MOOSE SURVEY

NORTH CANOL

EARLY-WINTER 2012

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Summary

We conducted an early-winter survey of moose in the North Canol study area northeast of Ross River from 17 to 23 November 2012. The main purpose of this survey was to estimate the abundance, distribution, composition, population trend, and harvest rate of the local moose population.

- We counted all moose observed in selected survey blocks that covered about 38% of the survey area. We observed 394 moose: 119 adult bulls, 202 adult and yearling cows, 27 yearling bulls, and 46 calves.
- We estimated the population size for the entire survey area at 661 ± 18% moose. This represents an average density of approximately 204 moose per 1000 km² over the total survey area.
- The moose population was similar to the 2001 population estimate but lower than the population peak observed in 1991 shortly after the end of the wolf control program. In the absence of measures to reduce predation, results suggest that the moose population returned to natural moose densities sometime between 1996 and 2001.
- We estimated there were 64 ± 23% adult bulls for every 100 adult cows. This figure is well above the minimum of 30 adult bulls per 100 adult cows required to prevent negative impacts on reproductive rates as recommended in the *Science-Based Guidelines for Management, Harvest, and Mitigation of Land Use Activities: Moose*.
- We estimated there were 26 ± 22% calves and 40 ± 50% yearlings for every 100 adult cows in the total survey area. These ratios suggest that the survival of calves was moderate during summer and fall of 2012 and good for calves born in 2011.
- Based on all available data, the current harvest rate, including estimates of non-licenced harvest, of 3.0% within the Ross River Moose Management Unit appears to be at sustainable levels as set out in the *Science-based Guidelines for Management, Harvest, and Mitigation of Land Use Activities: Moose*.
- Complete harvest information that includes harvest data from all users is required to provide a more accurate assessment of the harvest rate for the Ross River Moose Management Unit.

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Introduction

This report summarizes the results of the early-winter moose survey in the North Canol survey area conducted between 17 and 23 November 2012 (Figure 1). The main purpose of this survey was to estimate the abundance, distribution, composition, and trend of the moose population in the Ross River Moose Management Unit (MMU) in response to continuing community concerns about the moose harvest along the North Canol Road corridor and adjacent areas where most of the harvest occurs. Hunters often favour easily accessible areas; ensuring the sustainability of moose harvest requires that government agencies monitor moose populations in accessible areas and implement harvest management actions if necessary. The North Canol Road corridor has a long history of mineral exploration that has left behind an extensive footprint of access roads and trails that penetrates deep within the mountain blocks throughout the Ross River MMU.

The 2012 North Canol survey is part of continued monitoring by Environment Yukon of high-priority moose populations (Figure 1). Yukon-wide priorities for moose population inventory and monitoring are established with consideration given to access levels, harvest levels, quality of ecological information, current and anticipated land use activities, habitat availability, and population health. These factors are weighed together with social, financial, and political considerations to produce annual and multi-year survey schedules (Environment Yukon, *in prep.*). The North Canol survey area has the most comprehensive moose survey history of any area in southeast Yukon.

Previous Surveys

Finlayson Lake Predator Control Study

Environment Yukon conducted the Finlayson Lake predator control study from 1983 to 1989 over an area slightly larger than the range of the Finlayson caribou herd in an effort to increase recruitment rates and the total population size of this herd (Figure 2; Farnell et al. 2008). Wolves in the control area were annually reduced to less than 20% of their natural density (Hayes and Harestad 2000a). Results from the moose surveys conducted between 1987 and 2001 (e.g. Jingfors 1988, Larsen and Ward 1995, Environment Yukon 2000, 2003) were used to study the functional and numerical response of moose and caribou during and following the Finlayson Lake predator control study (e.g. Hayes 1995, Hayes and Harestad 2000a, 2000b, Farnell et al. 2008, Adamczewski et al. 2010). Changes in moose numbers in the North Canol survey area during this period appear directly linked to the wolf control program.

Intensive Population Surveys

Monitoring of the moose population in the North Canol area to determine its abundance, distribution, and composition began in 1987 with an early-winter intensive population survey, herein referred to as a census survey (Jingfors 1988; Figure 1). As part of this survey, Environment Yukon extended the stratification

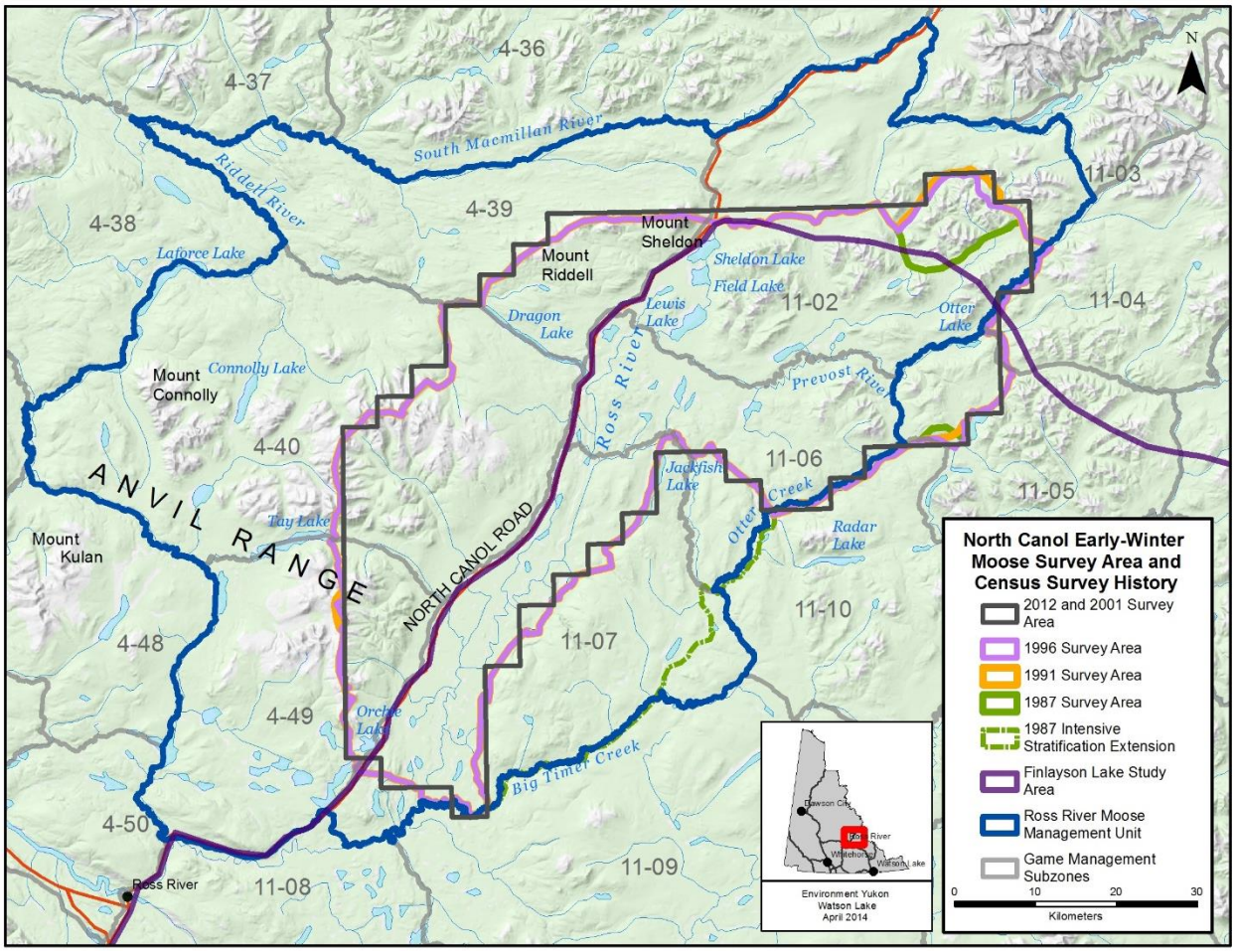

Figure 1. 2012 North Canol early-winter moose survey area and census survey history, southeast Yukon. The 1987, 1991 and 1996 survey areas are almost identical, with minor deviations in the northeast portion.

component of the survey by 696 km^2 in an area adjacent to the southeastern portion of the survey area (Figure 1) to compare the relative distribution and density of moose over a larger area.

