Ecology of Boreal Woodland Caribou in the Lower Mackenzie Valley:

Work Completed in the Inuvik Region 1 April 2002 to 31 March 2003

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1.0 Introduction

Little scientific knowledge is available for boreal woodland caribou (*Rangifer tarandus caribou*) that occur along the Mackenzie River Valley from the NWT/Alberta border in the South Slave Region to the Mackenzie Delta in the Inuvik Region. Unlike barren-ground (*R. t. groenlandicus*), Peary (*R. t. pearyi*), and mountain woodland caribou (*R. t. caribou*), these caribou have not been the focus of biological studies in the NWT.

Threats to boreal woodland caribou habitat include oil and gas exploration and development, the potential for road and hydro development, increased tourism and other non-consumptive human activity, forest fire, and climate change. At present, much boreal woodland caribou range in the Inuvik and Sahtu regions has been altered by past seismic work, wildfires, and road access (Figure 1). The degree of impact of these past human disturbances and wildfires on boreal woodland caribou in the NWT is not known, although where these woodland caribou occur elsewhere across Canada the cumulative effects of human activities and natural habitat disturbances have been shown to be negative to the point of caribou extirpation in many areas, including entire provinces (e.g., Nova Scotia and New Brunswick). Both the Inuvik and Sahtu regions, particularly the Mackenzie Delta, are currently experiencing a significant increase in oil and gas exploration and extraction activities.

Linear disturbances such as seismic lines, roads, and cutlines, have been shown to significantly impact wildlife populations throughout the world. Many wildlife species have been documented to avoid habitats with high densities of linear disturbances (McLellan and Shackleton, 1988). Renewed oil and gas development in the north will cause higher densities of linear disturbance, resulting mainly from seismic activity. Over 37,000 km of seismic lines were cut in the Mackenzie River delta from 1960 to 1990 (National Energy Board Records). Recent exploration activities in this area may increase line densities to over 2 km per square kilometer in some areas. The impacts of linear disturbance on wildlife in a northern environment have been poorly studied, however it is clear that permafrost terrain is easily degraded (Lambert, 1972; Mackay, 1970; Nicholas and Hinkel, 1996; Zoltai and Pettapiece, 1973) and vegetation is slow to recover (Billings, 1987; Harper and Kershaw, 1996). This suggests that 1) disturbance is more likely to alter wildlife habitat in the north; and 2) any alteration in wildlife habitat will persist for a longer period of time.

Climate change models for the Mackenzie River Valley predict an increase in wildfire frequency and severity (Kadonga 1997), increased snowfall across the region, the incursion of new species including forest pests (Sieben et al. 1997) and parasites (Kutz 1999), and significant changes in forest composition (Hartley and Marshall 1997). All of these could impact boreal woodland caribou, although the potential extent is unknown.

In response to these developments, the Department of Resources Wildlife and Economic Development (Inuvik and Sahtu regions) in partnership with the Gwich'in and Sahtu Renewable Resource Boards began collecting baseline information on boreal woodland caribou. Traditional knowledge of woodland caribou in these regions was documented during winter 2001/2002. This project was initiated in fall 2001 to collect baseline scientific information on the distribution and seasonal movements of, and habitats used/selected by boreal woodland caribou in the Lower Mackenzie River area (Inuvik Region). The primary objectives of this study are as follows:

- to produce a Landsat TM based vegetation map that can be used to accurately assess habitat use and selection by boreal woodland caribou.
- to assess use and selection of forested and non-forested vegetation by boreal woodland caribou.

This report summarizes work done in the Inuvik Region between 1 April 2002 and 31 March 2003.

2.0 Study Area

The primary study area in the Inuvik Region is the northern portion of the Gwich'in Settlement Area south and east of the Mackenzie Delta (Figure 1).

3.0 Methods

3.1 Reconnaissance and Capture Surveys

Reconnaissance surveys were conducted with a Cessna 206 or 185 fixed wing aircraft prior to and during capture surveys to locate caribou or fresh caribou tracks. Reconnaissance and dedicated flights to areas where caribou were observed by the fixed wing survey crew were conducted with a Bell 206 helicopter. Sightings of moose, wolves, and other wildlife were recorded by the fixed wing and helicopter survey and capture crews. A Garmin 12 XL or Garmin 12 CX GPS was used to record waypoints for all wildlife sightings and to create track files for all flights conducted.

3.2 Capture and Collaring

Caribou were captured using a net gun fired from a Bell 206 helicopter. A circular disc of tissue (1 cm in diameter) was extracted from the ear of each caribou captured for DNA analyses. Fecal samples were collected to determine diet and prevalence and intensity of infection by gastrointestinal parasites. These animals were either equipped with a Telonics Gen III GPS (5 caribou) or Telonics ST-14 ARGOS satellite transmitter (4 caribou). The GPS collars were programmed to provide 3 locations per day, one each at 01:00, 09:00, and 17:00 hours (MST). The ARGOS satellite collars were programmed to provide locations between 07:00 and 11:00 h (MST) every day between 15 May to 21 June and every 5 days for the remainder of the year.

3.3 Analyses of GPS Location Data

3.3.1 Rates of Travel

The GPS location data obtained between 2 May 2002 and 31 March 2003 were sorted as follows:

- 1) in sequence by day, month, year, and hour (01:00, 09:00, and 17:00 hours), and
- 2) in sequence by hour (01:00, 09:00, and 17:00 hours), day, month, year

to create 2 data sets for analyses of distances between locations for each caribou.

For the data resulting from the first sort, we selected only those distances that were generated for locations that were obtained approximately 8 hours apart (range 7:57 to 8:03 hours). This analysis generated distances for 3 time periods:

- period 1: 01:00 to 09:00 h,
- period 2: 09:00 to 17:00 h, and
- period 3: 17:00 to 01:00 h.

This allowed us to obtain estimates of rates of travel during these three time periods

This data set was further summarized to select all possible 24 hour time periods (range 23:57 to 24:02 hours) for which we obtained distance measures for 3 consecutive 8 hour periods (4 successive locations obtained 8 hours apart). These included:

- 01:00 (day 1) to 09:00 h, 09:00 to 17:00 h, and 17:00 to 01:00 h (day 2)
- 09:00 (day 1) to 17:00 h, 17:00 to 01:00 h, and 01:00 to 09:00 h (day 2), and
- 17:00 (day 1) to 01:00 h, 01:00 to 09:00, and 09:00 h to 17:00 h (day 2).

This allowed us to obtain estimates of daily rates of travel calculated as the total distance between 4 locations obtained over a 24 hour time period.

For the data resulting from the second sort, we selected only those distances that were generated for 2 locations that were obtained approximately 24 hours apart (range 23:57 to 24:03 h). The 24-hour time periods for which we obtained estimates of daily rates of travel using this method included:

- 01:00 h (day 1) and 01:00 h (day2),
- 09:00 h (day 1) and 09:00 h (day2), and
- 17:00 h (day 1) and 17:00 h (day2).

The "calculate successive distances" function in ArcView extension Animal Movement V.2.0 was used to calculate distances between locations. This tool calculates distances between locations and adds them to an existing data table. Kruskal-Wallis nonparametric tests were used to compare the distances between locations for each 8-hour time interval and for each of the estimates of daily rates of travel among months. The Mann-Whitney U nonparametric test was used to compare the distances between locations between months. In addition, we used the Mann-Whitney U test to compare the two estimates of daily rates of travel by month and for the period 2 May 2002 to 31 March 2003.

3.3.2 Home Range Size

Home range size was estimated using the "minimum convex polygon" function in ArcView extension Animal Movement V.2.0.

3.3.3 Calving and Breeding Dates

Calving dates were estimate by plotting the 3 estimates of travel rates for May and early June. Calving was assumed to have occurred during the period when the 3 rates of travel converged to near zero. The gestation period was assumed to be 242 days or 8 month. Breeding dates were estimated by backdating from calving dates.

3.4 Habitat Availability

3.4.1 Forest Management Vegetation Cover Map

Forestry Division, DRWED, has produced a Landsat TM image based vegetation map for the Inuvik Region. The boreal woodland caribou study area falls within an area that was mapped using TM imagery taken in late July 1993 and late August 1998 (Figure 2). During the course of the fieldwork we located a 70,000 hectare area that burned in 1993 and was not reflected on the vegetation cover maps produced by Forest Management. Because the vegetation map for the study area was generated using dated imagery it currently has limited value to assess patterns of habitat availability and selection. Forest Management is updating their vegetation cover maps for the area using current TM imagery.

3.4.2 Ducks Unlimited Vegetation Cover Map

Ducks Unlimited Canada (DU) produced a vegetation cover map for the Lower Mackenzie River Delta (Ducks Unlimited Canada 2002) (Figure 3). In addition, DU is preparing a similar vegetation cover map for the Peel Plateau (TM scene south of the Lower Mackenzie River Delta project) that should be available in October 2003. Because the Lower Mackenzie River Delta vegetation map was completed during fall 2002 and associated levels of classification accuracy were assessed, these data were used to determine habitat use.

3.4.3 Descriptions of Vegetation at Caribou GPS Locations

During late August 2002 we flew via helicopter to and described the vegetation associated with 123 caribou GPS locations. We selected one location for each day for which we obtain GPS locations for each collared caribou during the period 2 May to 11 August 2002. Locations that were obtained at 09:00 were selected whenever possible. We visited 56 locations obtained for caribou 35983 and 67 locations obtained for caribou 36182. We navigated the helicopter to each site using a GPS, selected a distinctive feature that centered on the GPS location, circled that distinctive feature, and described the vegetation within a 20 m radius around the GPS location. The DU method of aerial classification of vegetation was used to describe the characteristics of the vegetation at each site (Ducks Unlimited Canada 2002) (Appendix A, B, and C). The information collected at these 123 sites will be used as trainings sites for the DU Peel Plateau vegetation map and to produce a habitat map for the study area if required.

3.5 Habitat Use

We overlaid the locations obtained for the two GPS collared caribou on the Lower Mackenzie River Delta vegetation map (Ducks Unlimited 2002) using ArcView and determined the vegetation types associated with those that fell within the area classified by DU. The vegetation types described and mapped by DU were generalized into 7 vegetation classes for analysis (Table 1). We also overlaid the GPS locations for these animals on the fire history maps produced by Forest Management using ArcView to determine the fire history of sites used. In combination these data were used to describe the vegetation classes and fire history of sites used by these caribou between 2 May 2002 and 31 March 2003. Data were summarized in tabular form.

4.0 Results and Discussion

4.1 Reconnaissance and Capture Surveys

4.1.1 Late April/Early May 2002

Tracks of reconnaissance and capture surveys flown between 28 April and 2 May 2002 are shown in Figure 4. During these flights we located 11 groups or 69 boreal woodland caribou (Figure 5 and Table 2). These included 52 bull, 4 calves, and 13 age 1+ cows. Mean group size was 6.9 (range 1 to 25). The calf:cow ratio was 30.8 calves per 100 age 1+ cows, although this was based on a small sample size. During the course of these surveys we observed 7 moose (Figure 6) and 3 sites with fresh wolf tracks (Figure 7).

4.1.2 Late March/Early April 2003

Tracks of reconnaissance and capture surveys flown between 27 March and 2 April 2003 are shown in Figure 8. During these flights we located 16 groups or 135 boreal woodland caribou Figure 9 and Table 2). These included 74 bulls, 16 calves, and 45 age 1+ cows. Mean group size was 8.4 (range 3 to 23). The calf:cow ratio was 35.6 calves per 100 age 1+ cows. During the course of these surveys we observed 36 moose and 6 wolves. The distribution of sightings and fresh tracks of moose and wolves observed are shown on Figures 10 and 11.

4.1.3 Capture and Collaring

Nine adult female caribou were captured. Two of these were captured and equipped with GPS collars on 1 May 2002. Seven caribou were captured between 28 March and 2 April 2003 and were equipped with either GPS (3 caribou) or ARGOS satellite collars (4 caribou). Capture sites are shown on Figure 12.

4.2 Analyses of GPS Location Data

4.2.1 Performance of GPS Collars

The GPS collars were programmed to provide 3 locations per day. During the period 2 May 2002 to 31 March 2003 we should have obtained approximately 1005 locations for each of the two collared caribou. The GPS collar on caribou 35983 provided 337 or 33.5% of the optimal number of locations. This collar provided approximately 60% of the possible number of locations during May 2002, but its performance declined progressively during the following months (Table 3). Similarly, the GPS collar on caribou 36182 provided 503 or 50% of the optimal number of locations. This collar performed much better than that on caribou 35983 and provided between 34 and 70% percent of the possible number of locations each month (Table 3). The reason for the less than optimal performance of these collars is not known.

4.2.2 Rates of Travel

4.2.2.a Travel rates over 8 hour time interval

Estimates of travel rates obtained for period 1 (01:00 to 09:00 h) during June through October were significantly greater than those obtained during Feb, March, and May (Table 4 and Figure 13). This suggests that travel rates during the late evening and early morning during June through October are greater than those during February though May. The highest median travel rates for this time period occurred during July through October (1.26 to 1.91 km per 8 hour period, Table 4).

Estimates of travel rates obtained for period 2 (09:00 to 17:00 h) during September through December were significantly greater than those obtained during March, May, June, and July (Table 5 and Figure 14). This suggests that travel rates are greater during the day during September through December than they are during March through July. The highest median travel rates for this time period occurred during August through January (1.10 to 2.41 km per 8 hour period, Table 5).

Estimates of travel rates obtained for period 3 (17:00 to 01:00 h) during July through December were significantly greater than those observed during March (Table 6 and Figure 15). Similarly estimates of travel rates for the period July through October were significantly greater than those observed during May, and estimates of travel rates for August and September were significantly greater than those observed in June. This suggests that travel rates during the late afternoon/early evening are generally greater during July though February than they are during March though June. The highest median travel rates for this time period occurred during August to November (1.01 to 1.47 km per 8 hour period, Table 6).

In general travel rates were lowest in late winter (March) and during the calving/post calving period (May and June) during all 8 hour time periods.

4.2.2.b Daily rate of travel (3 successive 8 hour time periods)

In general, daily rates of travel measured as the total distance between 4 successive locations obtained 8 hours apart over a 24 hour period were significantly greater during June through December than during March and May (Table 7 and Figure 16). Similarly, these distances were significantly greater during August through November than during June. In general, this suggests that daily travel rates are significantly greater during the period July through November than they are during late winter (March) and during the calving and post calving period (May and June).

4.2.2.c Daily rate of travel (2 successive locations obtained at a 24 hour time interval)

In general, daily rates of travel measured as the distances between 2 successive locations obtained 24 hours apart were significantly greater during January and February than during March and May (Table 8 and Figure 17). These distances were significantly greater during

August through November than during March, May, June, and July (Table 8). This suggests that travel rates during March (late winter) and May (calving) were significantly lower than those during most other months.

4.2.2.d Comparison of two measures of daily rates of travel

Overall, the daily rates of travel measured as the total distance between 4 successive locations obtained 8 hours apart over a 24 hour period were significantly greater than those measured as the total distance between 2 successive locations obtained 24 hours apart (Table 9 and Figure 18). These distances were significantly greater during most months (Table 9). As expected, daily travel rates are best estimated when more locations are obtained during the day.

4.2.3 Home Range Size

The movements and home ranges of Caribou 35983 and 36182 for the period 2 May 2002 to 31 March 2003 are shown in Figures 19, 20, and 21. The size of the home range for Caribou 35983 was 1,796 km^2, while that for Caribou 36182 was 1,914 km^2. More sophisticated methods of home range analyses will be completed once we have a full year of data for these caribou and have a better understanding of seasonal movements.

4.2.4 Calving and Breeding Dates

For cow 35983, the 3 distance measures converged near 0 km on 20 May and remained near 0 km until 23 May (Figure 22). This suggests that cow 35983 calved between 20 and 23 May 2002. Similarly for cow 36182, the 3 distance measures converged near 0 km on 18 May and remained near 0 km until 20 May (Figure 23). This suggests that cow 36182 calved between 18 and 20 May 2002. Assuming a 242-day gestation period (8 months), these cows would have been bred between 18 and 23 September 2001 or about a month earlier than barren-ground caribou.

