compared. The KRD was originally delineated at the request of BLM to inform management decisions and the ARA to assess the moose population in an area that has been proposed for the development of an industrial mining road; both were included in this survey to facilitate comparisons with the 2015 survey and to meet the same objectives. The terrain in GAAR and KRD varies from rugged, mountainous areas $6,560$ feet ($2,000 \text{ m}$) in elevation, with a mix of alpine, shrub, and boreal forest habitat types. The landscape in the ARA is comparatively flat and largely composed of boreal forest and small lakes.

Gates of the Arctic NPP Moose Survey Survey Area March 2022

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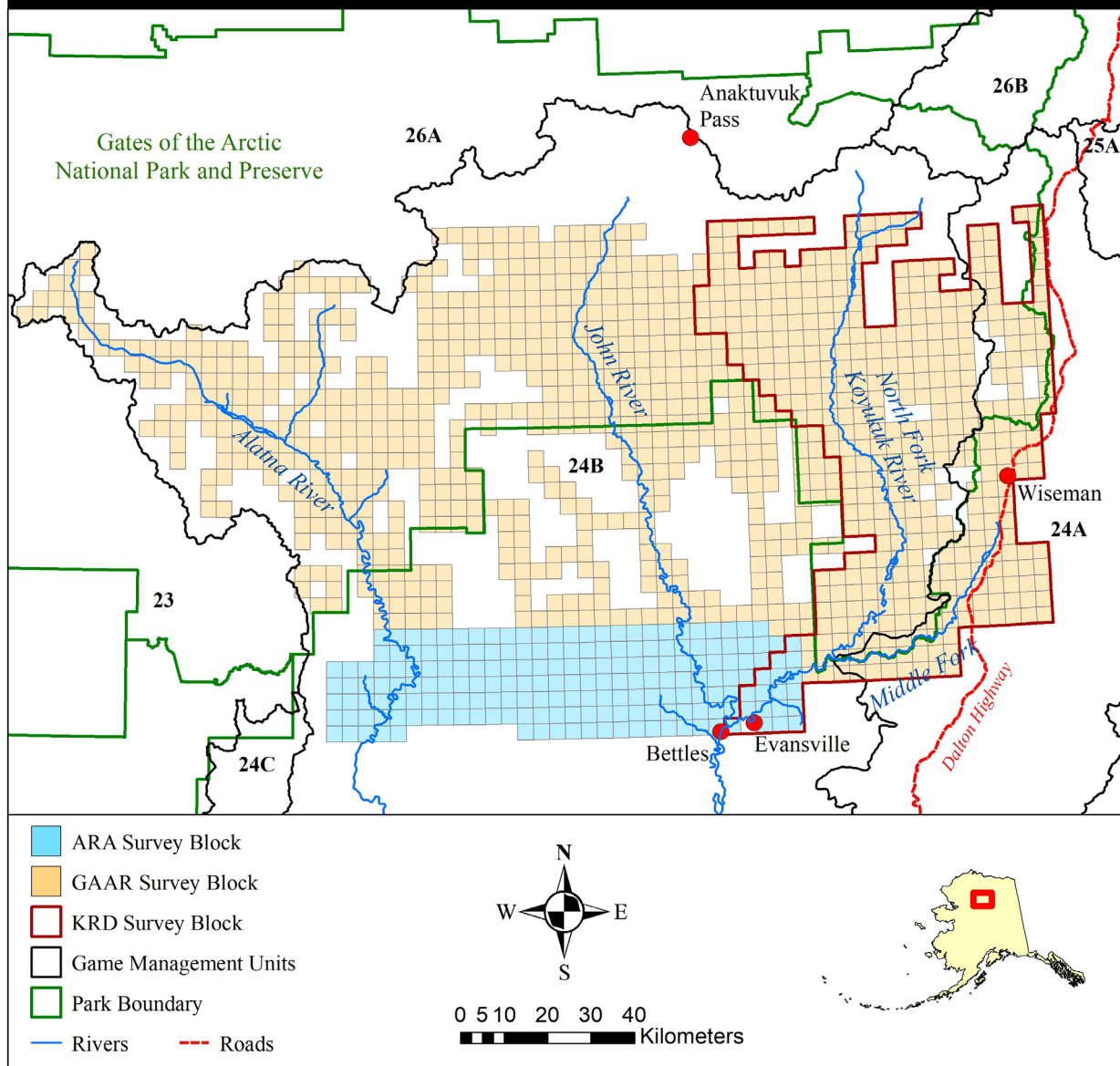


