Yukon

SR-24-10

Moose Survey

Faro Moose Management Unit, Early-winter 2020

October 2024

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Government of Yukon
Fish and Wildlife Branch
SR-24-10

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Summary

- We conducted an early-winter survey of moose in the Faro Moose Management Unit (MMU) survey area from November 10th to 13th, 2020. The purpose of the survey was to estimate the abundance, distribution, and composition of the moose population in the MMU.
- We counted moose in 43 of 112 survey blocks, or about 38% of the total area. We observed a total of 407 moose, including 84 mature bulls; 246 mature and yearling cows; 38 yearling bulls; and 39 calves.
- We estimated 600 (90% confident that the population is between 519 and 725) moose in the Faro MMU. This number is equal to a density of 335 moose over the total area or 423 moose per 1,000 km^2 of suitable habitat. This value is above the typical range of moose densities in the Yukon (100-250 per 1,000 km^2 of suitable moose habitat).
- We estimated 19 calves per 100 adult cows, which is at the lower end of recruitment observed in surveyed areas across the Yukon.
- We estimated 36 yearlings per 100 adult cows, which is above the average recruitment observed in surveyed areas across the Yukon.
- We estimated 40 adult bulls per 100 adult cows, above the minimum threshold of 30 adult bulls per 100 adult cows identified in our moose management guidelines.
- There has been no change in the population since the last survey in 2011 indicating that the level of harvest between 2011 and 2020 was sustainable.
- Licensed hunters are currently harvesting most of the sustainable harvest in this MMU. First Nation harvest information would be beneficial to ensure that total harvest remains within sustainable levels.
- Licensed harvest in the Faro MMU has been on a mandatory threshold since 2015. Results from this survey will inform the threshold number available to licensed hunters.

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Contents

Introduction

This report summarizes the results of the early-winter census survey of moose in the Faro Moose Management Unit (MMU; Figure 1) conducted November 10th to 13th, 2020. The purpose of this survey was to estimate the abundance, distribution, and composition of the moose population. We use this information to assess the sustainability of the current moose harvest and to inform the threshold limit available to licensed hunters in the Faro MMU.

Previous surveys and monitoring programs

Since 1997, the Yukon Fish and Wildlife Branch has conducted seven moose surveys in the Faro area (Figure 2).

We first completed a census survey in Game Management Subzone (GMS) 4-45 because of increased access and harvest pressure concerns (Yukon Renewable Resources, 1997). In 1998, we carried out a low intensity early-winter composition survey in the greater Faro region. In 1999, we conducted a less intensive trend survey of the sub-alpine plateau in GMS 4-45 to monitor population composition and trend (Yukon Renewable Resources, 1999). We also carried out two low intensity early-winter composition surveys in 1998 and 1999 (Yukon Renewable Resources, 1998, 1999).

Between 2002 and 2005, we conducted a telemetry study in which satellite radio collars were deployed on 13 adult moose. The goal of the study was to determine the proportion of resident and non-resident moose rutting in the area. We also wanted to understand moose movement patterns and travel distances, and if the area could sustain a high annual harvest rate (Environment Yukon, 2007). Results indicate that collared moose ventured outside of the Faro MMU boundaries but predominantly remained within the MMU year-round, reinforcing the importance of managing harvest at the MMU scale.

Lastly, we completed census surveys in 2004 and 2011 in the Faro area to address continuing concerns regarding increased moose harvest, and to quantify moose numbers, distribution, and composition (Environment Yukon, 2007 and 2012).

Community involvement

Moose have been a key part of First Nation peoples' subsistence lifestyle for generations and today are the most widely hunted game species by both Yukon First Nation and non-First Nation hunters. There is ongoing interest from the communities of Ross River and Faro to ensure that moose harvest is sustainable and that there is an opportunity to harvest. Both Faro and Ross River community members have participated as observers in moose surveys in the area. Knowledge holders and local experts provided local knowledge about moose in the Faro MMU in early-winter that contributed to the 'expert opinion' layer that was used to inform the study design (selection of survey blocks where observers count and classify moose).

Survey area

The survey area falls entirely within the Faro Moose Management Unit (MMU; Environment Yukon, 2016). Moose management units were developed to monitor and manage moose at the scale of populations throughout the territory.

The Faro MMU includes Game Management Subzones (GMS) 4-44, 4-45, 4-46, 4-51 (Figure 1). The northern extent follows the Tay River near Barwell Lake, while the southern border is bounded by the Pelly River. The eastern border follows a section of Blind Creek and lies west of Mount Kulan and Swim Lakes. The western border intersects Rose Mountain and follows Anvil Creek, immediately west of Mount Aho (Figure 1).

The total survey area is 1,792 km^2 and most of the survey area (about 1,418 km^2) is habitable moose range. This excludes alpine habitats that are above 1,676 m (5,500 ft.) and water bodies greater than 0.5 km^2. Therefore, 374 km^2 or 21% of the survey area is considered unsuitable moose habitat. Most of the Faro MMU is characterized by rolling mountain and plateau areas, with some subalpine and alpine habitats. There are a number of small drainages and creeks throughout the MMU, with some smaller waterbodies.

The survey area lies in the Yukon Plateau North ecoregion (Yukon Ecoregions Working Group, 2004). This ecoregion is made up of rolling highlands with an east–west orientation. Mean annual temperatures are near –5°C, but temperatures vary widely by season and elevation. Extreme temperatures in the lower valley floors have ranged from –62°C to 36°C (Yukon Ecoregions Working Group, 2004). At higher elevations, the extremes are moderate. Rain and snow fall is also moderate in the ecoregion, with annual amounts ranging from 300 to 600 mm. Winds are usually light, and become moderate to strong only during thunderstorms or in unusually active weather systems (Yukon Ecoregions Working Group, 2004). High elevation slopes (1,500–1,800 m) are mainly covered with willow (*Salix sp.*) and shrub birch (*Betula glandulosa*). Lower elevations are covered with black spruce (*Picea mariana*) and white spruce (*P. glauca*). Trembling aspen (*Populus tremuloides*) or lodgepole pine (*Pinus contorta*) grow in warmer and better-drained sites (Yukon Ecoregions Working Group 2004).

Large, older wildfires have occurred in this region in the north and south of the survey area. Wildfires have also occurred south of the Faro town site in 1958 (Figure 3).