4.3 Habitat Use

4.3.1 Monthly Patterns of Habitat Use

The GPS collars provide a total of 840 locations during 2 May 2002 to 31 March 2003. The vegetation cover at and fire history of sites used by month by the two collared caribou is given in Table 10. A total of 182 (22 percent) of the these locations fell outside of the area of the Lower Mackenzie River Delta Ducks Unlimited vegetation classification study area. The majority of these locations were obtained during September 2002 to January 2003 (Figure 24). We will not be able to undertake a complete assessment of the monthly patterns of habitat use until a vegetation map is available for the entire boreal woodland caribou study area. The vegetation classes derived by DU will be refined to better define potential boreal woodland caribou habitat during 2003-2004.

4.3.2 Use of Burns

Thirty-four percent of the locations obtained for the two collared caribou (286 of 840 locations) were in areas that had been burned in recent years (Table 11). Use of burned areas varied by month but was lowest during March (approximately 10 percent of locations obtained for the month) and May (none of the sites obtained during the month were in burned areas) and was the highest during October (Table 11). A total of 191 locations (22.7 percent) of these locations fell within an area that was burned in 1993. This high degree of use of burned areas was not expected.

4.3.3 Calving Habitat

The vegetation characteristics of the sites used by the 2 collared caribou were described during aerial habitat surveys that were done in late August 2002.

Caribou 35983 calved in an area with open needle leaf (black spruce dominated) and woodland needle leaf (black spruce and paper birch dominated) vegetation cover (Figure 25). In addition, the vegetation cover in the area had the following characteristics:

- 20 to 25 percent tree cover,
- 10 to 15 percent medium/tall shrub cover dominated by willow and bog birch,
- 15 to 30 percent low shrub cover dominated by Labrador tea,
- 5 percent herbaceous cover, primarily Calamagrostis,
- 20 to 45% moss cover, and
- 5 to 20 percent reindeer lichen cover

The area was flat and imperfectly to poorly drained.

Caribou 36182 calved in an area with open needle leaf (black spruce dominated) vegetation cover (Figure 26). In addition, the vegetation cover in the area had the following characteristics:

- 25 to 30 percent tree cover,
- 15 to 25 percent medium/tall shrub cover dominated by alder and bog birch,
- 30 percent low shrub cover dominated by Labrador tea and alpine blueberry,
- 5 percent dwarf shrub cover dominated by bear berry,
- 5 to 10 percent moss cover, and
- 10 to 15 percent reindeer lichen cover.

The area was flat and imperfectly drained.

The sample size is too small to describe preferred calving habitats. The sites used by the 9 collared cows during the 2003 calving period will be visited during summer 2003 to describe the vegetation cover.

4.4 Observation of Note Made During Capture Work

A majority of the caribou that we located during reconnaissance and capture surveys were found in open forested areas (Figure 27), although some groups were found on lakes near shoreline. Although we made a few sighting of fresh tracks in burns, we did not observe caribou in burns. Similarly, the majority of GPS locations that we obtained for caribou 35983 and 36182 during

March and May 2002 were in areas that had not been burned-this pattern appears to be true for the sites used to date by the 7 caribou that we collared in late March/early April 2003. This suggests that boreal woodland caribou may avoid burned areas during March through May. This also suggests that it may be useful to focus future survey and capture efforts during March through May in “un burned” areas to increase the probability of locating boreal woodland caribou.

We investigated a number of cratering sites from the air and on the ground. Most of these sites were in open timbered areas. At most sites the caribou appeared to be cratering in areas where reindeer lichens were available (Figure 28). This suggests that unburned open timbered areas with lichen cover may be particularly important for boreal woodland caribou during late winter/early spring. Availability of these habitats may be limiting.

We found a number of cratering sites along shorelines of lakes—often these were some distance from forest cover. We investigated one of these shoreline sites. Tracks and feces in the area indicated that it was a caribou crater. At this site the caribou cratered through approximately 122 cm or 1 foot of hard-crusted snow to get at the forage below (Figure 29). The cured stalks of horsetail (*Equisetum* spp) and moss appeared to be the dominant vegetation types available at this site.

We also found a few sites where the caribou had walked out onto lakes to what we first believed were muskrat push-ups. Upon investigation we found that they were muskrat pushup sized islands of mineral soil. The surface of these mounds of soil had been “licked” smooth suggesting that the caribou were using these sites as “mineral licks”.

On 28 March 2003 we located a group of 15 caribou on a small lake east of Caribou Lake. The group was comprised of 13 bulls and 2 cows. The bulls were determined to be boreal woodland caribou based on size, color, and gait. As a result we captured one of the cows. Upon examination we determined that the cow was a barren-ground caribou. We found a number of small groups of barren-ground caribou in the general area. This suggest that boreal woodland and barren-ground caribou may occur in mixed groups in areas where their ranges overlap during winter.

5.0 Work Plan for 2003-2004

The following tasks will be completed during the current year if sufficient funds are secured:

- revise the vegetation classes defined by DU to better identify potential boreal woodland caribou habitat and revise the DU classification decision tree to reflect those changes.

- complete classification of sites visited in August 2002 using the revised DU classification and compare these with vegetation classes assigned by DU for these sites using TM image analyses.

- visit and describe the vegetation at approximately 120 randomly selected caribou GPS locations obtained during the period August 2002 to June 2003. This work will be completed during July 2003. The DU method of aerial vegetation classification will be used. These site description will be forwarded to DU for use as training sites, where applicable, to complete vegetation maps for the Peel Plateau or Middle Mackenzie study areas.

- begin work to produce an accurately geo referenced database for cutlines, winter roads, and other anthropogenic features.

- locate and describe characteristics of calving sites used by the 9 collared caribou during May 2003.

- complete analyses of location data obtained during the period May 2002 and April 2003 for caribou 35983 and 36182, including home range size and core seasonal ranges.

- complete habitat use and selection analyses once the DU Peel Plateau vegetation map digital database is available.

- initiate a winter ecology study. A number of caribou GPS locations will be visited each month during winter to obtain the following information and samples:
    - habitat types used for bedding, cratering, etc. including tree heights, species, stem density, and security cover
    - forage types apparent at cratering sites
    - snow depth, density, and hardness in areas adjacent to cratering sites and at randomly located sites
    - GPS location for all cratering sites observed and determine distance to sesimic lines and winter roads, etc
    - feces to determine diet, prevalence and intensity of infection by gastro intestinal parasites, and possibly cortisol levels
    - fresh urine collected from snow to determine relative body condition

- deploy up to 5 Argos satellite collars on cow or bull boreal woodland caribou in the Mackenzie Valley Pipeline corridor between Campbell and Travaillant lakes.

- survey unburned areas in late March/early April within the study area to obtain estimates of numbers of boreal woodland caribou in the area and to estimate recruitment rates.

- continue to document incidental observations of boreal woodland caribou reported by DRWED staff and other people in the region.

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7.0 Literature Cited

Billings, W.D. 1987. Constraints to plant growth, reproduction, and establishment in the arctic environments. Journal of Artic and Alpine Research. Vol. 19(4), pages 357-365

Harper, K.A. and G.P. Kershaw. 1996. Natural revegetation on borrow pits and vehicle tracks in shrub tundra, 48 years following construction of the CANOL No.1 Pipeline, N.W.T., Canada. Arctic and Alpine Research 28: 163-171.

Hartley, I. and P. Marshall. 1997. Modelling forest dynamics in the Mackenzie Basin under a changing climate. pp. 146-156 *in* S. J. Cohen (ed.) Mackenzie Basin impact study – final report. Environment Canada, Ottawa, ON. 372 pp.

Kadonga, L. 1997. Forecasting future fire susceptibility in the Mackenzie Basin. pp. 157-1165 *in* S. J. Cohen (ed.) Mackenzie Basin impact study – final report. Environment Canada, Ottawa, ON. 372 pp.

Kutz, S. J. 1999. *Umingmakstrongylus pallikuukensis* in muskoxen. Ph.D. Thesis, University of Saskatchewan, Saskatoon, SK. 190 pp.

Lambert, J.D.H. 1972. Botanical changes resulting from seismic and drilling poeration, Mackenzie Delta area. ALUR report 1971-72.

Mackay, J.R. 1970. Disturbances to the tundra and forest tundra environment of the western arctic. Canadian Geotechnical Journal, 7: 420-432.

McLellan and Shackleton, 1988, Grizzly bears and resource-extraction industries: effects of rods on behavior, habitat use, and demography. Journal of Applied Ecology. Vol. 25 pages 451-460

Nicholas, J.R.J. and K.M. Hinkel. 1996. Concurrent permafrost aggradation induced by forest clearing, Central Alaska, U.S.A. Arctic and Alpine Research 28: 294-299.

Sieben, B., D. L. Spittlehouse, J. A. McLean, and R. A. Benton. 1997. White pine weevil hazard under GISS climate-change scenarios in the Mackenzie Basin using radiosonde derived lapse rates. pp. 166-175 *in* S. J. Cohen (ed.) Mackenzie Basin impact study – final report. Environment Canada, Ottawa, ON. 372 pp.

Zoltai, S.C. and W.W. Pettapiece. 1973. Studies of vegetation, landform, and permafrost in the Mackenzie Valley: Terrain, vegetation, and permafrost relationships in the northern part of the Mackenzie Valley and northern Yukon. Environmental-Social Committee, Northern. Ottawa, ON. Report # 73-4

Table 1. Generalized vegetation classes derived by grouping Ducks Unlimited vegetation classes.

Generalized Vegetation Class	Ducks Unlimited Vegetation Classes Grouped
1) ripparian/mesic/dry	Mesic/Dry Graminoid Meadow
	Aquatic Bed
	Clear Water
	Emergent Vegetation
	Mesic/Dry Forb
	Turbid Water
	Wet Forb
	Wet Graminoid
2) low shrub	Low Shrub Lichen
	Low Shrub Other
	Low Shrub Willow/Alder
3) tall shrub	Closed Tall Shrub
	Open Tall Shrub
4) needle leaf, woodland	Woodland Needle leaf Lichen
	Woodland Needle leaf Moss
	Woodland Needle leaf Other
5) needle leaf, mixed	Closed Mixed Needle leaf/Deciduous
	Open Mixed Needle leaf Other
	Open Mixed Needle leaf/Deciduous
6) spruce	Closed Spruce
	Open Spruce Lichen
	Open Spruce Moss
	Open Spruce Other
7) other	Burn
	Closed Birch
	Non-Vegetated Soil
	Sparse Vegetation

Table 2. Number of cow, calf, and bull boreal woodland caribou observed during reconnaissance and capture surveys completed during 28 April to 2 May 2002 and 27 March to 2 April 2003.

Day	Year	Group	Cows	Calves	Bulls	Total
29-Apr	2002	BWC01	-	-	25	25
29-Apr	2002	BWC02	-	-	8	8
1-May	2002	BWC03	-	-	3	3
1-May	2002	BWC05	6	2	-	8
1-May	2002	BWC06	1	2	1	4
1-May	2002	BWC07	2	-	4	6
1-May	2002	BWC08	-	-	4	4
1-May	2002	BWC09	-	-	3	3
1-May	2002	BWC10	4	-	3	7
1-May	2002	BWC11	-	-	1	1
		Total	13	4	52	69
27-Mar	2003	BWC01	2	1	-	3
27-Mar	2003	BWC02	-	-	6	6
27-Mar	2003	BWC03	-	-	3	3
27-Mar	2003	BWC16	5	-	-	5
28-Mar	2003	BWC04	-	-	13	13
28-Mar	2003	BWC05	4	6	6	16
28-Mar	2003	BWC06	2	1	-	3
28-Mar	2003	BWC07	-	-	4	4
30-Mar	2003	BWC08	1	-	13	14
30-Mar	2003	BWC09	-	-	3	3
31-Mar	2003	BWC10	1	1	2	4
31-Mar	2003	BWC11	-	-	23	23
31-Mar	2003	BWC12	14	1	1	16
2-Apr	2003	BWC13	2	1	-	3
2-Apr	2003	BWC14	4	1	-	5
2-Apr	2003	BWC15	10	4	-	14
		Total	45	16	74	135

Table 3. Performance of the Telonics Gen III GPS collars.

Caribou	Month	Number of Locations		Percent of Possible Locations Obtained
		Obtained	Possible	
35983	May-02	56	93	60.2
	Jun-02	33	90	36.7
	Jul-02	33	93	35.5
	Aug-02	34	93	36.6
	Sep-02	47	90	52.2
	Oct-02	42	93	45.2
	Nov-02	31	90	34.4
	Dec-02	28	93	30.1
	Jan-03	7	93	7.5
	Feb-03	13	84	15.5
	Mar-03	13	93	14.0
	Total	337	1005	33.5
36182	May-02	65	93	69.9
	Jun-02	43	90	47.8
	Jul-02	42	93	45.2
	Aug-02	49	93	52.7
	Sep-02	40	90	44.4
	Oct-02	32	93	34.4
	Nov-02	46	90	51.1
	Dec-02	43	93	46.2
	Jan-03	42	93	45.2
	Feb-03	47	84	56.0
	Mar-03	54	93	58.1
	Total	503	1005	50.0

Table 4. **Mean, median, minimum, and maximum distances between locations obtained between 01:00 h (day 1) and 09:00 h (day 1) by month. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.**

		Distance Between Locations (km)				P Value (2-tailed) for Mann-Whitney U Test by Month											
Month	**N**	**Mean**	**Median**	**Min**	**Max**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Jan	7	1.34	**0.32**	0.05	4.17												
Feb	13	0.73	**0.27**	0.04	4.40	0.552											
Mar	13	0.40	**0.26**	0.08	1.30	0.782	0.817										
Apr																	
May	33	0.55	**0.28**	0.01	2.70	0.488	0.971	0.836									
June	24	1.36	**0.99**	0.07	3.87	0.508	**0.024**	**0.003**		**0.001**							
July	19	1.34	**1.26**	0.07	3.76	0.544	**0.013**	**0.002**		**0.001**	0.864						
Aug	26	2.75	**1.91**	0.24	11.71	0.103	**0.000**	**0.000**		**0.000**	**0.009**	**0.014**					
Sept	22	1.10	**1.06**	0.05	2.58	0.646	**0.014**	**0.002**		**0.001**	0.775	0.497	**0.001**				
Oct	21	1.86	**1.29**	0.15	6.41	0.212	**0.003**	**0.000**		**0.000**	0.339	0.573	0.057	0.198			
Nov	28	1.15	**0.80**	0.01	8.12	0.902	0.127	0.101		**0.032**	0.349	0.209	**0.000**	0.328	0.034		
Dec	20	0.91	**0.65**	0.03	5.11	0.699	0.097	**0.028**		**0.025**	0.164	0.054	**0.000**	0.113	0.014	0.867	

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 5. Mean, median, minimum, and maximum distances between locations obtained between 09:00 h (day 1) and 17:00 h (day 1) by month. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.

