Yukon

SR-24-08

Moose Survey

Goldfields Moose Management Unit, Early-winter 2015

September 2024

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Government of Yukon
Fish and Wildlife Branch
SR-24-08

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Summary

- We conducted an early winter moose survey in the Dawson Goldfields survey area from 11 November to 19 November, 2015. The main purpose of this survey was to estimate the abundance, distribution and composition of the moose population. The survey area covered 81% of the Dawson Goldfields Moose Management Unit (MMU).
- We counted all moose in 117 of the 390 survey blocks, or about 30% of the survey area. We observed a total of 857 moose: 235 adult bulls, 437 cows, 66 yearling bulls and 119 calves. We estimated a population of 1583 moose for the survey area and we are 90% confident that the population was between 1449 and 1739. This number is equal to a density of approximately 265 moose/1000 km^2 over the entire survey area, or 268 moose/1000 km^2 of suitable moose habitat. This is at the upper end of the typical range of moose densities in Yukon (100-250 / 1000km^2 of suitable moose habitat).
- We estimated 29 calves for every 100 adult cows in the survey area which is consistent with other areas surveyed in the Yukon (mean of 29 calves per 100 adult cows). We estimated 11 yearlings per 100 adult cows which is at the lower end of observed recruitment in the Yukon (mean of 18 yearlings/100 adult cows).
- We estimated 46 adult bulls for every 100 adult cows in the survey area. This adult sex-ratio is above the minimum threshold of 30 bulls/100 adult cows identified in our moose management guidelines.
- We estimated a sustainable harvest of 50 bulls per year for the Dawson Goldfields MMU. The average annual licensed harvest (2011-2015) was 31 bulls per year.
- Estimated total moose abundance in the survey area appears stable since the last survey in 2008 suggesting that total harvest levels are sustainable. Information on First Nation harvest is required to accurately quantify the level of harvest in this population.

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Contents

Introduction

This report summarizes the results of the early-winter moose survey conducted on 11 to 19 November 2015 in the Dawson Goldfields Moose survey area (Fig. 1). The purpose of the survey was to estimate abundance, distribution and composition of the moose population in the Dawson Goldfields survey area, and to use this information to assess the sustainability of the current moose harvest in the Dawson Goldfields Moose Management Unit (MMU).

Previous Surveys

There have been numerous surveys in different seasons using different methods to monitor moose abundance, population trends and distribution in this survey area (Fig. 2).

Census Surveys

The first survey to estimate moose abundance was completed in 1989 in Game Management Subzones 3-07 and 3-10 (Larsen and Ward 1991a). This survey area, called the Dawson East area was re-surveyed in 1997 (Government of Yukon, 1998a). A larger area, the Dawson Goldfields survey area (previously referred to as the Dawson survey area), was flown for the first time in 2002 (Government of Yukon, 2003) and was re-surveyed in 2008 (Cooley et al. 2012) and 2015 (this report).

Early winter trend surveys

Early winter trend surveys are smaller in spatial scale than census surveys, though cover the entire area surveyed using fixed-wing aircraft. An early winter trend survey in the Dawson East area was first completed in 1989 and again, covering a slightly larger survey area, in 1997, 1998 and 1999/2000 (Larsen and Ward 1991b, Government of Yukon 1997, 1998b and 2000).

Stratification surveys

Stratification surveys involve flying survey blocks and classifying each based on the likelihood they contain high or low relative numbers of moose based on local knowledge, habitat, and observed moose sign. A low-intensity stratification survey (1 flight line through each survey block) conducted in 2000 (Government of Yukon, 2003) covered the entire Dawson Goldfields survey area and informed the 2002 census survey. In 2005 and 2007, high-intensity stratification surveys (3-4 flightlines per survey block) focused on the Dawson East area (Government of Yukon 2006, 2008). Prior to the 2008 census survey (Cooley et al. 2012), 83 survey blocks were flown by helicopter to determine if stratification data required updating as several wildfires had occurred in the survey area since the last stratification.

Several late-winter moose distribution and stratification surveys covered portions of the Dawson Goldfields survey area in 2008 (Government of Yukon 2010a), 2009 (Government of Yukon 2010b), and 2010 (Government of Yukon, 2011) as part of Dawson Land Use Plan development.

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.

Tr'ondëk Hwëch'in, and the Dawson District Renewable Resources Council recommended that this survey occur to ensure the harvest in the Goldfields MMU is sustainable. Staff based in Dawson from the Department of Environment, the Department of Energy, Mines and Resources, Tr'ondëk Hwëch'in, and the Dawson District Renewable Resources Council participated in this survey, and community members with long-term knowledge of the area assisted with an expert-based stratification of the survey area that informed survey sampling (see *Methods* for details). Funding for the survey was provided, in part, by the Dawson District Renewable Resource Council.

Study Area

The Dawson Goldfields moose survey area is composed of survey blocks overlapping Game Management Subzones (GMS) 3-07, 3-08, 3-10, 3-11 and 3-12 which combined, cover 5982.8 km^2 (Figure 2). The survey area represents 81% of the Dawson Goldfields MMU (excludes GMS 224 and 225). The survey boundaries for the 2015 survey ran from Dawson City, south along the Yukon River to the Stewart River, east along the Stewart River to west of Australia Mountain, north to Strickland Lake, then west along the North Klondike Highway back to Dawson City.