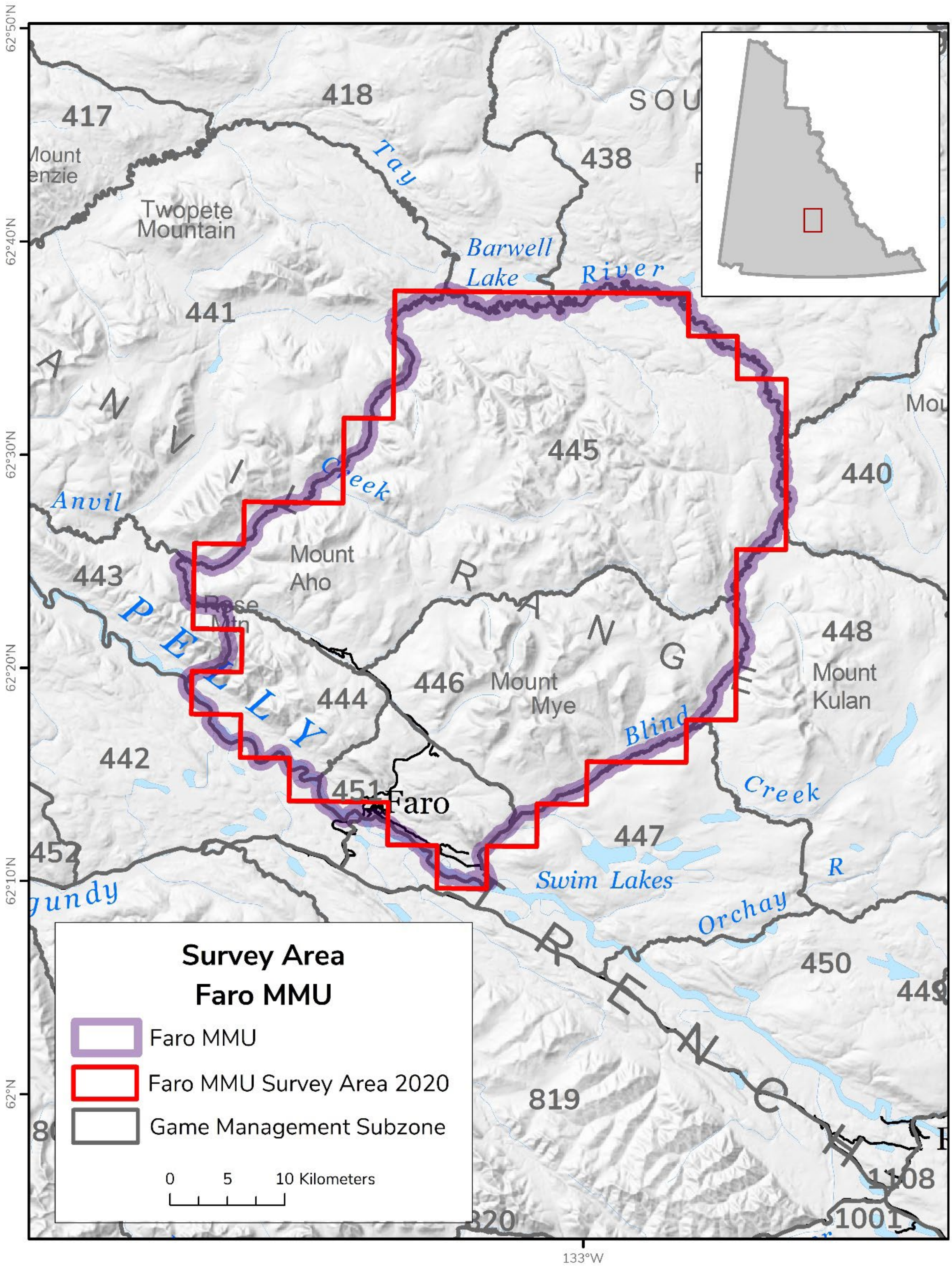

Figure 1. Faro Moose Management Unit (MMU) survey area, November 2020.

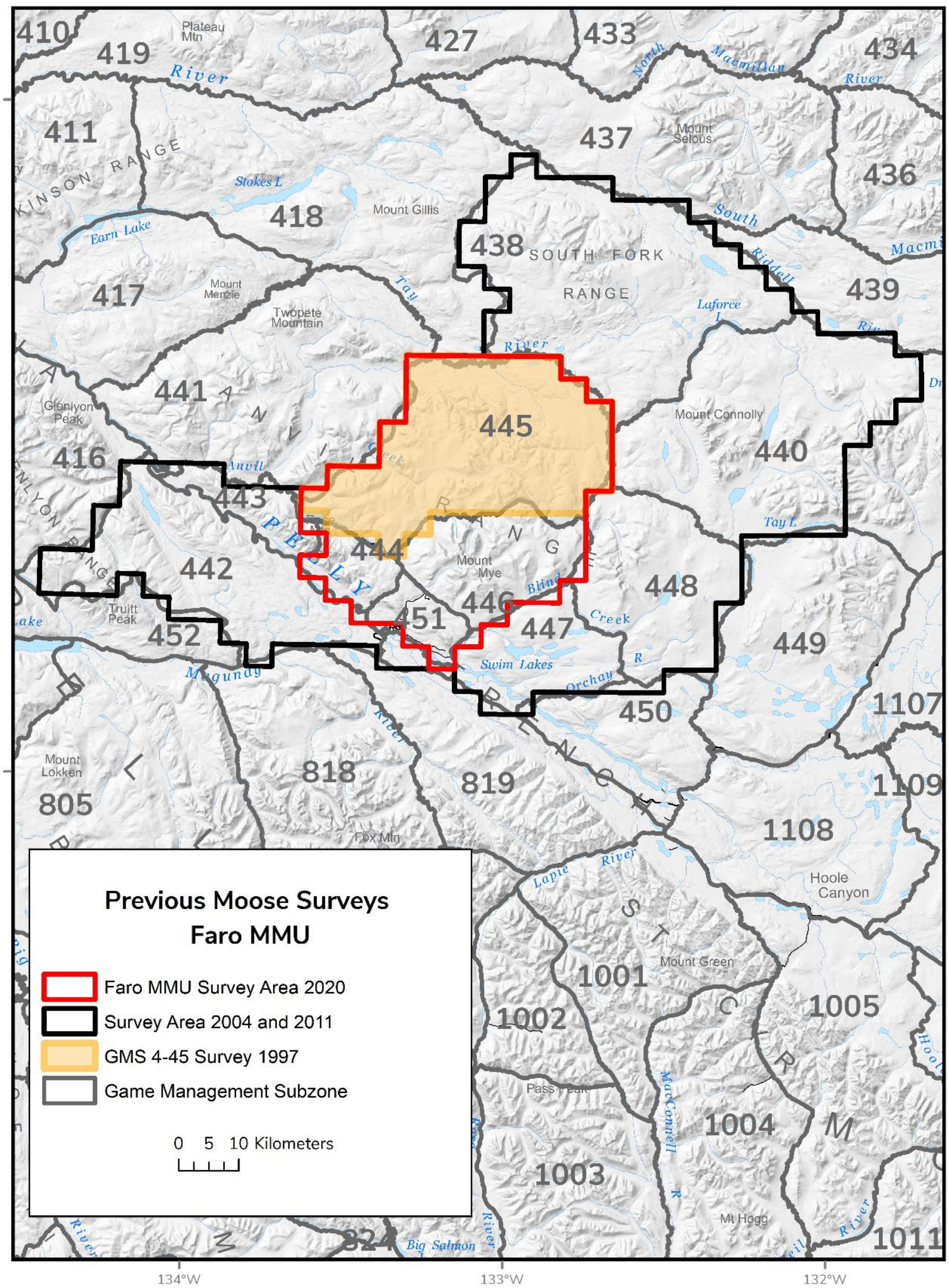

Figure 2. Previous moose surveys in the Faro Moose Management Unit (MMU).

