MOOSE SURVEY WHITEHORSE SOUTH EARLY-WINTER 2010

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Summary

- We conducted an early-winter moose survey in the Whitehorse South area from 18 November to 6 December 2010. The purpose of the survey was to estimate abundance, distribution, age and sex composition, and examine population trends.
- We surveyed about 28% of the total area, counting a total of 238 moose, 76 of which were adult bulls, 128 were adult and yearling cows, 6 were yearling bulls, and 28 were calves.
- We estimated that there were 961 ± 35% moose in the Whitehorse South survey area, equaling a density of 149 moose per 1,000 km^2. Based on available historical estimates in a subset of the study area, we estimate that the moose population has declined by about 30% since the early 1980s.
- Estimated calf recruitment was 24 calves per 100 cows, slightly lower than what is recommended to maintain stable moose populations and below average for Yukon.
- Estimated yearling recruitment was 7 yearlings per 100 adult moose, also lower than what is recommended to maintain stable moose populations.
- The estimated bull/cow ratio was 57/100, which is above recommended minimum levels to breed cows.
- Current licensed harvest in the survey area averages less than 1% of the estimated moose population. This harvest is limited through a Permit Hunt Authorization (PHA) system that has been in place since 1989. First Nation harvest is unknown.
- Complete harvest information is an important component in formulating a recovery plan for moose in the Whitehorse South region.

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Introduction

This report summarizes results of the early-winter moose survey in the Whitehorse South survey area, conducted on November 18, 22, 24-27 and December 1-3 and 6, 2010. The survey was done to estimate abundance, distribution, age and sex composition, and population trends for this area. This area was selected as a management priority because of historic overharvest, interest in moose population recovery, and continuing human-induced pressures on moose in this area.

Moose numbers in the Whitehorse South area declined in the mid-1980s, particularly in accessible areas (Larsen et al. 1989). The decline was attributed to over-harvest and in response, discussions regarding the possible implementation of a permit hunt authorization (PHA) system for moose in Game Management Zones (GMZ) 7 and 9 were initiated in 1982. Cow harvest was curtailed in GMZ 7 and Game Management Subzone (GMS) 9-03 in 1982 with the rest of the Yukon following suit in 1984. Also in 1984, the hunting season for moose was shortened to only 2 weeks (September 1 to 15) for several subzones in GMZ 7 as well as GMS 9-04. This shortened season was adopted for all of GMZ 7 and 9 in 1985 and was in place until 1989.

Concurrent to the above legislative changes in moose harvest policy, the Yukon government conducted a large-scale experimental study to identify factors limiting the growth of the moose population by manipulating predator densities in southern Yukon (Larsen et al. 1989). Specifically, 134 adult female moose and 135 calves were collared and monitored between 1983 and 1988 while predator numbers were reduced. The average estimated total harvest rate (licensed and First Nation hunters, excluding poaching) ranged between 6.6% and 8.5% during the study (Larsen et al. 1989). In Yukon, annual allowable harvest (AAH) rates of 3-4% are considered sustainable for stable populations whereas lower or no harvest is required to increase populations following a decline (Environment Yukon, *in prep.*). Harvest rates in excess of 5% of the total moose population can carry an unacceptably high risk of initiating a population decline (Gasaway et al. 1992; Environment Yukon, *in prep.*). Therefore, the estimated total harvest rate during the study was approximately twice the recommended AAH rate for stable populations.

Grizzly bear predation was the primary cause of overall moose mortality during the study (48% of all deaths), followed by wolves (29%) and hunting (9%). Grizzly bears accounted for most of the calf mortalities (58%) and these occurred within the first 8 weeks after birth (Larsen et al. 1989).

In 1985, there were an estimated 16 grizzly bears/1000 km^2 of total land area (Larsen, unpublished data). Efforts to update this density estimate are ongoing. Wolf density was estimated at 12 wolves/1000 km^2 in 1982 (Hayes, Yukon Government unpublished data), but was most recently observed at 4.5 wolves/1000km^2 in 2009 (Baer 2010).

Predation was the dominant factor affecting moose population dynamics in most other studied moose-bear-wolf systems and bears were the major cause of mortality for moose calves (Ballard et al. 1991, Gasaway et al.1992, Bowyer et al. 1998, Boertje et al. 2010). However, there is little evidence from studies across North America that predation by itself causes moose populations to permanently decline (Ballard and Larsen 1987). However, the combination of predation and overharvest can cause severe declines in moose numbers (Gasaway et al. 1992).

The telemetry study did not detect a change in moose numbers after a reduction of 62% in the wolf population between the winters of 1982/83 and 1986/87. Because calf survival to 6 months did increase subsequent to wolf removals, authors suggest that wolf reduction would have stimulated population growth had it been carried out over a longer time period (Larsen et al. 1989). Grizzly bear reductions averaged 4% over the course of the study and were considered insufficient to increase moose numbers.

These results are consistent with other studies in similar systems where high levels of sustained wolf and/or bear reductions were required to observe an increase in moose populations (Gasaway et al. 1986, Van Ballenberghe 1987, Ballard et al. 1991). Given the high total harvest rate observed during the study, more severe licensed harvest restrictions began in 1989 when a PHA system for moose was finally adopted within GMZ 7 and GMS 9-01 to 9-07 with a total of 10 permits available for licensed hunters. This was increased to 20 permits in 1994. Despite these measures, moose numbers remained low; surveys done in 1994 and 1995 showed substantially lower moose populations than the early- to mid-1980s. In 1998, the allocation of permits within GMZ 7 and 9 was refined, with specific numbers of permits available for smaller areas. This change made only 11 permits available for GMS 7-13 to 7-36 and 9-01 to 9-07, which includes almost the entire area encompassed within the 2010 Whitehorse South survey area boundary. This allocation of permits is still in place. In the last five years, overall success rates for permit hunters in the area has been approximately 33%, and on average less than two moose per year were harvested in the study area.

The Southern Lakes Wildlife Coordinating Committee (SLWCC) was established in 2008 and included representatives from 9 governments: Carcross/Tagish First Nation, Champagne and Aishihik First Nations, Kwanlin Dün First Nation, Ta'an Kwäch'än Council, Taku River Tlingit First Nation, Teslin Tlingit Council, Yukon, British Columbia, and Canada.

The SLWCC was tasked with 1) making recommendations to its various member governments with respect to the management of wildlife, such as moose, and their habitat in the Southern Lakes area, and 2) producing a wildlife assessment for the Southern Lakes area (SCWCC, 2012).

Results from this survey were used in the assessment of moose populations in the southern lakes (SLWCC, 2012).

Moose are a highly valued wildlife species in the Yukon. The subsistence culture of the Yukon First Nations has been closely tied to moose harvest for generations. Today moose is the most widely hunted game species in Yukon by both First Nation and non-First Nation hunters. Reflecting the interest and concerns of First Nations and communities in the Whitehorse South survey area, several First Nation and Renewable Resource Council members participated in the survey as observers.

Study Area

The 2010 Whitehorse South survey area covered 6,460 km^2, including GMS 7-13 to 7-27, 7-30 to 7-32, and 9-01 to 9-04. It covered the area south of Whitehorse from Marsh Lake in the east to Bennett Lake in the south, Kusawa Lake in the west, and the Alaska Highway in the north (Map 1).

Approximately 75% of the study area (4,829 km^2) is habitable moose terrain.

The remaining 25% is considered non-habitable terrain, comprised of large water bodies (0.5 km^2 or greater in size) and elevations at or higher than 1,524 m (5,000 ft.) above sea level.

The majority of the survey area is located within the Yukon Southern Lakes ecoregion, dominated by the Coast Mountains in the southwest and bordered by the large lake systems that are characteristic of this ecoregion (Yukon Ecoregions Working Group 2004). The climate is generally dry or arid, falling within the rain shadow of the St. Elias-Coast Mountains. Winds are common in due to the area's proximity to the Gulf of Alaska. The southern portions of the survey area are within the Yukon Stikine Highlands ecoregion, an area characterized by milder temperatures and heavy precipitation influenced by maritime weather systems.

Higher elevations are dominated by willow (*Salix* sp.), shrub birch (*Betula glandulosa*), and sub-alpine fir (*Abies lasiocarpa*). Lower elevations are often composed of mixed woodland, but dominated by pine (*Pinus contorta*) and white spruce (*Picea glauca*). Forest fires have produced some localized patches of sub-climax stands dominated by willow and pine, but fires have not been widespread in the survey area.

Approximately 417 km^2 (6% of the survey area) has burned over the last 65 years (Map 4; fire history data prior to 1946 is not available for mapping).

The most recent fires were a 27 km^2 burn to the north of Primrose Mountain in 2004, and several small fires totalling about 22 km^2 near the southwest border of the study area in 2003.

Approximately 112 km^2 of the study area burned in 1998, mostly part of a large burn to the south and east of Rose Lake and a smaller burn near Ibex Lake. About 186 km^2 of the northern portion of the study area near Ibex Valley burned in 1958, part of the large Takhini burn. In 1991, a fire on Haekel Hill burned approximately 7 km^2 just to the west of Whitehorse.

The general Whitehorse South area has been surveyed many times since 1980; however, the survey boundaries have varied over time (Map 2).

Therefore, to provide trends in moose abundance we divided our 2010 survey area into two sub-areas: the Carcross comparison area and the Whitehorse South comparison area (Map 3).

Weather and Snow Conditions

In general, early-winter moose surveys start in the beginning of November when there is enough snow to easily see moose and their tracks. However, the 2010 survey did not start until 17 November due to lack of sufficient snow in the study area. Snow depth was low (less than 15 cm) at the beginning, and intermediate (ranging from 17 to 26 cm) for the remainder of the survey; with snow coverage ranging from 75 to 100 percent.

Temperatures were relatively mild through November (-14°C to 2°C) but colder in early December, ranging from -31°C to -9°C on most days. Light conditions were mainly flat on most days with a few sunny breaks at the beginning and end of the survey.

Once started, weather conditions were variable and sometimes challenging over the survey period. Heavy fresh snowfall occurred during the first week of the survey and again at the end of November.

Despite the initial lack of snow, the average amount of snow on the ground at the Whitehorse Airport weather station in November 2010 was about 16 cm, above the average November snow depth of 10 cm recorded for this station between 1971 and 2000 (Environment Canada 2012).

We were unable to fly 4 days at the beginning of the survey due to snow or high winds, and lost 3 days because of a snow storm at the end of November. High winds prevented flying another 2 days at the end of the first week of December, with 3 additional days cut short as a result of weather and visibility problems (low ceiling, fog, and icing conditions).