		Distance Between Locations (km)				P Value (2-tailed) for Mann-Whitney U Test by Month											
Month	**N**	**Mean**	**Median**	**Min**	**Max**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Jan	11	2.19	**2.41**	0.24	5.07												
Feb	12	1.34	**0.79**	0.53	4.03	0.580											
Mar	8	0.54	**0.37**	0.06	1.31	**0.039**	**0.037**										
Apr																	
May	32	0.60	**0.15**	0.01	2.98	**0.002**	**0.004**	0.417									
June	11	0.50	**0.26**	0.04	1.16	**0.011**	**0.010**	0.869		0.478							
July	16	0.70	**0.62**	0.01	2.18	**0.026**	0.063	0.759		0.314	0.554						
Aug	13	1.82	**1.13**	0.14	9.26	0.524	0.957	0.051		**0.004**	**0.012**	0.072					
Sept	13	2.51	**1.48**	0.28	9.29	0.862	0.192	**0.007**		**0.000**	**0.003**	**0.007**	0.305				
Oct	7	3.44	**2.05**	0.36	9.43	0.441	0.128	**0.015**		**0.003**	**0.002**	**0.009**	0.166	0.500			
Nov	9	1.92	**1.10**	0.51	4.87	0.879	0.434	**0.021**		**0.003**	**0.011**	**0.024**	0.616	0.920	0.315		
Dec	11	1.87	**1.62**	0.45	5.12	0.895	0.389	**0.013**		**0.001**	**0.002**	**0.008**	0.339	0.794	0.441	0.909	

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 6. **Mean, median, minimum, and maximum distances between locations obtained between 17:00 h (day 1) and 01:00 h (day 2) by month. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.**

		Distance Between Locations (km)				P Value (2-tailed) for Mann-Whitney U Test by Month											
Month	**N**	**mean**	**median**	**min**	**max**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Jan	3	0.08	**0.11**	0.00	0.13												
Feb	8	1.46	**0.83**	0.16	5.31	-											
Mar	16	0.51	**0.31**	0.04	2.05	-	0.076										
Apr																	
May	31	0.81	**0.22**	0.00	5.97	-	0.088	0.637									
June	12	0.88	**0.52**	0.01	3.25	-	0.355	0.516		0.279							
July	9	1.41	**0.82**	0.27	4.20	-	0.847	**0.022**		**0.043**	0.256						
Aug	12	1.43	**1.41**	0.38	2.49	-	0.280	**0.001**		**0.005**	**0.040**	0.320					
Sept	17	1.85	**1.47**	0.20	7.44	-	0.382	**0.001**		**0.002**	**0.042**	0.403	0.877				
Oct	10	2.76	**1.01**	0.32	17.37	-	0.534	**0.007**		**0.034**	0.129	0.806	0.391	0.514			
Nov	8	1.30	**1.38**	0.08	2.98	-	0.600	**0.032**		0.051	0.217	0.847	0.700	0.727	0.929		
Dec	10	0.87	**0.87**	0.33	1.24	-	1.000	**0.015**		0.122	0.391	0.806	**0.025**	0.071	0.597	0.286	

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 7. Mean, median, minimum, and maximum daily travel rates measured as the total distance between 4 successive locations each obtained 8 hours apart over a 24 hour period. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.

		Distance Between Locations (km)				P Value (2-tailed) for Mann-Whitney U Test by Month											
Month	**N**	**Mean**	**Median**	**Min**	**Max**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Jan	2	4.78	**4.78**	2.57	6.98												
Feb	13	3.16	**2.10**	0.96	11.07	-											
Mar	19	1.40	**1.04**	0.46	4.66	-	**0.003**										
Apr																	
May	65	1.81	**0.50**	0.05	9.33	-	**0.005**	0.173									
June	25	2.48	**2.49**	0.25	5.63	-	0.569	**0.034**		**0.006**							
July	18	3.31	**3.02**	0.50	8.26	-	0.496	**0.000**		**0.001**	0.209						
Aug	14	5.43	**4.99**	1.69	13.96	-	**0.010**	**0.000**		**0.000**	**0.001**	**0.025**					
Sept	15	4.51	**3.09**	1.59	18.47	-	0.102	**0.000**		**0.000**	**0.049**	0.347	0.150				
Oct	7	6.80	**4.88**	1.67	16.97	-	0.063	**0.001**		**0.001**	**0.019**	0.069	1.000	0.341			
Nov	18	4.29	**4.35**	0.79	8.65	-	0.118	**0.000**		**0.000**	**0.007**	0.155	0.323	0.613	0.397		
Dec	17	3.25	**2.36**	1.43	7.51	-	0.464	**0.000**		**0.000**	0.224	0.895	**0.014**	0.234	0.120	0.187	

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 8. **Mean, median, minimum, and maximum daily travel rates measured as the distance between 2 locations obtained 24 hour apart. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.**

		Distance Between Locations (km)				P Value (2-tailed) for Mann-Whitney U Test by Month											
Month	**N**	**Mean**	**Median**	**Min**	**Max**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Jan	23	3.40	**2.28**	0.44	16.94												
Feb	27	2.66	**1.14**	0.27	12.26	0.527											
Mar	43	1.17	**0.98**	0.20	4.42	**0.003**	**0.049**										
Apr																	
May	85	1.50	**0.36**	0.01	14.61	**0.000**	**0.000**	**0.006**									
June	31	1.49	**1.23**	0.06	5.56	**0.044**	0.227	0.264		**0.006**							
July	32	1.73	**1.40**	0.05	5.14	0.246	0.755	**0.024**		**0.001**	0.339						
Aug	29	4.37	**2.79**	0.36	31.22	0.220	0.052	**0.000**		**0.000**	**0.000**	**0.003**					
Sept	33	3.15	**2.05**	0.14	16.21	0.671	0.204	**0.000**		**0.000**	**0.005**	**0.016**	0.397				
Oct	19	7.72	**4.48**	1.27	22.65	**0.002**	**0.000**	**0.000**		**0.000**	**0.000**	**0.000**	**0.019**	**0.002**			
Nov	31	4.29	**4.04**	0.36	16.56	0.109	**0.016**	**0.000**		**0.000**	**0.000**	**0.000**	0.420	0.134	0.103		
Dec	25	1.98	**1.39**	0.35	6.71	0.307	0.805	0.058		**0.001**	0.327	0.834	**0.017**	0.061	**0.000**	**0.002**	

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 9. Comparison of daily rates of travel measured a) as the distance between 2 locations obtained 24 hours apart and b) as the total distance between 4 successive locations each obtained 8 hours apart over a 24 hour period. P values (2-tailed) for Mann-Whitney U tests for comparisons of distances observed between months are provided.

Month	n	a) 24 Hour				b) 24 Hour (3-8 Hour Periods)				P-Value (2-tailed)[A]
		Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	
January	2	4.24	**4.24**	2.32	6.16	4.78	**4.78**	2.57	6.98	0.439
February	13	2.15	**1.05**	0.50	6.80	3.16	**2.10**	0.96	11.07	0.096
March	19	0.90	**0.71**	0.20	3.86	1.40	**1.04**	0.46	4.66	**0.025**
April	-	-	**-**	-	-	-	**-**	-	-	-
May	65	1.19	**0.27**	0.02	8.84	1.81	**0.50**	0.05	9.33	**0.012**
June	25	1.34	**1.11**	0.20	3.61	2.48	**2.49**	0.25	5.63	**0.011**
July	18	1.55	**1.30**	0.05	4.46	3.31	**3.02**	0.50	8.26	**0.001**
August	14	3.49	**2.74**	0.74	12.48	5.43	**4.99**	1.69	13.96	**0.019**
September	15	3.24	**1.66**	0.14	16.21	4.51	**3.09**	1.59	18.47	**0.049**
October	7	5.95	**3.72**	1.27	16.87	6.80	**4.88**	1.67	16.97	0.338
November	18	3.03	**1.75**	0.36	7.66	4.29	**4.35**	0.79	8.65	0.110
December	17	1.93	**1.35**	0.35	6.71	3.25	**2.36**	1.43	7.51	**0.004**
Total	213	1.96	**1.17**	0.02	16.87	3.00	**2.29**	0.05	18.47	**0.000**

Median distance and P values (2-tailed) for comparisons between months that are significant at $P \leq .05$ are in bold.

Table 10. Vegetation cover at and fire history of sites used by month by caribou 35983 and 36182 during 2 May 2002 to 31 March 2003.

Vegetation Class	Month											Total
	Jan	Feb	Mar	May	June	July	Aug	Sept	Oct	Nov	Dec	
Ripparian/Mesic/Dry	2	3		13	1	3	2	2		1		27
Ripparian/Mesic/Dry (1965-74 burn)	2											2
Ripparian/Mesic/Dry (1993 burn)	4	5			3	11	6	5	1	2		37
Low Shrub	1	4	5	5	2	3	3	3		6	7	39
Low Shrub (1989 burn)		1								4		5
Low Shrub (1993 burn)	2	1			3	8	3	6	2	4	1	30
Low Shrub (age of burn unknown)			1									1
Tall Shrub		5	4	3	7	1	4	1	1	2	3	31
Tall Shrub (1965-74 burn)		1							1			2
Tall Shrub (1989 burn)											1	1
Tall Shrub (1993 burn)	1	2			8	4	8			1		24
Needle Leaf, Woodland	3	17	14	39	16	8	18	22		13	10	160
Needle Leaf, Woodland (1965-74 burn)	2	2				3				1		8
Needle Leaf, Woodland (1989 burn)		1										1
Needle Leaf, Woodland (1993 burn)	5	6			2	5	5	2	1	1	2	29
Needle Leaf, Woodland (age of burn unknown)			4									4

Table 10. Vegetation cover at sites used by month by caribou 35983 and 36182 during 2 May 2002 to 31 March 2003. (continued)

Vegetation Class	Month											Total
	Jan	Feb	Mar	May	June	July	Aug	Sept	Oct	Nov	Dec	
Needle Leaf, Mixed	1	6	21	37	23	15	22	11		7	14	157
Needle Leaf, Mixed (1965-74 burn)						1						1
Needle Leaf, Mixed (1989 burn)											1	1
Needle Leaf, Mixed (1993 burn)	1	2			1	1		1	2	1		9
Needle Leaf, Mixed (age of burn unknown)			1									1
Spruce		2	16	18	10	6	11	7		4	5	79
Spruce (1965-74 burn)						1					1	2
Spruce (1993 burn)	1											1
Spruce (age of burn unknown)			1									1
Other				2								2
Other (1965-74 burn)	1											1
Other (1993 burn)											1	1
Other (age of burn unknown)											1	1
Area not classified by DU	6			4		5	1	7	15	13	8	59
Area not classified by DU (1965-74 burn)	1							9	7			17
Area not classified by DU (1976 burn)										1		1
Area not classified by DU (1989 burn)										2		2
Area not classified by DU (1993 burn)	16	2							17	9	16	60
Area not classified by DU (age of burn unknown)								11	27	5		43

Table 11. **Fire history of sites used by month by caribou 35983 and 36182 during 2 May 2002 to March 2003.**

Month	Year of Burn 1965-74	1976	1989	1993	Unknown	Not Burned	Total	Percent of Locations in Unburned Areas
January 2003	6			30		13	49	26.5
February 2003	3		2	18		37	60	61.7
March 2003					7	60	67	89.6
May 2002						121	121	100.0
June 2002				17		59	76	77.6
July 2002	5			29		41	75	54.7
August 2002				22		61	83	73.5
September 2002	9			14	11	53	87	60.9
October 2002	8			23	27	16	74	21.6
November 2002	1	1	6	18	5	46	77	59.7
December 2002	1		2	20	1	47	71	66.2
Total	33	1	10	191	51	554	840	66.0
Percent of Total	3.9	0.1	1.2	22.7	6.1	66.0		

Figure 1. Location of Inuvik Region boreal woodland caribou study area. The distribution of anthropogenic features and areas burned by wild fires in the Inuvik and Sahtu regions is shown.

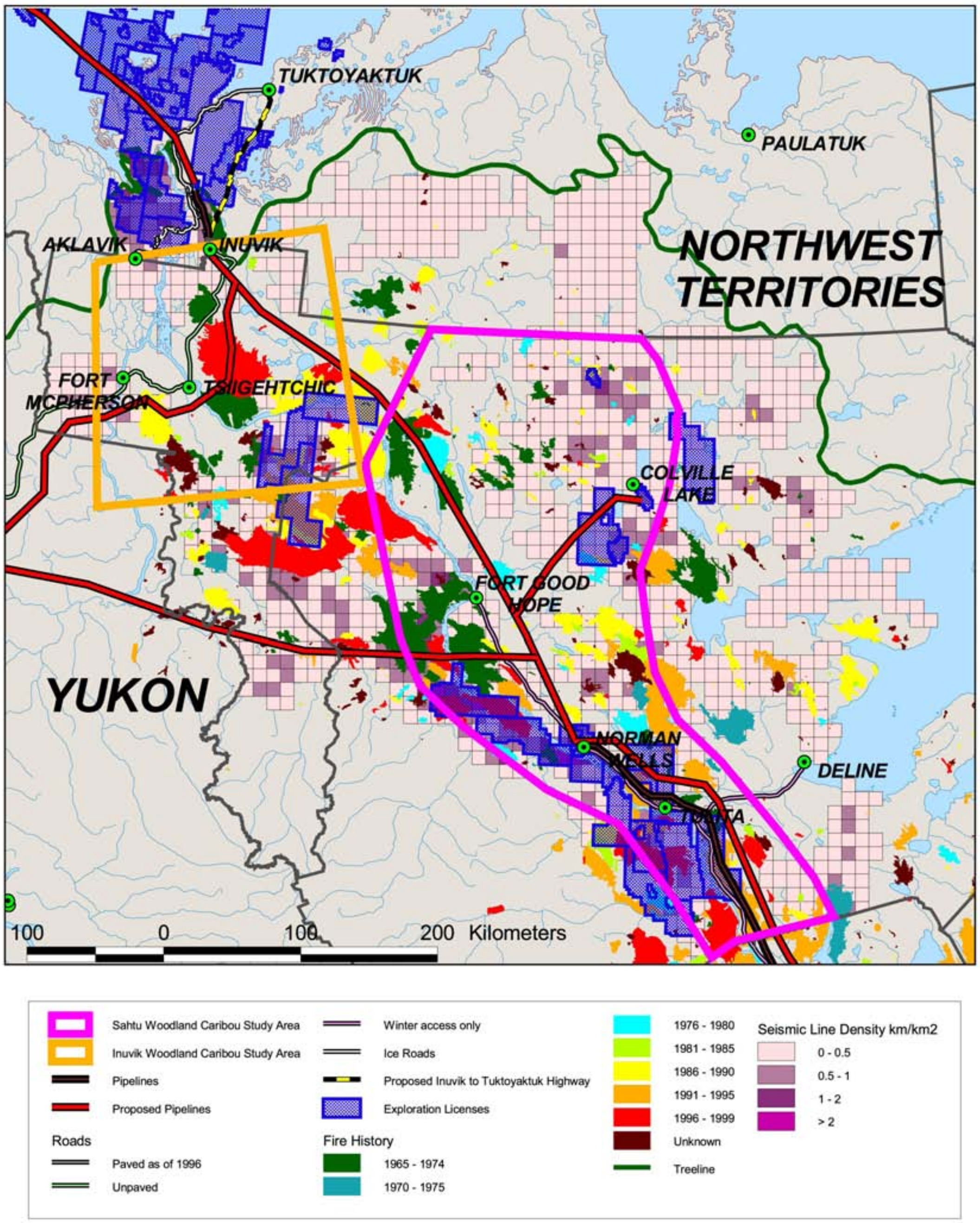


Figure 2. Date and extent of TM satellite images used to produce Forest Management vegetation cover maps available during summer 2002.

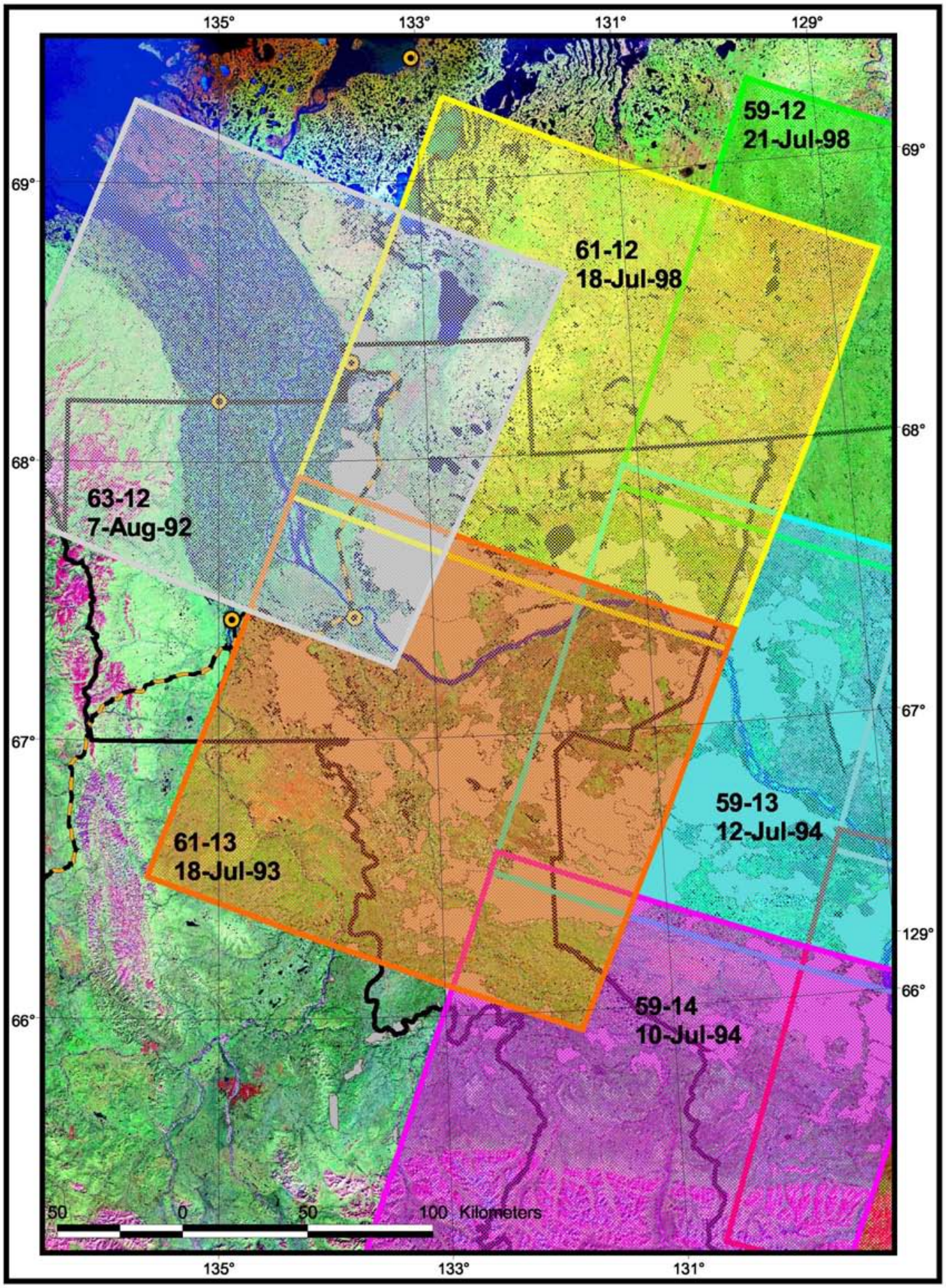


Figure 3. Extents of the Lower Mackenzie River Delta, Peel Plateau, and Middle Mackenzie Ducks Unlimited Canada vegetation classification study areas.