The Goldfields moose survey area is part of the Klondike Plateau ecoregion which has never been glaciated. It is uniform in character with smooth topped ridges (1200 – 1500 m a.s.l.) dissected by deep, narrow, "v"-shaped valleys. Most of the survey area is considered suitable moose habitat with only 1% of the total survey area (70 km^2) considered unsuitable including large water bodies (0.5 km^2 or larger). Areas above 1524 m a.s.l. (5000 feet) are also considered non-moose habitat, though no peaks exceed 1524 m a.s.l. in the survey area.

Throughout the study area, there is also an extensive road and trail system providing access to mineral claims and mining operations which are typically operated on a seasonal basis from February to October/November. This area is therefore accessible to hunters and experiences some of the highest harvest pressure in the Dawson region.

Below 1,000 m a.s.l., black and white spruce forests are dominant, and occasionally are present in mixed stands of poplar, birch and aspen. Poplar, birch and aspen occasionally dominate on specific landforms or on particular aspects. Subalpine areas are typically dominated by dwarf birch, interspersed with stunted white spruce. Willows and alders are often limited to drainages and regenerating areas (e.g. tailings, slides, burns).

This ecoregion also receives the most lightning strikes in the territory. Consequently, much of the survey area has been burned by wildfire at some point over the last 60 years (Fig. 3).

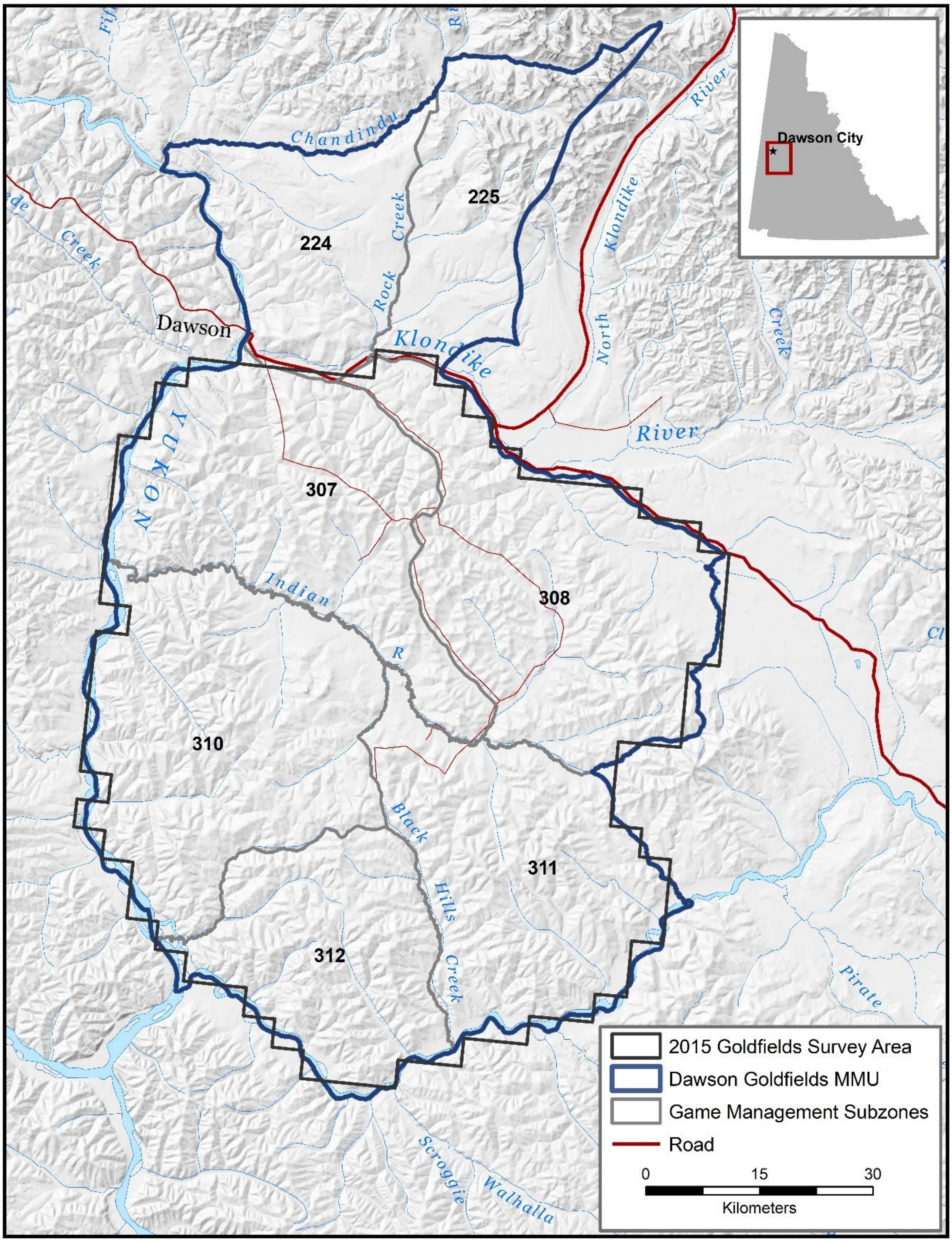

Figure 1. Dawson Goldfields early-winter moose census survey area, Dawson Goldfields Moose Management Unit (MMU), and Game Management Subzones.