Previous Surveys

Early-winter intensive population or census surveys were conducted in the Whitehorse South comparison area in 1981 (Larsen 1982), 1982 (Johnston and McLeod 1983), 1983 (Markel and Larsen 1987*a*), 1986 (Jingfors and Markel 1987), 1995 (unpublished data), and 2000 (unpublished data). Census surveys in the Carcross comparison area were conducted in 1980 (Larsen and Nette 1980), 1982 (Markel and Larsen 1983), 1983 (Markel and Larsen 1987*b*), and 1994 (unpublished data).

A census survey encompassing the Whitehorse South and Carcross comparison areas was initiated in 2005, but was cancelled due to poor snow and weather conditions.

Less intensive early-winter stratification surveys that estimated relative abundance and distribution of moose were flown in or south of the Whitehorse South comparison area in 1983 (unpublished data) and 1994 (unpublished data); and in the Carcross comparison area in 2000 (unpublished data).

In addition, a stratification survey encompassing both sub-areas was flown in 2004 (Florkiewicz 2004).

Late-winter moose reconnaissance surveys to observe moose density, demographics, and habitat use in GMZ 7, which encompasses the Whitehorse South comparison area, were flown in 1973 (Hoefs 1974) and 1979 (Hoefs and Larsen 1979, Larsen 1979, Larsen et al. 1979).

Late-winter recruitment surveys, to determine if enough calves were surviving to maintain a stable population, were also conducted in and south of the Whitehorse South comparison area in 1999 (Florkiewicz 1999) and 2000 (Domes et al. 2000); in the Carcross comparison area in 1981 (unpublished data) and 2002 (Domes 2002); and in the Whitehorse South and Carcross region in 2004 (Westover 2004).

Methods

Data Collection and Analysis

We used the geospatial survey technique, developed by the Alaska Department of Fish and Game (Kellie and DeLong 2006), to estimate moose abundance in this study. This replaced the stratified random block technique (Gasaway et al. 1986) used by Environment Yukon up until 2006. Geospatial analysis offers better population estimation procedures and generally produces tighter confidence intervals.

The survey area was divided into 379 uniform blocks about 17 km^2 which we stratified by expected moose abundance into high or low stratum. We did this by reusing results from surveys in 2000 (unpublished data) and 2004 (Florkiewicz 2004), rather than flying a separate stratification survey. We reclassified 7 survey units because forest fires had burned in those units since 2005.

We randomly selected blocks for survey, attempting to fly a suitable sample of blocks to allow extrapolation of results to the entire survey area. We flew each block in a Bell 206 helicopter with a targeted search intensity of 2 minutes per km^2, or about 34 minutes per block. Each helicopter had 3 observers in addition to the pilot. Observers attempted to sight every moose in each block. Moose were classified by age (adult, yearling, or calf) and sex. Because yearling cows are often difficult to distinguish from adult cows, they were counted together.

After completion of a sub-sample of blocks, we immediately re-surveyed a corner (25%) of the block at twice the search intensity. This data was used to develop a sightability correction factor (SCF) for each stratum, in order to account for any moose missed during the regular survey (Becker and Reed 1990).

Data analysis for the abundance estimate was done using an online tool provided by the Alaska Department of Fish and Game (Kellie and DeLong 2006). The SCF was applied to the total number within each stratum to account for moose that we missed (Becker and Reed 1990). Age and sex ratios were calculated using Moosepop (Gasaway et al. 1986).

In order to allow comparison between survey years, we compared surveys that used the Geospatial method with those using the stratified random block method, but did not apply the SCF because it was not calculated during the earlier surveys. We used variance-weighted least squares regression to obtain estimates for long-term changes in population estimates and bull/cow ratios. This analysis accounts for the confidence intervals for each individual survey when calculating overall trends. Linear regression was appropriate to model ratio data because values were between 0.2 and 0.8 (Long 1997). In some cases we made comparisons between individual years using a Z-test (Mendenhall 1971).

Results and Discussion

Stratification (Identification of high and low moose density blocks)

We classified 149 (39%) of the 379 survey blocks as having high expected moose abundance and 230 (61%) as having low expected abundance (Map 5).

Coverage

We surveyed 108 blocks (28% of survey area) including 51 of 149 blocks (34%) expected to contain relatively high numbers of moose and 57 of 230 blocks (25%) expected to contain few or no moose.

Total survey time was 50.7 hours for a total search intensity of about 1.65 minutes per km². Survey intensity was similar in high-abundance blocks (1.68 minutes per km²) and low-abundance blocks (1.63 minutes per km²). Overall search intensity was somewhat lower than the goal of 2 minutes per km² for population surveys but the relatively large proportion of non-habitable terrain in the study area required less coverage and lower search time overall.

We resurveyed a portion of 29 blocks (14 highs and 15 lows) in order to calculate the SCF, requiring an additional 8.2 hours.

Another 25.4 hours of helicopter time was used in ferrying between survey blocks; to remote fuel caches near Kusawa Lake, Carcross, and the Wheaton River; and back and forth to Whitehorse. Total flight time (survey and ferry time combined) was 89.8 hours.

Observations of Moose

We counted 238 moose in the 108 surveyed blocks (Map 6), which included 76 adult bulls, 128 adult and yearling cows, 6 yearling bulls, and 28 calves (Table 1).

We observed an average of 160 moose for every 1,000 km² in the high-abundance blocks, and 102 moose per 1,000 km² in the low blocks.

Several factors resulted in higher than usual numbers of moose being seen in the low abundance blocks. Low snowfall in early November delayed the start of the survey, and high snowfall and poor weather caused several delays which pushed the completion of the survey into early December (see *Weather and Snow Conditions*). The above-average snowfall that occurred in only the last 2 weeks of November, as well as high winds and the late timing of the survey in general may have contributed to the movement of moose to lower elevations during the survey period.

Due to the conditions described above, we likely saw higher densities in the low stratum (as well as lower densities in the high stratum) than we would have seen under more ideal survey conditions. Additionally, several low blocks had small patches of high quality habitat containing moose, indicating that at least some low blocks may have been stratified incorrectly.

Table 1. Observations of moose during the Whitehorse South survey, 2010.

	High Blocks	Low Blocks	Total
Number of blocks counted	51	57	108
Number of adult bulls observed	52	24	76
Number of adult and yearling cows observed	71	57	128
Number of yearling bulls observed	2	4	6
Number of calves observed	14	14	28
Number of unknown age/sex	0	0	0
Total Moose Observed	**139**	**99**	**238**

Table 2. Estimated abundance of moose in the Whitehorse South survey area, 2010.

	Best Estimate ± 90% Confidence Interval (%)	90% Confidence Interval (Range) [1]
Estimated Total Number of Moose[2]	961 ± 35%	628-1294
Adult Bulls	288 ± 35%	187-389
Adult Cows[3]	493 ± 36%	317-670
Yearlings[4]	58 ± 71%	17-100
Calves	123 ± 49%	63-183
Unknown Age/Sex	0	0

[1] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number lies within this range of numbers. Our best estimate is in the middle of this range.

[2] Estimated numbers provided were obtained using geospatial software and are based on a Not-Pooled SCF.

[3] The adult cow count is made by subtracting the number of yearling bulls from the count of total cows (the number of yearling cows is assumed to equal the estimated number of yearling bulls in the population).

[4] Total yearlings equals the number of yearling bulls times 2.

Abundance of Moose

We estimated there were 961 ± 35% moose in the entire 2010 Whitehorse survey area (Table 2). This estimate includes an SCF for moose missed of 0% in the high blocks and 44% in the low blocks.

An SCF value of 44% should be regarded with caution; it has a large impact on the density and estimated population size of moose in the low density blocks across the survey area. Only 3 SCF blocks contributed to the 44% SCF in the low stratum (of 15 surveyed blocks). All of them were flown towards the end of the survey (November 26, December 1, and December 2) when moose were likely moving to lower elevations.

It is easier to miss moose in low blocks (due to timber cover), so higher numbers of moose present in the low blocks likely contributed to the high SCF.

The estimated density of moose in the entire survey area was 149 per 1,000 km² of total area, or 199 moose per 1,000 km² of suitable moose habitat.

Sex and Age Ratios

Wildlife managers use sex and age ratios to assess the health of wildlife populations. For example, low numbers of adult bulls compared to adult cows could indicate that selective harvest of bulls is reducing their numbers. If bull numbers become too low, then some cows may not have an opportunity to breed during the rut. The numbers of calves and yearlings are used to measure recruitment, or the number of young that survive to enter the adult population. If annual recruitment is outweighed by adult mortality, populations will decline.

However, numbers of calves or yearlings can vary widely as their survival is linked to factors such as weather and snow conditions. Therefore, a single year of poor recruitment is not necessarily cause for concern, but multiple years of poor recruitment may indicate a population in decline. Guidelines for age and sex ratios are discussed in the Yukon Moose Management Guidelines (Environment Yukon, *in prep.*).

The adult bull/cow ratio was 57/100 in the Whitehorse South survey area in 2010 (Table 3). This is above the recommended minimum of 30/100 (Environment Yukon, *in prep.*).

The calf/cow ratio in the Whitehorse South survey area in 2010 was 24/100 (Table 3), near the recommended minimum 25/100 (Environment Yukon, *in prep.*).

The yearling/adult moose ratio was 7/100, below the recommended 8-15/100.

The recommended recruitment guidelines represent the minimum number of recruits considered necessary to maintain stable moose populations in areas with typical harvest and mortality rates (Environment, *in prep.*).

Population Status and Trends

Population trends are presented for the Whitehorse South comparison area and the Carcross comparison area (Map 3).

While these areas do not encompass the entire 2010 survey area, they do comprise the majority of the region, and provide a good indication of trends.

To make the results comparable between years, we present the data with no SCF applied because an SCF was not calculated for the 1980 to 1983 and 1986 surveys.

Because these comparisons do not use SCF-corrected data the issues related to the high SCF seen in low density blocks do not apply to the comparisons discussed below.

Table 3. Estimated age and sex ratios of moose in the Whitehorse South survey area, 2010.

Estimated Age and Sex Ratios[1]	Best Estimate ± 90% Confidence Interval (%)	90% Confidence Interval (Range) [2]
Adult bulls per 100 adult cows	57 ± 29%	41-74
Yearlings per 100 adult cows	11 ± 66%	4-19
Yearlings per 100 adult moose	7 ± 60%	3-11
Calves per 100 adult cows	24 ± 32%	16-32
% of cow-calf groups with twins[3]	11% ± 95%	1-21%

[1] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number lies within this range of numbers. Our best estimate is in the middle of this range.