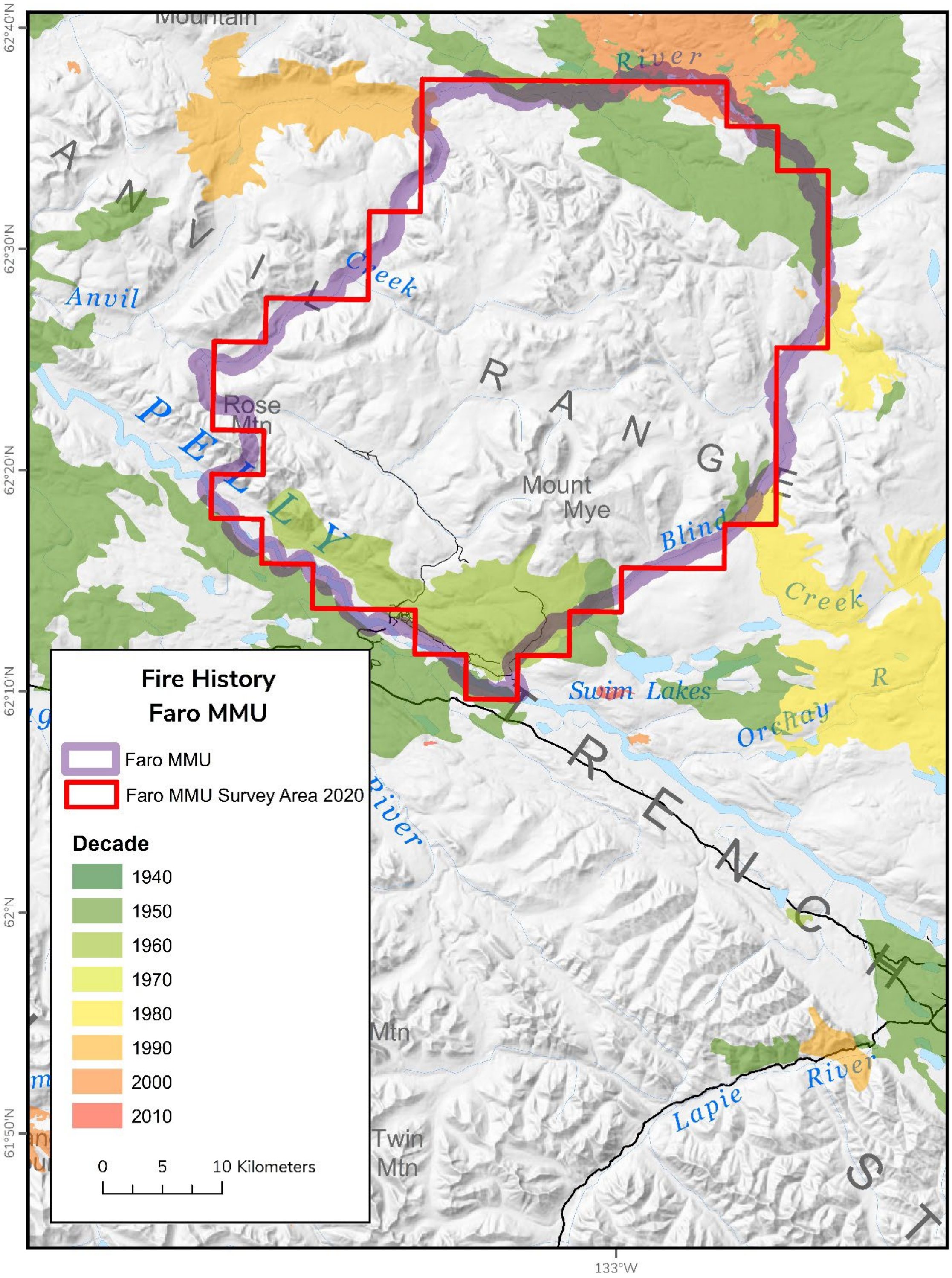

Figure 3. Faro Moose Management Unit (MMU) fire history.

Methods

Overview

We use a model-based technique to survey and estimate moose populations and composition in the territory (Czetwertynski et al., *in prep;* Appendix 1). Specifically, we develop models that relate moose abundance to information in individual survey blocks flown during the survey. This information is a combination of available local knowledge, landscape information, and habitat characteristics. These models are then used to estimate moose abundance over the areas where we did not count moose. We use any observed relationships between composition of the moose population (by age and sex) and the habitat or landscape to correct for any bias in our sample. This analysis allows us to incorporate factors found to affect the distribution of different age and sex classes across the landscape and predict the moose population composition for the entire area. Advantages of this survey method include the ability to utilise local knowledge, estimate abundance in subsets of the survey area, account for differences in composition throughout the area and target our sampling to areas where uncertainty is greatest.

The survey area is divided into rectangular blocks 14.9-15.2 km² (2' latitude x 5' longitude) in size. We select specific blocks and use helicopters to fly transects that are about 350 to 400 m wide (search intensity of about 2 minutes per km²) and count and classify every moose observed. Generally, we survey approximately 30% of the blocks within a survey area. During ferries, all survey staff record observations about moose habitat quality and moose abundance in as many different survey blocks as possible. This information is used to evaluate the final model predictions.

Within blocks selected for sampling, we classify all moose by age class (adult, yearling, calf) and sex. In early-winter surveys, we can reliably distinguish yearling bulls from adults based on antler size. However, yearling cows are often difficult to distinguish from adults. Therefore, we use the yearling bull estimate to account for yearling cows (the total number of yearlings is assumed to equal twice the estimated number of yearling bulls). The adult cow estimate is then accordingly reduced.

Finally, we use a Yukon average “sightability correction factor” of 9%, based on data from previous moose surveys, to estimate the number of moose we missed during our searches of each survey block, and to correct our final population estimates accordingly. When comparing moose population data between years, we consider there to be a significant change when 90% confidence intervals or prediction intervals do not overlap.