Environment Yukon surveyed this area again in 1991 soon after the completion of the predator control study and results showed a significant increase in moose numbers throughout the area (Larsen and Ward 1995; Figure 1). Environment Yukon conducted further surveys in 1996 (Environment Yukon 2000) and 2001 (Environment Yukon 2003) to monitor the long-term effects of predator control on ungulate populations (Figure 1). Without further implementation of predator control measures in the region, both the 1996 and 2001 surveys documented declines in moose populations relative to the 1991 estimate.

Low Intensity Surveys

Markel and Larsen (1986) conducted early-winter and late-winter surveys of the moose population over a large

area centered on the North Canol Road from Ross River to MacMillan Pass during the winter of 1981-82. The intent of this study was to collect baseline information on the relative distribution, habitat selection, and population composition of moose post-rut and in late winter in advance of potential mining developments.

Early-winter moose population trend surveys were conducted annually in the North Canol area from 1989 to 1999 to monitor moose numbers between intensive surveys following the predator control study (Yukon Renewable Resources 1997, *unpublished data*). These surveys were flown over a 317.6 km^2 survey area that overlapped the northeastern region of the census survey study area. Generally, these surveys showed an increase in recruitment up to 1992 and moose numbers to 1994 followed by declines consistent with the recovery of wolf populations.

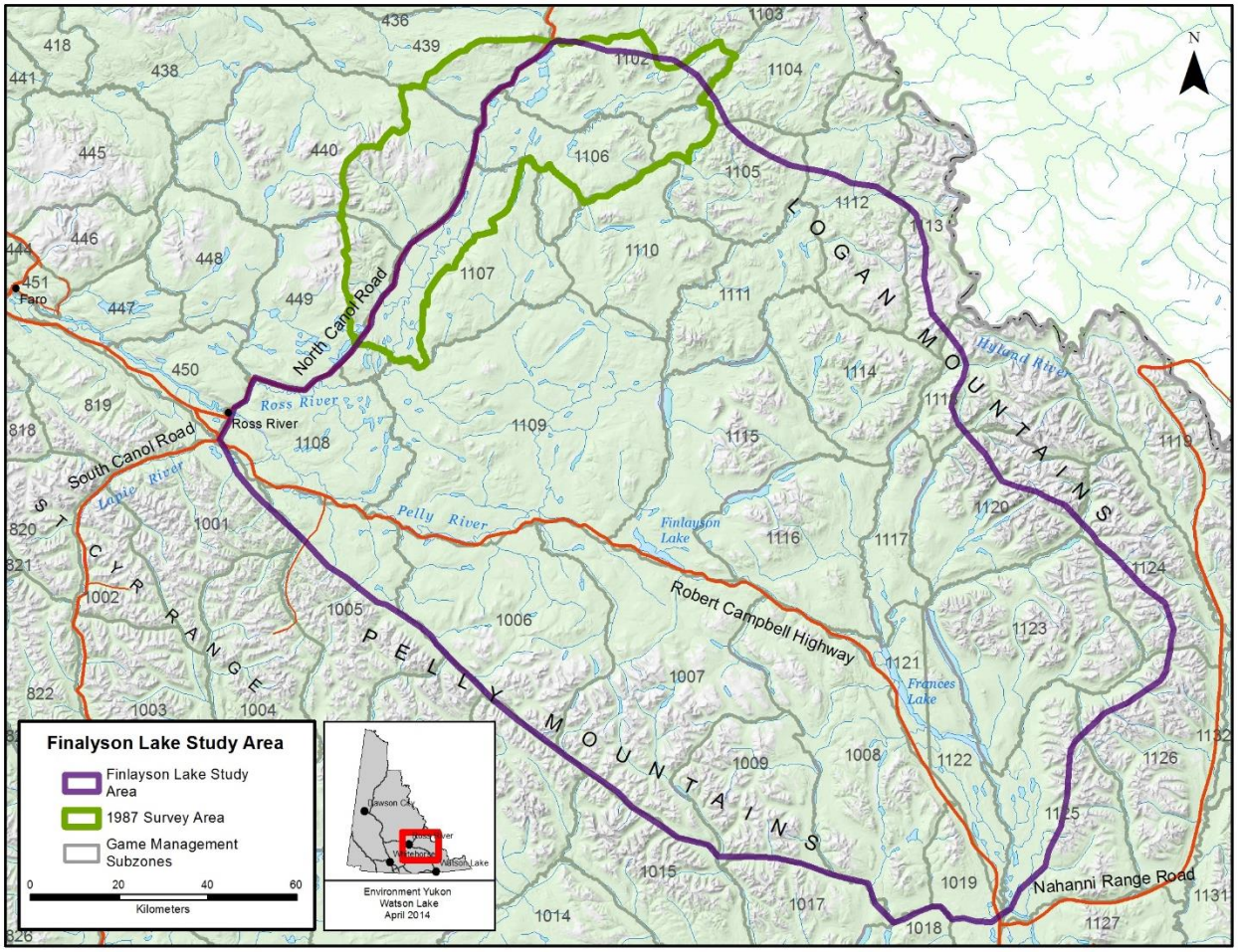

Figure 2. Finlayson Lake Predator Control Study area, southeast Yukon. We show the 1987 moose survey area on this map for reference purposes.

Recruitment Surveys

Environment Yukon conducted late-winter moose calf recruitment surveys annually within the larger Finlayson Lake study area between 1986 and 2000. The purpose of these surveys was to estimate how many moose calves survived their first winter. For the first eleven years, the recruitment data was monitored over this large area to determine response to wolf population control efforts (Ward et al. *in prep.*), but between 1997 and 2000, the recruitment data was collected specifically to assess moose recruitment in three focused survey areas including one along the North Canol Road (Foos 1997, 1998, Hennings 1999, 2000).

Late-winter Stratification Surveys

We conducted a late-winter intensive stratification survey in February 2009 that covered the entire North Canol Road corridor from Ross River to the Northwest Territories border (Drummond 2009). The purpose of this survey was to identify key moose wintering areas along the North Canol Road corridor—an area experiencing high levels of mineral exploration and proposed developments—to inform environmental assessment recommendations.

Community Involvement

Moose have been a key part of First Nation peoples' subsistence lifestyle for generations and today are the most widely hunted Yukon game species by both First Nation and non-First Nation hunters.

Ross River community members have voiced their concerns about the perceived high hunting pressure along the North Canol Road since the mid-1980's. In response to these concerns, Environment Yukon has monitored moose populations and harvest regularly in this region.

Reflecting their interest in responsible moose management and their concerns about the perceived high hunting pressure along the North Canol Road, community members of Ross River and Faro have participated in arranging observers or taking part as observers in this and other moose surveys in the area (e.g. Westover et al. 2008, Clarke et al. 2012, Fontaine et al. *in prep.*).

From 1991 to 1994 and again from 1996 to 1999, Yukon Environment and the Ross River Dena Council operated the North Canol Game Check Station at the Pelly River ferry crossing and along the North Canol Road. The program was operated in response to local concerns about the number of hunters and the level of harvest in this area. Licenced hunters were asked to report on their hunting activities. Check Station results tended to underestimate harvest compared to other data sources such as the mandatory harvest reporting system for licenced hunters.