Figure 1. Gates of the Arctic National Park and Preserve moose survey unit boundaries. White areas within the survey boundary were excluded as high alpine and non-moose habitat.

Methods

We conducted a moose population survey using the GSPE, a modification of a technique initially developed by Gasaway et al. (1986). The GSPE, which is widely used in Alaska, allows comparison between survey areas. The methodology is discussed in detail in Kellie and DeLong (2006) but is summarized in this report.

The survey area was delineated using a Geographical Information System (GIS) layer developed by the Alaska Department of Fish and Game (ADFG) that divides the state into a grid of sample units that measure 2 minutes latitude by 5 minutes longitude. Sample units in our survey area averaged about 5.1 mi² (13.2 km²) in size, and we used the same survey area as in 2015 (Sorum et al. 2015).

GSPE surveys have 2 components: stratification and intensive surveys. A stratification improves the precision of population estimates by reducing the variance of the resulting estimate. Stratification flights were conducted within the survey area in 2015 to assign sample units to “high” or “low” moose density strata. During the stratification flights, each unit was evaluated and then classified as “high” or “low” based on habitat characteristics, the number of moose observed, and/or the presence of moose tracks. High strata were defined as likely having 1 or more moose in the unit and low strata as no moose. Prior to the 2022 survey, we updated the stratification with the results from the 2015 survey in the following way: if a unit was classified as “low” and had 1 or more moose detected in the unit in 2015, we reclassified it as a “high” unit for the 2022 survey.

Sample units for the intensive surveys were randomly selected from each density strata (Kellie and DeLong 2006). Sampling density affects the precision of the population estimate. Approximately 20% of the units were withheld from the random selection and subjectively used to fill in between blocks of units because results are improved if there are no gaps (<50 km) among surveyed units. Observations are also more variable in the high strata than the low strata, therefore, it was recommended to sample a greater proportion of the highs to reduce variance (Taras 2014). Therefore, our target was to sample 20% and 10% of the high and low strata, respectively.

The survey utilized 4 planes, each with a pilot and 1 observer. We had 5 observers that rotated days surveying. Planes included 1 Piper Super Cub (Shadow Aviation) and 3 Piper Top Cubs (FWS and NPS). All pilots and 3 of the observers had previous experience in aerial moose surveys.

Survey aircraft used Global Positioning System (GPS) receivers to identify the boundaries of sample units. Search intensity varied with habitat. Greater effort was spent in areas with higher canopy cover (e.g., forests versus muskeg) or where fresh moose tracks were observed. Survey methodology assumes 100% sightability of moose (although this assumption is likely never met; Boertje, ADFG, unpublished data). Detected moose were recorded as groups (spatially distinct from other moose), numbers of moose in each group were recorded, and moose were categorized as either adult or calf. Moose population estimates within the survey area were made using the web-based GSPE analysis program (Ver Hoef 2002; winfonet.alaska.gov).

This was the second moose survey to use the NPS iPad application Park Observer to record data in flight and iPad setup and methodology followed that used in the latest fall moose survey in Yukon-Charley Rivers National Preserve (Cameron and Schertz 2020). Moose observed were assigned a group number and the coordinates of the group were recorded using Park Observer and the aircraft GPS receivers as back-up. For each moose group detected, observers recorded the location, number of adults, and number of calves. Additionally, Park Observer records a tracklog of the flight and allows observers to take notes on the habitat type and overall conditions within each unit.