Survey block selection

We select blocks to survey using different criteria in each of three phases of the census survey:

In phase 1, we use any available local knowledge and information from previous or nearby surveys to classify blocks as having either high, medium, low or very low expected moose numbers. We use this information to select survey blocks to be flown during the first 2 to 3 days of the survey (approximately 30% of the total number of blocks we expect to survey). We select blocks such that they are distributed across the survey area and cover the range of available habitat types and areas of different expected numbers of moose.

In phase 2, we use a combination of landscape characteristics (land cover, slope, elevation) and local information from phase 1 to fit the best model describing moose abundance in surveyed blocks. We then use this model to predict the number of moose in un-sampled blocks. Survey blocks to fly the following day are selected based primarily on where the level of uncertainty in the predictions is greatest and to ensure we collect appropriate data to evaluate predictor-moose abundance relationships. This process (model selection, fitting, prediction, identification of blocks to sample) is repeated nightly with additional data from each day of flying. This phase of the survey is complete when four criteria are met. They are 1) sampling provides a total population estimate with adequate precision to make management decisions for the area, 2) sampling meets all assumptions for the final model, 3) enough blocks have been counted in each subarea for which estimates are desired and 4) sampling is appropriate to estimate population composition by age and sex. In this phase we sample approximately 60% of the total number of blocks we expect to survey.

In phase 3, we generate a map showing the predicted number of moose in un-sampled blocks based on the best model and have the field crew select blocks where they believe the predictions are the least accurate. We use local knowledge plus incidental observations made during the census to select additional blocks to count. This phase represents the last 1 or 2 days of the survey depending on survey-specific conditions. Lastly, the final model is re-evaluated with all available data to determine if further sampling is required.

Results and discussion

Weather and snow conditions

The weather was clear during the survey, with temperatures ranging between -9°C and -14°C. Weather was consistently sunny with high clouds. Wind varied from light to strong winds.

Snow cover was complete at intermediate depths. We had fresh snow when the survey commenced which aided in spotting fresh tracks on the first few days of the survey. Light conditions were mostly bright, however some flat conditions did occur.

Coverage

We surveyed 43 of 112 survey blocks with one helicopter, or about 38% of the total area (Figure 4) and used a total of 24.72 flight hours. We spent 19.98 hours counting moose in these blocks for a search intensity of 1.74 minutes per km^2 (Figure 4). We used 4.73 hours of helicopter time to ferry between survey blocks, our fuel caches, and to and from Faro.

Observations of moose

We observed moose in 34 of the 43 blocks that we surveyed. We observed a total of 407 moose, including 84 (21%) mature bulls, 246 (60%) mature cows, 38 (9%) yearling bulls and 39 (10%) calves (Table 1). However, these values (total number and composition by age and sex) cannot be directly applied as estimates in unsurveyed blocks because our sampling was biased towards blocks with greater numbers of moose.

Table 1. Observations of moose in survey blocks during the Faro Moose Management Unit (MMU) survey, November 2020.

	Total
Number of blocks counted	43
Number of adult bulls	84
Number of adult and yearling cows*	246
Number of yearling bulls	38
Number of calves	39
Total number of moose observed	**407**

*Adult and yearling cows cannot be reliably distinguished from the air, so they are counted together.

Distribution of moose

As expected in early winter, moose were concentrated in the subalpine willow flats, and creek draws with abundant willows. In 2020, the highest numbers of moose were observed in high-elevation subalpine habitats in the Anvil mountain range, with few moose seen in the valley bottoms (Figure 5). We counted few moose in lowland and forested areas. In general, the distribution of moose remained consistent with previous early-winter surveys in this area (Environment Yukon, 2004, 2012).

Abundance of moose

The number of moose observed in a survey block was positively correlated to the “habitat quality” of the survey block. Specifically, moose selected for elevations between 1400 to 1600 m and high quality shrub habitats (Appendix 1).

The estimated number of moose in the entire survey area, based on our survey counts and model predictions, was 600, and we are 90% confident that the population was between 519 and 725 (Table 2).

The estimated density of moose in the entire survey area was 335 moose per 1,000 km^2, or 423 per 1,000 km^2 of suitable moose habitat (Table 2). This is above the typical Yukon moose densities of 100 to 250 moose per 1,000 km^2 of suitable habitat (Environment Yukon, 2016).