[2] Ratio estimates and associated confidence intervals were calculated using the Gasaway (1986) method in program Moosepop.

[3] Twinning rate is the number of cows with 2 calves divided by the total number of cows with calves.

Whitehorse South Comparison Area (GMSs 7-13 to 7-27)

Population Abundance

The 2010 population estimate (with no SCF applied) in the Whitehorse South comparison area was 443 moose (90% Confidence Range: 343-542 moose; Table 4).

This represents an average density of 120 moose per 1,000 km^2 of total area, or 157 moose per 1000 km^2 of suitable moose habitat.

This was similar to the average density of 97 moose per 1,000 km^2 of total area, and 128 moose per 1,000 km^2 of moose habitat from the early winter survey of this same area that was conducted in 2000.

We found that moose abundance had declined approximately 30% since the early 1980s (Figure 1; model x^2=12.82, df=6, P<0.001).

However, we found no difference in moose abundance between 2010 and the previous survey in 2000 (Z = 0.90, P = 0.37) and moose abundance seems to have remained relatively stable since 1995 (Figure 1).

Sex and Age Ratios

We estimate that there were approximately 144 (90% Confidence Range: 103 - 184) adult bulls and 233 (90% Confidence Range: 178 - 288) adult cows in the Whitehorse South comparison area in 2010 (Table 4). The adult bull/ cow ratio was 60/100 in 2010. We detected an increase in the proportion of adult bulls to adult cows from a low of 31 per 100 cows in 1981 to 60 per 100 cows in 2010 (Figure 2; model x^2= 13.07, df=6, P<0.001). This change in sex ratio is likely due to the implementation of Permit Hunt Authorizations since the 1990's, which closely regulates the number of bulls that can be harvested by licensed hunters.

The adult bull to adult cow ratio appears to have remained relatively stable since 1995 (Figure 2). The estimated calf/cow ratio in the 2010 Whitehorse South comparison area was low at 22/100 (Table 4), indicating that survival to early-winter was relatively poor. The observed yearling/adult ratio was also low at 5/100, indicating poor survival during the previous year. These measures of recruitment were both below what is required to maintain a stable population (Environment Yukon, *in prep*.).

Carcross Comparison Area (GMS 9-01, 9-02 and 9-04)

Population Abundance

The 2010 total population estimate (with no SCF applied) for the Carcross comparison area was 153 moose (90% Confidence Range: 113 - 194 moose; Table 5). This represents an average density of 158 moose per 1,000 km^2 of total area, or 172 moose per 1,000 km^2 of suitable moose habitat. This is higher than the 106 moose per 1,000 km^2 of total area, and the 111 moose per 1000 km^2 of moose habitat observed during the previous survey in 1994 ($Z = 1.98$, $P < 0.05$).

Large confidence intervals surrounding the 1980 and 1982 estimates limit our ability to detect change over the long-term (Figure 2; model $x^2=0.13$, df=4, $P=0.72$). However, anecdotal information and high moose density observed in the neighbouring Whitehorse South comparison area during that time period seem to corroborate the high population estimates of 1980 and 1982.

This suggests that moose numbers have declined over the surveyed period, and though moose numbers have increased since 1994, they have yet to recover to pre-1980s levels.

Sex and Age Ratios

We estimated that there were approximately 40 (90% Confidence Range: 25 - 57) adult bulls and 82 (90% Confidence Range: 58 - 106) adult cows in the Carcross comparison area in 2010 (Table 5). The adult bull/ cow ratio was 48/100 in 2010 (Table 5). We did not detect long-term changes in the sex-ratio between 1980 and 2010 (Figure 4; model x2=0.03, df=4, $P=0.86$) nor differences in sex-ratios between individual years ($p>0.1$).

The calf/cow ratio was estimated at 28/100 in 2010, indicating moderate survival of calves. However, the yearling/adult ratio was only 6/100, indicating poor survival in the previous year.

Table 4. Results of the 2010, 2000, 1995, 1986, 1983, 1982, and 1981 early-winter moose surveys in the Whitehorse South comparison area (GMS 7-13 to 7-27).

Survey Year	**2010**	**2000**	**1995**	**1986**	**1983**	**1982**	**1981**
Survey method	Geospatial	Geospatial	Stratified Random Block	Stratified Random Block	Stratified Random Block	Stratified Random Block	Stratified Random Block
Estimated abundance[1] (90% Confidence Range)[2]							
Total moose	443 ± 22% (343-542)	359 ± 33% (240-478)	442 ± 15% (375-508)	736 ± 20% (592-880)	656 ± 22% (509-802)	675 ± 36% (435-914)	608 ± 18% (497-719)
Adult bulls (≥ 30 months)	144 ± 28% (103-184)	89 ± 46% (47-130)	112 ± 26% (84-141)	114 ± 24% (86-142)	154 ± 33% (104-204)	139 ± 44% (78-199)	107 ± 34% (70-143)
Adult cows (≥ 30 months)	233 ± 24% (178-288)	169 ± 34% (111-227)	194 ± 21% (154-234)	417 ± 25% (312-522)	374 ± 25% (281-467)	409 ± 32% (280-538)	343 ± 21% (270-416)
Yearlings (approx. 18 months)	20 ± 77% (5-35)	48 ± 108% (0-99)	54 ± 44% (30-78)	77 ± 27% (57-98)	16 ± 0% (16)	26 ± 110% (0-56)	86 ± 39% (52-119)
Calves (≤ 12 months)	52 ± 41% (30-73)	51 ± 48% (26-76)	81 ± 20% (64-98)	127 ± 22% (99-155)	112 ± 53% (53-171)	101 ± 43% (58-143)	72 ± 29% (51-94)
Estimated population Ratios (90% Confidence Range)[2]							
Adult bulls per 100 adult cows	60 ± 30% (42-78)	53 ± 41% (31-76)	58 ± 22% (45-71)	27 ± 18% (22-32)	41 ± 43% (24-59)	34 ± 26% (25-43)	31 ± 26% (23-39)
Yearlings per 100 adult cows	8 ± 77% (2-15)	28 ± 113% (0-60)	28 ± 55% (12-43)	18 ± 37% (12-25)	4 ± 25% (3-5)	6 ± 90% (1-12)	25 ± 46% (14-36)
Yearlings per 100 adult moose	5 ± 79% (1-9)	16 ± 113% (0-33)	15 ± 46% (8-22)	13 ± 31% (9-17)	3 ± 19% (2-3)	5 ± 82% (1-8)	16 ± 40% (9-22)
Calves per 100 adult cows	22 ± 42% (13-31)	30 ±54% (14-46)	42 ± 22% (32-51)	30 ± 23% (23-37)	30 ± 37% (19-41)	24 ± 27% (18-31)	21 ± 29% (15-27)
% of cow-calf groups with twins[3]	Insufficient Data	Insufficient Data	8 ± 78% (2-14)	Not Avail.	Not Avail.	Not Avail.	Not Avail.
Density of moose (per 1,000 km^2)[1]							
Total area	120	97	Not avail.	Not avail.	~169	~ 174	~157
Moose habitat only[4]	157	128	156	288	245	252	227
Total area (km^2)	3705.4	3705.4	Not avail.	Not avail.	~3879	~3879	~3879
Habitable area (km^2)[4]	2812.0	2812.0	2824.8	2551.3	2680.0	2680.0	2680.0

[1] SCF was not calculated for the 1981 to 1983 and 1986 surveys. To allow for comparison across years, no SCF is included in estimates provided.

[2] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number lies within this range of numbers.

[3] 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. In past surveys (pre 1987) cow and calf data was collected separately and a twinning rate data could not be calculated.

[4] Suitable moose habitat is considered all areas at elevations lower than 1,524 m (5,000ft), excluding all water bodies 0.5 km^2 or greater in size.

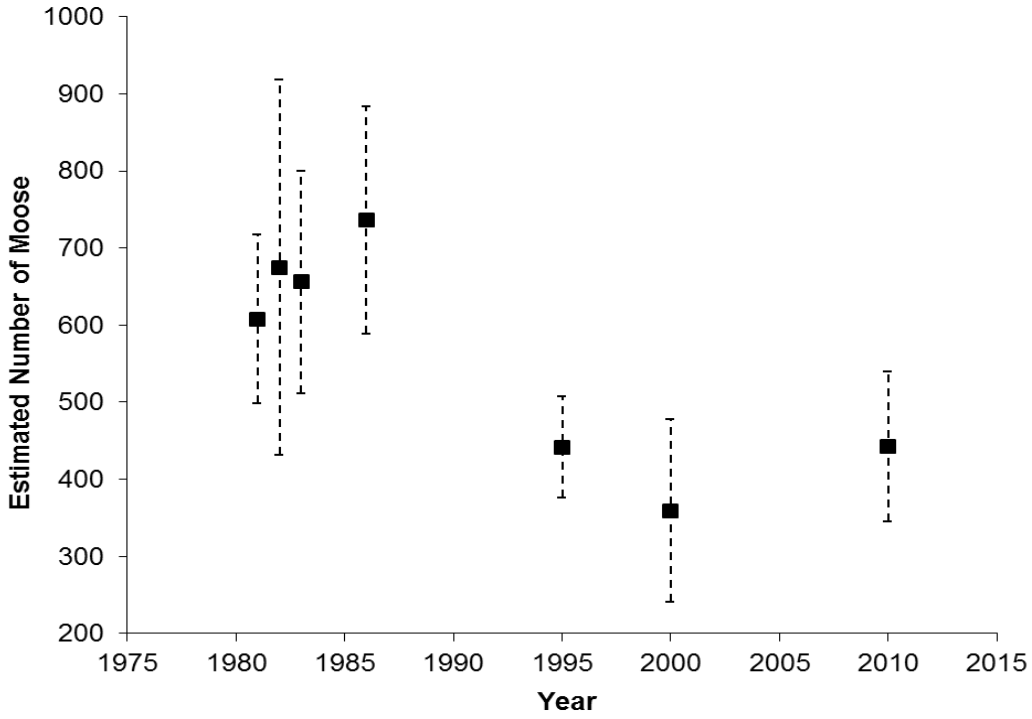

Figure 1. Estimated abundance (dots) with 90% confidence intervals (vertical error bars) from moose surveys in the Whitehorse South comparison area from 1981 to 2010.