Results

Stratification

Of the 472 high and 723 low units classified in 2015 for the entire study area, 21 low units had moose observations in them during the survey and were reclassified as high for the 2022 survey (Table 1). This resulted in 440 (44%) and 561 (56%) high and low units, respectively, in GAAR. The KRD had 221 (53%) high and 199 (47%) low units in the 2022 survey. The ARA had 53 (27%) high units and 141 (73%) low units (Figure 2).

Table 1. Number of survey units and strata within the survey area and subareas, and proportion of survey units intensively surveyed during the Gates of the Arctic National Park and Preserve moose survey, Alaska, March 2022.

Study Area	Survey Units (#)			Units Surveyed (%)		
	Total	High	Low	Total	High	Low
Entire Area	1195	493	702	193 (16)	117 (24)	76 (11)
GAAR	1001	440	561	159 (16)	100 (23)	59 (11)
KRD	420	221	199	69 (16)	43 (19)	26 (12)
ARA	194	53	141	34 (17)	17 (32)	17 (12)

Weather and Snow Conditions

The weather conditions for flying the survey were mostly fair to excellent. The daily average temperatures ranged from 20.5 °F to 25.5 °F in Bettles during the survey (NOAA Regional Climate Centers, 2022). While there was complete snow cover in most of the study area except for some eastern sections of the KRD, it had not snowed in the area for almost a month prior to the survey. This made using tracks to find moose difficult as it was hard to estimate the age of the tracks. Despite this, snow depth for the study area in 2022 was greater than during the previous survey in 2015. In March 2022, the snow depth recorded at the Bettles airport was 33 inches compared to 25 inches in March 2015 (NOAA Regional Climate Centers, 2022).