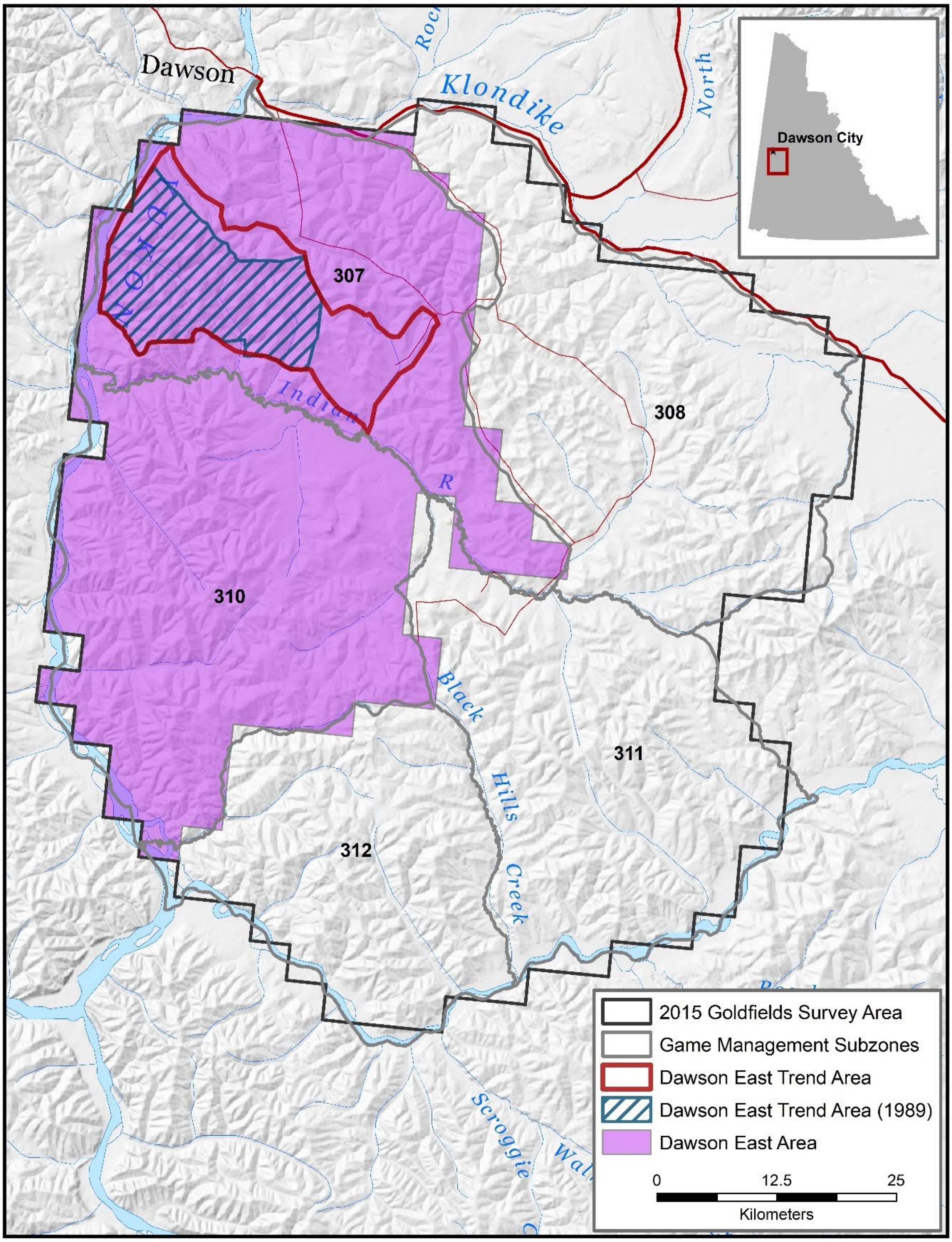

Figure 2. Previous moose trend and census surveys in the Dawson Goldfields Moose survey area.