Study Area

The North Canol survey area is approximately 3,239 km^2. Most of the area is habitable moose range (~3,085 km^2), except for alpine habitats that are 1,676 m or more above sea level and water bodies 0.5 km^2 or greater in size. The survey area extends north from Orchie Lake to Mounts Riddell and Sheldon and then southeast to

Otter Lake and Otter Creek (Figure 1). The North Canol Road bisects the survey area. The survey area includes the eastern portions of Game Management Subzones (GMS) 4-39, 4-40, 4-49, the western portions of 11-05 and 11-07, most of 11-06, and the southern half of 11-02. The study area also includes very small portions of GMSs 11-04, 11-09, and 11-10. Major geographic features of the area include the valleys and riparian flats of the Ross and Prevost Rivers and Otter Creek, the eastern end of the Anvil Range, and Mounts Riddell and Sheldon. The area also encompasses numerous medium sized lakes such as Orchie, Jackfish, Dragon, Lewis, Field, Sheldon, and Otter Lakes.

Most of the survey area lies within the Yukon Plateau North ecoregion. A small portion of the Selwyn Mountains ecoregion extends into the northeastern boundary of the study area; however, this area has more in common with the Yukon Plateau North ecoregion despite being part of the Selwyn Mountains ecoregion. (Yukon Ecoregions Working Group 2004). Characteristic of this landscape are small, well defined, and steep sloped mountain blocks isolated from the Itsi Mountain Range by the wide valleys of the South MacMillan River and Ross River (Figure 1).

The survey area consists of rolling highlands with an east–west orientation. Mean annual temperatures are –5°C, but temperatures vary widely by season and elevation. Mean January temperatures range from below –30°C in the lower valleys to above –20°C over higher terrain. This gradient shifts in July when mean temperatures are 15°C in the valley bottoms and 8°C over higher terrain. The incidence of temperature extremes is higher in the lower valley floors than at higher elevation. Rain and snowfall is moderate in the ecoregion, but is greater in the east because of upslope conditions over the higher terrain. Annual precipitation amounts range from 300 to 600 mm. Winds are usually light, and only moderate to strong in thunderstorms or unusually active weather systems.

Vegetation cover ranges from boreal to alpine. Alpine environments are characterized by low ericaceous shrubs, small willows (*Salix sp.*), and lichens. Subalpine environments are typically vegetated with willow and shrub birch (*Betula glandulosa*) with scattered lodgepole pine (*Pinus contorta*), white spruce (*Picea glauca*), and subalpine fir (*Abies lasiocarpa*). Extensive shrub lands are often present on steep slopes subject to cold air drainage. At lower elevations, black spruce (*P. mariana*) and white spruce forests grow over moist sites. Trembling aspen (*Populus tremuloides*), lodgepole pine, and white spruce stands grow in warmer and better-drained sites. Black spruce bogs are common in lowlands areas throughout the region. Wide riparian flats dominated by a mix of shrub lands, grasslands, and black spruce can be found along the Ross and Prevost Rivers.

The survey area is located near the Tintina Trench, which has a high incidence of thunderstorms. Consequently, the study area has a complex and diverse forest fire history resulting in a high diversity of forest covers (Figure 3). Lodgepole pine often

forms extensive forests over burned areas. Most of the recent fires in the study area occurred in two large blocks, one from Sheldon and Field Lakes south to the Prevost River in 2004, and the other south of Dragon Lake in 2012. In addition, two large fires occurred through the 1990's, one north of Dragon Lake (1996) and the other in the Jackfish Lake area (1998). Older fires worth noting include two extensive burns that covered large extents of the south end of the study area on both sides of the North Canol Road in 1951 and 1989, and a 1989 fire north of the Prevost River in the eastern portion of the study area.

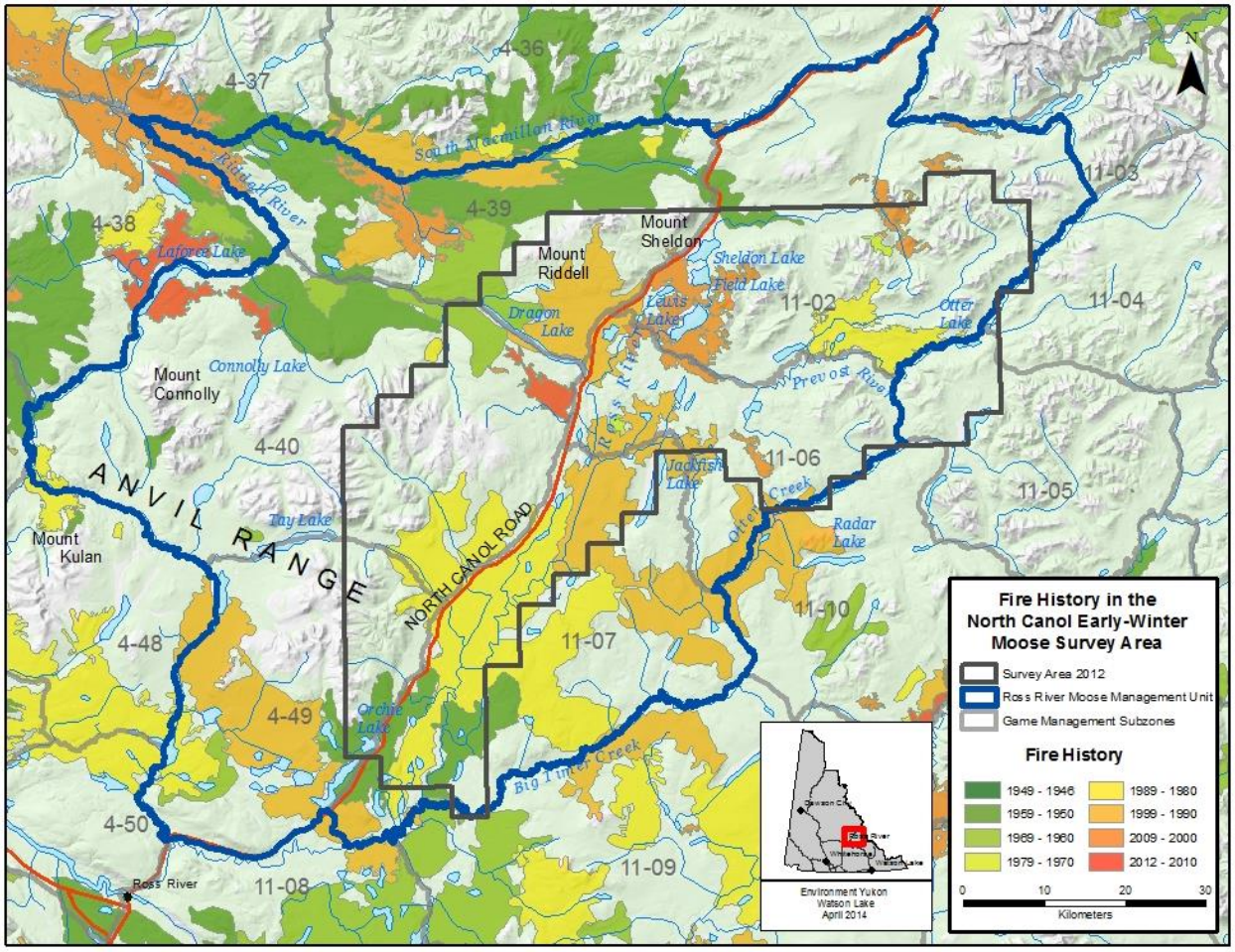

Figure 3. Fire history in the North Canol early-winter moose survey area, southeast Yukon, 2012.