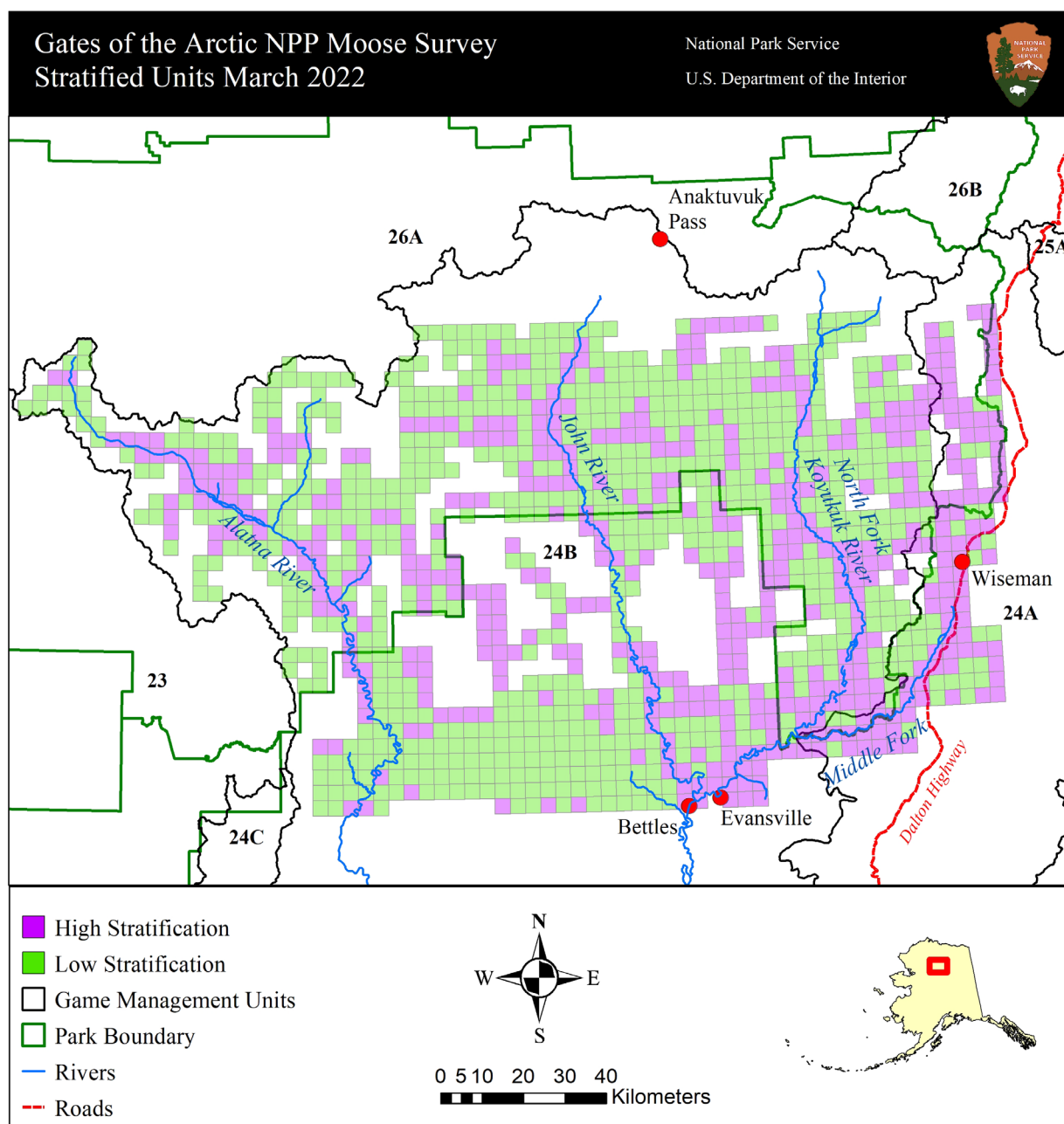


Figure 2. High- and low-density moose strata determined from an aerial stratification March 2015 and updated March 2022 from previous survey results.

Population survey results

Over the entire study area, we surveyed 193 units of the 1195 available sample units. Of the 1001 sample units within GAAR, 159 (16%) were surveyed, corresponding to a survey effort of 23% for the high and 11% for the low strata units within the subarea (Table 1). Of the 420 sample units within KRD, 69 (16%) were surveyed, corresponding to a survey effort of 19% for the high and 12% for the low strata units (Table 1). Of the 194 sample units within the ARA, 34 (17%) were surveyed, representing an effort of 32% for the high and 12% for the low strata units (Table 1). The number of

survey planes used ranged from 3–4 airplanes per day and the average number of units surveyed by any one plane during a survey day was 14 (range = 5–22). Survey time averaged 20.8 minutes per unit (SD = 10.1 min) and ranged from 2 to 54 min. Variation in survey time per unit depended largely on habitat cover type (i.e., units with closed tree canopy required more time to survey and conversely, units with very little habitat required less time to survey), as well as number of moose in a unit and local weather conditions. While the average time per unit is lower than that typical for GSPE surveys (Kellie and DeLong 2006), it was comparable to previous surveys for this low-density area (Sorum et al. 2015). The shortest time in unit was notably short, and this was due to the unit being primarily high-elevation non-vegetated habitat with a small riparian stringer of habitat that was completely surveyed in that time. Flight tracks from the intensive survey are presented in Appendix I.