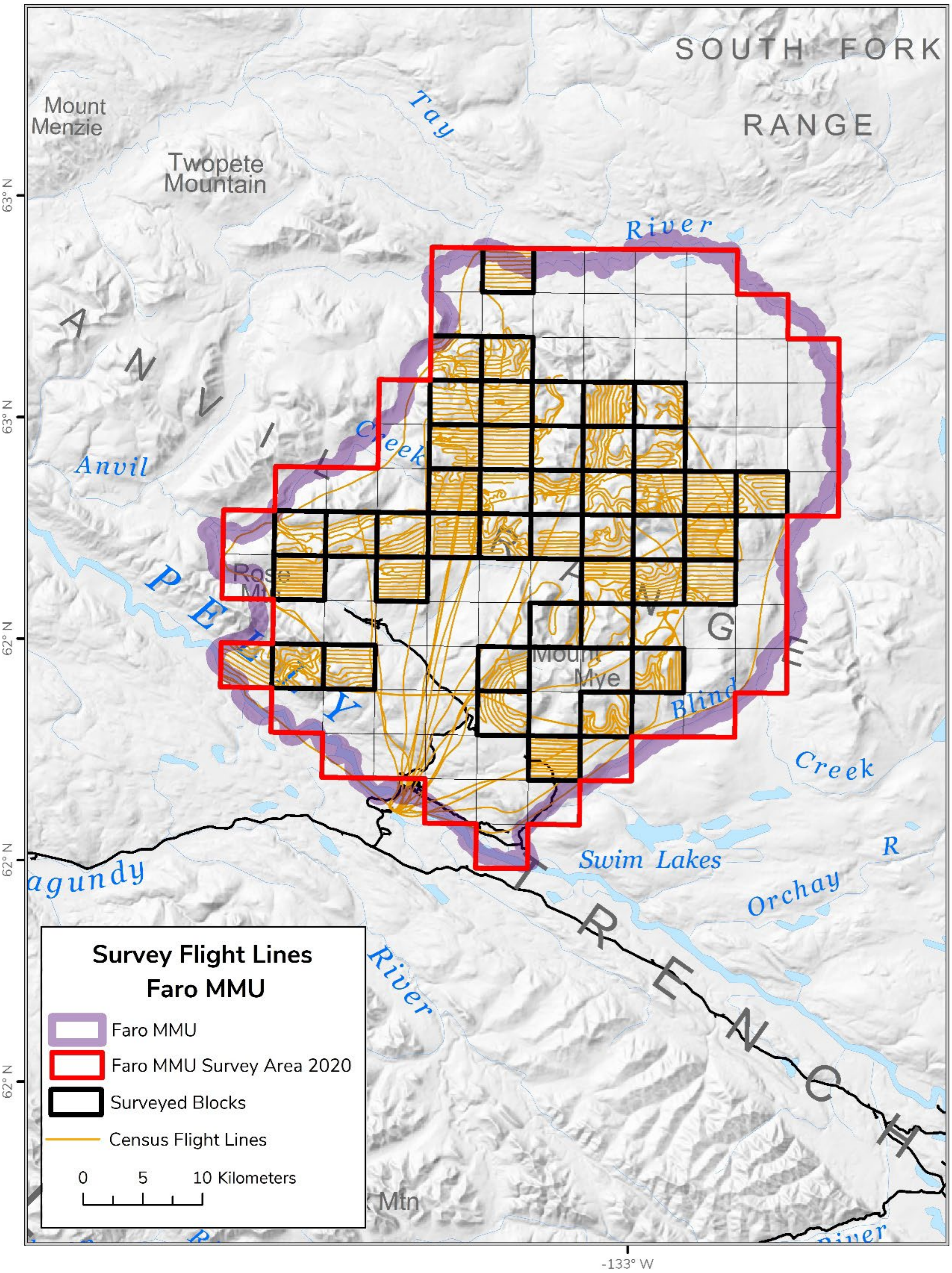

Figure 4. Helicopter flight lines and surveyed blocks from the Faro Moose Management Unit (MMU) survey, November 2020. Navigators direct helicopters such that ferry routes cover most of the unsurveyed blocks. This approach allows crews to describe the areas and later evaluate model predictions of moose abundance.

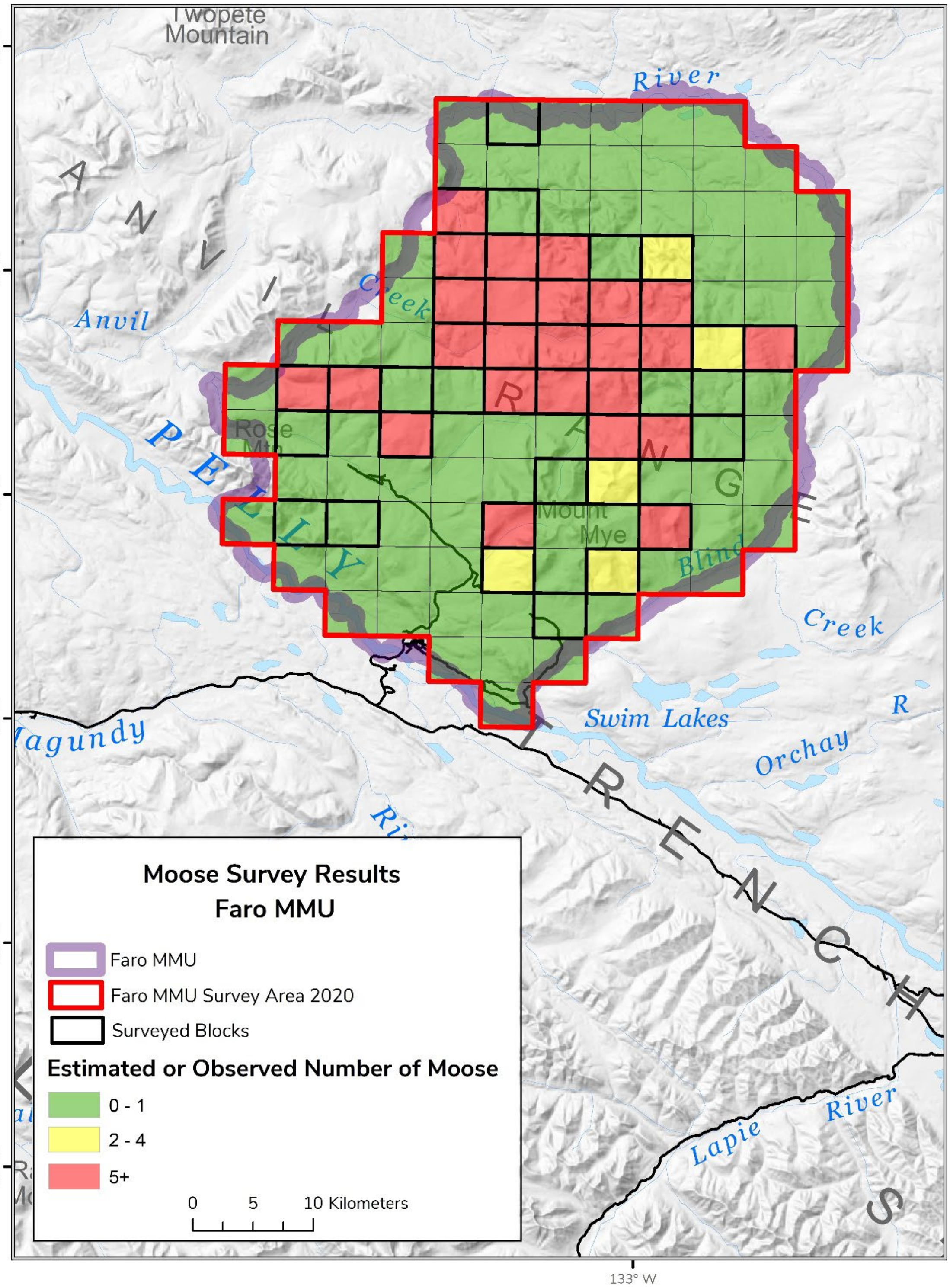

Figure 5. Estimated or observed number of moose in the Faro Moose Management Unit (MMU) survey, November 2020.

Table 2. Estimated abundance of moose, corrected for sightability (91%), in the Faro Moose Management Unit (MMU), November 2020.

	Best estimate*	90% prediction intervals **
Estimated total number of moose	600	519 - 725
Adult bulls	123	106 - 156
Adult cows	307	266 - 381
Yearlings	111	94 - 142
Calves	57	48 - 72
Density of moose (per 1,000 km^2)		
Entire area	335	290 - 405
Moose habitat only ***	423	366 - 511

* The sum of the estimated numbers of adult bulls, adult cows, yearlings, and calves is slightly different that the estimated total number of moose in the study area because we rounded off estimates of total moose in each block to the nearest moose for the compositional analysis.

** A '90% prediction interval' means that, based on our survey results, we are 90% confident that the true number lies within this range. Our best estimate is near the middle (at the median) of this range.

*** Suitable moose habitat is considered to be all areas at elevations lower than 1,676 m (5,500 ft.), excluding water bodies 0.5 km^2 or greater in size.

Ages and sexes of moose

We did not detect any habitat characteristics that affected the distribution of age/sex classes of moose in surveyed blocks and used this information to predict the distribution of moose in unsurveyed blocks (Appendix 1).