Methods

We adapted a moose survey technique developed by the Alaska Department of Fish and Game (Kellie and DeLong 2006). This adapted technique has 6 steps:

1. We divided the survey area into rectangular blocks about 16 km² in size based on lines of latitude and longitude.

2. We used fixed-wing overflights of all survey blocks to classify, or "stratify", each block as having either high, medium, low, or very low expected moose numbers, based on local knowledge, number of moose seen, tracks, and habitat. This is called a "low intensity stratification" survey. We flew this portion of the survey with a Cessna 206 on the afternoons of 17 and 18 November with a crew of three observers in addition to the pilot.
3. We combined these categories of blocks into high or low "strata," and then randomly selected a sample of blocks in each stratum for our census. Given that the variability in the data is frequently found in the high blocks, a larger proportion of the high blocks are usually selected to be surveyed.
4. We counted every moose within the selected blocks (the "census" part of the survey), using helicopters at a search intensity of about 2 minutes per km^2. We classified all moose by age (adult or calf) and sex. Bull moose are classified as either adult or immature (yearlings). Yearling cows are often difficult to distinguish from adults, so counts were combined. We flew the census survey between 19 and 23 November with two helicopters, one Bell 206 and one Eurocopter A-Star, each with a crew of three observers in addition to the pilot.
5. We used the computer program MoosePop to estimate the total number of moose by age and sex in the entire survey area (Gasaway et al. 1986). We based the estimate on the numbers of moose counted in the blocks during the census, the distribution of these blocks and how we classified the blocks we did not count. Generally, the more blocks that are searched during the census portion of the survey, the more precise and reliable the resulting population estimate will be.
6. We estimated the number of moose that we missed during Step 4 using a "sightability correction factor" (SCF; Becker and Reed 1990) to correct the census results for moose that we overlooked. This correction factor is the Yukon average calculated from previous early-winter censuses that repeated moose counts at double the search intensity in a portion of survey blocks. The SCF is equal to 1.09 (i.e. it assumes we missed about 9% of moose) with a variance of 0.004. When comparing population data between years, we presented the results of the 2012 and all other previous surveys without SCF calculations given that the 1987 and 2001 surveys did not calculate population demographics using a SCF.

In the harvest section of this report, we estimate total moose numbers in each GMS by multiplying the average estimated moose density in the high and low stratum blocks by the number of high and low stratum blocks per GMS respectively.

We used two-tailed T-tests to compare population estimates between survey years with alpha = 0.1 as the cut-off for significance and Chi-squared tests to compare age and sex ratios between survey years

Although survey methodologies used for North Canol census surveys conducted from 1987 to 2012 have evolved over time, we compared all results to evaluate trends in the population. The main difference between these census surveys is that the sample units of the 1987, 1991, and 1996 surveys were based on topographic features identified on national topographic maps. By 2001, the introduction and use of Geographic Positioning Systems (GPS) for navigating during surveys and the use of Geographic Information Systems (GIS) for mapping purposes allowed us to define survey blocks based on lines of latitude and longitude. As a result of these updated survey blocks, the size of the survey area increased by approximately 189 km² between the 1996 and 2001 surveys.

Further differences between surveys include a "desktop" stratification in 2001 based on results from previous surveys as opposed to an actual stratification survey. Lastly, small improvements to the GIS base maps used in the 2012 survey resulted in a slightly different area considered as habitable moose range.

Weather and Snow Conditions

Weather conditions were consistent throughout this survey. Daily ground temperature over the duration of the survey ranged from –14° C to –20°C. Winds were mainly light with a few short periods of moderate winds, usually over higher elevation terrain. During the stratification portion of the survey (17 and 18 November), light snow prevented us from flying until late morning. We were able to fly full days every day of the census portion of the survey (19 to 23 November). All survey days, except 22 November, were overcast with small and localized snow showers moving through the survey area. Clouds and light snow at high altitude obscured the western survey blocks. As a result, light conditions were generally flat.

Snow depth across the study area averaged approximately 30 cm at the start of the survey and 45 cm by the end of the survey, with some variability across the study area due to terrain features. Snow coverage was complete. Localized snow showers moving though the study area throughout the census portion of the survey maintained fresh snow on the landscape and helped survey crews to track and sight moose. Although snow depth and accumulation were higher than normal in the Faro and Ross River areas (Yukon Department of Environment 2013), snow conditions are not believed to have affected the distribution of moose—high snow depth can force moose down into low elevation habitats more typical of late-winter range.

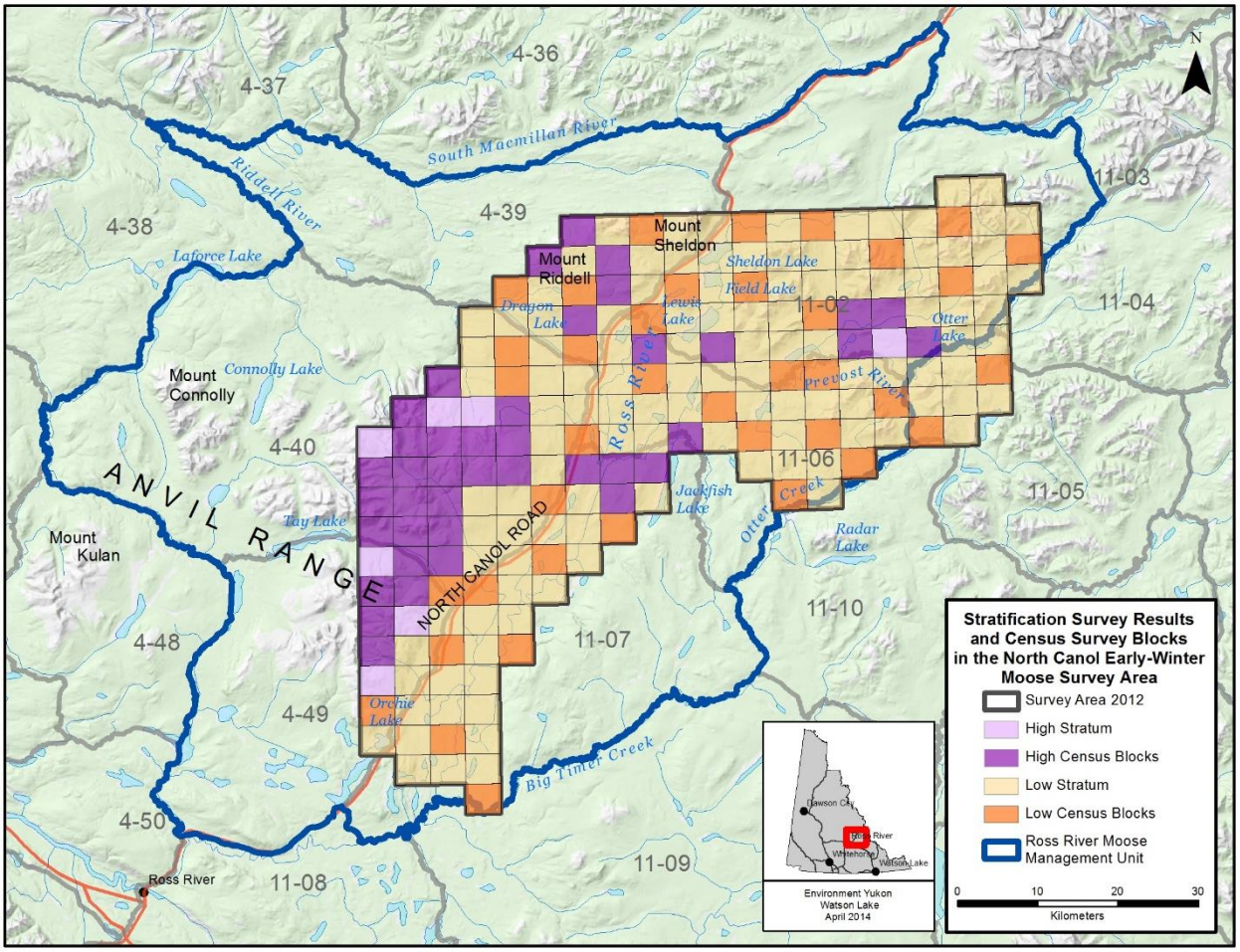

Figure 4. Stratification results and census survey blocks of the North Canol early-winter moose survey, southeast Yukon, 2012.