Observers classified a total of 238 moose in the 193 units surveyed in our study area. There were 216 adults and 22 calves. Of the 22 calves, two sets of twins were recorded. We detected 126 moose groups and the average moose group size was 1.8 moose (range = 1–8 moose). There were 198 observable moose within the 159 units surveyed in GAAR with a range of 0–27 moose in a single unit (Figure 3). This yielded an average count of about 1.2 moose per surveyed unit. Of these moose, 181 adults and 17 calves were classified. Observers classified 130 observable moose within the 69 units surveyed in KRD and counted a range of 0–27 moose in a single unit. This yielded an average count of about 1.9 moose per surveyed unit. Of these moose, 119 adults and 11 calves were classified. Observers classified 40 observable moose within the 34 units surveyed in ARA and counted a range of 0–6 moose in a unit. This yielded an average count of about 1.1 moose per surveyed unit. Five moose were classified as calves and 35 as adults. The GSPE population estimate for the entire study area was 1,308 moose (90% confidence interval [CI] = 1,062–1,554, relative precision [CI half-width divided by point estimate] = 19%) and a density of 0.21 moose/mi² (0.08 moose/km²; Table 2). Within GAAR, 1,129 moose (90% CI = 915–1,342, relative precision = 19%) were estimated which yielded a density of 0.22 moose/mi² (0.09 moose/km²; Table 2). The KRD population estimate was 637 moose (90% CI = 519–755, relative precision = 18%) for a density of 0.30 moose/mi² (0.11 moose/km²; Table 2). The ARA population estimate was 179 moose (90% CI = 121–237, relative precision = 32%) for a density of 0.18 moose/mi² (0.07 moose/km²; Table 2).

Aviation and project costs for the 2022 Gates of the Arctic NPP spring moose survey are found in Appendix I. Complete survey results for the entire 2022 survey are archived in, and can be retrieved from, the ADFG WINFONET database under the survey name “2022, GAARALL” (<http://winfonet.alaska.gov/>; accessed 14 April 2022).

Table 2. Estimated number, density and composition of moose in and around the Gates of the Arctic National Park and Preserve study area including the 3 sub-areas of analysis, Alaska.

Study Area	Year	Total Moose		90% CI ^a		Density (moose/mi ²)	Composition Calves: 100 Adults
		#	(±SE)	Range	(Rel. Prec.) ^b		
Entire Area	2015	929	(83.6)	791–1,067	(15)	0.15	9.8
Entire Area	2022	1,308	(149.5)	1,062–1,554	(19)	0.21	10.2
GAAR	2004	968	(140.5)	737–1,199	(24)	0.18	14.0
GAAR	2015	833	(75.0)	710–957	(15)	0.16	10.0
GAAR	2022	1,129	(130.0)	915–1,342	(19)	0.22	9.4
KRD	2015	430	(46.0)	354–505	(18)	0.20	9.8
KRD	2022	637	(71.6)	519–755	(18)	0.3	9.2
ARA	2015	96	(25.2)	54–137	(43)	0.09	8.4
ARA	2022	179	(20.8)	121–237	(32)	0.18	14.3

^a Upper and lower bounds of 90% confidence intervals (CI).

^b Relative Precision = The confidence interval half-width divided by the estimate.

Gates of the Arctic NPP Moose Survey Surveyed Units and Moose Detections March 2022