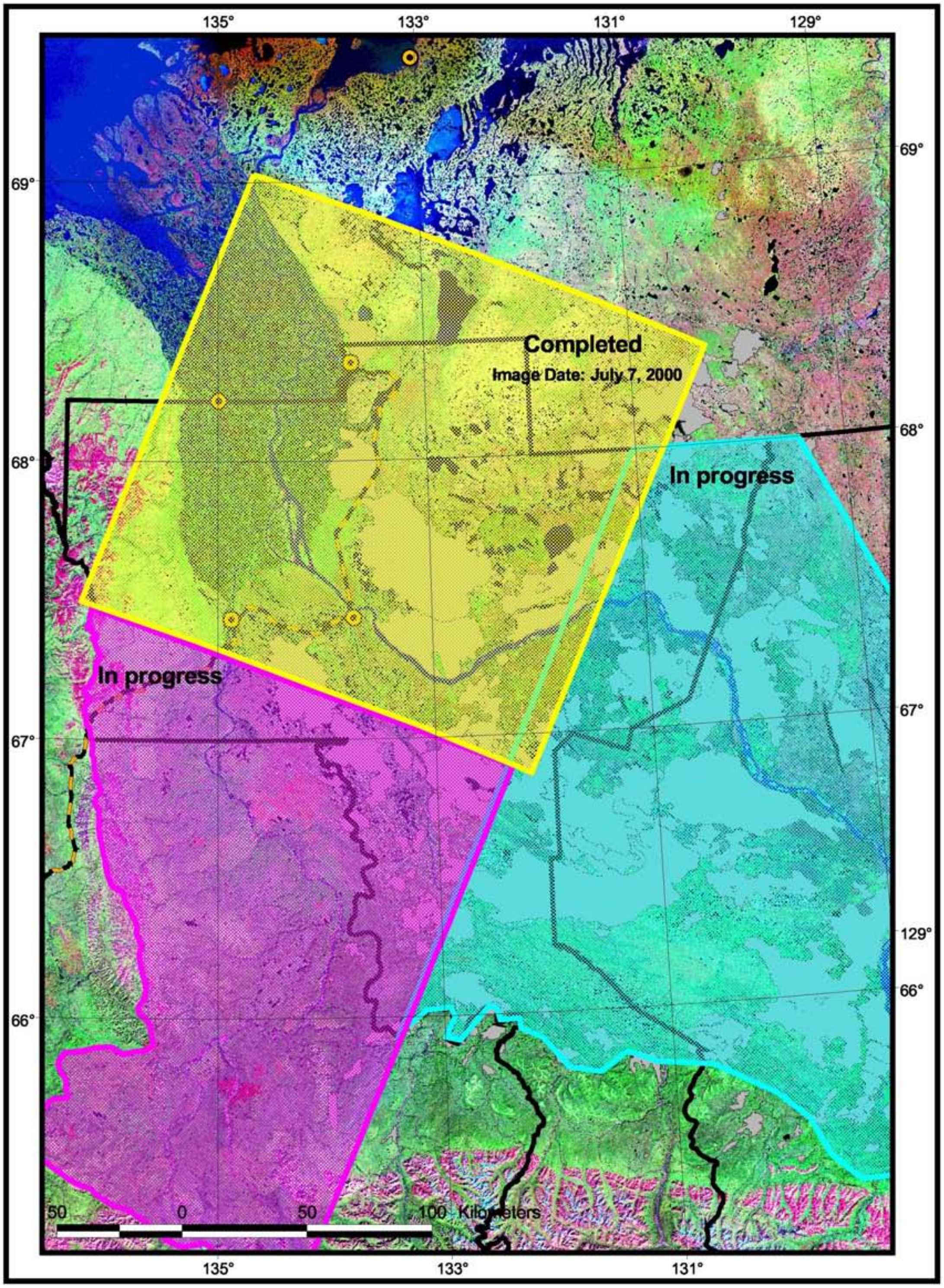


Figure 4. **Tracks flown by fixed wing aircraft and helicopter between 28 April and 2 May 2002 to located boreal woodland caribou.**

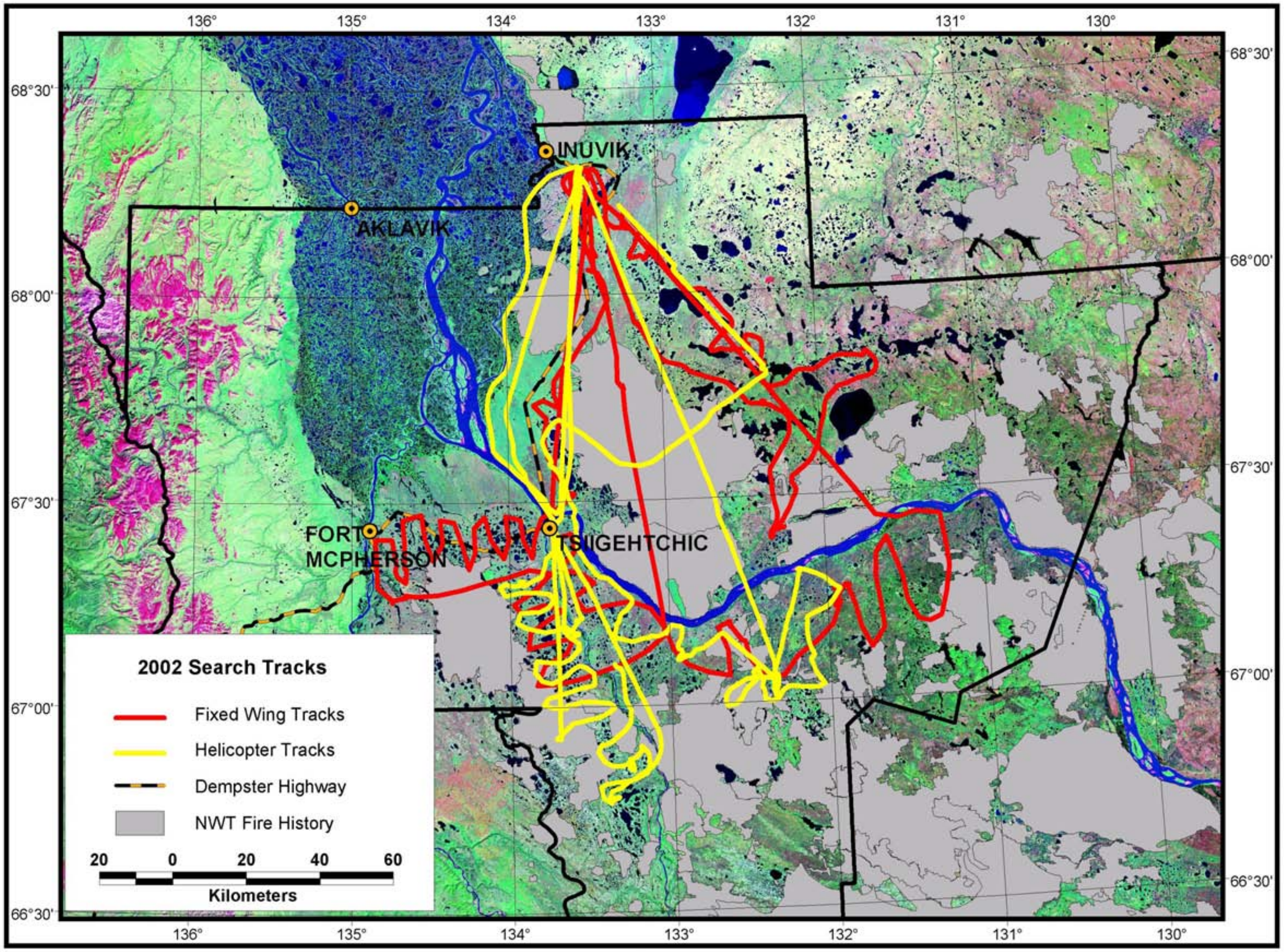


Figure 5. Distribution of groups and fresh tracks of boreal woodland caribou observed during reconnaissance and capture surveys done between 28 April and 2 May 2002.

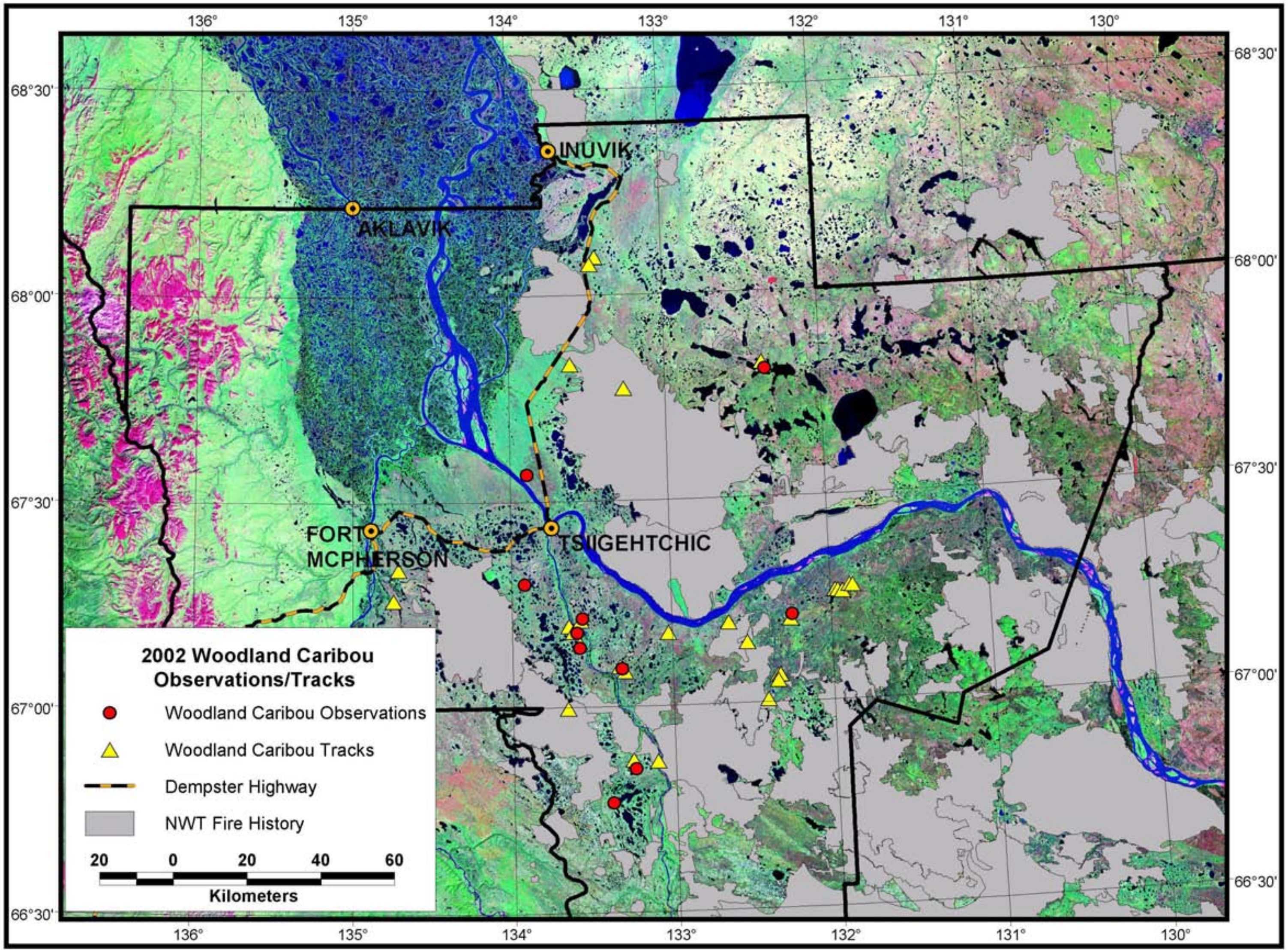


Figure 6. Distribution of sightings of moose made during reconnaissance and capture surveys done between 28 April and 2 May 2002.