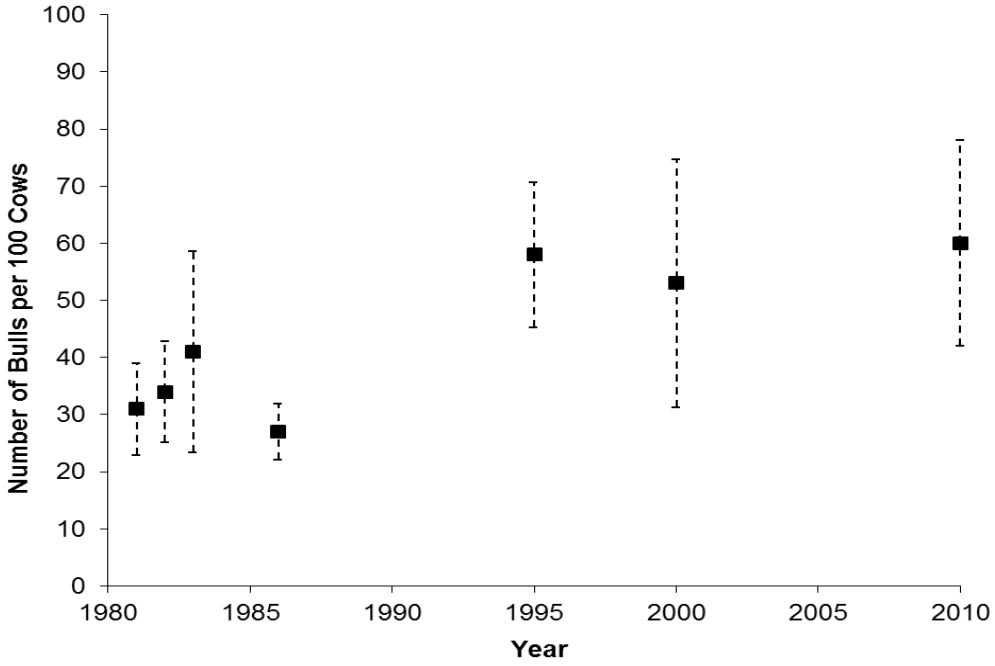

Figure 2. Estimated ratio of bulls per 100 cows (dots) with 90% confidence intervals (vertical error bars) from moose surveys in the Whitehorse South comparison area from 1981 to 2010.

Table 5. Results of the 2010, 1994, 1983, 1982, and 1980 early-winter moose surveys in the Carcross subset area (GMS 9-01, 9-02 and 9-04).

Survey Year	**2010**	**1994**	**1983**	**1982**	**1980**
Survey Method	Geospatial	Stratified Random Block	Stratified Random Block	Stratified Random Block	Stratified Random Block
Estimated abundance[1] (90% Confidence Range)[2]					
Total moose	153 ± 26% (113-194)	102 ± 14% (88-117)	171 ± 35% (110-231)	300 ± 74% (79-521)	396 ± 63% (147-644)
Adult bulls (≥ 30 months)	40 ± 42% (23-57)	35 ± 19% (28-42)	54 ± 37% (34-74)	124 ± 109% (0-258)	94 ± 49% (48-139)
Adult cows (≥ 30 months)	82 ± 29% (58-106)	49 ± 19% (40-58)	105 ± 36% (68-143)	161 ± 68% (52-270)	172 ± 61% (68-276)
Yearlings (approx. 18 months)	7 ± 87% (1-13)	8 ± 50% (4-12)	8 ± 100% (0-15)	2 ± 0% (2)	68 ± 149% (0-170)
Calves (≤ 12 months)	22 ± 40% (13-30)	10 ± 27% (7-13)	4 ± 99% (0-8)	14 ± 125% (0-31)	62 ± 163% (0-163)
Estimated population Ratios (90% Confidence Range)[2]					
Adult bulls per 100 adult Cows	48 ± 43% (27-68)	72 ± 26% (53-90)	51 ± 20% (41-62)	77 ± 86% (10-143)	54 ± 38% (34-75)
Yearlings per 100 adult cows	8 ± 88% (1-16)	17 ± 56% (7-26)	7 ± 82% (1-)13	1 ± 68% (0-2)	40 ± 174% (0-108)
Yearlings per 100 adult Moose	6 ± 91% (1-11)	9 ± 45% (5-13)	4 ± 83% (1-8)	1 ± 76% (0-1)	20 ± 137% (0-48)
Calves per 100 adult cows	28 ± 45% (15-40)	21 ± 26% (15-26)	4 ± 102% (0-7)	8 ± 132% (0-20)	36 ± 104% (0-73)
% of cow-calf groups with	Insufficient Data	0	Not Avail.	Not Avail.	2 ± 165% (0-4)
Density of Moose (per 1,000					
Total area	158	106	165	Not Avail.	397
Moose habitat only[5]	172	111	184	324	Not Avail.
Total area (km^2)	972.6	963.9	1031.9	Not Avail.	995.7
Habitable area (km^2)[5]	891.9	926.9	926.9	926.9	Not Avail.

[1] To allow for comparison across years, no SCF is included in estimates provided.

[2] A "90% confidence interval" means that, based on our survey results, we are 90% sure that the true number lies within this range of numbers. Our best estimate is in the middle of this range.

[3] 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. In past surveys (pre 1987) cow and calf data was collected separately and a twinning rate data could not be calculated.

[4] Suitable moose habitat is considered all areas at elevations lower than 1,524 m (5,000 ft.), excluding water bodies 0.5 km^2 or greater in size.

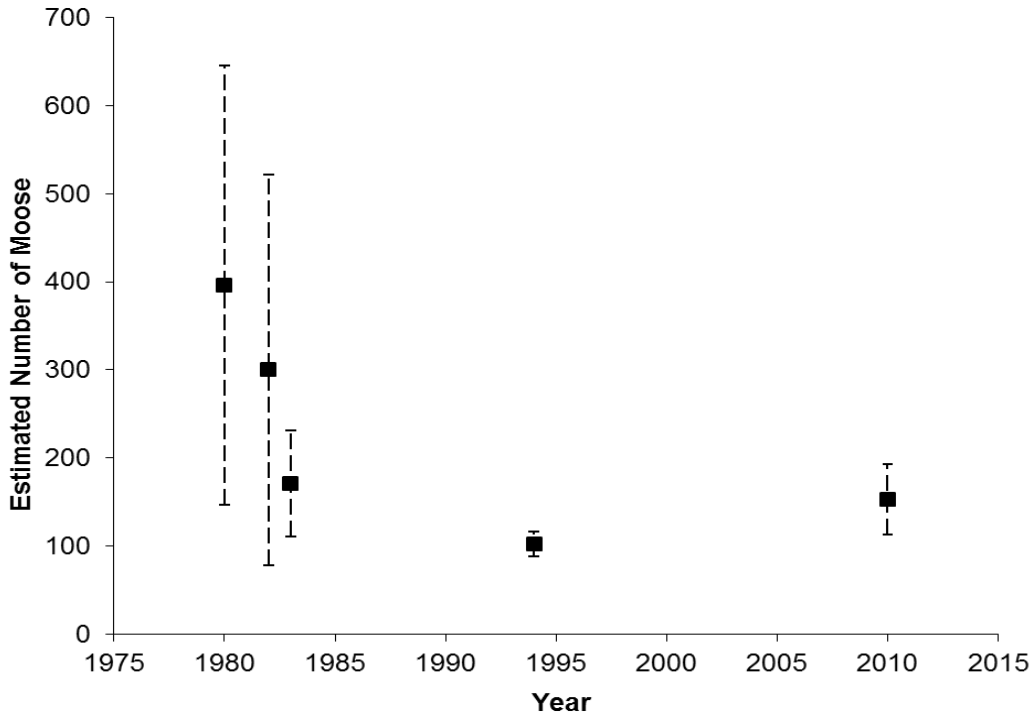

Figure 3. Estimated abundance (dots) with 90% confidence intervals (vertical error bars) from moose surveys in the Carcross comparison area from 1980 to 2010.

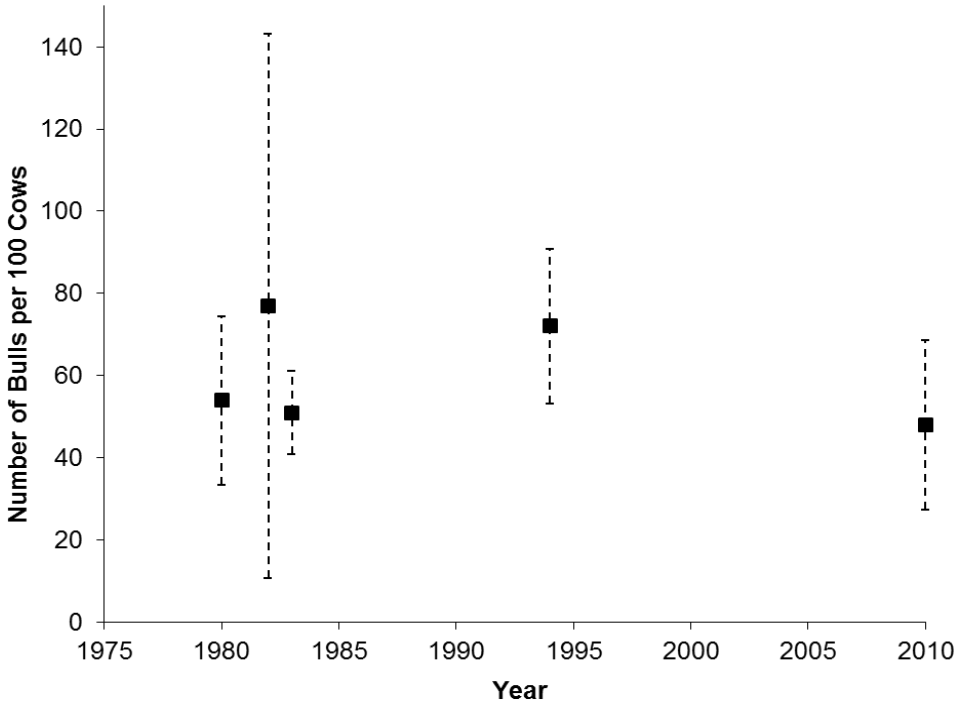

Figure 4. Estimated ratio of bulls per 100 cows (dots) with 90% confidence intervals (vertical error bars) from moose surveys in the Carcross comparison area from 1980 to 2010.