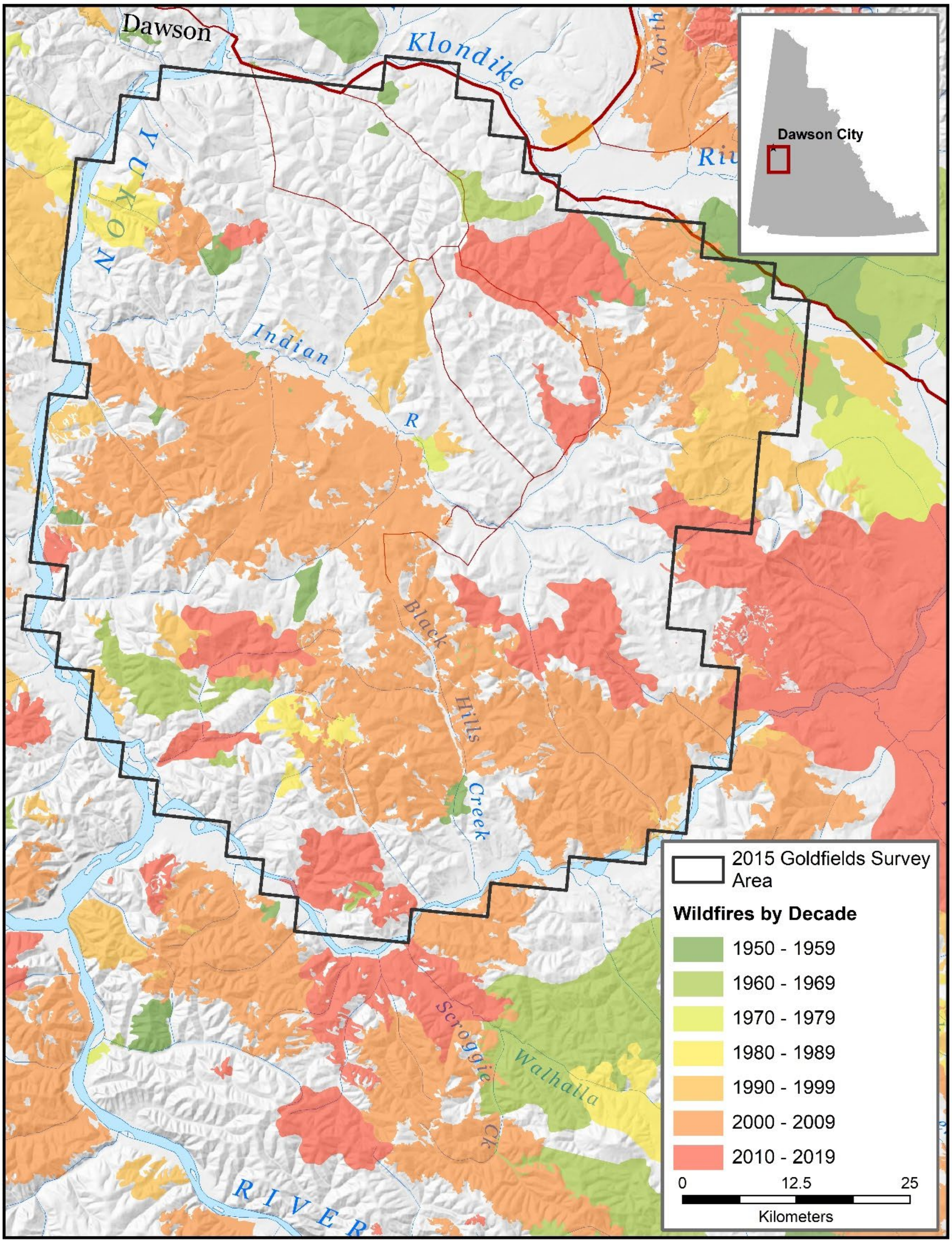

Figure 3. Dawson Goldfields 2015 moose survey area fire history.

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, previous stratification flights, 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, landscape or other factors to correct for any bias in our sample. This analysis allows us to incorporate factors that affect the distribution of different age and sex classes across the landscape and predict the moose 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 survey 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. 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.

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 used a sightability correction factor (SCF) of 1.05 (5%), based on sightability flights from previous moose surveys in the Dawson Goldfields. This is the number of moose we estimate were missed during our searches of each survey block and is used 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:

1. In phase 1, we use 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 2-3 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. For this survey, we used the stratification information from previous surveys and local knowledge to select survey blocks.

2. In phase 2, we use a combination of landscape characteristics (land cover, slope, elevation), stratification data, and local information 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 sampling 1) provides a total population estimate with adequate precision to make management decisions for the area, 2) meets all assumptions for the final model, 3) has enough blocks counted in each subarea for which estimates are desired, and 4) 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.

3. 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.

Weather and snow conditions

Weather and snow cover conditions during the survey were good. Snow cover was complete (100%), but depth was shallow (<6 inches) in most areas, and light conditions ranged from flat to bright. Weather was overcast, with occasional patches of fog and mild to moderate winds. Temperatures ranged from -13 to -28°C with icing conditions on the 16th of November forcing helicopters to return to the base early.

Results and Discussion

Coverage

We counted moose in 117 of the 390 blocks, or about 30% of the total area (Fig. 4). It took 55.7 hours to count moose in these blocks using two helicopter crews (27.9 and 27.8, respectively), for a search intensity of 1.86 minutes/km². We used another 22.42 hours of helicopter time to ferry between survey blocks and fuel caches, and back and forth to Dawson.

Observations of moose

A total of 857 moose were observed within surveyed units including 235 (27%) mature bulls; 437 (51%) cows; 66 (8%) yearling bulls; and 119 (14%) calves (Table 1).

Table 1. Observations of moose in survey blocks in the Dawson Goldfields survey area during the November early-winter survey, 2015.

	Total
Number of blocks counted	117
Number of adult bulls	235
Number of cows	437
Number of yearling bulls	66
Number of calves	119
Number of unclassified adults	0
Total Number of moose observed	**857**

Distribution of moose

Moose were widely distributed in the survey area with the highest numbers observed in areas burned within the past 15 years. We saw most moose in areas of subalpine burns dating from 2004 (Fig. 3, 4). We observed few moose in mature birch, aspen and spruce forests. We expected to see higher numbers of moose in GMS 308 burn areas, however much of the regeneration in this area appeared to be aspen and birch with little willow regrowth.

Abundance of moose

The final model that best predicted moose abundance in the survey area included 3 explanatory variables (Appendix 1). Specifically, we found a positive correlation between moose abundance in a survey block and the proportion of higher elevation areas burned between 11 and 30 years prior to the survey. In addition, a 2-category survey block stratification (high abundance and low abundance) based on available local information was included in the best model.

Based on our survey counts and model predictions, we estimated a population of 1583 moose in the survey area, and we are 90% confident that the population was between 1449 and 1739 moose (Table 2). This includes a sightability correction factor (SCF) of 1.05 (see *Methods*), which assumes observers missed 5% of moose during the survey.

The estimated density of moose in the entire survey area was 265 moose per 1000 km², or, 268 per 1000 km² of suitable moose habitat (Table 2). This is at the high end of the range of typical Yukon moose densities of 100 – 250 moose/1000 km² of suitable moose habitat (Table 2; Government of Yukon, 2016).