We estimated 19 calves for every 100 adult cows in the population, which is below the Yukon average of 29 calves per 100 adult cows, but similar to the 2011 survey (Table 3; Environment Yukon, 2012, 2016). We estimated 36 yearlings for every 100 adult cows in the population which is above the Yukon average of 29 calves per 100 adult cows (Table 3; Environment Yukon, 2016). However, estimates of recruitment from one survey are snapshots in time and survival varies from year to year.

We estimated 40 adult bulls for every 100 adult cows in the survey area (Table 3). This is above the minimum level of 30 bulls per 100 adult cows recommended in the Science-based Guidelines for Management of Moose in Yukon (Environment Yukon, 2016).

Table 3. Estimated composition of the moose population in the Faro Moose Management Unit (MMU), November 2020.

	Best Estimate	90% prediction intervals*
% Adult bulls	21	19 - 22
% Adult cows	51	49 - 53
% Yearlings	19	17 - 21
% Calves	10	9 - 11
Adult bulls per 100 adult cows	40	37 - 44
Yearlings per 100 adult cows	36	31 - 42
Yearlings per 100 adults (recruitment rate)	21	18 - 23
Calves per 100 adult cows	19	16 - 21
% of cow-calf groups with twins	2	2 - 5

* A "90% prediction interval" means that based on our survey results, we are 90% confident that the true number lies within this range, and that our best estimate is near the middle (at the median) of this range.

Population status and trends

We have intensively monitored moose in Game Management Subzone (GMS) 4-45 since 1997 and present population and composition information for this comparison area in Table 4. The low adult bull/adult cow ratio in 1997 (30 adult bulls per 100 adult cows) and local information suggested that this population was already heavily harvested prior to the 1997 survey and had likely already experienced some level of decline (Environment Yukon 2012). The change in total population between the 1997 survey (566 moose, 90% CI 452-681) and the 2011 survey (406 moose, 90% CI 452-681) represents a 28% decline likely from the high level of harvest (Environment Yukon 2012). In 2015, licensed moose harvest was restricted with a threshold hunt. Results from this survey (428 moose, 90% PI 389-504) indicate that the moose population has remained stable since the 2011 survey. However, the consistent low adult bull/adult cow ratio across all surveys including the 2020 survey indicates that total harvest is at the maximum sustainable level for this population.

Table 4. Results of the 1997, 2004, 2011, and 2020 early-winter moose population surveys in the Faro Game Management Subzone (GMS) 4-45 comparison area.

	Game Management Subzone 4-45 Comparison Area			
Survey Year	2020	2011	2004	1997
Survey Method	Model-Based	Geospatial[2]	Geospatial[2]	Stratified Random Block
Estimated Abundance[1] (90% Confidence or Prediction Interval)[3]				
Total moose	428 (389-504)	406 (293-519)	485 (338-632)	566 (452-681)
Adult bulls	82 (73-99)	83 (54-113)	115 (66-164)	88 (61-115)
Adult cows	225 (202-263)	251 (177-325)	236 (162-309)	291 (220-361)
Yearlings[4]	82 (72-98)	23 (9-37)	38 (5-71)	84 (51-117)
Calves	40 (35-49)	50 (37-63)	106 (63-148)	101 (62-141)
Unknown age/sex	-	-	-	2 (0-6)
Estimated Population Ratios[1] (90% Confidence or Prediction Interval)[3]				
% Adult bulls	19% (18-20%)	20% (16-24%)	23% (16-30%)	16% (12-19%)
% Adult cows	52% (50-54%)	63% (54-72%)	48% (42-55%)	51% (46-57%)
% Yearlings	19% (17-21%)	5% (2-8%)	8% (2-14%)	15% (9-21%)
% Calves	9% (8-10%)	12% (10-14%)	22% (11-33%)	18% (13-23%)
% Unknown age/sex	-	-	-	<1% (0-1%)
Adult bulls per 100 adult cows	36 (33-39)	32 (24-40)	47 (28-66)	30 (22-38)
Yearlings per 100 adult cows	37 (32-42)	9 (3-14)	16 (3-30)	29 (14-43)
Yearlings per 100 adult moose	21 (19-23)	6 (3-10)	9 (1-18)	18 (11-25)
Calves per 100 adult cows	18 (16-20)	20 (16-24)	45 (22-68)	35 (25-45)
% of cow-calf groups with twins[5]	3% (2-5%)	3% (1-4%)	10% (0-19%)	7% (0-13%)
Density of Moose (per 1,000 km^2)[1]				
Total Area	406	386	461	548
Moose Habitat only[6]	433	412	492	586
Total Area (km^2)	1053.0	1053.0	1053.0	1033.5
Habitable Area (km^2)[6]	986.5	986.5	986.5	966.7

[1] To allow for comparison across years, no sightability correction factor is included in estimates provided.
[2] For Geospatial data, the difference between total estimated numbers of moose and the sum of adults, yearling, calf and unknown numbers is because individual age/sex classes are unlikely to exhibit the same spatial correlation as that found in the sum of all observed moose in sampled units. The two sums may differ as a result.
[3] This means that we are 90% confident that the true number of moose in the area lies within the range of moose numbers given in the brackets. The 2021 survey estimates have prediction intervals whereas previous surveys are presented with confidence intervals.
[4] To account for yearling cows that cannot be identified from the air, the total number of yearlings is assumed to equal the estimated number of yearling bulls in the population x 2.
[5] Twinning Rate = the number of cows with 2 calves divided by the total number of cows with calves. It represents what percentage of cows that had calves, had twins.
[6] Suitable moose habitat is considered all areas at elevations lower than ~1,676 m (5,500 ft.), excluding water bodies 0.5 km^2 or greater in size.

Harvest

In the Yukon, moose are managed by Moose Management Units (MMUs), which are generally groupings of game management subzones that encompass biologically appropriate moose populations to the best extent possible (Environment Yukon, 2016). We estimate sustainable harvests for moose populations at the MMU scale. Specifically, in areas where survey information is available, we estimate that 10% of the adult bull population can be sustainably harvested annually with minimal risk of a population decline (Environment Yukon, 2016). In areas with multiple surveys, we consider population trend to be the strongest indicator of whether the total harvest is sustainable, particularly when First Nation harvest information is not available.

A harvest threshold system has been used in the Faro area since 1999. This program was developed in collaboration with Faro area residents and was voluntary; however, harvest levels were consistently exceeding the voluntary threshold and a regulation change was proposed in 2013 to implement a mandatory threshold hunt in 2015 of 21 bull moose. In 2016 the threshold was reduced to the current limit of 15 bull moose.