Harvest and Mortality

The 5-year (2006 to 2010 average) total reported annual licensed harvest in the entire 2010 Whitehouse South survey area was 1.4 moose per year, or about 0.1% of the total 992 moose estimated for this area (Table 6). Harvest rates were below 1% of the estimated total moose within each individual GMS in the survey area.

The reported harvest does not include moose harvested by First Nation hunters as this is not currently available.

First Nation harvest is likely greater than licensed harvest in this area since the licensed harvest is restricted by limited entry permits. First Nation harvest may also include cow moose, which has a greater impact on populations relative to harvest of bulls.

Highway collisions are another source of moose mortality. Between 2006 and 2010, an average of 2.6 moose per year were killed on highways within or bordering the survey area. This number could be higher as not all road collisions are reported. The combination of licensed harvest and other known human-induced mortality result in an annual mortality rate below 1% of the annual allowable harvest (AAH), not including First Nation harvest.

However, the moose population has failed to recover to the level that was seen in the early 1980s, indicating that overall harvest and mortality may be too high to allow population growth.

If population recovery is to occur, a lower AAH objective may be necessary.

Harvest data for licensed hunters (includes resident, non-resident, and special guided hunters) in the entire Whitehorse South survey area has been recorded since 1979 (Figure 5). Licensed harvest in the Whitehorse South comparison area was well above the 3-4% AAH in the early 1980s but has been below AAH since 1985 when hunting restrictions were first applied (Figure 6). A similar pattern is seen for the Carcross comparison area (Figure 7).

Access

The Whitehorse South survey area is the backyard for many recreational enthusiasts that live in or near the city of Whitehorse. Since the 1960's, access to the backcountry has been facilitated by the construction of several roads, such as the Kusawa Lake Road, Fish Lake Road, Coal Lake Road, Copper Haul Road, and Annie Lake Road, to name a few (Map 7). As is commonly observed when new roads are constructed, new trail networks extended from these roads, opening up the backcountry to many users who would otherwise be unable to access these areas. Improved access to the Whitehorse South backcountry and improvements in Off-Road Vehicle technology also improved access to a high density moose population, resulting in a harvest of more than 120 animals in 1979.

Although harvest levels declined in subsequent years, harvest followed the trajectory of the moose population, suggesting harvest pressure was still high as the population was declining. Although harvest has been regulated since the 1990s by limited entry permits, this moose population has not recovered to historical levels.

Other Wildlife Sightings

In addition to the 238 moose we counted during the 2010 survey, we also observed 127 moose outside of the blocks that were surveyed, or just outside of the survey boundary.

The total number observed during the entire survey period was 365 moose.

We observed 413 caribou belonging to the Ibex and Carcross caribou herds. Most caribou observed were likely Ibex caribou as they were mostly seen in the headwaters of the Ibex and Primrose rivers in the northwest portion of the survey area.

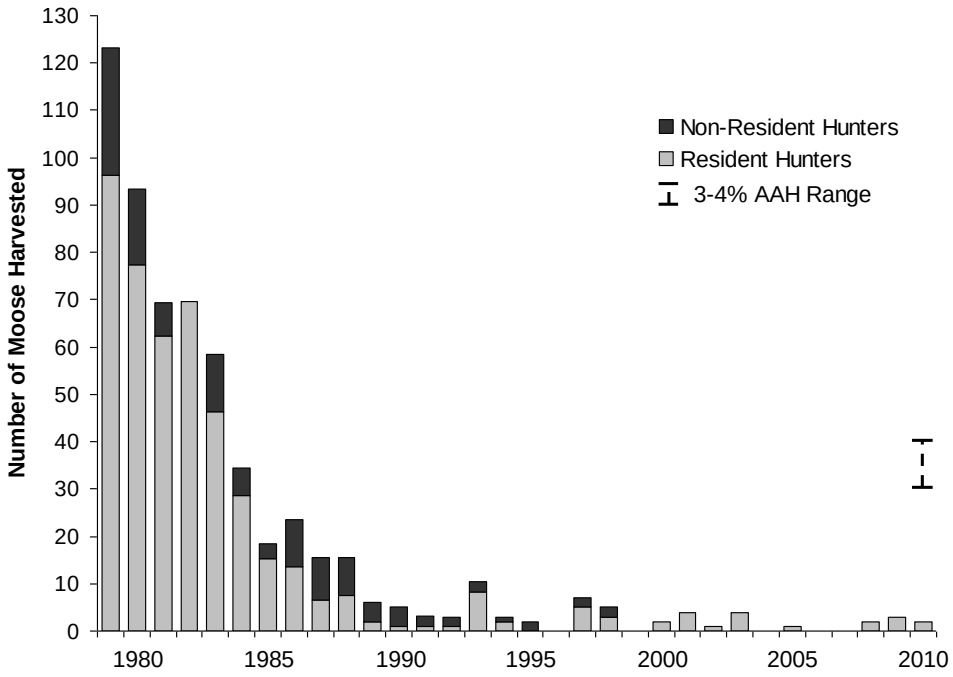

Figure 5. Annual reported moose harvest (does not include First Nation harvest) from 1979 – 2010 in the entire Whitehorse South survey area (GMSs 7-13 to 7-27, 7-30 to 7-32, and 9-01 to 9-04)), Note that there was 1 moose harvested by special guide licence in 1982 (not shown).

Table 6. Average annual reported moose harvest (2006 – 2010) and allowable harvest summary for the 2010 Whitehorse South survey area.

GMS	GMS Area (km^2)	Estimated Density[1] (moose/ 1000 km^2)	Total Estimated number of Moose[2]	Average Resident Harvest	Average Non-Resident Harvest	Average (Special Guided) Harvest	Average Reported Harvest[3] (2006-2010)	Current Harvest Rate (% of total population)	2% Allowable Annual Harvest	3% Allowable Annual Harvest	4% Allowable Annual Harvest
7-13	415.1	140	58.1	0.0	0.0	0.0	0.0	0.0	1.2	1.7	2.3
7-14	195.9	160	31.3	0.0	0.0	0.0	0.0	0.0	0.6	0.9	1.3
7-15	183.5	155	28.4	0.0	0.0	0.0	0.0	0.0	0.6	0.9	1.1
7-16	266.1	155	41.2	0.0	0.0	0.0	0.0	0.0	0.8	1.2	1.6
7-17	276.6	190	52.6	0.0	0.0	0.0	0.0	0.0	1.1	1.6	2.1
7-18	220.6	150	33.1	0.0	0.0	0.0	0.0	0.0	0.7	1.0	1.3
7-19	196.6	165	32.4	0.0	0.0	0.0	0.0	0.0	0.6	1.0	1.3
7-20	93.1	165	15.4	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.6
7-21	427.4	160	68.4	0.4	0.0	0.0	0.4	0.6	1.4	2.1	2.7
7-22	561.9	155	87.1	0.2	0.0	0.0	0.2	0.2	1.7	2.6	3.5
7-23	211.4	170	35.9	0.2	0.0	0.0	0.2	0.6	0.7	1.1	1.4
7-24	220.1	155	34.1	0.0	0.0	0.0	0.0	0.0	0.7	1.0	1.4
7-25	132.3	145	19.2	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.8
7-26	300.1	155	46.5	0.2	0.0	0.0	0.2	0.4	0.9	1.4	1.9
7-27	110.6	180	19.9	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.8
7-30	572.5	145	83.0	0.0	0.0	0.0	0.0	0.0	1.7	2.5	3.3
7-31	242.7	165	40.0	0.0	0.0	0.0	0.0	0.0	0.8	1.2	1.6
7-32	529.3	160	84.7	0.0	0.0	0.0	0.0	0.0	1.7	2.5	3.4
9-01	429.6	140	60.1	0.0	0.0	0.0	0.0	0.0	1.2	1.8	2.4
9-02	113.2	180	20.4	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.8
9-03	346.5	145	50.2	0.0	0.0	0.0	0.0	0.0	1.0	1.5	2.0
9-04	481.8	155	74.7	0.4	0.0	0.0	0.4	0.5	1.5	2.2	3.0
Total	**6526.9**	**152**	**992**	**1.4**	**0**	**0**	**1.4**	**0.1**	**19.8**	**29.8**	**39.7**

[1] Based on 2010 Whitehorse South Moosepop SCF Not-pooled moose survey results.

[2] This number is based on the GMS area multiplied by the density of moose. It differs slightly from the population estimate for the entire survey area (961 moose; Table 2) because the total area and estimated density are slightly different.

[3] Does not include First Nations harvest.

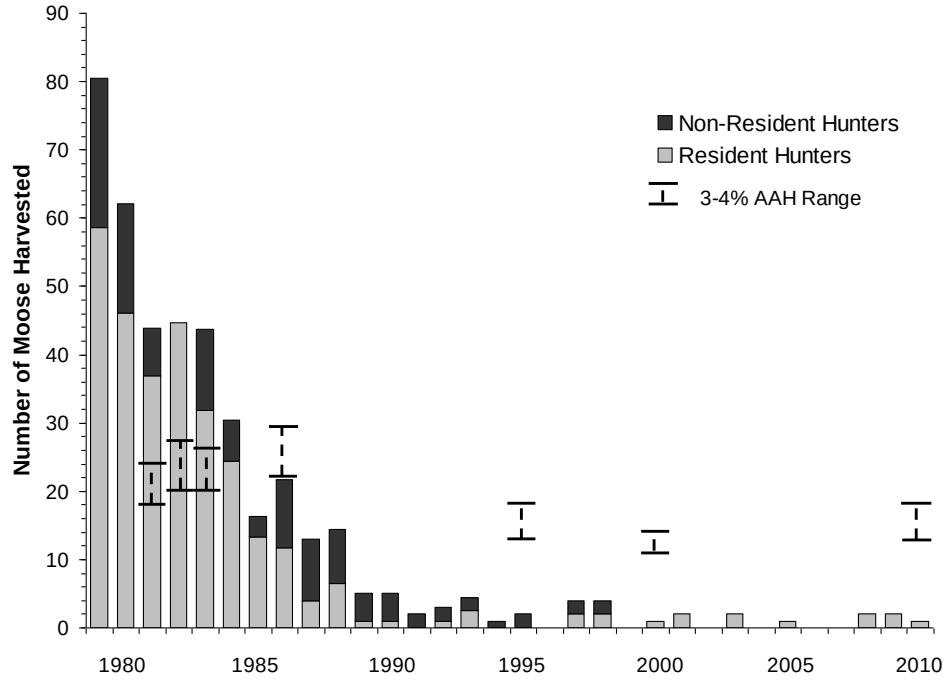

Figure 6. Annual reported moose harvest (does not include First Nation harvest) from 1979 – 2010 in the Whitehorse South comparison area (GMS 7-13 to 7-27), including Annual Allowable Harvest (AAH) range.