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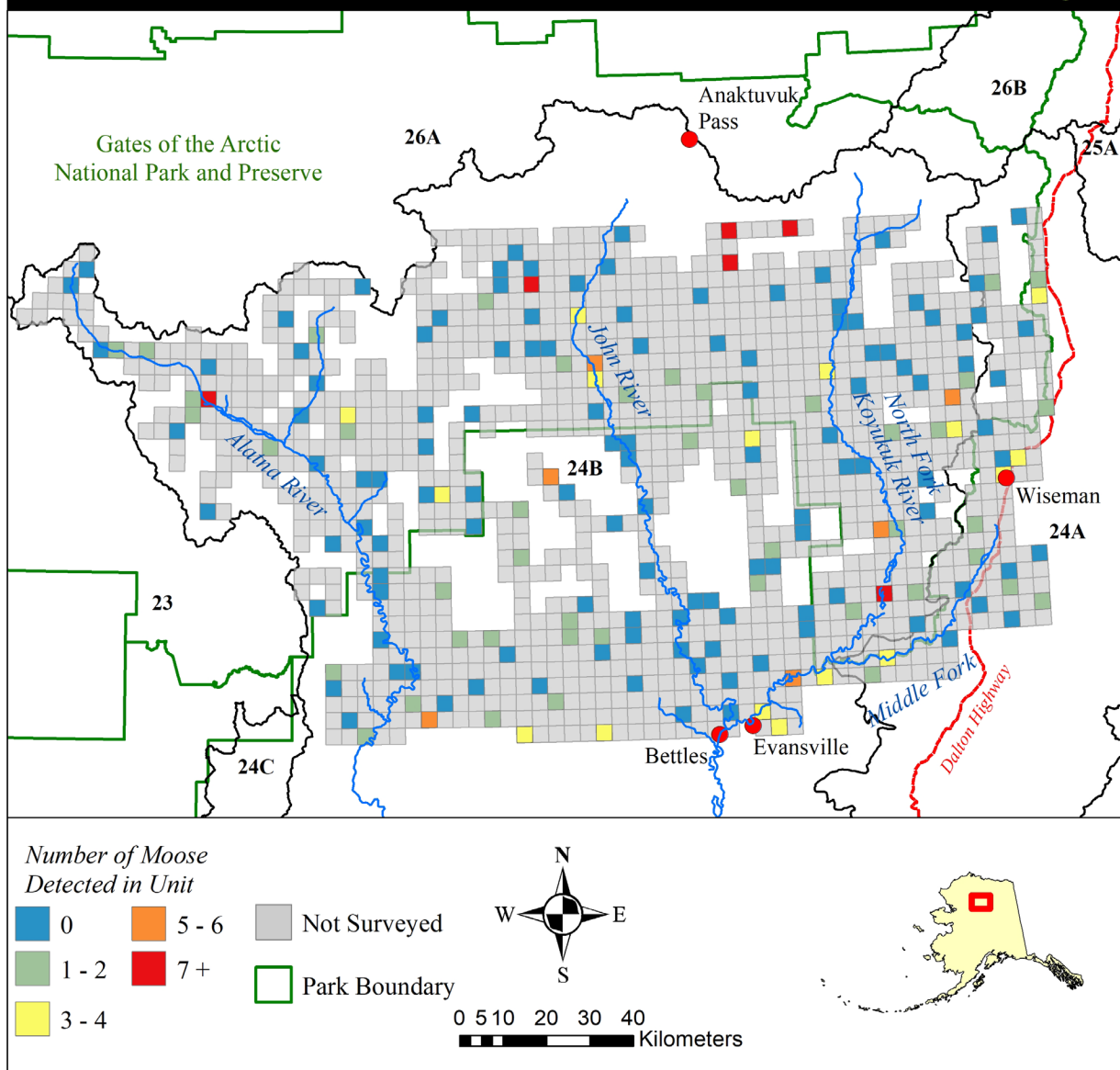


Figure 3. Survey units delineated for a moose survey within and around Gates of the Arctic National Park and Preserve. Randomly selected units that were surveyed are indicated on the map, including those units that were found to contain moose.

Discussion

Our results suggest the moose abundance within the greater GAAR study area has remained stable or increased since 2015. All point and range estimates for the 3 subareas in 2022 were higher than the point estimates found in 2015, however, the overlapping 90% CIs (Table 2) for all subareas indicate that remaining uncertainty precludes reporting a definite increase. This is the second spring GSPE conducted in this study area and is an important data point for future analyses of potential population trends and drivers.