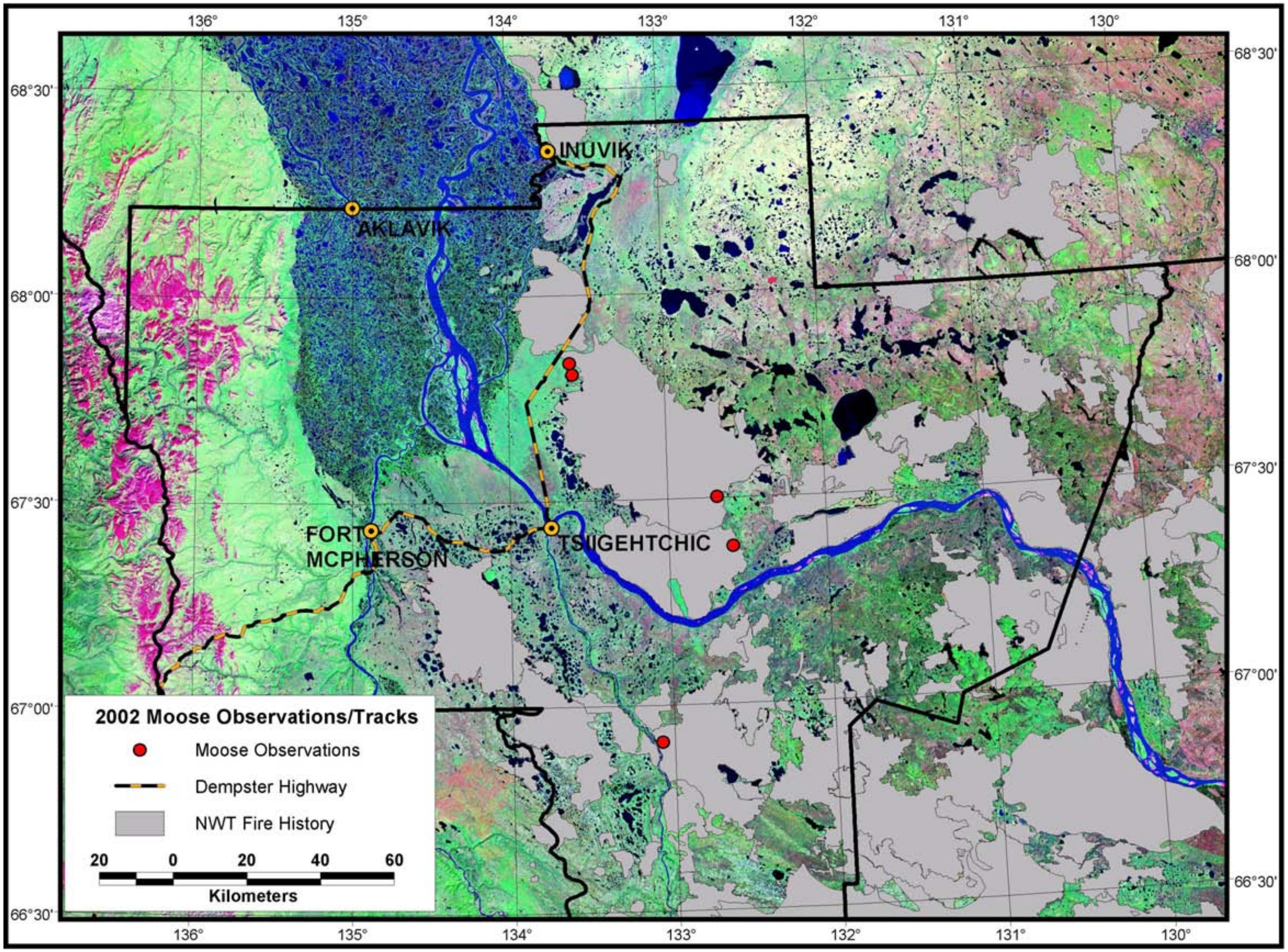


Figure 7. **Distribution of fresh wolf tracks observed during reconnaissance and capture surveys done between 28 April and 2 May 2002.**

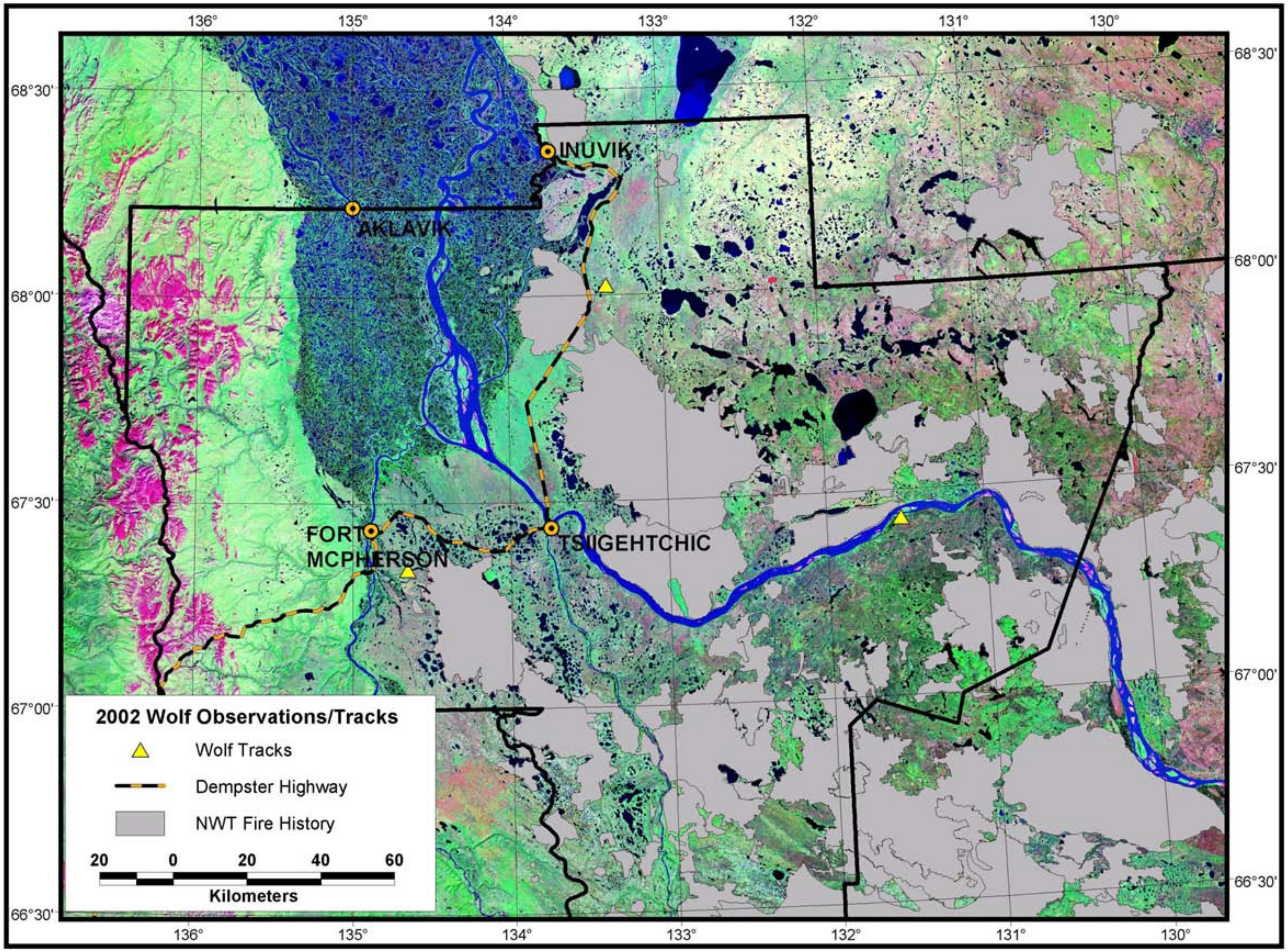


Figure 8. **Tracks flown by fixed wing aircraft and helicopter between 27 March and 2 April 2003 to located boreal woodland caribou.**

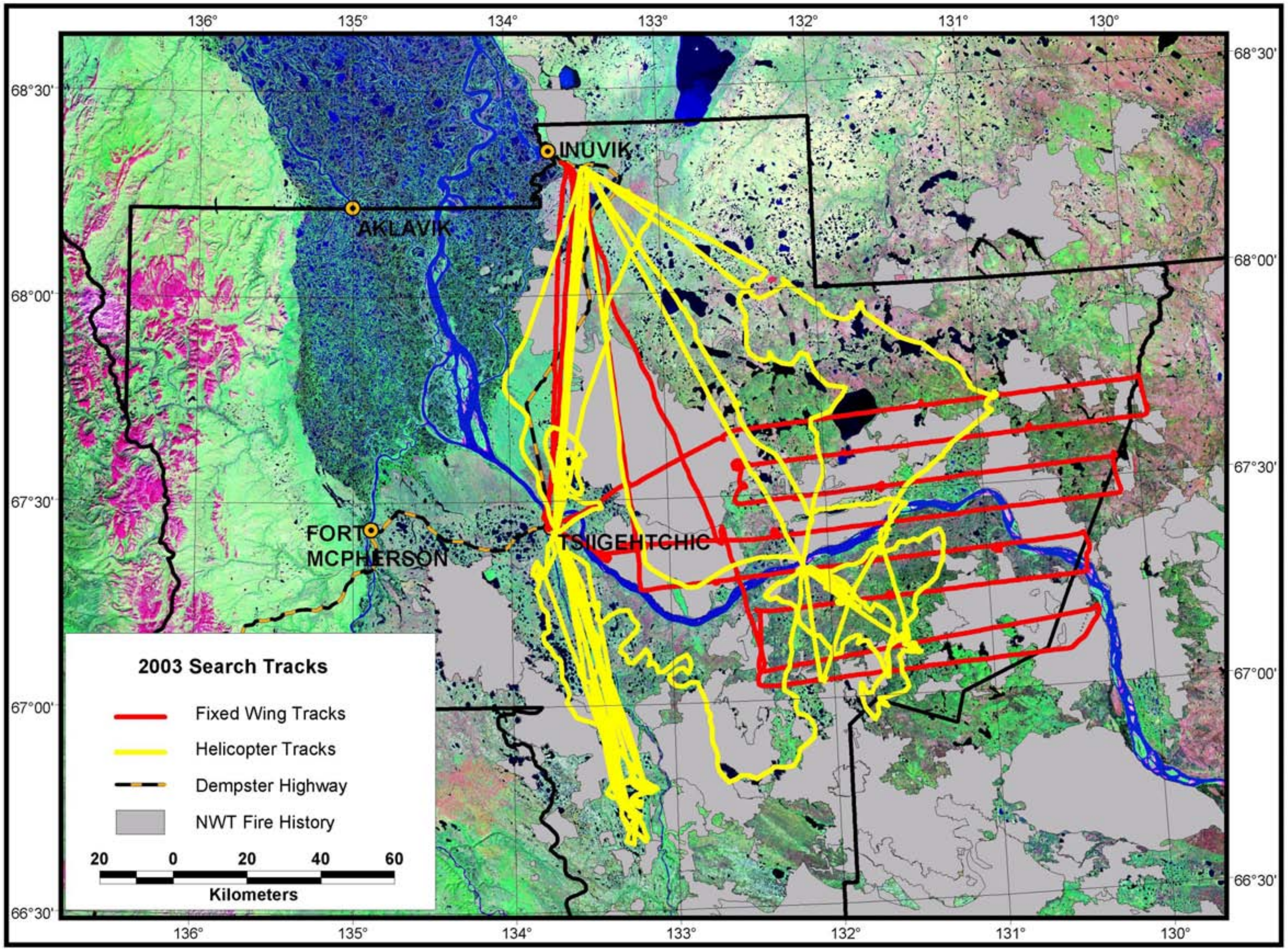


Figure 9. Distribution of groups and fresh tracks of boreal woodland caribou observed during reconnaissance and capture surveys done between 27 March and 2 April 2003.

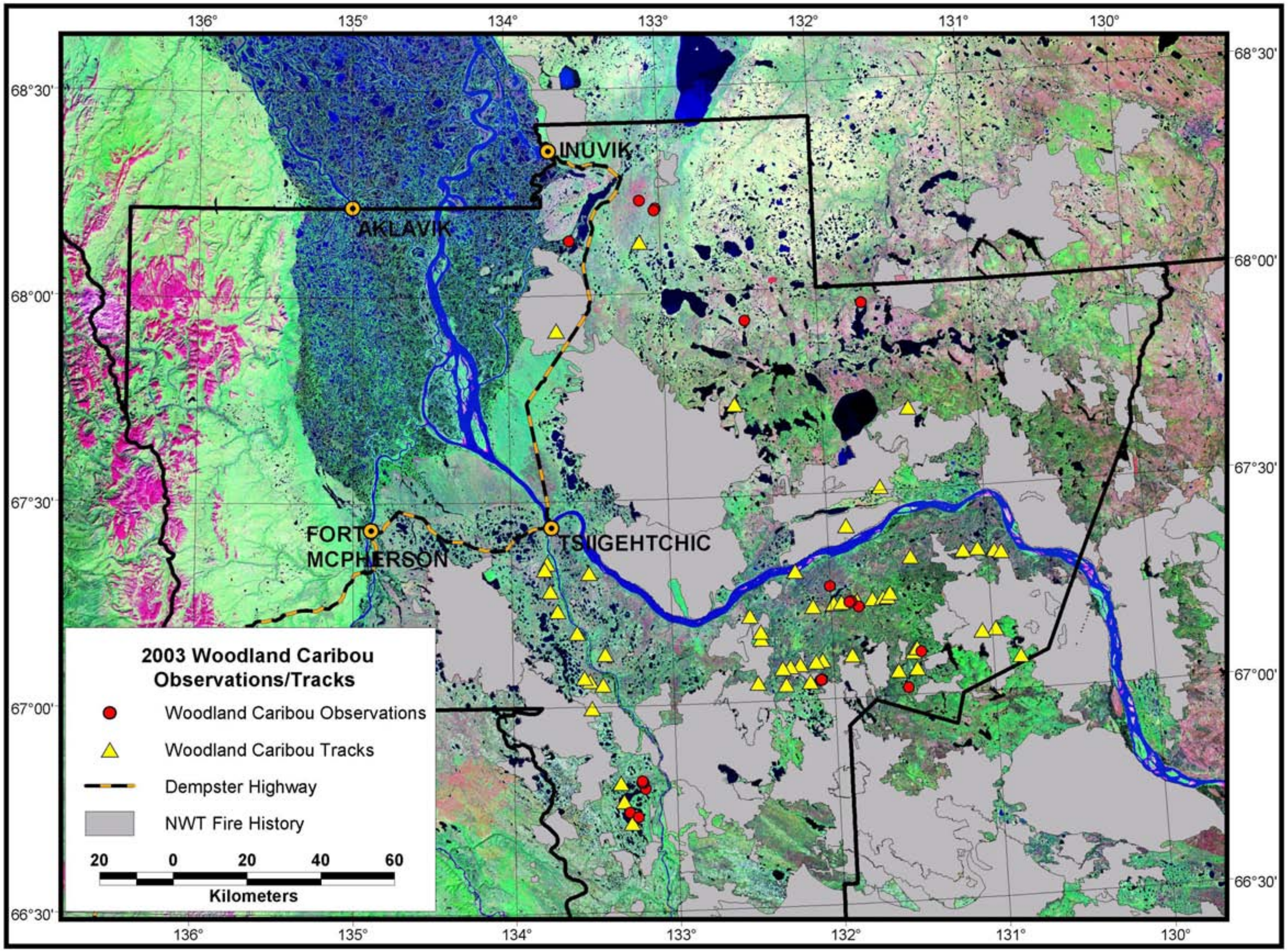


Figure 10. **Distribution of sightings and fresh tracks of moose observed during reconnaissance and capture surveys done between 27 March and 2 April 2003.**

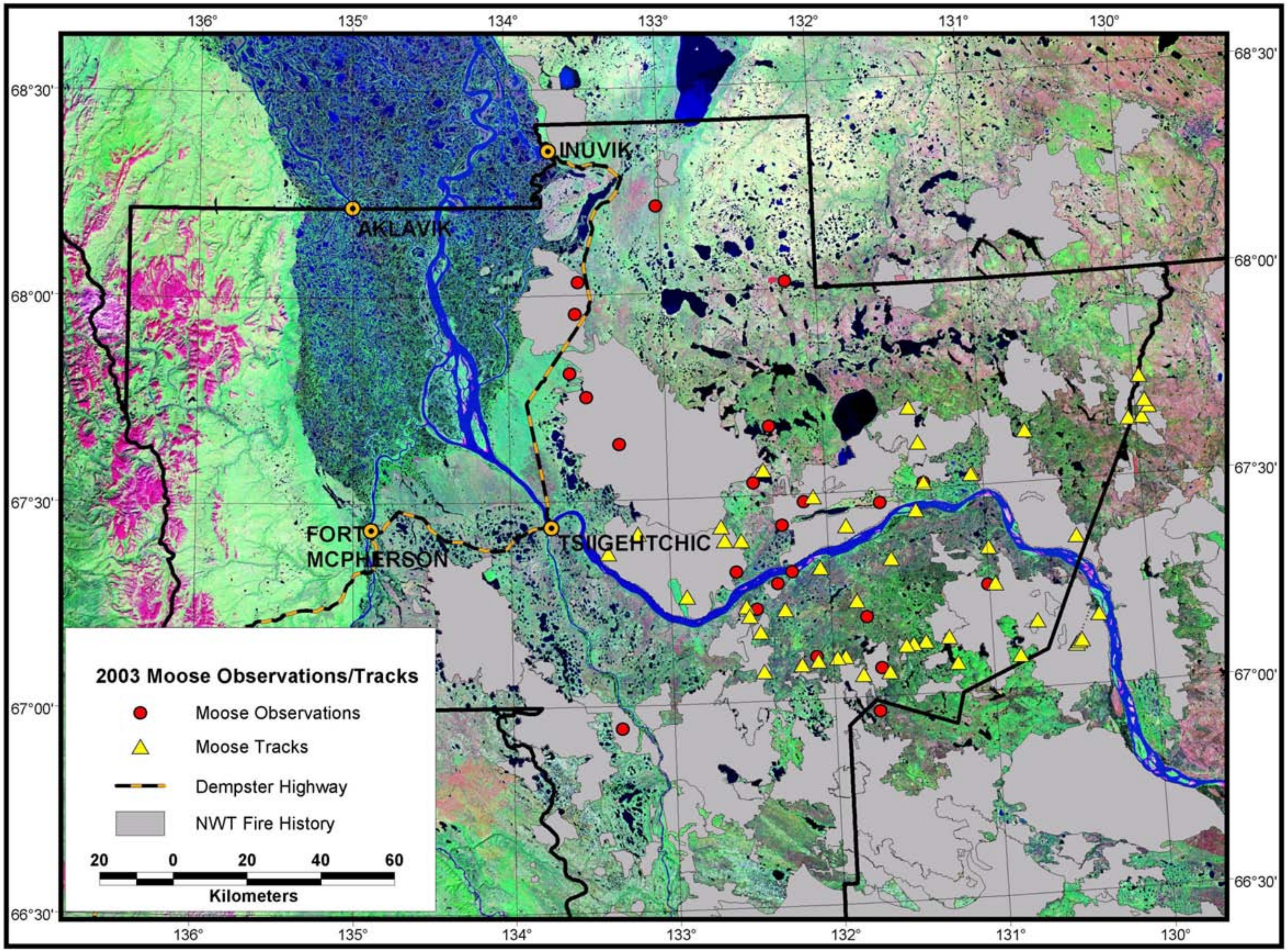


Figure 11. Distribution of sightings and fresh tracks of wolves observed during reconnaissance and capture surveys done between 27 March and 2 April 2003.