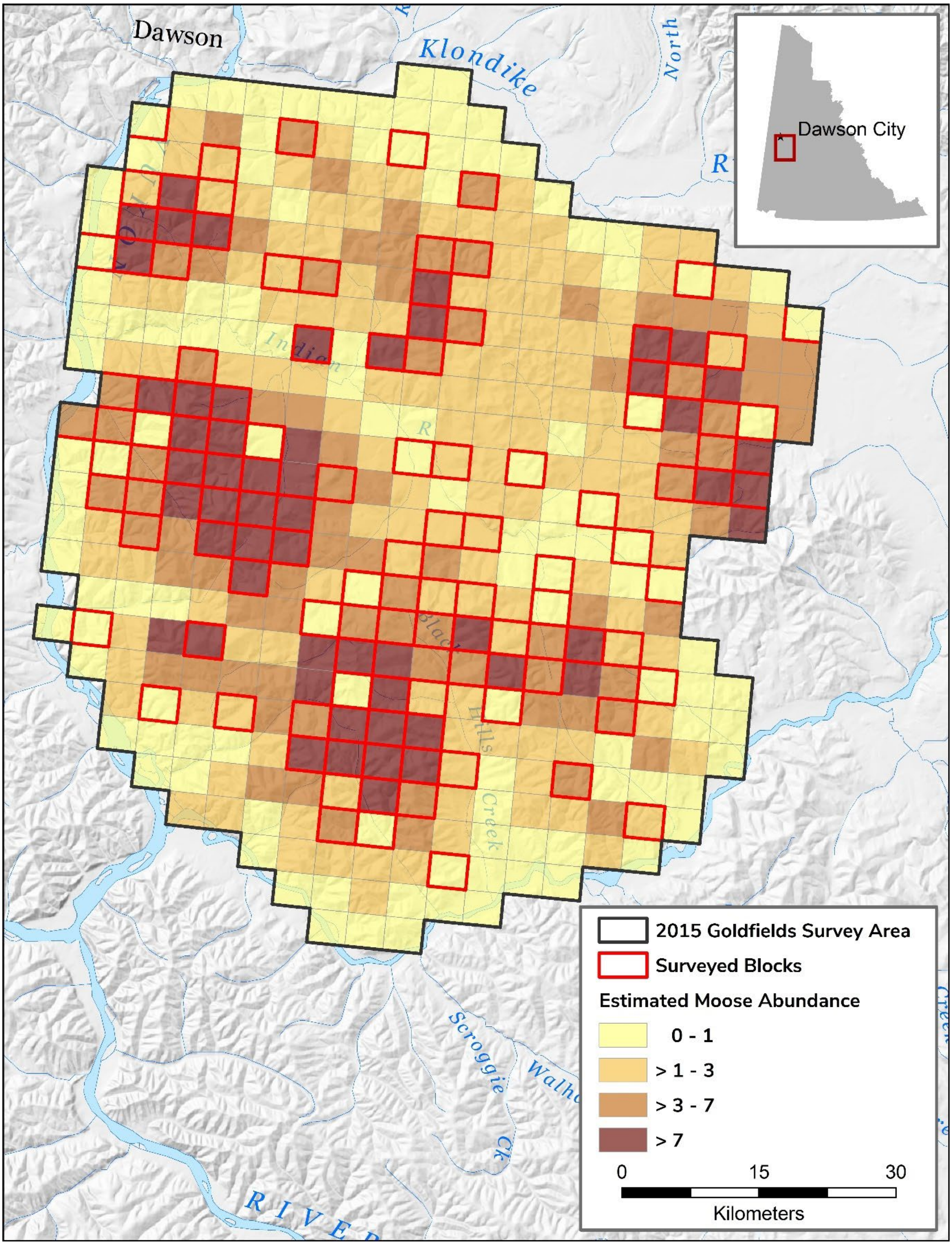

Figure 4. Observed (surveyed blocks) or predicted (model-based) numbers of moose in the Dawson Goldfields survey area, November 2015.

Table 2. Estimated abundance of moose, corrected for sightability (Correction Factor: 1.05), in the Dawson Goldfields survey area in November 2015.

	Best Estimate*	90% Prediction Interval **
Estimated total number of moose	1583	1449 - 1739
Adult bulls	396	380 - 415
Adult cows	860	836 - 884
Yearlings	95	82 - 107
Calves	247	231 - 264
Density of moose (per 1000 km^2*)**		
Survey area	265	
Moose habitat only	268	

* The sum of the estimated numbers of adult bulls, adult cows, yearlings and calves is slightly different than the estimated total number of moose in the study area because we rounded off estimates from individual survey blocks in the compositional analysis to estimate numbers in each age and sex category of moose.

** 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.

*** Survey area refers to the total area of survey blocks included in the survey area (390). Suitable moose habitat is all areas at elevations below 1524 m (5000 ft), excluding water bodies 0.5 km^2 or greater in size.

Ages and sexes of moose

The composition of moose in a survey block was influenced by the total number of moose observed or predicted in the block. Specifically, when more than 9 moose were counted or predicted in a block, the composition was more likely to include a greater proportion of adult bulls, yearling bulls, and cows without calves. We used this relationship to estimate moose composition in unsurveyed blocks (Appendix 1).