Because we detected no change in the total moose estimated in the comparison area (GMS 4-45) since the 2011 survey, our data suggest that the total harvest between the two surveys was sustainable. Reported licensed harvest available for the nine years since the survey (2011-2020) has been between 14 and 29 bulls with an average of 18 bulls harvested per year. Licensed harvest does not include moose harvested by First Nation hunters, however recent local knowledge indicates that the annual First Nation subsistence harvest in the Faro MMU averages 3 bull moose, and has ranged from 2-5 moose annually. Therefore, this population is harvested at the upper range of what we consider the sustainable limit. First Nation harvest information would be beneficial to assess the total level of harvest in this population.

Results from this survey will inform the threshold hunt number available to licensed hunters while providing for subsistence harvest by First Nation hunters.

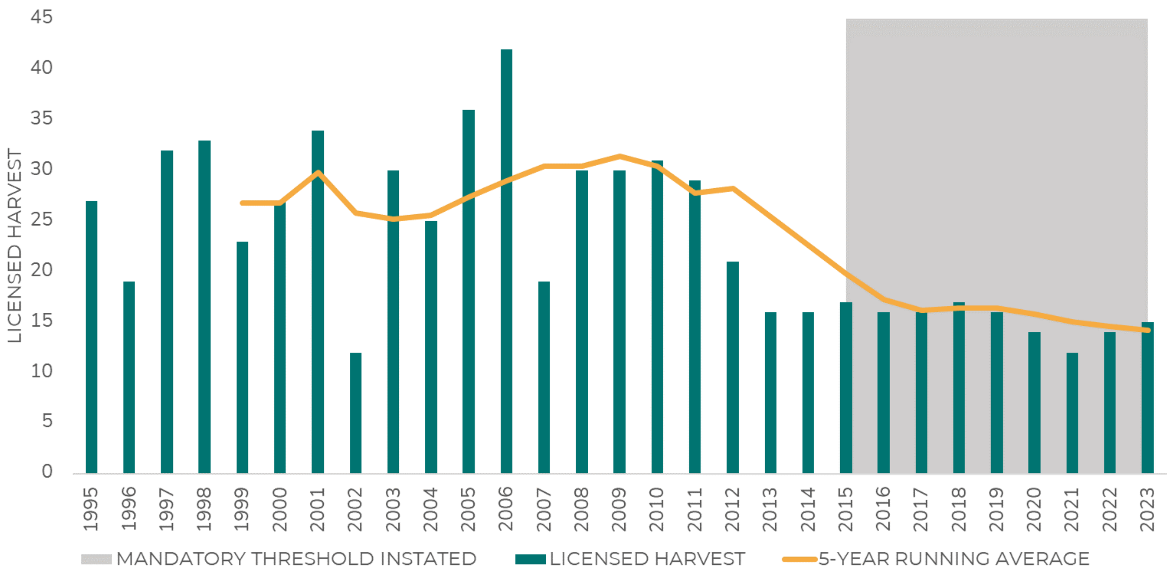

Figure 6. Licensed harvest of moose in the Faro Moose Management Unit. First Nation harvest is not included.

Other wildlife wightings

In addition to the 407 moose we saw during the survey, we counted 59 moose in 25 groups outside of the surveyed blocks or while travelling between blocks. We also saw 77 caribou in 15 groups. The caribou observed were from the Tay River caribou herd and the majority of the caribou were located in GMS 4-45, north of Mount Mye. Three groups of thinhorn sheep were observed in GMS 4-45, two groups of 2 sheep and one group of 16 sheep.

Conclusions and recommendations

- We found a high density moose population in the Faro MMU compared to other areas surveyed in the territory.
- The ratio of adult bulls to adult cows is above the recommended minimum of 30 adult bulls per 100 adult cows identified in our moose management guidelines.
- This moose population likely experienced a decline from pre-1997 numbers but has remained stable since the last survey in 2011.
- Because we detected no change in the total moose estimated in the comparison area since the 2011 survey, our data indicate that the total harvest between the two surveys was sustainable.
- The current total harvest of moose (reported licensed and estimated First Nation harvest) in the Faro MMU is at the upper end of the sustainable limit for this population.
- Actual First Nation harvest information would be beneficial to ensure that total harvest does not exceed sustainable limits. Harvest management and the sharing of harvest data should be discussed with the affected First Nations.
- We should continue to manage licensed harvest, and when required adjust the threshold limit to reflect available First Nation harvest and moose population information.
- We should continue to monitor moose populations in this area.

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Appendices

Appendix 1. Analyses and models used to estimate the abundance and composition of moose in the Faro Moose Management Unit from 2020 early-winter survey data.

We estimated abundance and composition of moose in the Faro Moose Management Unit (MMU) using a three-staged approach. We first used moose locations in surveyed blocks to generate Resource Selection Probability Functions (RSPFs). This information was then scaled up to the survey block and used with abundance information to generate count models and provide estimates of moose with prediction intervals for unsampled survey blocks. Lastly, we used predicted and observed moose abundance together with moose composition information from surveyed blocks to estimate the composition of moose over the entire survey area.

For all analyses, potential covariates were screened/sampled to ensure that they met model assumptions, were spatially representative, and biologically relevant. We used screened covariates to generate potential models and selected the best model based on Akaike's Information Criterion (AIC; Burnham and Anderson 2002) and AIC weights (Wagenmakers and Farrell 2004).

1) Abundance estimation

We generated a small-scale grid such that within each survey block (approximately 4km x 4km) there were 100 sub-blocks (approximately 400m x 400m). We selected this sub-block size because we believe it captures the approximate error in moose locations taken from the helicopter and represents the scale at which moose site selection occurs (Third Order Selection, Johnson 1980). We queried each sub-block for landscape and vegetation characteristics that could potentially influence moose occurrence/abundance. All covariates were screened for their relationship to occurrence/abundance and those that had biologically and statistically significant relationships were considered in candidate models (Table S1).

Our initial dataset included 469 moose locations and we generated 5,000 random locations (approximately 100 random points for each moose location). We restricted random locations to sub-blocks that were within sampled survey blocks and within sub-blocks where we observed no moose (unused sub-blocks). We intersected the moose and random locations within sub-blocks to describe the landscape and vegetation characteristics for each point location at the 400m scale.

To estimate the RSPF, we assumed that habitat selection is similar for all age/sex animals excluding calves so calf-cow groups were considered as 1 location. Therefore, the final dataset included 412 moose locations and 5,000 random locations. For simplicity, we used logistic regression to estimate coefficients for the RSPF model because of our used and unused sub-block design. The model that best described moose habitat selection at the 400m scale included 3 covariates (Table S2). Specifically, moose selected for sub-blocks where the majority landcover (250m scale) was burns (1981 to 2011), shrubland, or mixed-forest. Moose further selected for higher elevations and sub-blocks with greater percentage of shrub cover (30m scale, Table S3). We used this model to predict RSPF values for sub-blocks in unsampled survey blocks and then summed all RSPF values within each survey block. These block-level RSPF values then represented a general "habitat quality" covariate used in further analyses.