Results and Discussion

Stratification: Identification of High and Low Moose Density Blocks

We classified 47 blocks (23.2%) of the 203 survey blocks as having high expected moose numbers and 156 (76.8%) as having low expected moose numbers (Figure 4).

We flew 5.6 hours to stratify all 203 blocks with an additional 2.2 hours of flight time needed to ferry between our home base in Faro and the survey area. Total flight time was 7.8 hours.

We observed 144 moose during the stratification flights. Most of the blocks with expected higher moose numbers were in subalpine habitats of mountain blocks found in GMS 4-40 and 4-49 and on the middle to upper slopes of areas with a history of forest fires that occurred between 1989 and 2004 (such as the rolling hills south of Mount Riddell and east of Jackfish Lake; figures 2 and 3). Blocks with expected lower moose numbers were generally located over low elevation habitats and forested areas (Figure 4).

Census

Coverage

We intensively surveyed 78 of the 203 blocks, or 38% of the survey area (Figure 4). This number included 40 of 47 (85.1%) blocks expected to contain relatively high numbers of moose, and 38 of 156 (24.4%) blocks expected to contain few or no moose.

We flew 34.4 hours to count moose in these blocks, for an average search intensity of 1.66 minutes per km². Search intensity was slightly lower in the high-abundance blocks (1.64 minutes per km²) than in the low-abundance blocks (1.69 minutes per km²). Average search intensity was somewhat lower than normal for population surveys (2 minutes per km²), but non-habitable terrain and snow fields in mountainous regions in the northeast, north end, and along the western edge of the study area required less coverage.

We used another 19.8 hours of helicopter time ferrying between survey blocks and fuel caches located at the Ross River airport and near Sheldon Lake and to our home base in Faro. Total flight time was 54.2 hours.

Moose Observations and Distribution

We observed 394 moose: 119 adult bulls, 202 adult and yearling cows, 27 yearling bulls, and 46 calves (Table 1). Specifically, we observed an average of 540 moose per 1,000 km² in the high abundance blocks, and 81 moose per 1,000 km² in the low abundance blocks.

Table 1. Observations of moose during the 2012 North Canol early-winter moose survey.

	High Blocks	**Low Blocks**	**Total**
Number of blocks counted	40	38	78
Number of adult bulls	109	10	119
Number of adult and yearling cows[a]	175	27	202
Number of yearling bulls	20	7	27
Number of calves	41	5	46
Number of unknown age or sex	0	0	0
Total moose observed	345	49	394
Density of moose (per 1000 km²)	540	81	204

[a] Adult and yearling cows cannot always be reliably distinguished from the air, so their counts are combined. Assuming that equal numbers of males and females are born and that survival is similar between sexes, the number of yearling cows and bulls observed should be approximately equal. We therefore 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. Similarly, we estimate the total number of yearlings by doubling the number of observed yearling bulls. The estimate of adult cows and total yearlings in the population is presented in Table 2 below.

We observed the majority of moose in and around subalpine willow flats and creek draws in the eastern end of the Anvil mountain range; and in the mid to upper slopes of areas with a history of forest fires that occurred between 1989 and 2004 and good shrub re-growth (figures 2 and 3). In general, the distribution of moose was consistent with the previous early-winter surveys but with some variability related to forest fire history (Jingfors 1988, Larsen and Ward 1995, Environment Yukon 2000, Environment Yukon 2003).

Population Abundance

We estimated a population size of 661 ± 18% moose in the 2012 North Canol survey area (Table 2). This represents an average density of 214 moose per 1000 km² of habitable moose habitat or 204 moose per 1000 km² over the entire survey area (Table 2).

Of the 661 moose estimated to occupy the survey area, 184 ± 22% were adult bulls (28% of the total population), 288 ± 21% were adult cows (44%), 114 ± 45% were yearlings (17%), and 75 ± 22% were calves (11%). We observed no cows with twins during the survey.

Population Composition and Ratios

We estimated there were 64 ± 23% adult bulls per 100 adult cows (Table 2). This is well above the minimum of 30 adult bulls per 100 adult cows needed to prevent negative impacts on reproductive rates (Environment Yukon, *in prep.*). High harvest rates can skew the sex ratio towards this lower limit.

Calf survival to early winter was 26 ± 22% calves per 100 adult cows (Table 2). We estimated 40 ± 50% yearlings per 100 adult cows, or 19 ± 35% yearlings per 100 adult moose within the study area (Table 2). These ratios suggest that the survival of calves was moderate during summer and fall of 2012 and good for calves born in 2011. These recruitment ratios are generally considered adequate to maintain stable moose populations in northern systems with naturally regulated predator populations (Hayes and Harestad 2000b). However, individual estimates of recruitment are "snapshots" in time that will vary from year to year and at least 5 years of recruitment ratio data are required to determine if a population is stable (Environment Yukon, *in prep.*).

Table 2. Results of the 2012 North Canol early-winter moose population survey including a Sightability Correction Factor.

	Best Estimate ± 90% Confidence Interval[a]
Estimated Abundance[b]	
Total Moose	661 ± 18% (540-782)
Adult Bulls (≥ 30 months)	184 ± 22% (144-225)
Adult Cows (≥ 30 months)	288 ± 21% (228-348)
Yearlings (Approx. 18 months)[c]	114 ± 45% (63-165)
Calves (≥ 12 months)	75 ± 22% (58-92)
Unknown age or sex	-
Estimated Population Ratios[b]	
% Adult Bulls	28% ± 12% (24-31%)
% Adult Cows	44% ± 15% (37-50%)
% Yearlings	17% ± 36% (11-23%)
% Calves	11% ± 17% (9-13%)
% Unknown Age or Sex	-
Adult Bulls per 100 Adult Cows	64 ± 23% (49-79)
Yearlings per 100 Adult Cows	40 ± 50% (20-59)
Yearlings per 100 Adults	19 ± 35% (13-26)
Calves per 100 Adult Cows	26 ± 22% (20-32)
% of Cow-Calf Groups with Twins[d]	0%
Density of Moose (per 1,000 km^2)[b]	
Total Area (3238.6 km^2)	204
Moose Habitat Only (3084.5 km^2)[e]	214

[a] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number of moose in the study area lies within the range of moose numbers given in the brackets, and that our best estimate is near the middle of this range.

[b] Estimated abundance and population ratios provided were obtained using MoosePop software and are based on a SCF Pooled "sightability correction factor" or SCF. In this survey, an SCF of 1.09 was applied to the High and Low stratum to correct the estimate of moose abundance for animals that were missed by the survey crews (see Step 6 of the Methods section for a description of how the SCF is calculated).

[c] 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.

[d] 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.

[e] Habitable moose habitat is considered to be all areas at elevations lower than ~1676 m, excluding water bodies 0.5 km^2 or greater in size.