One notable aspect of this survey was that snow levels were high in 2022, and this may have influenced our estimates by driving moose into larger groups across the study area. Compared to 2015, we counted more moose in fewer units and in larger groups on average in 2022. For the units in which we detected moose, we detected more groups on average (1.9 in 2022 and 1.6 in 2015) and more individuals on average (3.3 in 2022 and 2.4 in 2015; data collected in 2015, Sorum et al. 2015) than in 2015. These larger groups may have been easier for observers to detect, thereby increasing the detection rate in this survey compared to previous surveys, and this may have accounted for some of the increase in the population estimates. Future surveys may consider incorporating snow conditions as they conduct the survey and will be important for further improving our understanding of this population's trajectory.

Our results also suggest that recruitment was similar between the 2022 and 2015 surveys. Both surveys observed a ratio of 10 calves:100 adults over the entire study area. In comparison, a previous 5-year calf recruitment and survival study that tracked collared female moose in the southern KRD and Kanuti NWR found an average of 26 calves: 100 adult females that survived the first winter after being born (range = 0.21–0.36 calves/females; Joly et al. 2017). While we were not able to distinguish between males and females during the spring survey, the 2004 fall GAAR survey found that 61% of observed adult moose were female (Lawler et al. 2006). Based on this, it is likely that recruitment is generally slightly lower in our study area compared to the study area of Joly et al. (2017), although our ability to robustly test this is limited.

The 2022 survey is the third moose survey of the greater GAAR area and the second survey representing a spring moose population estimate. These previous spring surveys can be used in conjunction with future spring surveys to create more robust population estimates and potentially lower future surveying effort. Schmidt et al. (2022) outlines how using a Bayesian spatial general additive modeling approach that incorporates past survey events and spatial and temporal covariates (e.g., environmental variables) can increase estimator precision for previously conducted surveys and illuminate critical population drivers. The increased estimator precision, afforded by incorporating past survey results, might allow future surveys to reduce the number of units that need to be surveyed to reach a desired precision. This would reduce the cost of conducting these surveys and potentially make funding future surveys more reliable as agency budgets fluctuate. With the addition of environmental variables, we would not only be able to estimate the population trends but also be able to investigate the important drivers of the population dynamics that we observe. For example, in Yukon-Charley River National Preserve the moose population was found to have increased due to

more moose habitat created by recent fire events (Schmidt et al. 2022). Fire events have also occurred in the greater GAAR area, although the degree to which this has influenced the local moose population remains unaddressed. Using this and other new survey analysis techniques can help reduce the cost of these surveys to ensure they are conducted in the future and can increase the amount of information extracted from these surveys, making them even more valuable.

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Appendix 1. Survey Logistics

Table 3. Approximate aviation usage and cost during the 2022 spring moose survey. Survey hours include ferry flights.

Planes	Pilots	Description	Hours	Total
C-185	Seth McMillan	Shuttle	5.6	\$1,073
PA-18, Top Cub	Andy Greenblatt, Brett Nigus, Don Welty, Ed Mallek	Survey	125	\$24,294
Total				\$25,367

Table 4. Approximate overall project cost during 2022 spring moose survey.

Category	Description	Quantity	Cost/Unit	Total
Food	—	—	—	\$1,683
Fuel	Bettles 100LL ^a	672.9	\$10.00	\$6,729
	Coldfoot 100LL	163	\$8.50	\$1,386
	Fairbank100LL	162	\$7.18	\$1,163
	Bettles Heating Oil (hanger)	100	\$10.00	\$1,000
Personnel	Personnel costs	—	—	\$5,300
Aviation	Detailed in Table 3	—	—	\$25,367
Total Project Cost				\$42,628

^a BLM contributed 400 gallons of fuel.