We used Zero-Inflated Negative Binomial regression Models (ZINB) to describe the distribution of the number of moose counted in sampled survey blocks. These models best describe low density and spatially aggregated moose distribution across survey blocks in the Yukon because they account for overdispersion and excess zeros. We estimated models with the zeroinfl() function in the pscl package for R (Zeileis et al. 2008). The model that best described the data included 1 count model coefficient and 2 coefficients in the zero-inflation component (Table S4). The number of moose observed in a survey block was positively correlated to *RSPF*, the "habitat quality" of the survey block. In addition, there was a greater likelihood of observing 0 moose in a survey block at lower *RSPF* values and in blocks with greater than 80% conifer cover (*Conifer*). This model was used to predict the number of moose in unsurveyed units of the survey area (Table S5). The final population estimate and bootstrapped confidence intervals were obtained by combining the actual number of observed moose in sampled survey blocks with predictions from unsampled survey blocks (Czetwertynski et al., *in prep*). This approach enables us to generate realistic estimates of subsets of the survey area when required and allows for meaningful stakeholder participation.

<u>2) Composition estimation</u>

We used a compositional analysis to describe the composition of the moose population in the sampled dataset using the vglm() function in the VGAM package for R (Yee 2010). We found that the best model included the *RSPF* covariate that accounted for the lesser proportion of lone adult cows and adult bulls in survey blocks with lower quality moose habitat (Table S6). This model (Table S7) was then applied to unsurveyed sample units where the total number of moose was predicted by the ZINB model to obtain the composition estimates and associated bootstrapped confidence intervals of the moose population in the survey area (Czetwertynski et al., *in prep*).

Table S1. Description of selected list of coefficients considered for Resource Selection Probability Functions (RSPFs) and models of abundance/composition of moose in the Faro Moose Management Unit, November 2020.

Covariate Name	Description	Source
Landcover6	Categorical covariate of the majority Landcover class within sub-blocks reduced to 6 classes (Conifer, deciduous, mixed forest, shrubland, other, burns between 1981-2012).	North American Land Cover 2010 250m x 250m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada. Canadian National Fire Database.
Elev	Mean elevation in km of the sub-block.	Canadian Digital Elevation Model 30m x 30m resolution, Natural Resources Canada.
Shrub	Percent of the survey sub-block with either low or tall shrub cover type.	EOSD Land Cover Classification 25m x 25m resolution, Canadian Forest Service.
NALC_Conifer or NALC_Shrub	Percent of the survey block with needle leaf forest or shrub cover type.	North American Land Cover (NALC) 2010 250m x 250m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada. Canadian National Fire Database.
Burn1981-2012	Percent of the survey block burned between 1981 and 2012.	Natural Resources Canada. Canadian National Fire Database.
STRAT	Categorical covariate describing survey blocks as High, Medium, or Low probability of observing moose.	Fixed-wing flight prior to the survey with crew of a navigator and 2 rear-seat observers.

Table S2: List of best models describing the Resource Selection of moose observed in survey sub-blocks (approximately 400m x 400m) in the Faro Moose Management Unit (November 2020) with associated AIC scores and model weights.

Model	df	AIC	ΔAIC	w
Landcover6 + Elev + Shrub	8	2669.5	0.0	0.79
Landcover6 + Elev	7	2672.1	2.6	0.21
Landcover6 + Shrub	7	2745.3	75.8	0.00

Table S3. Logistic regression estimates for the Resource Selection Probability Function (RSPF) used to describe locations of moose observed in surveyed sub-blocks (approximately 400m x 400m) in the Faro survey area, November 2020 (n=412, Log-likelihood=-1327). We used this model to generate RSPF values for unsurveyed sub-blocks.

	Estimate	Standard Error	Z	P
(Intercept)	-6.423	0.374	-17.16	<0.001
Landcover6				
Deciduous	0.743	0.292	2.54	0.011
Mixed	0.275	0.207	1.33	0.185
Shrubland	0.416	0.261	1.60	0.111
Other	-0.544	0.729	-0.75	0.455
Burns(1981-2012)	1.660	0.152	10.93	<0.001
Elevation	2.897	0.329	8.81	<0.001
Shrub	0.556	0.256	2.17	0.030

Table S4. List of best models describing the number of moose observed in survey blocks in the Faro survey area (November 2020) with associated AIC scores and model weights.

Model		df	AIC	ΔAIC	w
Count Covariates	Zero Inflation Covariates				
RSPF	RSPF + Conifer	6	353.0	0	1.00
RSPF	STRAT	6	394.7	41.7	0
RSPF	RSPF	5	440.9	87.9	0
RSPF	Conifer	5	468.7	115.7	0

Table S5. Zero-Inflated Negative Binomial (ZINB) regression estimates for counts of moose observed in surveyed sample blocks (approximately 16 km^2) in the Faro survey area, November 2020 (n=116, Log-likelihood=-171). We used this model to generate the population estimate and prediction intervals for the Faro Moose Management Unit.

	Estimate	Standard Error	Z	P
Count model coefficients (negbin with log link):				
(Intercept)	0.726	0.198	3.670	0.00024
SUM_RSPF	0.087	0.019	4.549	5.4E-06
Log(theta)	1.403	0.329	4.263	2E-05
Zero-inflation model coefficients (binomial with logit link):				
(Intercept)	-0.253	1.248	-0.203	0.83919
SUM_RSPF	-0.879	0.290	-3.035	0.00241
NALC_Need	4.955	1.785	2.775	0.00552

Table S6. List of best models describing the composition of moose observed in the Faro survey area (November 2020) with associated AIC scores.

Model	AIC	ΔAIC
RSPF	647.8	0.0
Null	671.4	23.6
Burn1981-2012	671.6	23.7
NALC_Shrub	672.3	24.5
NALC_Conifer	675.4	27.6
Shrub	678.6	30.8

Table S7. Compositional model regression estimates for moose in the Faro survey area, November 2020 (n=116, Log-likelihood=-327). This model was used to generate the composition and related prediction intervals for the Faro Moose Management Unit (MMU).

	Estimate	Standard Error	Z	P
(Intercept):BULL_LARGE	0.031	0.301	0.102	0.919
(Intercept):BULL_SMALL	-0.865	0.590	-1.465	0.143
(Intercept):COW_1C	-0.207	0.359	-0.576	0.565
(Intercept):COW_2C	-2.622	0.949	NA	NA
(Intercept):LONE_COW	0.293	0.291	1.006	0.314
RSPF:BULL_LARGE	0.106	0.031	3.442	0.001
RSPF:BULL_SMALL	-0.126	0.088	-1.428	0.153
RSPF:COW_1C	0.005	0.039	0.126	0.900
RSPF:COW_2C	-0.007	0.107	-0.064	0.949
RSPF:LONE_COW	0.100	0.030	3.294	0.001

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