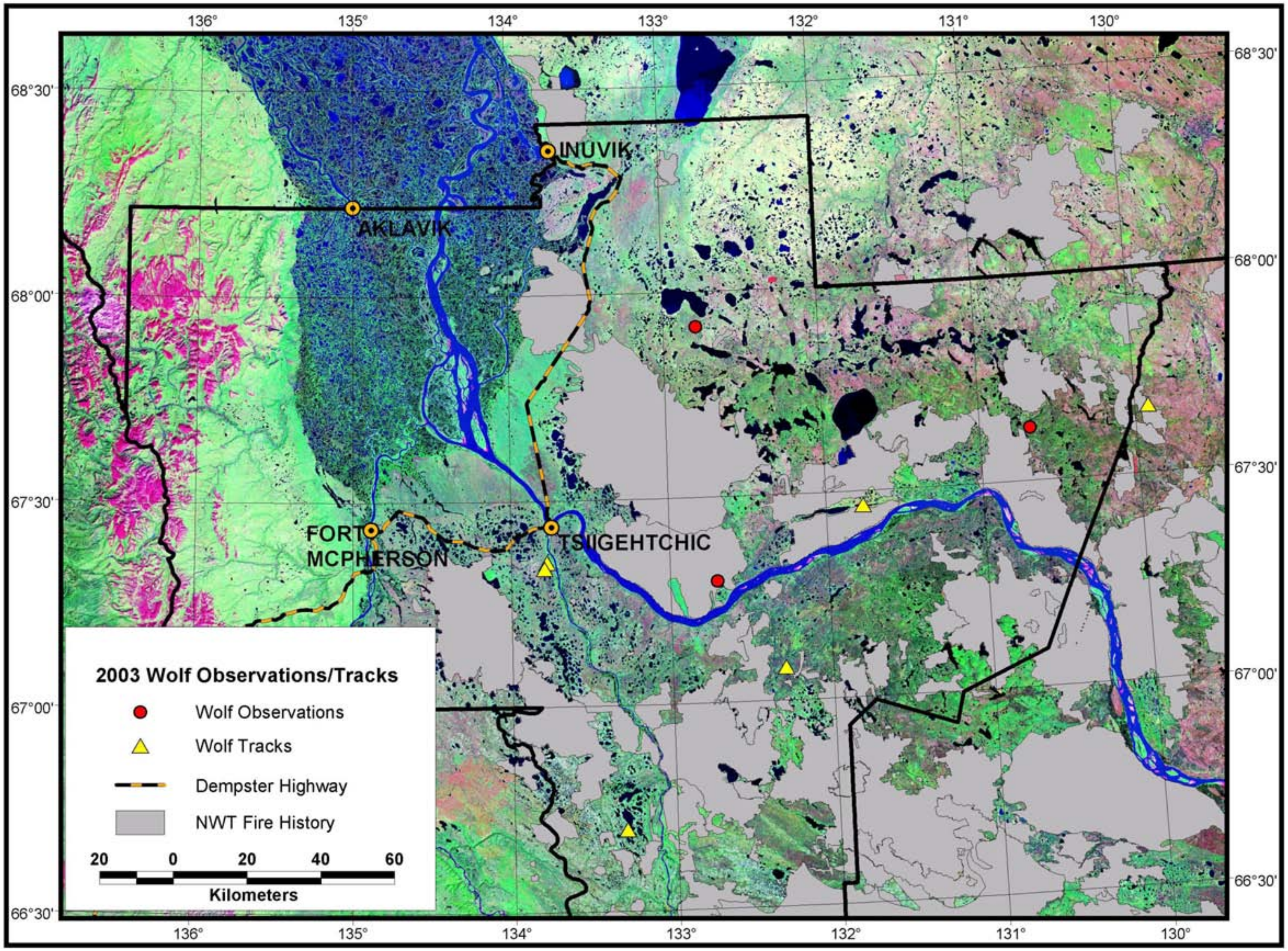


Figure 12. **Distribution of capture sites for boreal woodland caribou equipped with GPS or Argos satellite collars during late April/early May 2002 and late March/early April 2003.**

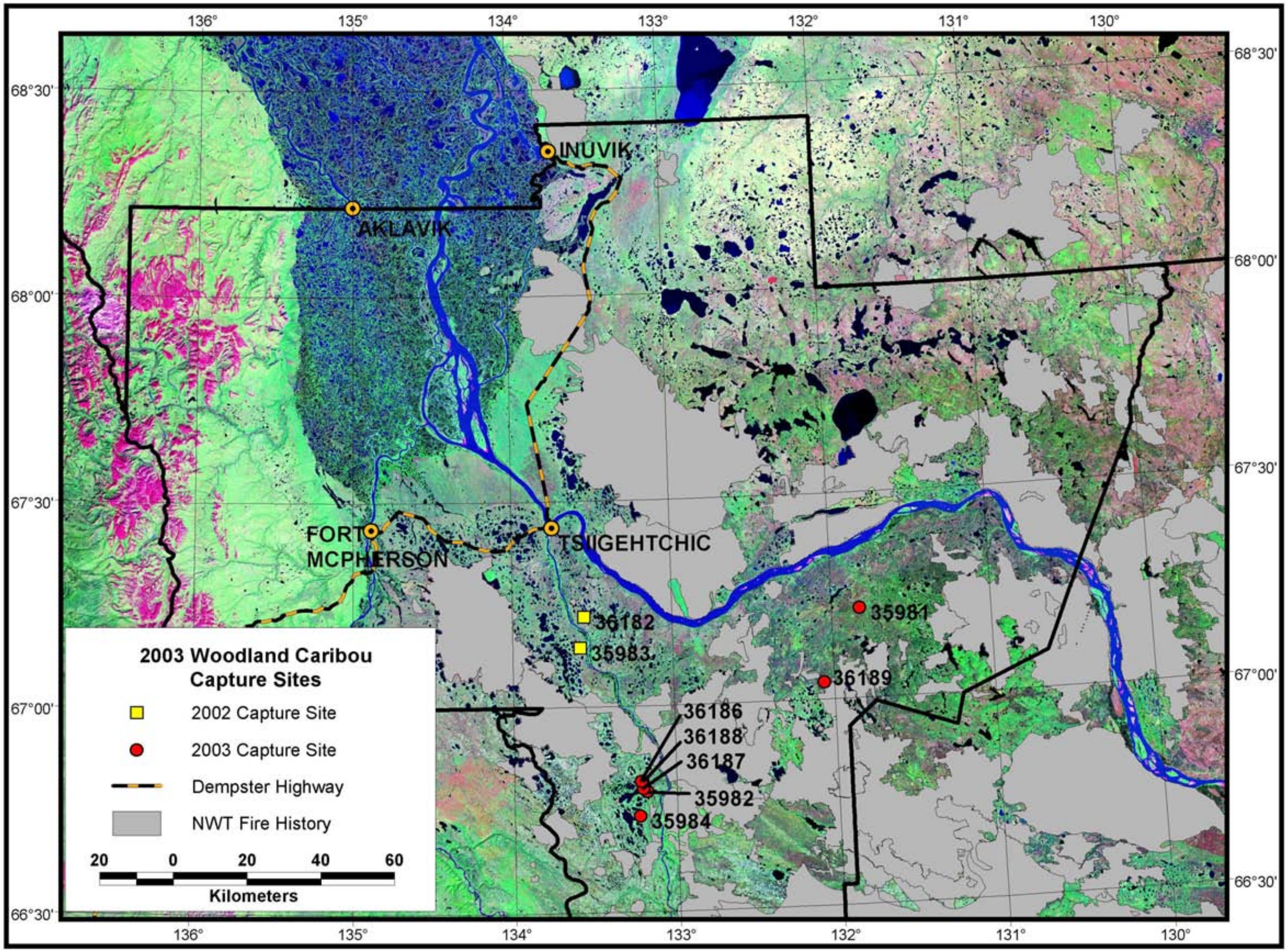


Figure 13. **Median, minimum, and maximum distances between locations obtained at 01:00 h (day 1) and 09:00 h (day 1) by month (May 2002 to March 2003).**

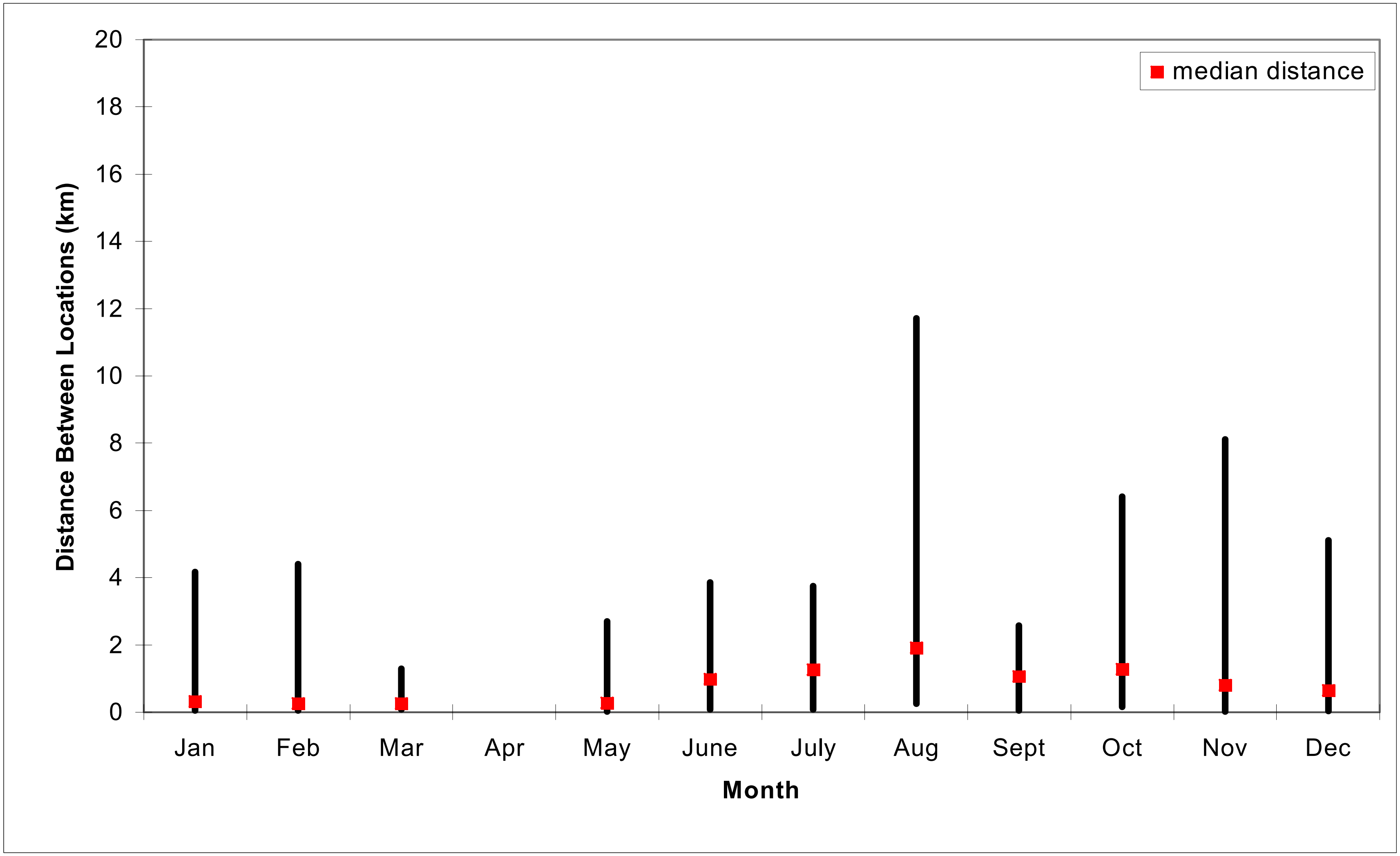


Figure 14. **Median, minimum, and maximum distances between locations obtained at 09:00 h (day 1) and 17:00 h (day 1) by month (May 2002 to March 2003).**

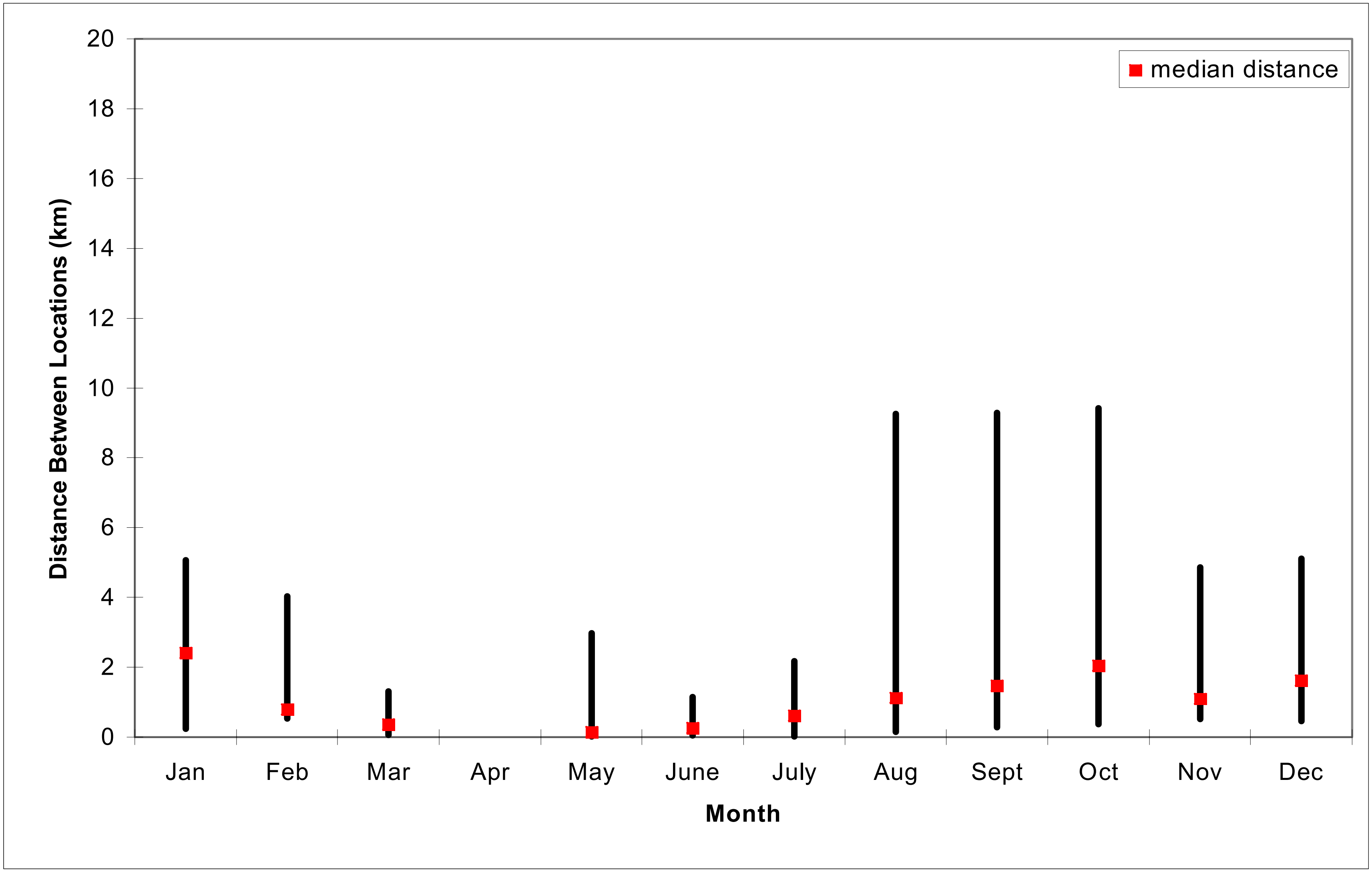


Figure 15. **Median, minimum, and maximum distances between locations obtained at 17:00 h (day 1) and 01:00 h (day 2) by month (May 2002 to March 2003).**