Appendix 2. Survey Effort Visualized

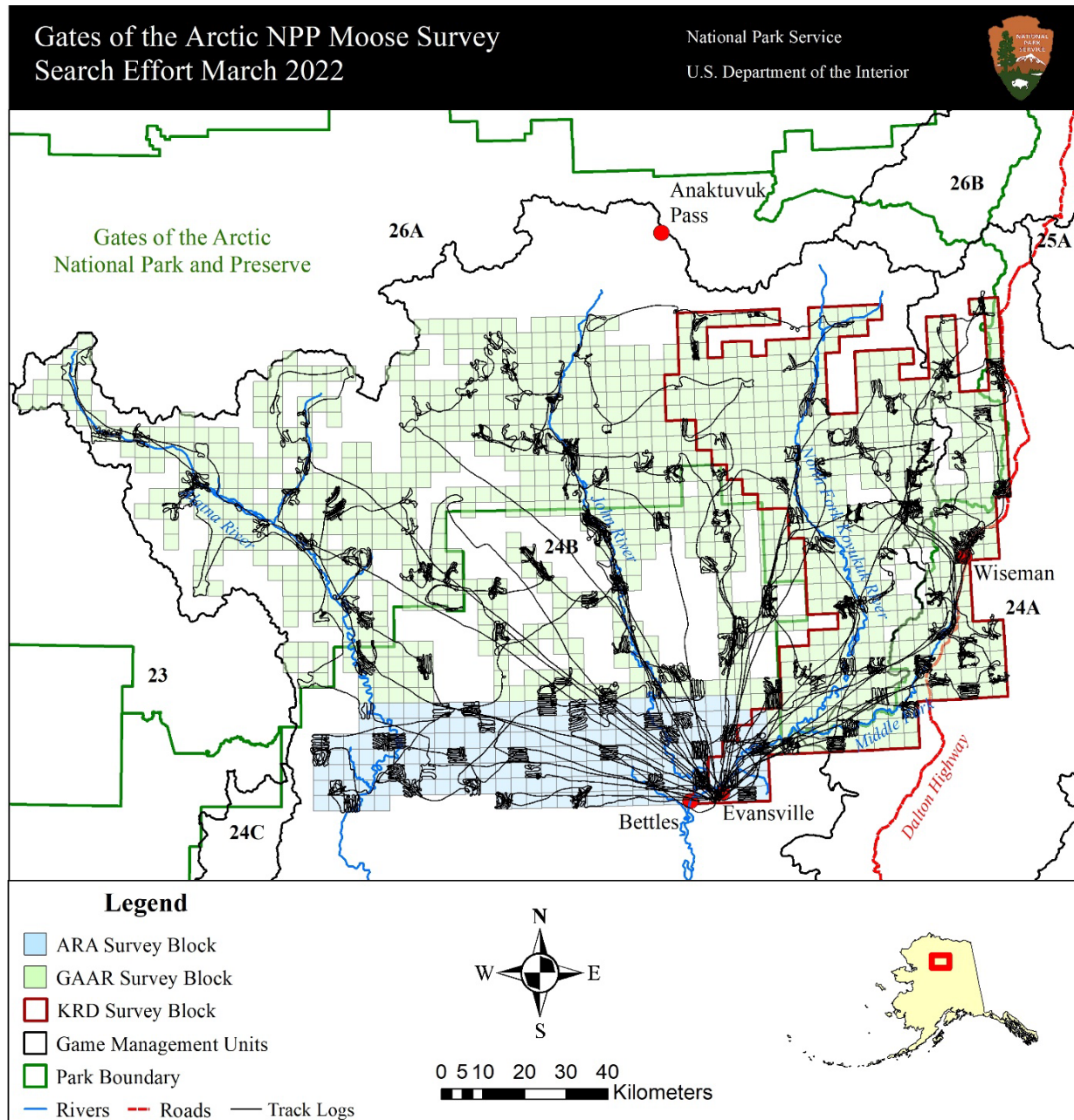


Figure 4. Flight paths of the four planes that conducted the 2022 moose survey from March 25–28th.



Figure 5. A special thanks to the entire survey crew that made this project so successful. From left to right: Andy Greenblatt, Brett Nigus, Ed Mallek, Dylan Schertz, Jared Hughey, Sophia Bracio, Jordan Pruszenski, Don Welty, and Matt Cameron.

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