Our survey results indicate the number of calves surviving to November in the Dawson Goldfields survey area is average when compared to other areas surveyed in the Yukon at 29 calves/100 adult cows (Table 3; Government of Yukon 2016). We estimated a 7% yearling recruitment ratio or 11 yearlings/100 adult cows, which is low compared to the Yukon average of 18 yearlings/100 adult cows. (Table 3, Government of Yukon 2016).

We estimated 396 adult bulls and 860 adult cows in the survey area (Table 2). The adult sex-ratio was 46 adult bulls/100 adult cows which is similar to previous surveys in the Dawson Goldfields survey area (Tables 3, 4 [see *Population Trend* section below]). This value is above the minimum threshold of 30 adult bulls/100 adult cows recommended in the Science-based Guidelines for Management of Moose in Yukon (Government of Yukon, 2016).

Table 3. Estimated composition of the moose population in the Dawson Goldfields survey area, November 2015.).

	Best Estimate	90% Prediction Interval
% Adult bulls	25	24 - 26
% Adult cows	54	53 - 56
% Yearlings	6	5 - 7
% Calves	16	15 - 17
Adult bulls per 100 adult cows	46	43 - 49
Yearlings per 100 adult cows	11	10 - 12
Calves per 100 adult cows	29	27 - 31
% of cow-calf groups with twins	4	4 - 6

* 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 Trend

The entire Dawson Goldfields survey area has been flown twice previous to this survey; in 2002 and 2008 (see *Previous Surveys* section). The 2002 population estimate is considered to be an underestimate due to a number of methodological challenges (Government of Yukon, 2003), while the 2008 population estimate is considered robust (Cooley et al., 2012). We compared population estimates between 2008 and 2015 survey years to assess potential population trends (Table 4). We did not include sightability correction factors when comparing between years.

Total population estimates for the Dawson Goldfields survey area are similar between 2008 and 2015. The 2008 population estimate was 1580 (CI: 1321 – 1839) and the 2015 population estimate was 1504 (PI: 1377 – 1652; Table 4). Confidence and prediction intervals for population estimates overlap suggesting there has been no significant change in the total population. The similarity in our total population estimates results in similar estimates of density (moose per 1000 km^2) between years in both the total survey area (264 in 2008; 265 in 2015), and in moose habitat only (267 in 2008; 268 in 2015 [Table 4]).

We found similar results for all composition analyses (age and sex) with confidence and prediction intervals between the 2008 and 2015 survey overlapping in all cases, and estimated values similar between years in most instances (Table 4). Recruitment estimates for both calves and yearlings remain within the range of surveyed populations in the Yukon, however, estimates of recruitment from one survey are snapshots in time, and survival varies from year to year (Government of Yukon 2016).

Table 4. Estimated abundance and composition of moose in the Dawson Goldfields survey area from 2008 and 2015*.

Dawson Goldfields Survey Area	Survey Year	
	2008	**2015****
Estimated total number of moose	1580 (1321 – 1839)	1504 (1377 – 1652)
Adult bulls	359 (254 – 464)	376 (361 – 394)
Adult cows***	817 (684 – 951)	817 (794 – 840)
Yearlings***	123 (74 – 172)	90 (78 – 102)
Calves	299 (224 – 374)	235 (219 – 251)
Adult bull : 100 adult cows	44 (29 – 58)	46 (43 – 49)
Yearlings : 100 adult cows	15 (8 – 22)	11 (10 – 13)
Calves : 100 adult cows	36 (26 – 47)	29 (27 – 31)
Density of moose (per 1,000 km^2)		
Entire survey area	264	265
Moose habitat only****	267	268

* No sightability correction was applied to any of the results to allow for comparison between years. Uncertainty in the estimates are expressed as Confidence Intervals in 2008 and Prediction Intervals in 2015.

**The sum of the estimated numbers of adult bulls, adult cows, yearlings and calves is slightly different than the estimated total number of moose in the study area because we rounded off estimates from individual survey blocks in the compositional analysis to estimate numbers in each age and sex category of moose.

*** To account for yearling cows that cannot be identified from the air, the total number of yearlings is assumed to equal twice the estimated number of yearling bulls in the population. We use this assumption to estimate the total number of adult cows in the survey area by subtracting the number of yearling bulls observed from the total number of cows counted.

**** Suitable moose habitat is considered to be all areas at elevations lower than 1524 m (5000 ft), excluding water bodies 0.5 km^2 or greater in size.

Harvest and Mortality

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 (Government of 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 (Government of 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.

This survey did not encompass the entire Goldfields MMU (GMS 224 and 225 were excluded) and therefore we must combine approaches from our guidelines to establish the sustainable harvest for this MMU. Based on our survey results, we estimate that the sustainable harvest for the survey area is 40 bulls (10% of the estimated 396 adult bulls). The estimated moose densities for GMS 224 and 225 (based on expert opinion and survey data in adjacent areas with similar habitat) are 235 and 206 moose per 1000 km^2 respectively. These GMSs do not have recent survey information, so our best estimate of the sustainable harvest is 10 bulls (3% of the estimated moose in GMS 224 and 225; Government of Yukon, 2016). Therefore, the estimated sustainable harvest for the Dawson Goldfields MMU is 50 bulls annually.