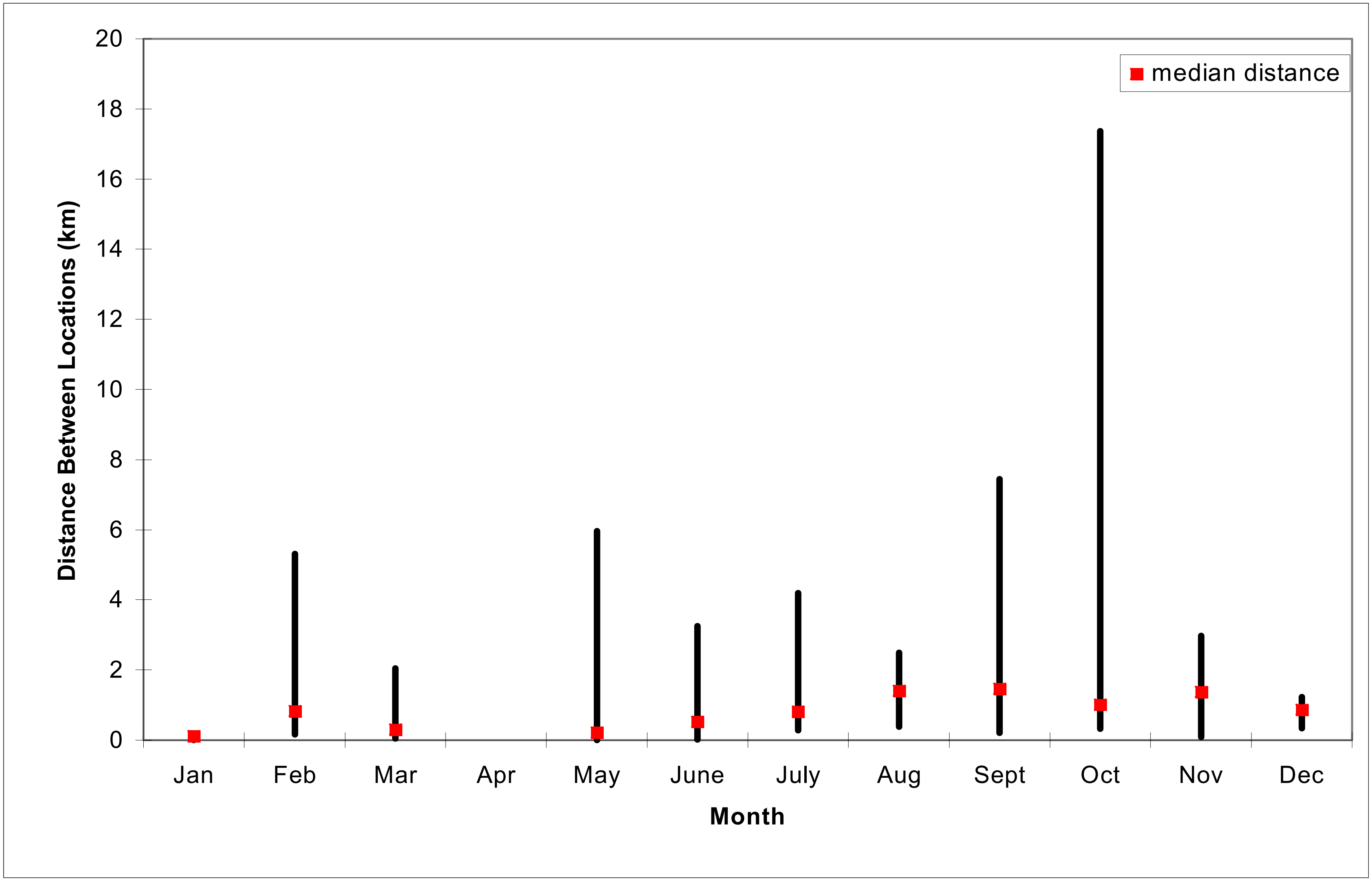


Figure 16. **Median, minimum, and maximum daily travel rates measured as the total distance between 4 successive locations each obtained 8 hours apart over a 24 hour period by month (May 2002 to March 2003).**

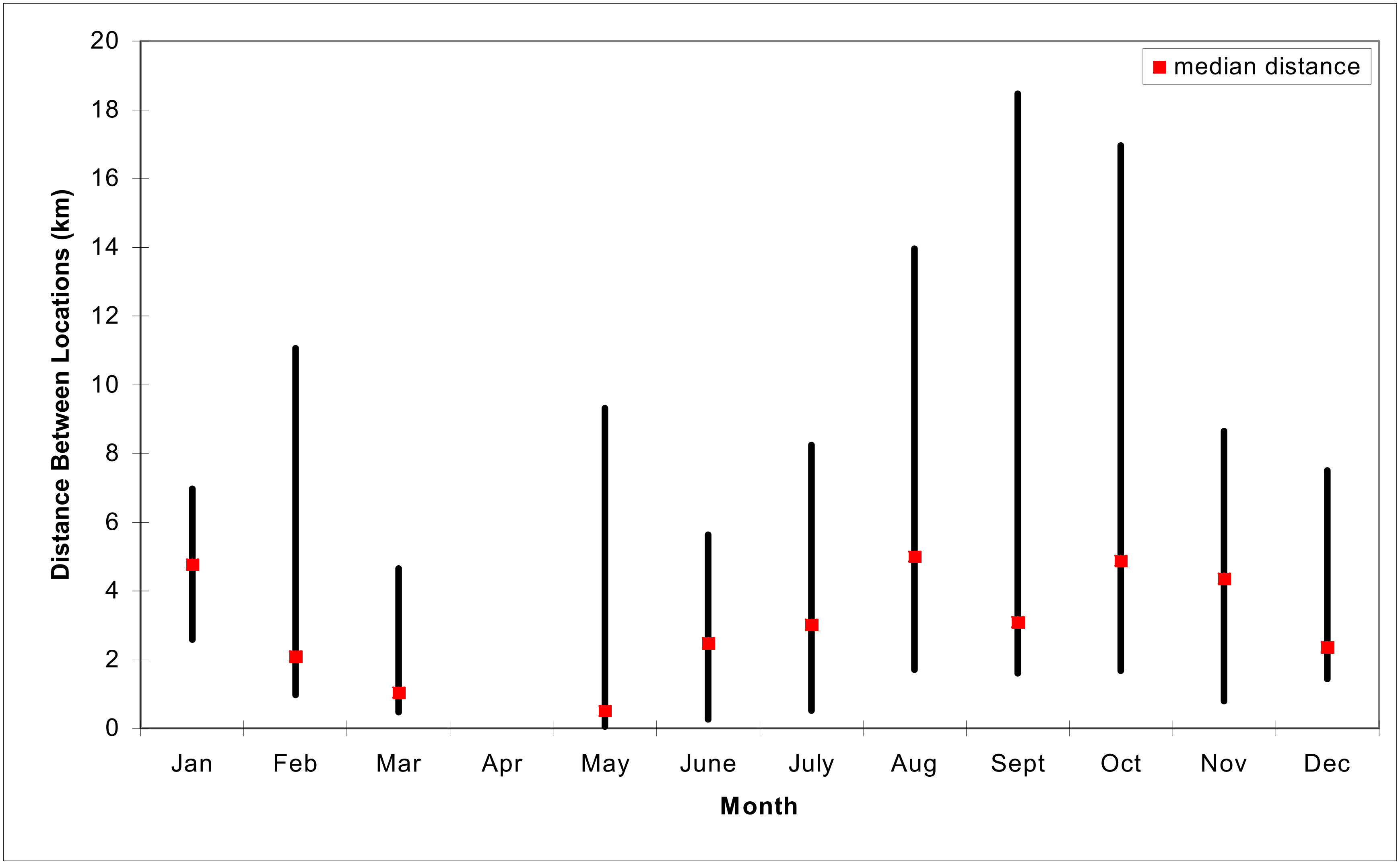


Figure 17. **Median, minimum, and maximum daily travel rates measured as the distance between 2 locations obtained 24 hour apart by month (May 2002 to March 2003).**

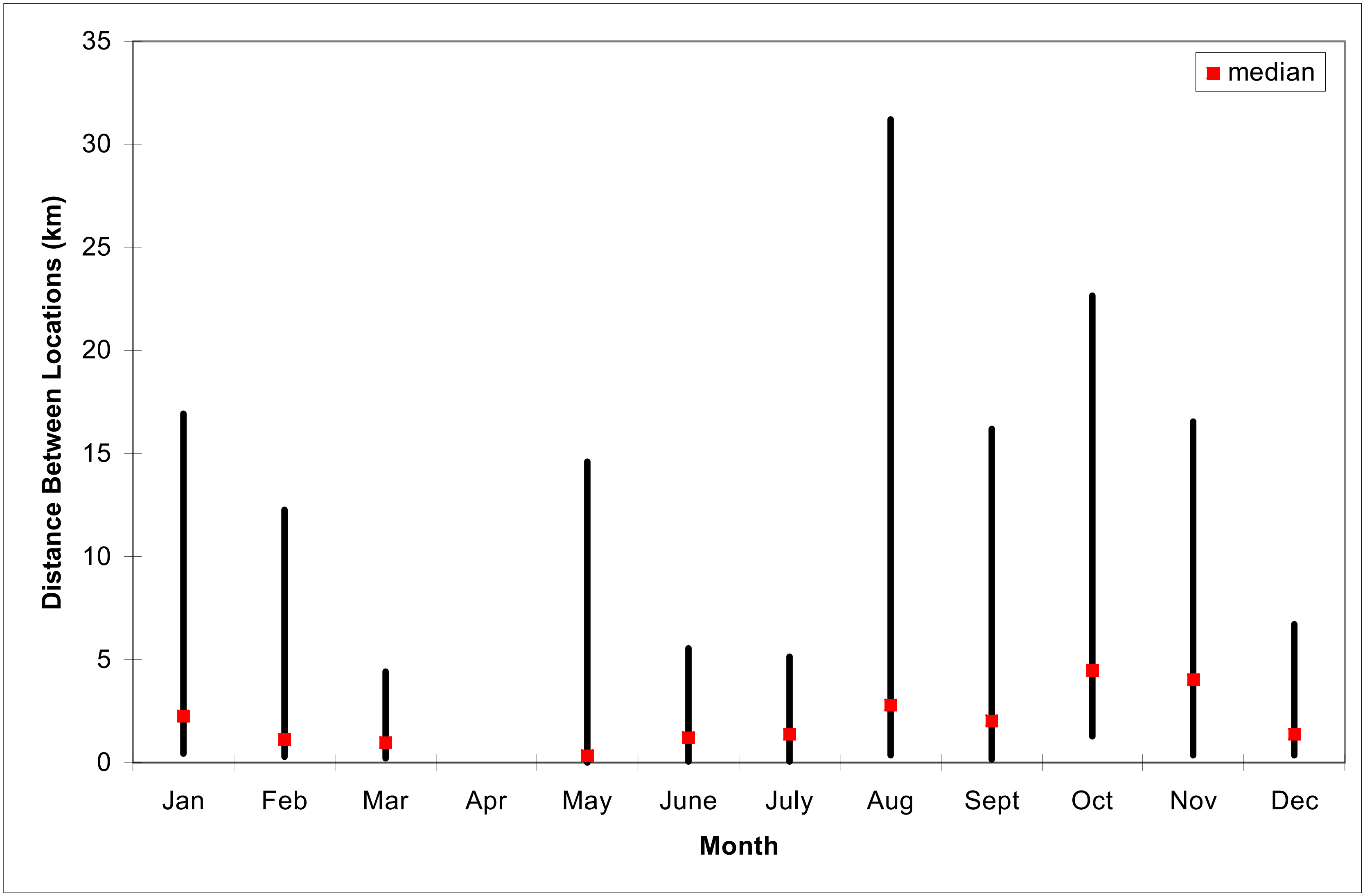


Figure 18. **Comparison of daily rates of travel measured a) as the total distances between 2 successive locations obtained at a 24 hour time period (red) and b) as the total distance between 4 successive locations obtained over a 24 hour period (black).**

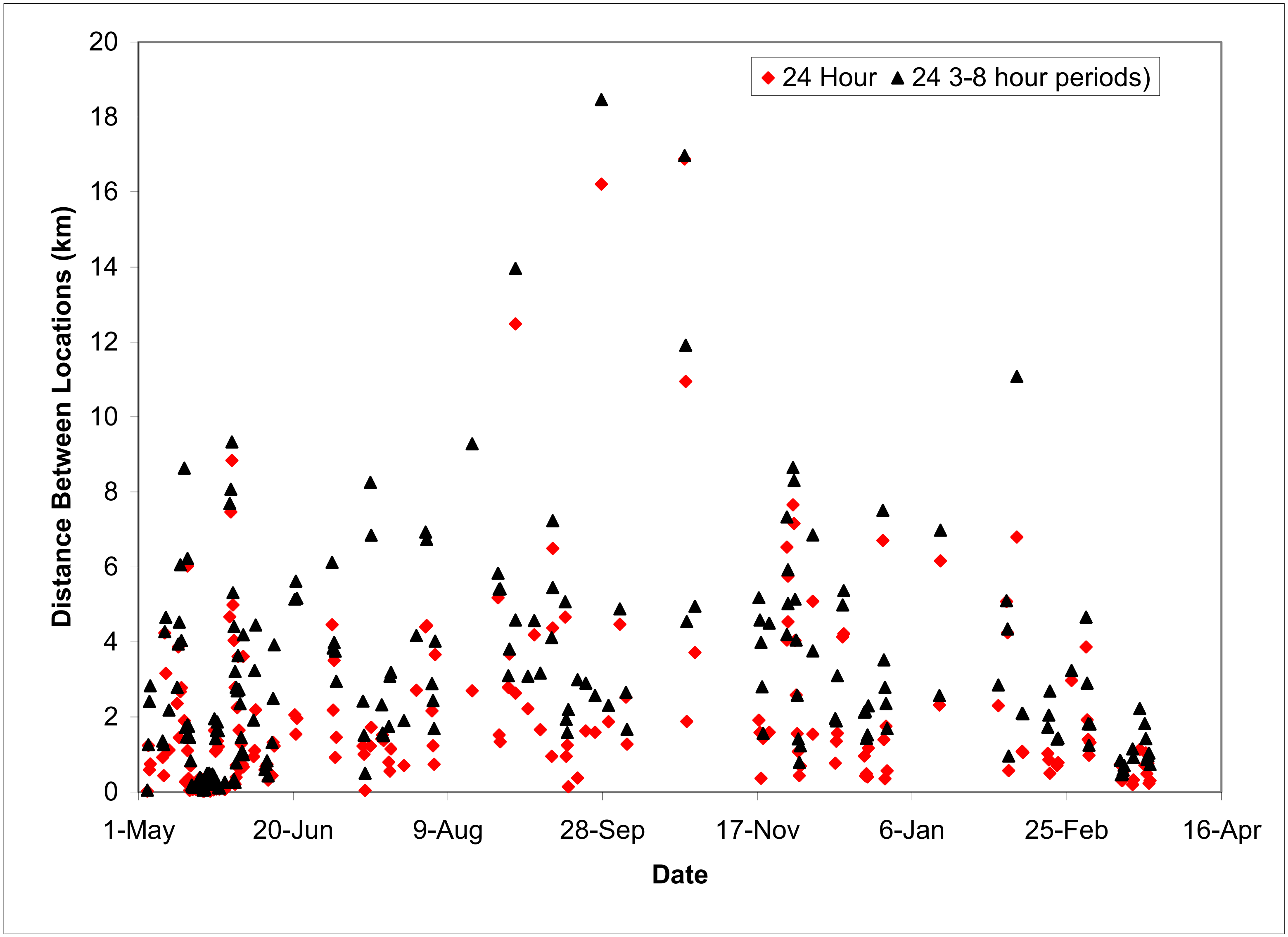


Figure 19. Movements of Caribou 35983 and 36182 during the period 2 May 2002 to 31 March 2003.