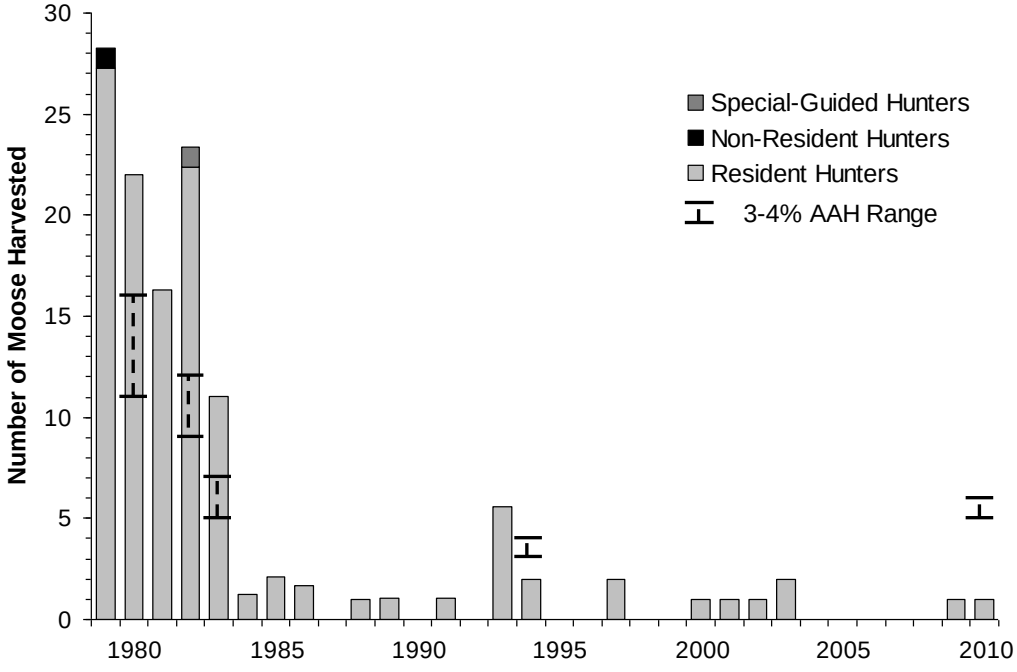

Figure 7. Annual reported moose harvest (does not include First Nation harvest) from 1979 – 2010 in the Carcross comparison area (GMS 9-01, 9-02, and 9-04), including Annual Allowable Harvest (AAH) range.

We saw 23 wolves, 19 of which were just to the southeast of Scout Lake in the northern portion of the survey area. A total of 245 sheep were distributed throughout the Coast Mountains. Sixteen mule deer were observed, 12 of which were located in the Lewes Lake area. We also saw 6 red fox, 2 otter, 1 golden eagle, and 2 gyrfalcons during the survey.

Conclusions and Recommendations

Based on available estimates, the moose population in the Whitehorse South comparison area has declined by about 30% since the 1980s, but appears to have been stable since 1995. Moose numbers may be increasing slowly in the Carcross comparison area, but are still well below numbers seen in the early 1980s.

This is consistent with the SLWCC moose assessment that estimates moose densities in some parts of the Southern Lakes area to be less than one-third of the population prior to 1980 (SLWCC 2012).

The proportion of bulls in the Whitehorse South comparison area has increased since the 1980s, possibly in response to hunting restrictions (permit hunt authorization) put in place in 1989.

However, populations have not recovered to levels seen in the early 1980s.

The average annual reported harvest in the survey area is now below 1% of the estimated population so licensed harvest is not seen as a limiting factor to population growth in this region. There is no information to suggest that moose habitat quality has changed significantly since 1980; therefore, habitat quality is unlikely to be a driving force behind the population decline, nor is it likely a hindrance to population recovery.

In low density moose-wolf-bear systems, predation can limit moose densities (Gasaway et al. 1992, Van Ballenberghe and Ballard 1994, Boertje et al. 2010). However, the relative importance of predation as a limiting factor for any moose population cannot be evaluated without complete harvest information.

Although the Yukon Wolf Conservation and Management Plan (Government of Yukon 2012) endorses certain wolf harvest strategies as management tools to reduce predation rates in local areas, it stipulates that such measures can only be considered when there is reliable and verifiable moose harvest data available for the area. The relative importance of predation in limiting this population cannot be evaluated while First Nation harvest is unknown.

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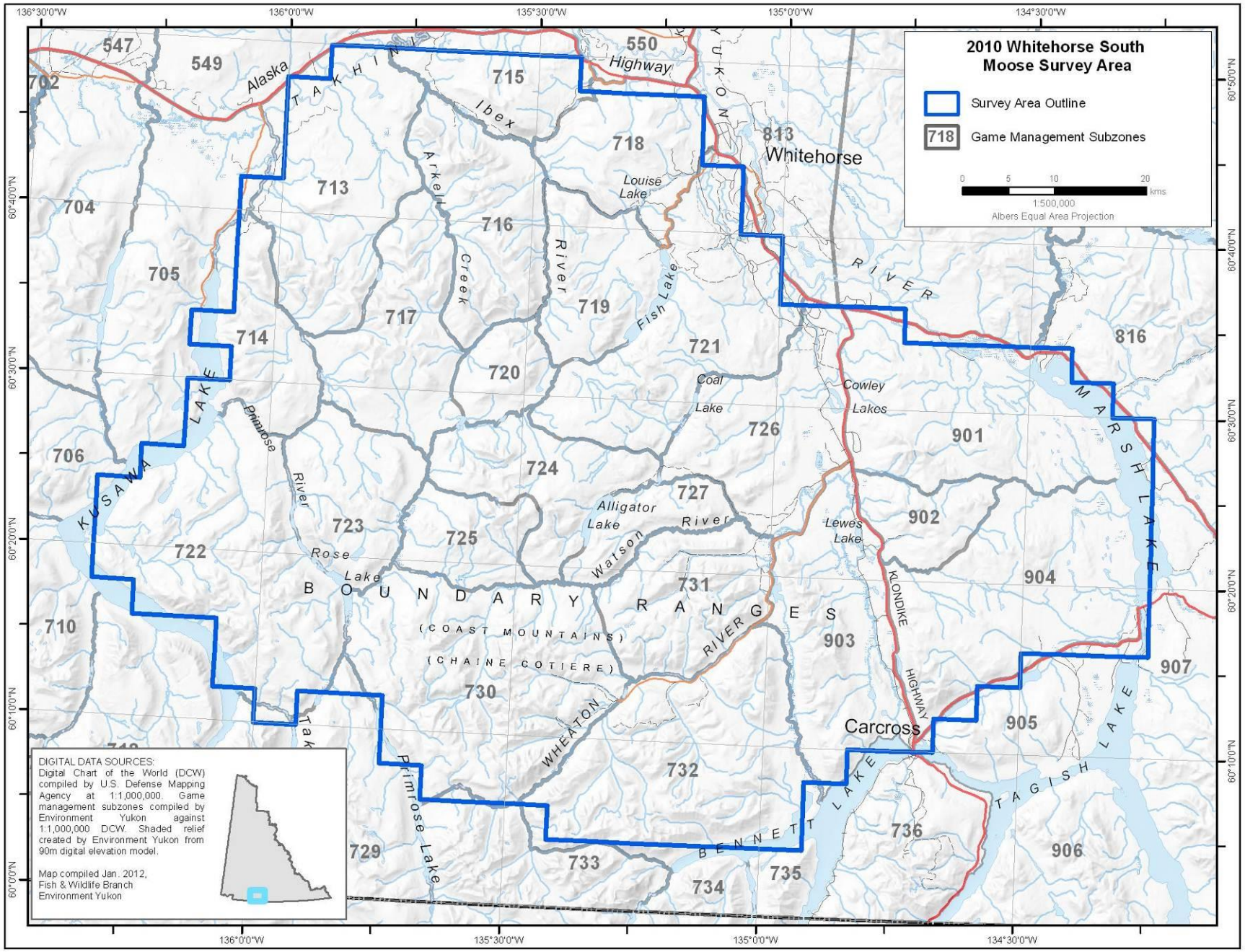
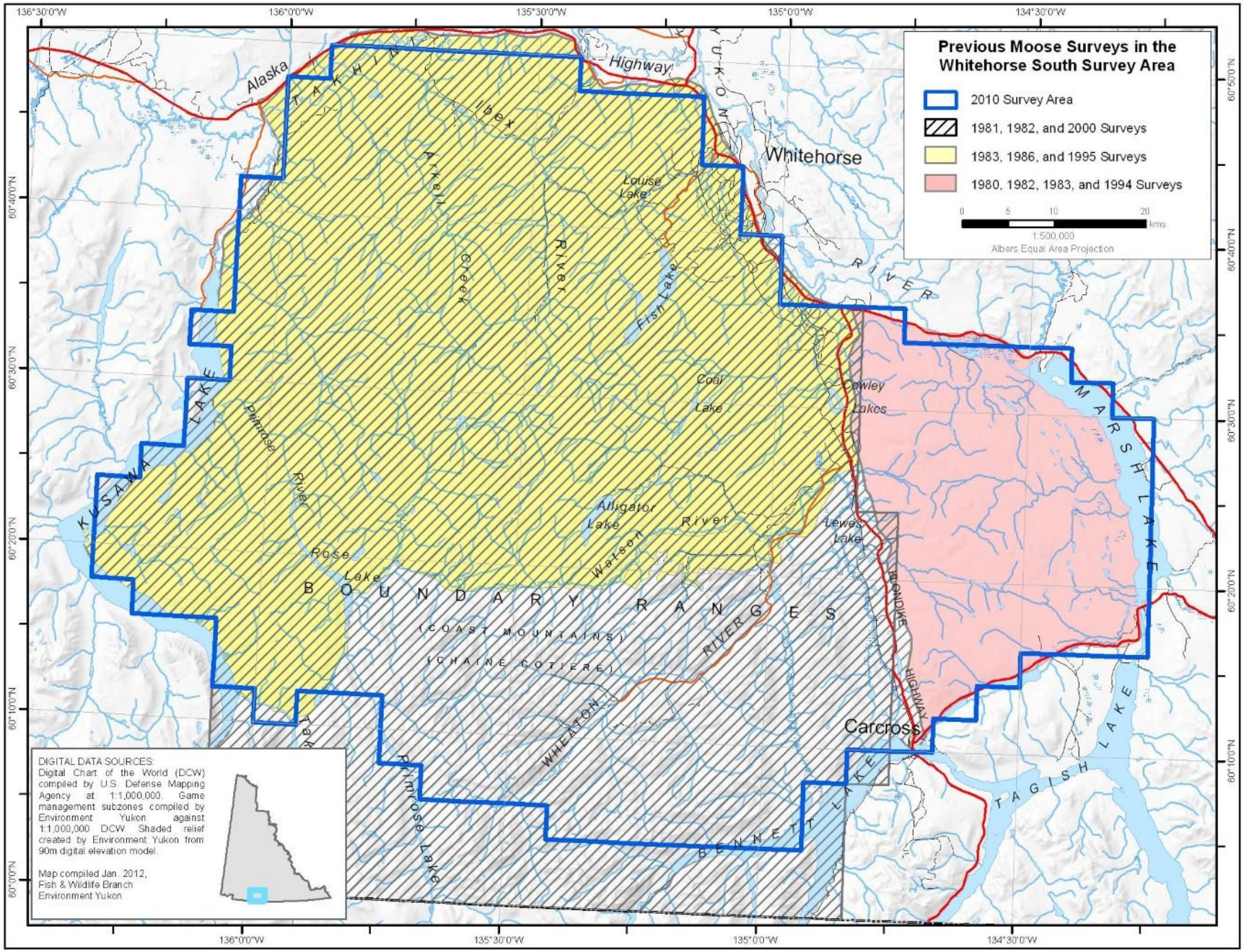
APPENDIX