Licensed harvest is predominantly composed of resident harvest in the Dawson Goldfields MMU, with only a small proportion of non-resident harvest. The 5-year average reported licensed harvest preceding this survey (2011-2015) for the MMU is 31 bulls or 62% of the estimated sustainable harvest. Because there was no change in the total moose estimated in the Dawson survey area since the 2008 survey, our data indicate that the total harvest between the 2 surveys was sustainable. Reported licensed harvest available for the 6 years since the survey (2016-2021) has been consistent (between 25 and 35 bulls) with an average of 31 bulls per year. Licensed harvest does not include moose harvested by First Nation hunters. Actual First Nation harvest information is required to accurately quantify the level of harvest in this population and ensure that total harvest does not exceed sustainable levels.

In addition to harvest mortality, moose in the survey area are frequently killed in road collisions, particularly along the Klondike Highway. Data indicates 2.8 moose are killed on average (2011-2015 inclusive) each year in collisions.

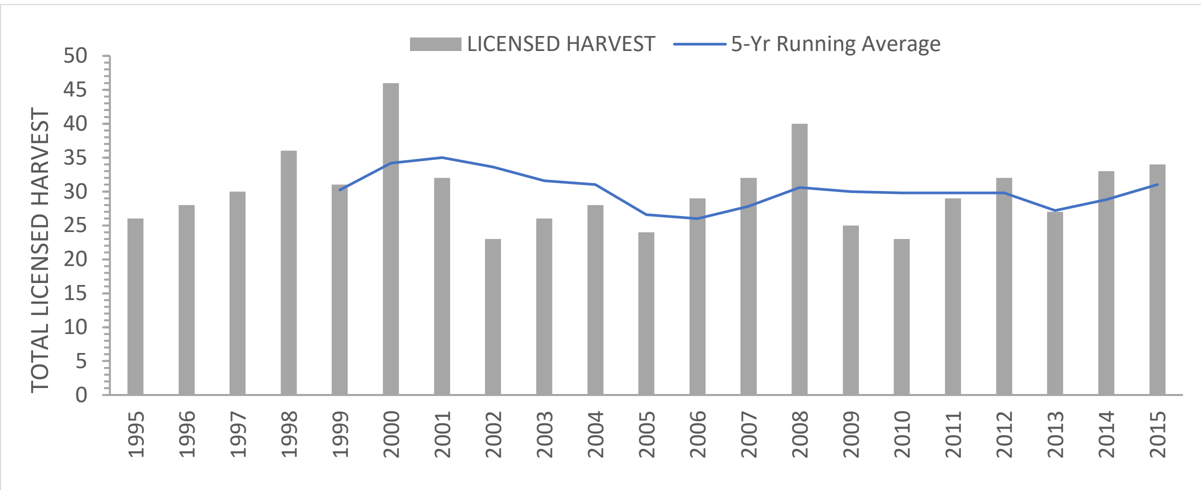

Figure 5. Total reported licensed harvest of moose in the Dawson Goldfields Moose Management Unit (MMU) with 5-year running average.

Other wildlife sightings

In addition to the 857 moose we counted during the 2015 census, we observed 284 moose outside of the surveyed blocks or while travelling between survey blocks. We also observed and documented a variety of other species during the survey: 4752 caribou, which were from the Fortymile herd, though some individuals from the Nelchina herd may have been in the area; 52 wolves (3 packs of 12 –13 wolves; 2 lone wolves); 111 sharp-tailed grouse; 2 great-horned owls; 1 gyrfalcon; 1 unknown raptor; and 1 snowshoe hare.

Conclusions and Recommendations

- We estimated 1583 moose in the Dawson Goldfields survey area in November 2015. Moose density in available moose habitat was approximately 268 moose/1,000 km^2, which is at the high end of the Yukon-wide range of moose densities of 100 – 250 moose/1000 km^2 in moose habitat. Based on previous, smaller-scale surveys since 1989 and a survey of the same area in 2008, the number of moose appears to have remained relatively stable.
- We estimated the adult sex-ratio at 46 bulls per 100 cows. This ratio is above the minimum of 30 bulls per 100 cows recommended by Yukon's Science Based Guidelines for the Management of Moose Management (2016) to reduce the risk to reproductive success (timing of breeding and birth, offspring sex-ratio and survival).
- Early-winter calf recruitment (29 calves per 100 adult cows) was near the average for areas surveyed in the Yukon. We estimated a low yearling per 100 adult cow ratio (11), which indicates low recruitment of 2014 calves. The 5-year average reported licensed harvest (2011-2015) for the Goldfields MMU is 31 bulls or 62% of the estimated sustainable harvest. Because we detected no change in the total moose estimated in the Dawson Goldfields survey area since the 2008 survey, our data indicates that the total harvest between the 2 surveys was sustainable.
- First Nation harvest information is required to monitor the level of harvest in this population and ensure that total harvest does not exceed sustainable levels.
- We should continue to monitor the Dawson Goldfields moose survey area. Periodic population aerial surveys including collection of calf and yearling recruitment data will help ensure the sustainability of harvest in the Goldfields MMU.

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Appendices

Appendix 1 – Analyses and models used to estimate the abundance and composition of moose in the Goldfields Survey Area from November 2015 survey data.

Overview

We estimated abundance and composition of moose in the Goldfields survey area with a two-staged approach (see Study Area section for details). We first used a combination of landscape covariates and expert information at the survey block scale to generate count models and provide estimates of moose abundance for unsampled survey blocks. Then, we used predicted and observed moose abundance with moose composition information from surveyed blocks to estimate the composition of moose over the entire survey area.

For all analyses, we included biologically relevant and spatially representative covariates expected to influence moose occurrence and composition. We used these covariates to generate candidate models and based further inference on the highest-ranking model determined using Akaike's Information Criterion (AIC; Burnham and Anderson 2002) and AIC weights (Wagenmakers and Farrell 2004).