Table 3. Results of the 1987, 1991, 1996, 2001 and 2012 North Canol early-winter moose population surveys. To facilitate comparison between surveys, no sightability correction factor is included in these results. (* = statistically significant change from the previous survey)

Survey Year	2012[a]	2001	1996	1991	1987
Estimated Abundance[a] (90% Confidence Range)[b]					
Total Moose	606 ± 16% (512-701)	624 ± 22% (484-763)	728 ± 17% (604-851)*	938 ± 13% (811-1064)*	514 ± 17% (427-602)
Adult Bulls (≥ 30 months)	169 ± 20% (135-203)	216 ± 30% (152-280)	275 ± 23% (210-339)	301 ± 20% (240-362)	121 ± 23% (94-149)
Adult Cows (≥ 30 months)	264 ± 19% (215-313)	286 ± 24% (217-354)	268 ± 17% (223-313)	336 ± 17% (279-393)	184 ± 23% (142-227)
Yearlings (Approx. 18 months)[c]	104 ± 44% (59-150)	31 ± 72% (9-53)	109 ± 35% (71-147)	127 ± 24% (96-158)	92 ± 28% (66-117)
Calves (≤ 12 months)	69 ± 20% (55-83)	91 ± 33% (61-122)	76 ± 28% (55-98)	174 ± 19% (140-207)	117 ± 24% (89-146)
Estimated Population Ratios[a] (90% Confidence Range)[b]					
% Adult Bulls	28 ± 12% (24-31%)	35 ± 18% (28-41%)	38 ± 14% (32-43%)	32 ± 13% (28-36%)	24 ± 20% (19-28%)
% Adult Cows	44 ± 15% (37-50%)	46 ± 11% (41-51%)	37 ± 11% (33-41%)	36 ± 10% (32-39%)	36 ± 12% (32-40%)
% Yearlings	17 ± 36% (11-23%)	5 ± 72% (1-8%)	15 ± 28% (11-19%)	14 ± 24% (10-17%)	18 ± 24% (13-22%)
% Calves	11 ± 17% (9-13%)	15 ± 20% (12-18%)	10 ± 22% (8-13%)	18 ± 13% (16-21%)	23 ± 15% (19-26%)
Adult Bulls per 100 Adult Cows	64 ± 23% (49-79)	75 ± 28% (54-96)*	102 ± 22% (80-125)	90 ± 21% (71-108)*	66 ± 27% (48-84)
Yearlings per 100 Adult Cows	40 ± 50% (20-59)*	11 ± 75% (3-19)*	41 ± 35% (27-55)	38 ± 32% (26-50)	50 ± 33% (33-66)
Yearlings per 100 Adult Moose	19 ± 35% (13-26)*	6 ± 71% (2-10)*	17 ± 28% (12-22)	17 ± 24% (13-21)*	23 ± 23% (18-28)
Calves per 100 Adult Cows	26 ± 22% (20-32)	32 ± 21% (25-39)	28 ± 24% (22-35)*	52 ± 12% (45-58)	64 ± 18% (52-75)
% of Cow-Calf Groups with Twins[d]	0%	0%	8 ± 91% (1-16)	9 ± 47% (5-13)	Est. value not avail. (Observed ratio= 9%)
Density of Moose (per 1,000 km²)[a]					
Total Area	187	193	~239	~307	~168
Moose Habitat only[e]	197	202	246	317	186
Total Area (km²)	3238.6	3238.6	~3050	~3050	~3050
Habitable Area (km²)[e]	3084.5	3088.3	2954.0	2954.0	2758.8

[a] To allow for comparison across years, no sightability correction factor is included in estimates provided. This explains the difference in values between Table 2 and Table 3.

[b] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number of moose in the study area lies within the range of moose numbers given in the brackets, and that our best estimate is near the middle of this range.

[c] 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.

[d] 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.

[e] Habitable moose habitat is considered all areas at elevations lower than 1,676 m (5,500 ft), excluding water bodies 0.5 km² or greater in size.

Population Status and Trend: 1987 to 2012

Population Abundance

Moose abundance data suggests that this population increased in response to wolf control but has now returned back to natural densities. Specifically, moose abundance in the North Canol study area increased 82% (514 ± 17% to 938 ± 13% moose; t-test, $P<0.001$) between 1987 and 1991 (Table 3) in response to wolf control when wolf numbers were reduced annually to less than 20% of their natural density (from nine to three wolves per 1000 km^2; Hayes and Harestad 2000a, Farnell et al. 2008). This represents an average population growth of about 16% per year, and an increase in moose density from 186 to 317 moose per 1000 km^2 of habitable moose habitat. Wolf numbers returned to pre-control levels (10 wolves per 1000 km^2) by about 1993-94, which likely corresponds to the time when moose numbers in the North Canol survey area began to return to natural levels. In 1996, moose abundance had decreased by 22% from the 1991 population estimate (938 ± 13% to 728 ± 17% moose; t-test, $P<0.05$), representing a decline in moose densities from 317 to 246 moose per 1000 km^2 of habitable moose habitat (Table 3). In 2001, the moose population was estimated at 624 ± 22% moose. Although the population estimate was not significantly different from the 1996 estimate (t-test, $P<0.5$), the results suggest that the population continued to decline albeit at a slower rate. The moose population estimated during the 2001 survey was similar to that estimated in 2012 (606 ± 16% moose) with corresponding population densities in both years near 200 moose per 1000 km^2 of habitable moose habitat. In the absence of measures to reduce predation, results suggest that the moose population returned to natural densities—similar to those estimated in 1987—sometime between 1996 and 2001. Natural moose densities prior to the wolf control program may actually be lower than those estimated in 1987 because the predator control study was already in its 4th year of implementation.

Population Composition

Recruitment of calves into the moose population was greater in 1987 and 1991 during and shortly after the wolf control program and lower in subsequent surveys (Table 3). Specifically, the proportion of calves per 100 adult cows was 64 ± 18% in 1987 and 52 ± 12% in 1991. Calf-cow ratios in 1996, 2001, and 2012 were significantly lower than in previous surveys (Table 3; $x^2=13.77$, $P<0.001$).

Yearling to adult moose ratios were generally consistent across survey years, except in 2001 when they were significantly lower (Table 3). Yearling recruitment in all surveys was 17 to 23 yearlings per 100 adult moose except in 2001 when we estimated 6 ± 71% yearlings per 100 adult moose (Table 3). This low yearling recruitment in 2001 is significantly different from 1996 ($x^2=32.42$, $P<0.001$) and to 2012 ($x^2=43.33$, $P<0.001$; Table 3).

The ratio of adult bulls to adult cows in the North Canol study area increased during and immediately following the wolf control program, and then returned back to 1987 levels by 2012 (Table 3). In 1987, we estimated 66 ± 27% adult bulls for every 100 adult cows. This ratio increased to 90 ± 21% (x^2=4.49, P<0.05) in 1991 and then to a peak of 102 ± 22% adult bulls for every 100 adult cows in 1996 (Table 3). This ratio declined significantly to 75 ± 28% by 2001 (x^2=5.77, P<0.025) and 64 ± 23% adult bulls per 100 adult cows by 2012 (Table 3). For all surveys, bull to cow ratios remained well above the minimum 30 adult bulls per 100 adult cows required to prevent negative impacts on reproductive rates (Environment Yukon, *in prep.*).

Harvest

The North Canol survey area only covered about 44% of the Ross River MMU; therefore, we extrapolated population estimates from this survey to the remaining area of the MMU to estimate current and historical harvest rates (Table 4).