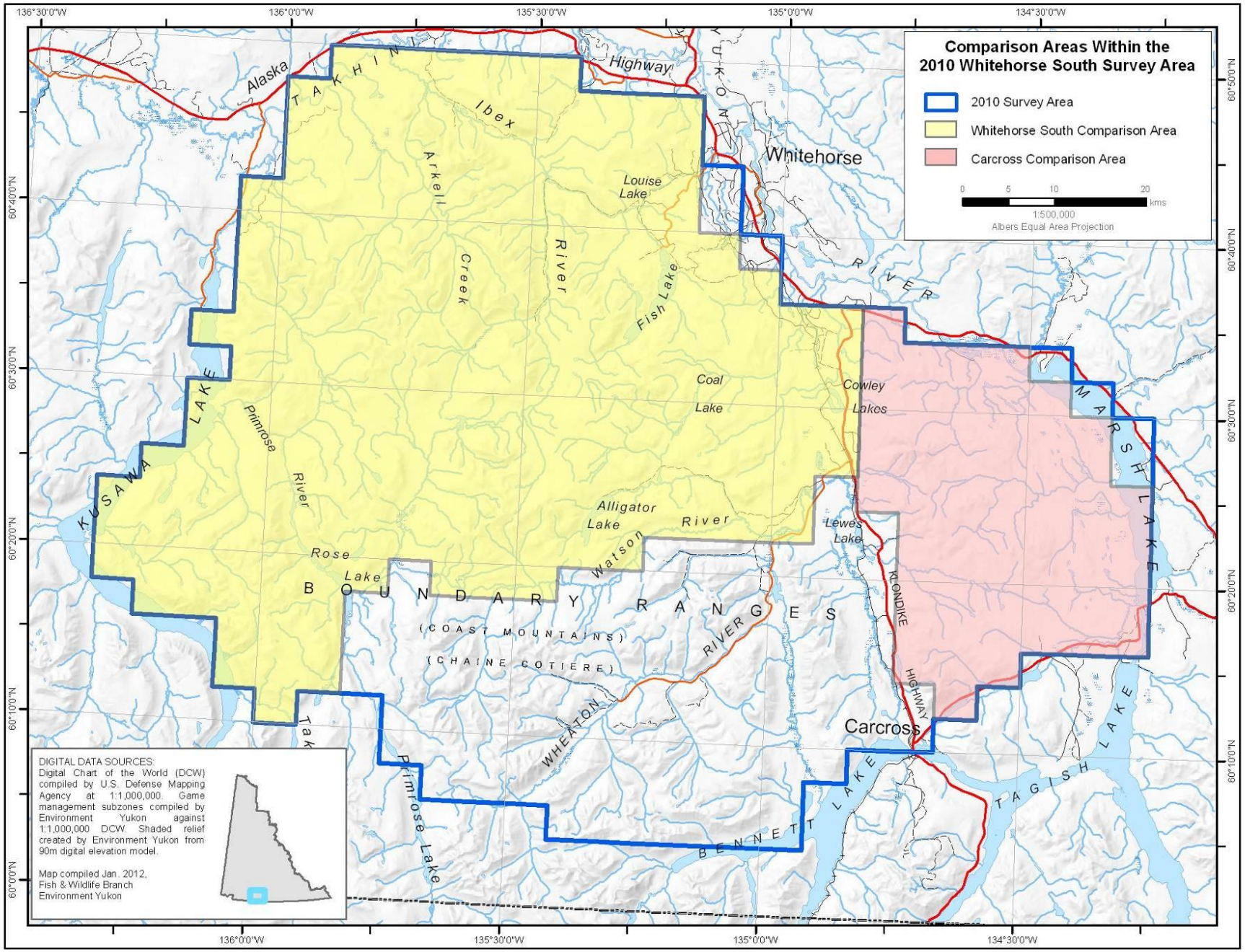
LIST OF MAPS



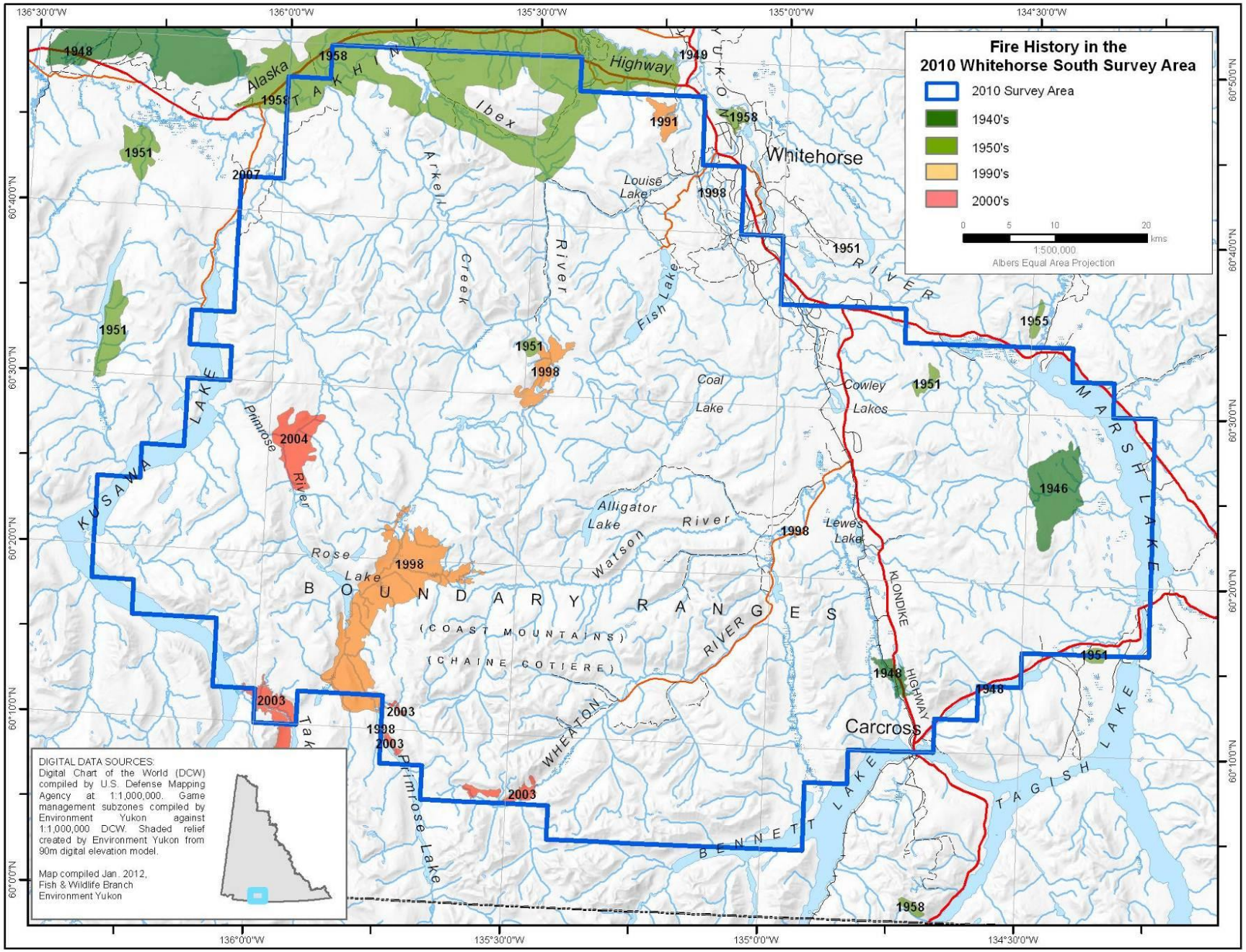
Map 1. Whitehorse South survey area, 2010.