Abundance estimation

We fit Zero-Inflated Negative Binomial regression Models (ZINB) to relate the number of moose counted in surveyed blocks with selected coefficients (Table 1). These models best describe low density and spatially aggregated moose distributions across survey blocks in 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; R Core Team, 2023). The most parsimonious model included the mean elevation of the survey block, the proportion of the block that burned 11 to 30 years prior to the survey, and expert information from the Regional Wildlife Technician (Table 2).

We used this abundance model to predict the number of moose in the remaining unsurveyed blocks (Table 3). We obtained the final population estimate and bootstrapped prediction intervals by combining the actual number of observed moose in sampled survey blocks with the distributions of predictions from unsurveyed blocks generated from 1,000 bootstraps (Czetwertynski et al., *in prep*). This approach enables us to generate realistic estimates of subsets of the survey area when required.

Composition estimation

We used a compositional analysis to describe the age/sex composition of the moose population in the surveyed blocks using the vglm() function in the VGAM package for R (Yee 2010). The number of moose counted in a survey block significantly affected the distribution of moose composition in the survey area (Table 4). Specifically, we found the composition of moose in blocks with more than 9 moose to have a significantly greater proportion of bulls and lone cows (Table 5). We applied this model to unsurveyed blocks where the median number of moose was predicted by the ZINB count model. We obtained the final composition estimates and associated prediction intervals of the surveyed area by iteratively bootstrapping (1,000 runs) the count and composition models (Czetwertynski et al., *in prep*).

Table 1: Description of selected covariates considered for Resource Selection Probability Functions (RSPFs) and models of abundance/composition of moose in the Whitehorse South survey area, November 2021.

Covariate Name	Description	Source
Elev	Mean elevation in km of the survey block.	Canadian Digital Elevation Model, 30m x 30m resolution. Natural Resources Canada.
Burns	Percent of survey unit burned between 11 and 30 years prior to the survey.	Canadian National Fire Database.
Expert	Binary covariate describing whether the Regional Biologist predicted high (1) or low (0) numbers of moose in the survey unit.	Martin Kienzler (Liard Regional Technician).
Conifer	Percent of the survey unit with Conifer forest cover type.	North American Land Cover 2010, Canada Center for Remote Sensing (CCRS), Natural Resources Canada.
Shrub	Percent of the survey unit with Shrub cover type.	North American Land Cover 2010, Canada Center for Remote Sensing (CCRS), Natural Resources Canada.

Table 2: List of best models describing the number of moose observed in survey blocks in the Goldfields survey area (November 2015) with associated AIC scores and model weights.

Model		Distribution	df	AIC	ΔAIC	w
Count Covariates	ZI Covariates					
Elev + Burns + Expert		ZINB	5	657.8	0.00	0.64
Elev + Shrub + Expert	Conifer	ZINB	6	659.3	1.55	0.30
Elev + Burns + Expert		ZINB	4	662.5	4.75	0.06
Elev + Burns		ZINB	5	683.7	25.98	0.00

Table 3: Zero-Inflated Negative Binomial (ZINB) regression estimates for counts of moose observed in surveyed blocks (approximately 16 km^2) in the Goldfields survey area, November 2015 (n = 131 ; Log-likelihood =-351.2).

	Estimate	Standard Error	Z	P
Count model coefficients (negbin with log link):				
(Intercept)	-2.113	0.515	-4.101	<0.001
Elev	3.126	0.623	5.016	<0.001
Burns	1.208	0.194	6.212	<0.001
Expert	0.753	0.242	3.111	0.002
Log(theta)	0.816	0.210	3.882	<0.001
Zero-inflation model coefficients (binomial with logit link):				
(Intercept)	-3.985	1.212	-3.288	0.001

Table 4: List of top-ranking models describing the composition of moose observed in the Goldfields survey area (November 2015) with associated AIC scores.

Model	AIC	ΔAIC	w
GR_9Moose	1071.1	0.0	0.95
GR_8Moose	1077.5	6.4	0.04
GR_7Moose	1079.5	8.4	0.01
Burn	1088.2	17.1	0.00
GR_6Moose	1088.8	17.8	0.00
Null	1091.0	20.0	0.00
Elev	1091.9	20.8	0.00
GR_5Moose	1092.6	21.5	0.00
GR_3Moose	1093.2	22.1	0.00
GR_4Moose	1095.2	24.1	0.00

Table 5: Compositional model regression estimates for moose in the Goldfields survey area, November 2015 (n = 131, Log-likelihood =-525.5).

	Estimate	Standard Error	*Z*	*P*
(Intercept):BULL_LARGE	0.202	0.177	1.143	0.253
(Intercept):BULL_SMALL	-2.269	0.429	-5.290	<0.001
(Intercept):COW_1C	-0.035	0.187	-0.187	0.851
(Intercept):COW_2C	-4.060	1.008	-4.027	<0.001
(Intercept):LONE_COW	0.881	0.156	5.643	<0.001
GR_9Moose:BULL_LARGE	0.734	0.227	3.235	0.001
GR_9Moose:BULL_SMALL	1.469	0.480	3.058	0.002
GR_9Moose:COW_1C	-0.192	0.260	-0.736	0.462
GR_9Moose:COW_2C	1.772	1.084	1.635	0.102
GR_9Moose:LONE_COW	0.344	0.208	1.658	0.097

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