Licenced harvest within the Ross River MMU averaged 30 bull moose annually between 2008 and 2012 for a 5-year average licenced harvest rate of 1.7% (Table 4). First Nation harvest information was not available. Therefore, we estimated First Nation harvest to be 1.1 and 1.2 times that of resident licenced hunters for Game Management Zones 4 and 11, respectively. This First Nations harvest rate estimate includes a correction factor for *cow harvest equivalency*—removal of a cow moose from the population has a larger impact than removal of a bull moose. The estimated annual First Nation harvest rate is 1.3% or 23.8 bull moose equivalents (Department of Environment, *unpublished data*). Summing licenced and First Nations harvest, we estimate a *total average* annual harvest of 3.0% (53.8 bull moose). While we cannot accurately report the total harvest rate without First Nation harvest data, we consider this estimate to be a reasonable approximation of the actual harvest pressure in this MMU because the population density has not changed between 2001 and 2012 (202 versus 197 moose per 1000 km^2 of habitable moose habitat without an SCF applied; Table 3).

Recognizing the uncertainty in harvest estimates, results suggest that moose harvest of the Ross River MMU population is currently at sustainable levels. The draft *Science-based Guidelines for Management, Harvest, and Mitigation of Land Use Activities: Moose* recommend a maximum harvest of 10% of the adult bull population for MMUs that have been recently surveyed (Environment Yukon, *in prep.*). For this MMU, harvest at this rate would represent 50.5 bull moose or 2.8% of the total population annually. Given that the moose population has remained stable between 2001 and 2012 (Table 3), the current harvest rate of 3.0% appears to be a sustainable for this population.

Table 4. Average annual (2008 to 2012) licenced bull moose harvest for the Ross River Moose Management Unit, southeast Yukon. Game Management Subzones 4-39, 4-40, 4-49, 11-02, 11-06, 11-07.

GMS	GMS Area (km^2)[a]	Estimated Density[b] (moose per 1000 km^2)	Total Estimated number of Moose[a]	Average Resident Harvest	Average Non-Resident Harvest	Average Special Guided Harvest	Average Licenced Harvest (2008 to 2012)[c]
4-39	1078.1	220	237.2	2.4	0.4	0.0	2.8
4-40	1903.8	375	713.9	2.8	6	1.8	10.6
4-49	942.9	395	372.4	1.8	0	0.0	1.8
11-02	1444.3	145	209.4	7.4	0	0.8	8.2
11-06	670.7	120	80.5	1.8	0	0.0	1.8
11-07	1259.9	150	189.0	4.2	0.4	0.2	4.8
Total	**7299.7**	**246.9**	**1802.4**	**20.4**	**6.8**	**2.8**	**30.0**

[a] As a result of the historical study area design, only portions of the GMSs within the Ross River Moose Management Unit (MMU) lie within the North Canol study area. Differences in the total estimated number of moose in Table 2 and Table 4 of the report are due to the different regions covered by each table (the total area covered by the North Canol study area as provided in Table 2 is 3,238.6 km^2 whereas the area covered by all GMS in the Ross River MMU in Table 4 is 7,299.7 km^2. This table also does not contain moose density and harvest information for GMS 11-05 which only had a very small proportion of coverage within the survey area boundaries and is not part of the Ross River MMU.

[b] Estimated density is based on 2012 North Canol MoosePop SCF Pooled moose survey results, with the exception of GMS 4-40 which is based on a combination of results from this survey and of the 2011 Faro MoosePop SCF Not Pooled moose survey results. A greater proportion of GMS 4-40 is found within the Faro study area and moose densities on the western side (Faro study area) were higher than those observed on the eastern side (North Canol study area).

[c] Does not include licenced or subsistence harvest by First Nation hunters.

Local perception is that this region is experiencing increasing harvest activity from hunters from other communities where hunting opportunities have decreased because of local hunting closures and restrictions associated with population declines. A higher number of hunters accessing the Northwest Territories through the North Canol Road in recent years may contribute to this perception.

At a finer scale, licenced harvest is high in GMS 4-40 and moderate in GMS 11-02 (average of 10.8 and 8.2 moose per year, respectively; Table 4, Figure 5). Combined, these two GMS account for 62.7% of all licenced harvest within this MMU. We use harvest patterns at the GMS scale to guide where management options may be most effective to maintain the total MMU harvest rates at sustainable levels.

The licenced harvest information in the Ross River MMU indicates variable annual harvest rates between 2001 and 2012 (Figure 6). Licenced harvest rates equal to or greater than 1.5% (27 moose) occurred in three of the past five years.

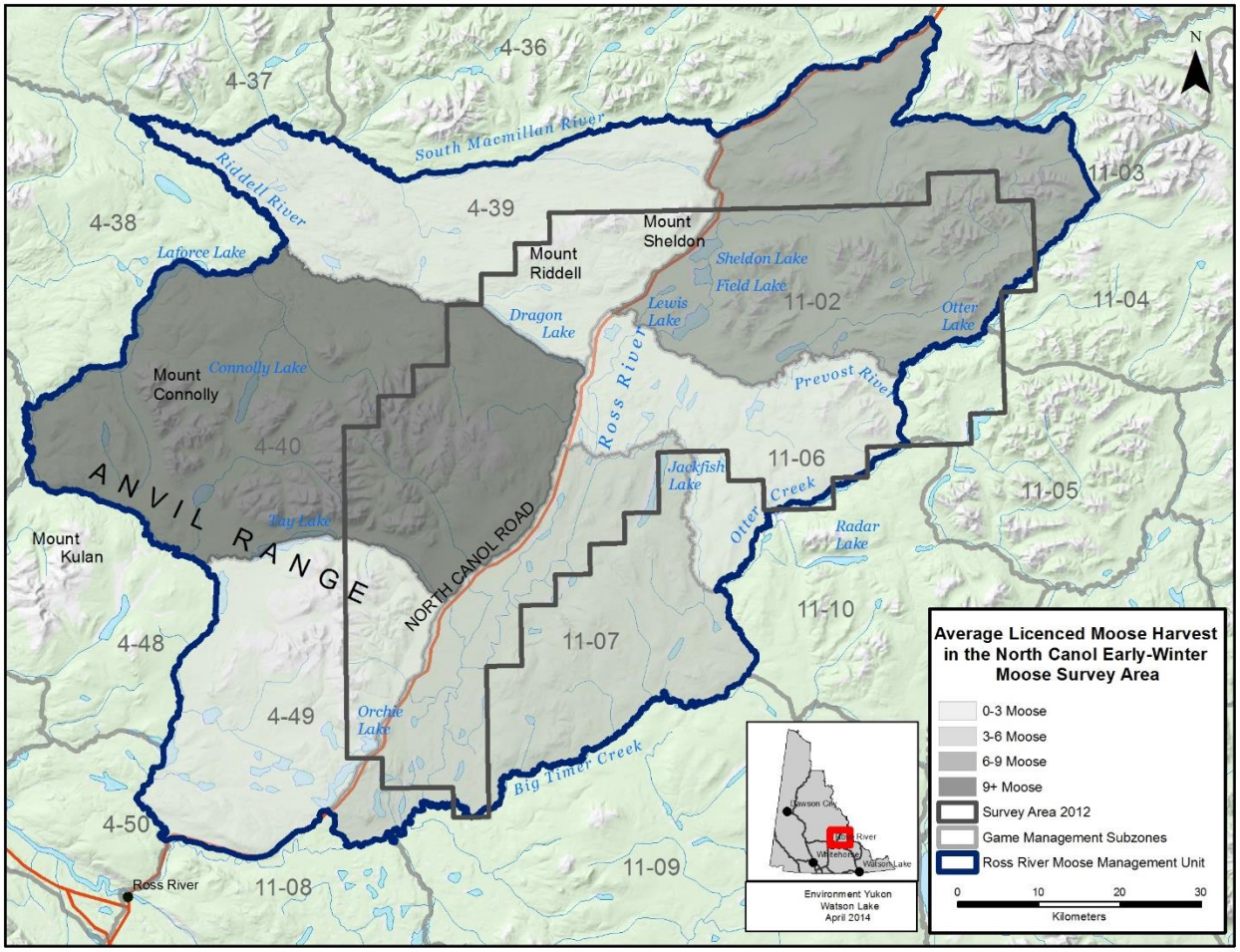

Figure 5. Spatial distribution of licenced bull moose harvest in the Ross River Moose Management Unit, southeast Yukon, 2008 to 2012.