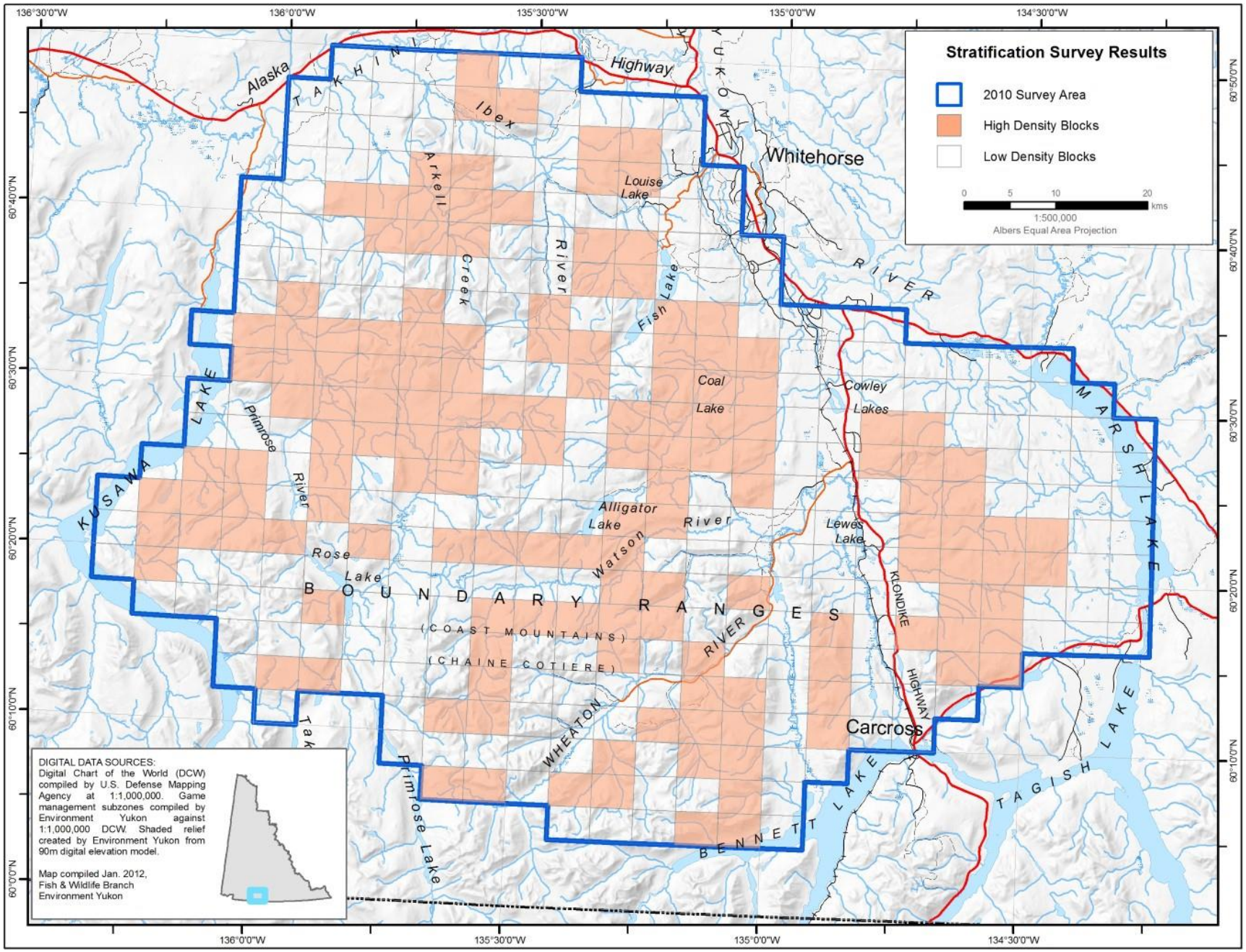
Map 2. Previous surveys within the Whitehorse South 2010 moose survey area.



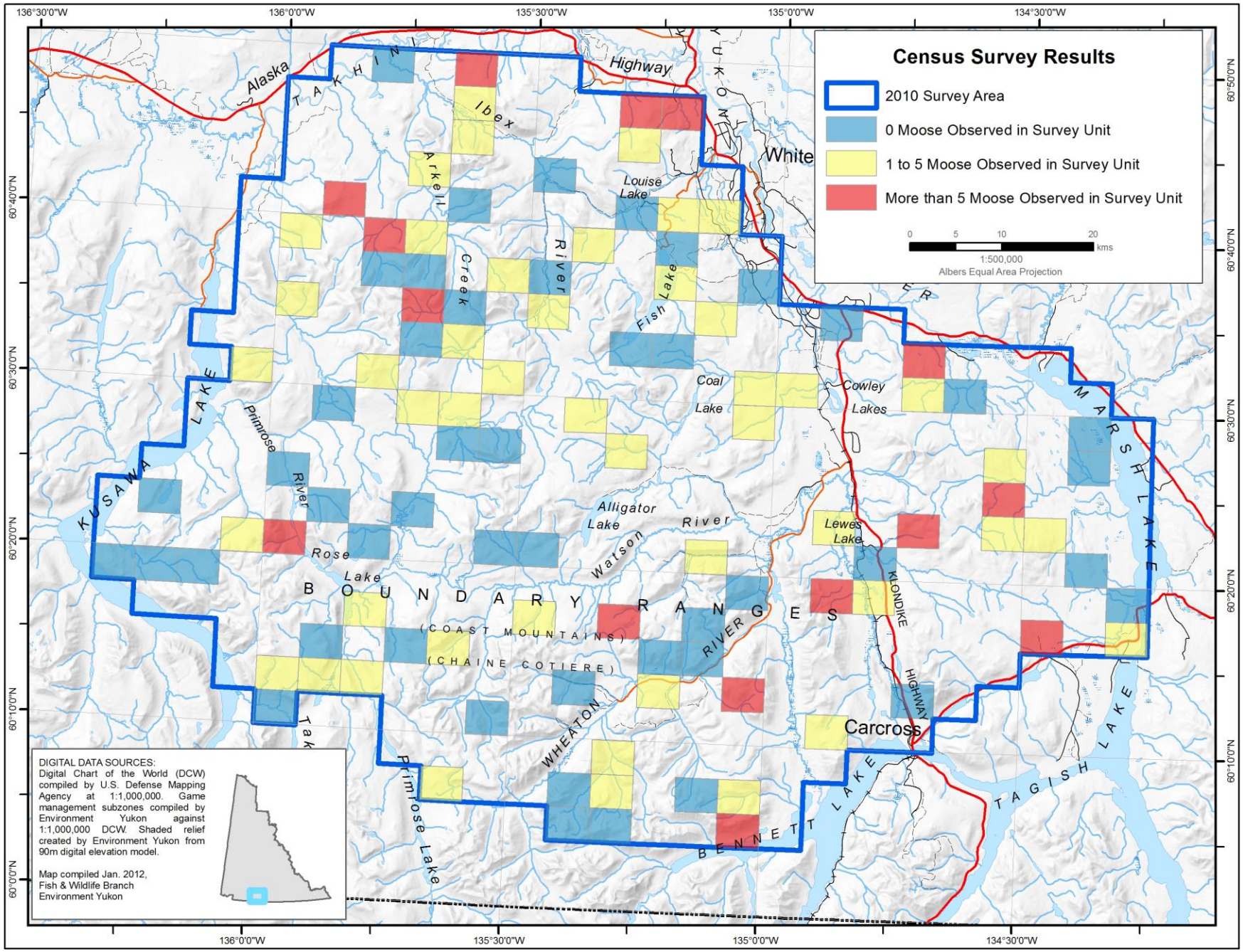
Map 3. Comparison area subsets within the Whitehorse South 2010 moose survey area.



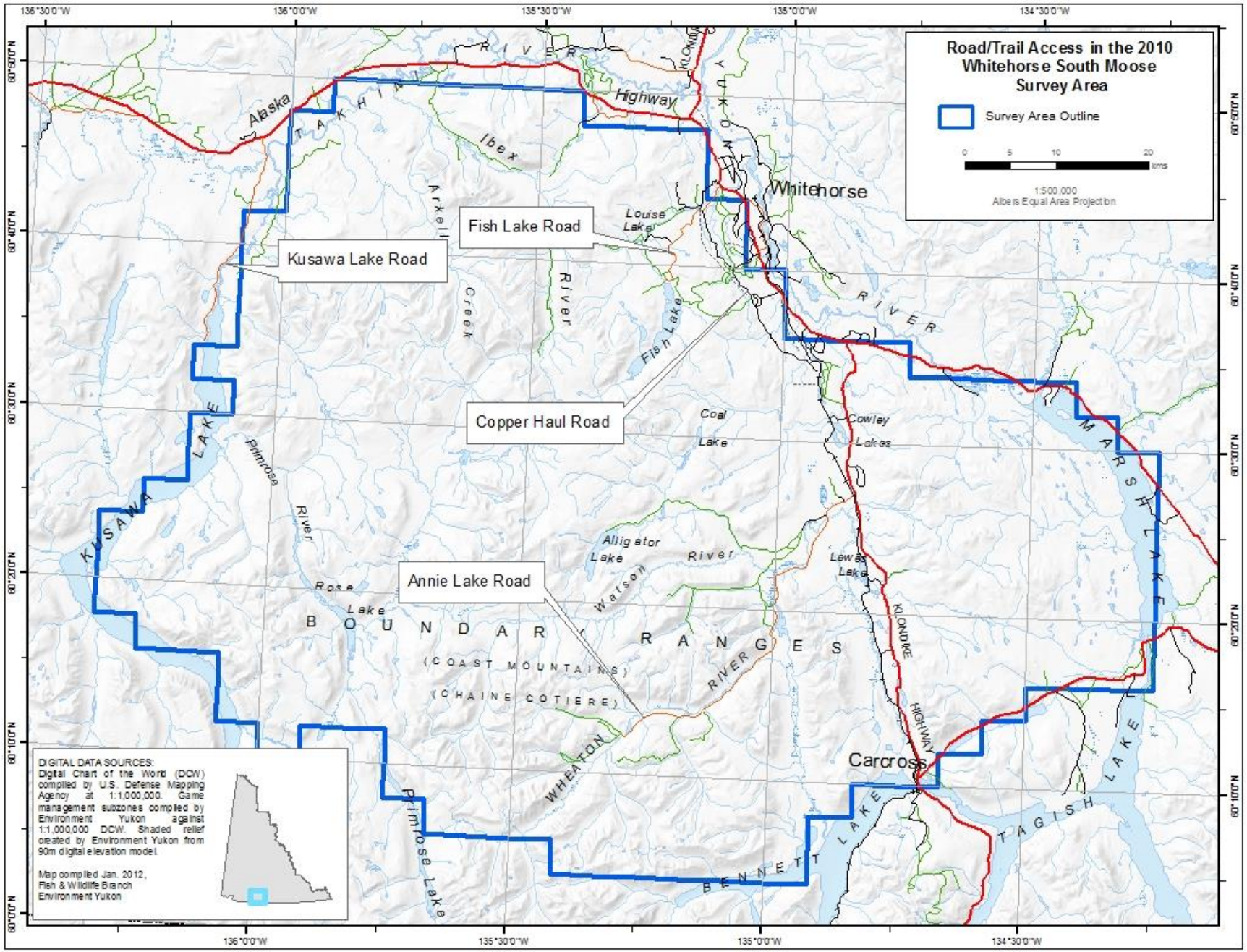
Map 4. Fire history from 1946 to 2010.



Map 5. Results of stratification survey.



Map 6. Results of census survey



Map 7. Major access roads and trails in the study area. Coal Lake Road is not shown