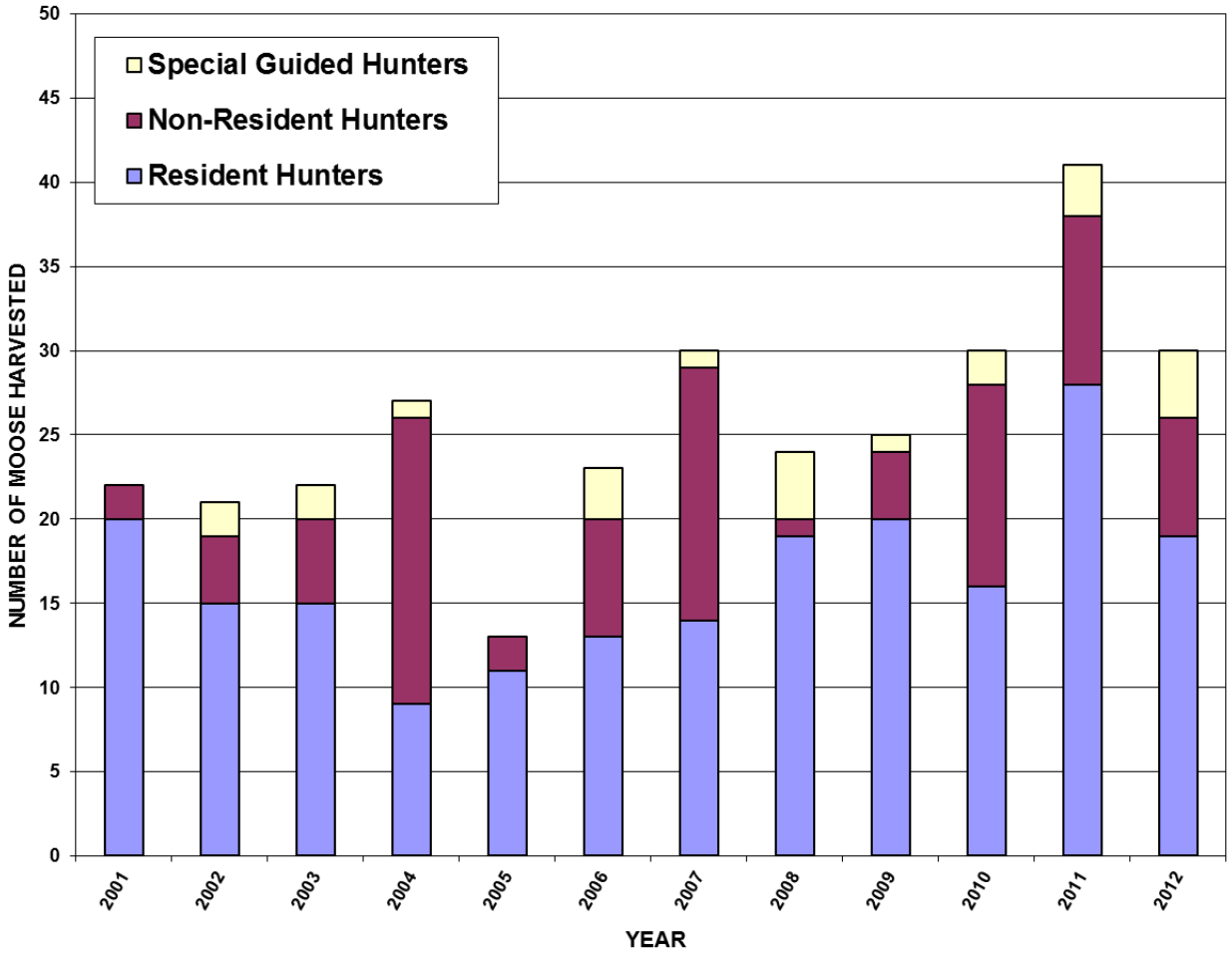

Figure 6. Annual reported bull moose harvest (2001 to 2012) in the Ross River Moose Management Unit (Game Management Subzones: 4-39, 4-40, 4-49, 11-02, 11-06, 11-07).

The North Canol Road corridor has a long history of mineral exploration that has left behind a substantial network of exploration trails easily accessible by all-terrain vehicles. Future industrial developments may result in substantial improvements to the road, including the construction of a bridge over the Pelly River and road upgrades to all-weather standards. Easily accessible areas along the North Canol Road have become popular hunting areas for many Yukon residents. Concentrations of moose during the rut, particularly in accessible sub-alpine regions and other open habitats make them vulnerable to over-harvest. Increased ease of access may result in a substantial increase in wildlife harvest along this corridor by licenced and First Nation hunters. Management actions should continue to ensure harvest in this MMU remains sustainable.

Other Wildlife Sightings

We only present incidental wildlife sightings observed within the study area.

We recorded 58 moose in groups of one to 6 animals at 27 separate locations in addition to those observed during the stratification and census. In total, we observed 596 moose during the entire survey period.

We located 78 caribou in groups of one to 15 animals (average group size was 5 caribou) at 15 separate locations. Based on their locations, we presume that 45 of these caribou belong to the Finlayson herd and 33 caribou belong to the Tay herd. We predominantly observed Finlayson caribou within a 19 km radius of Jackfish Lake and a 6 km radius of Otter Lake. We observed all Tay caribou within a 17 km radius of Tay Lake. In contrast, survey crews sighted only 6 caribou incidentally during the 2001 survey (Environment Yukon 2003).

Wolf tracks were ubiquitous throughout the study area. We located 12 wolves in 2 packs and a single injured wolf. The first pack consisted of four black wolves located near the Prevost River approximately 10 km northwest of Otter Lake. We observed the injured wolf, another black individual, two days later on the edge of a burn approximately 11 km northwest of Otter Lake. Based on its location, it may well have been part of the previously described pack. We observed the second pack, consisting of 6 black and 2 grey wolves, 12 km east of Tay Lake.

Additionally, we recorded the presence of a bald eagle or osprey nest along the Ross River approximately 12 km SW of Jackfish Lake, a group of 6 thinhorn sheep at the east end of the Anvil Mountain Range, and one wolverine near the North Canol Road southwest of Jackfish Lake. We observed small game animals such as snowshoe hare, spruce grouse, and ptarmigan throughout the study area.

Conclusions and Recommendations

- We estimated that there were 661 ± 18% moose in the entire North Canol survey area in 2012, for an average density of about 204 moose per 1,000 km^2. The population appears to have stabilized at a density comparable to pre-predator control densities.
- Licenced harvest averaged 30.0 bull moose annually between 2008 and 2012 for a 5-year average licenced harvest rate of 1.7%. The recommended maximum sustainable harvest rate for both licenced and First Nations hunters for this MMU is 2.8% or 50.5 bull moose.
- Using licenced harvest from 2008 to 2012 and an approximation of First Nations harvest, we estimated the total average annual harvest rate at 3.0% for the Ross River MMU.
- All available data suggests that the moose population in the Ross River MMU is currently harvested at a sustainable rate. Most of the harvest within the MMU occurs in the North Canol survey area along the North Canol Road corridor.
- We need complete harvest information from both licenced hunters and First Nation subsistence hunters to more

accurately estimate harvest and ensure that total harvest stays within sustainable limits.

- To reduce the risk of a population decline, management decisions in this MMU should continue to ensure that harvest in this area remains sustainable.

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