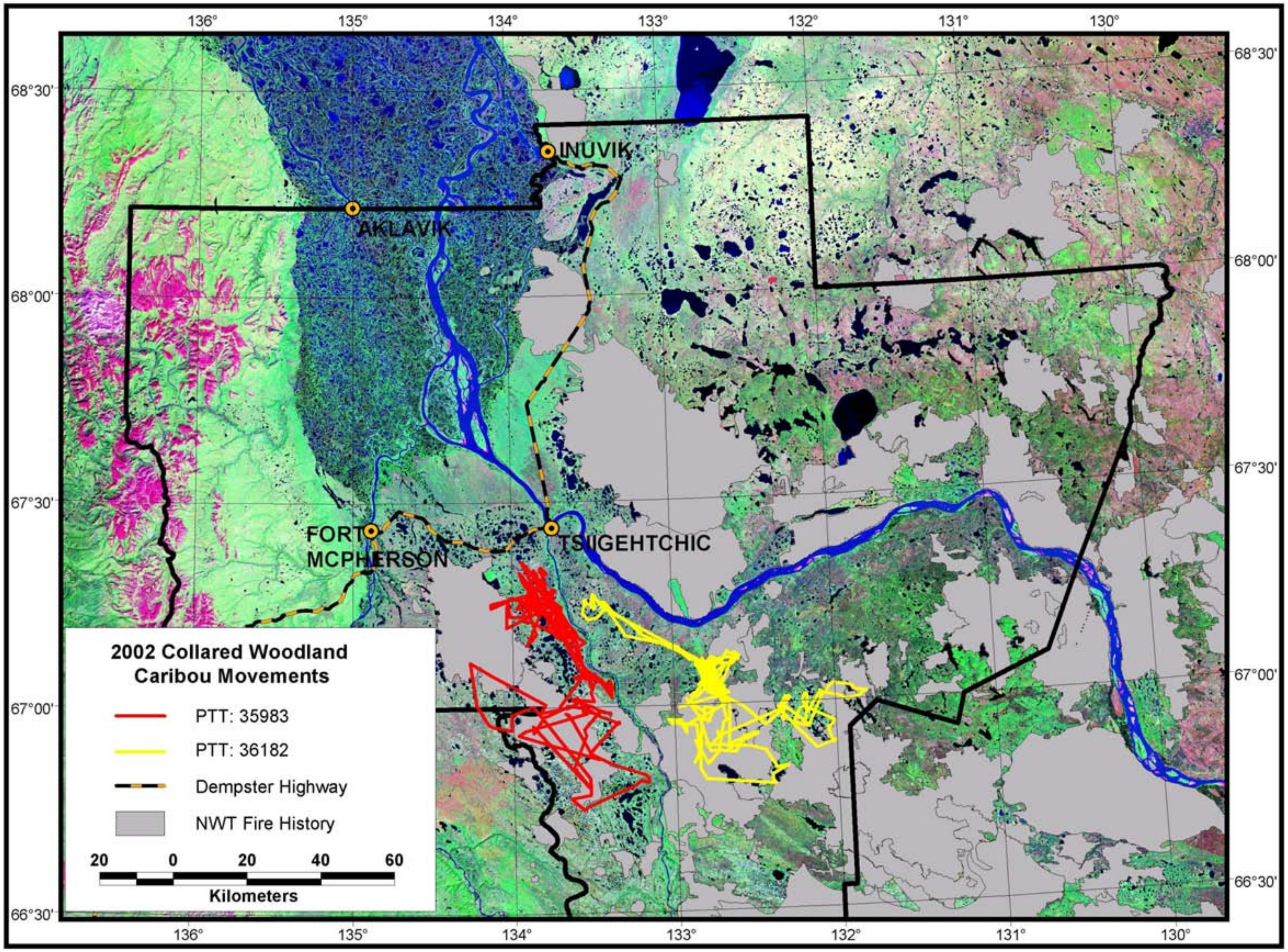


Figure 20. **Monthly distribution and movements of Caribou 35983, 2 May 2002 to 31 March 2003 (n = 337 locations).**

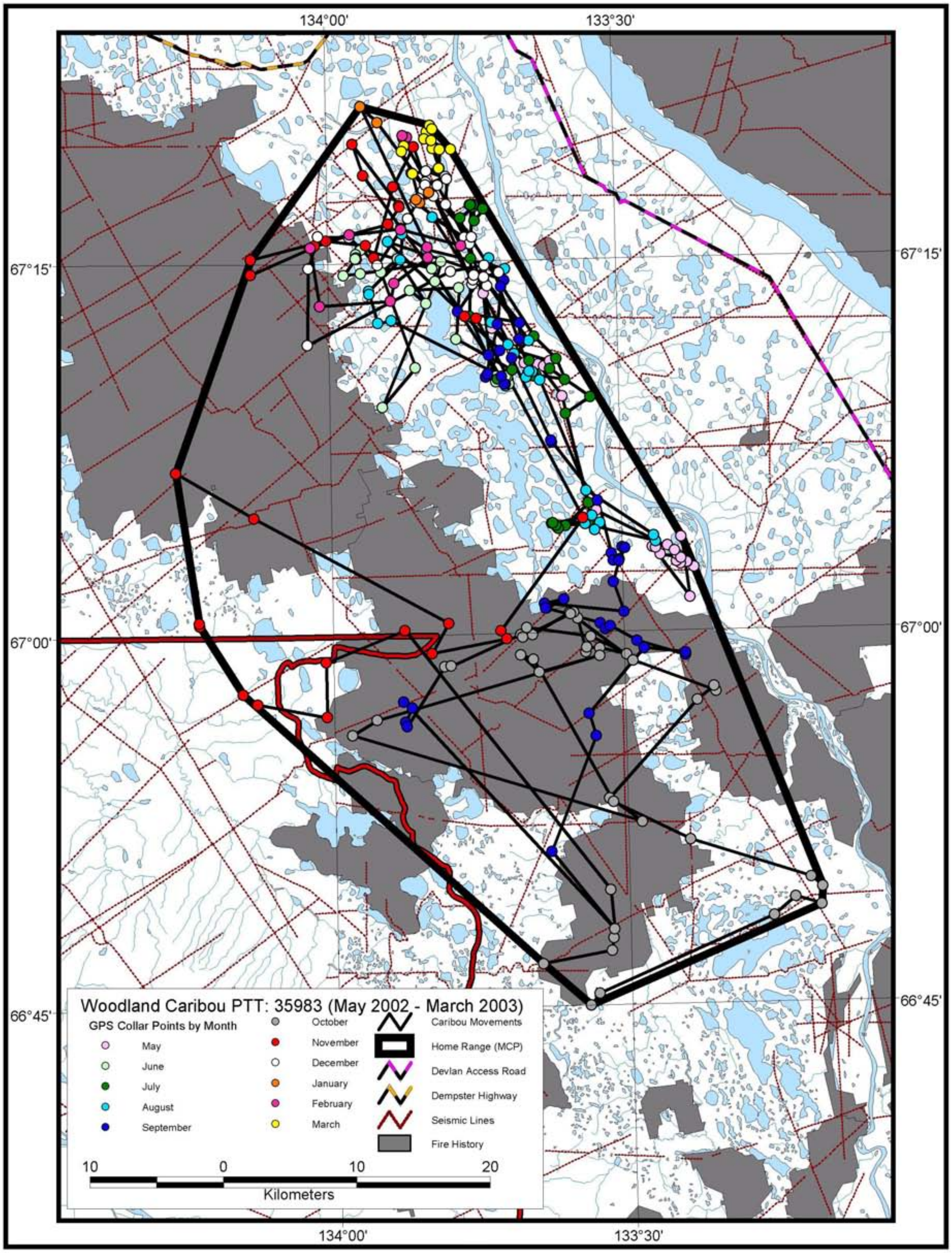


Figure 21. Monthly distribution and movements of Caribou 36182, 2 May 2002 to 31 March 2003 (n = 503 locations).

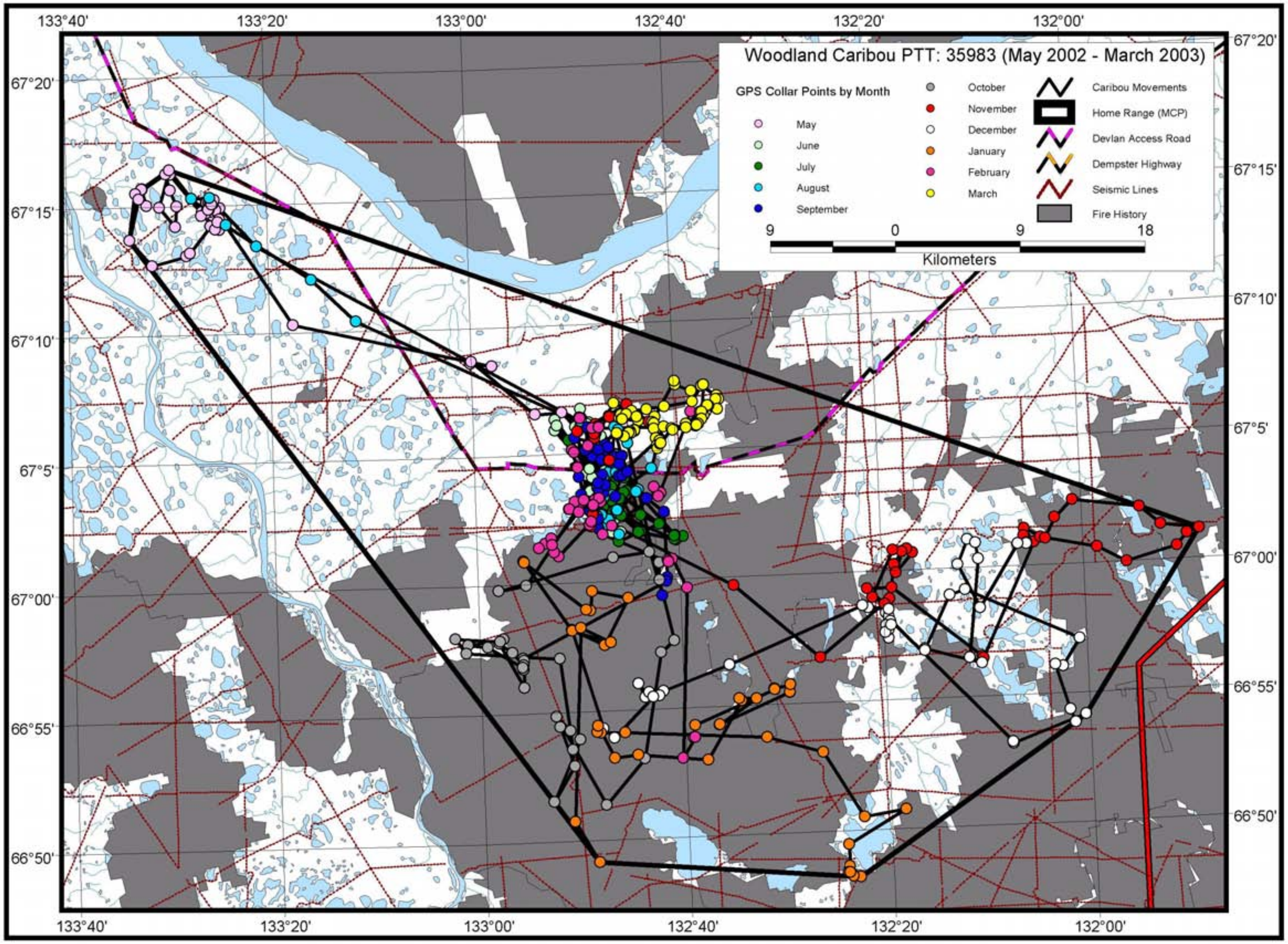


Figure 22. Measures of distance traveled for Caribou 35983 during May 2002. Changes in travel rates suggests that calving occurred between 20 and 23 May.

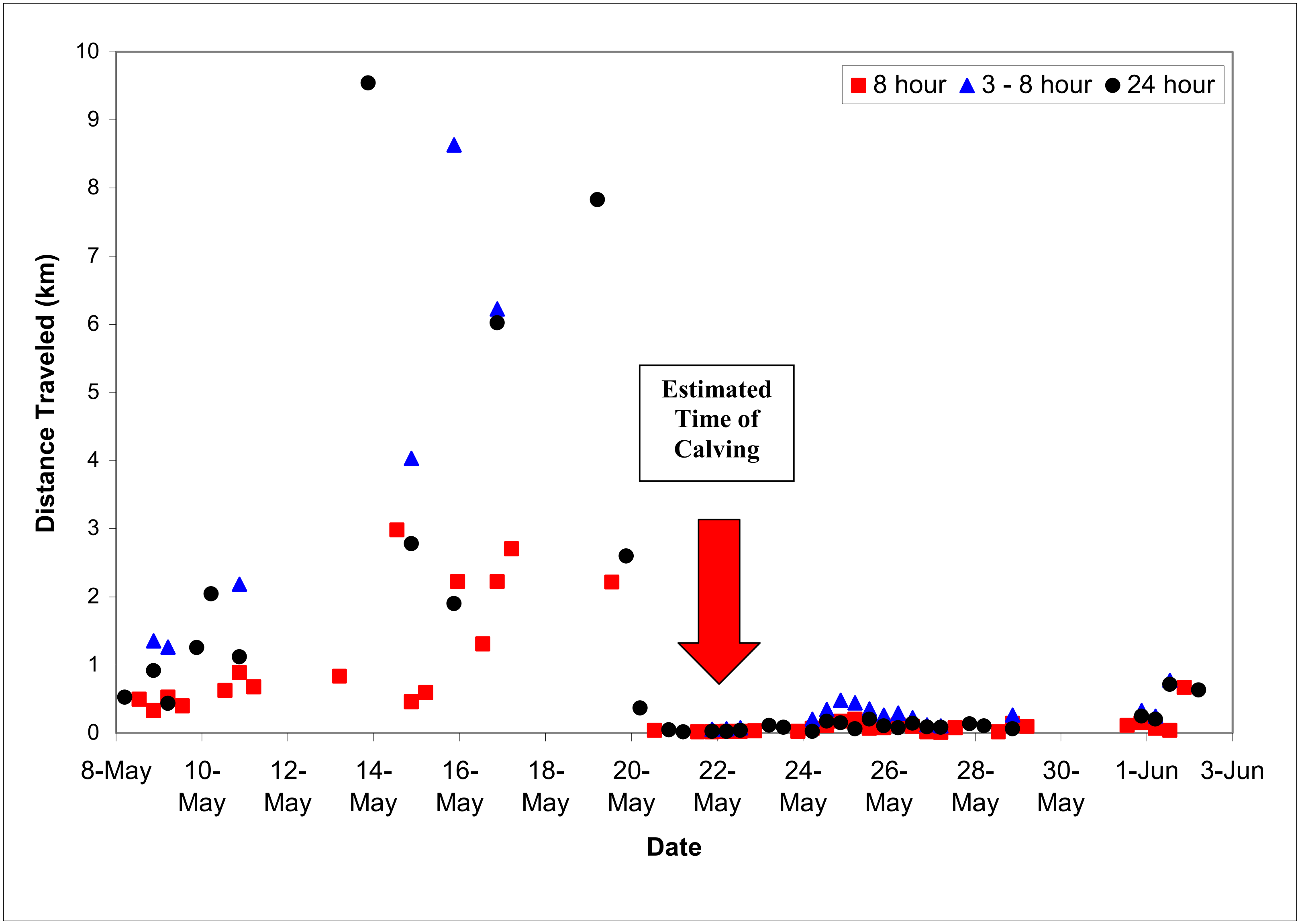


Figure 23. **Measures of distance traveled by Caribou 36182 during May 2002. Changes in travel rates suggests that calving occurred during 18 and 20 May.**

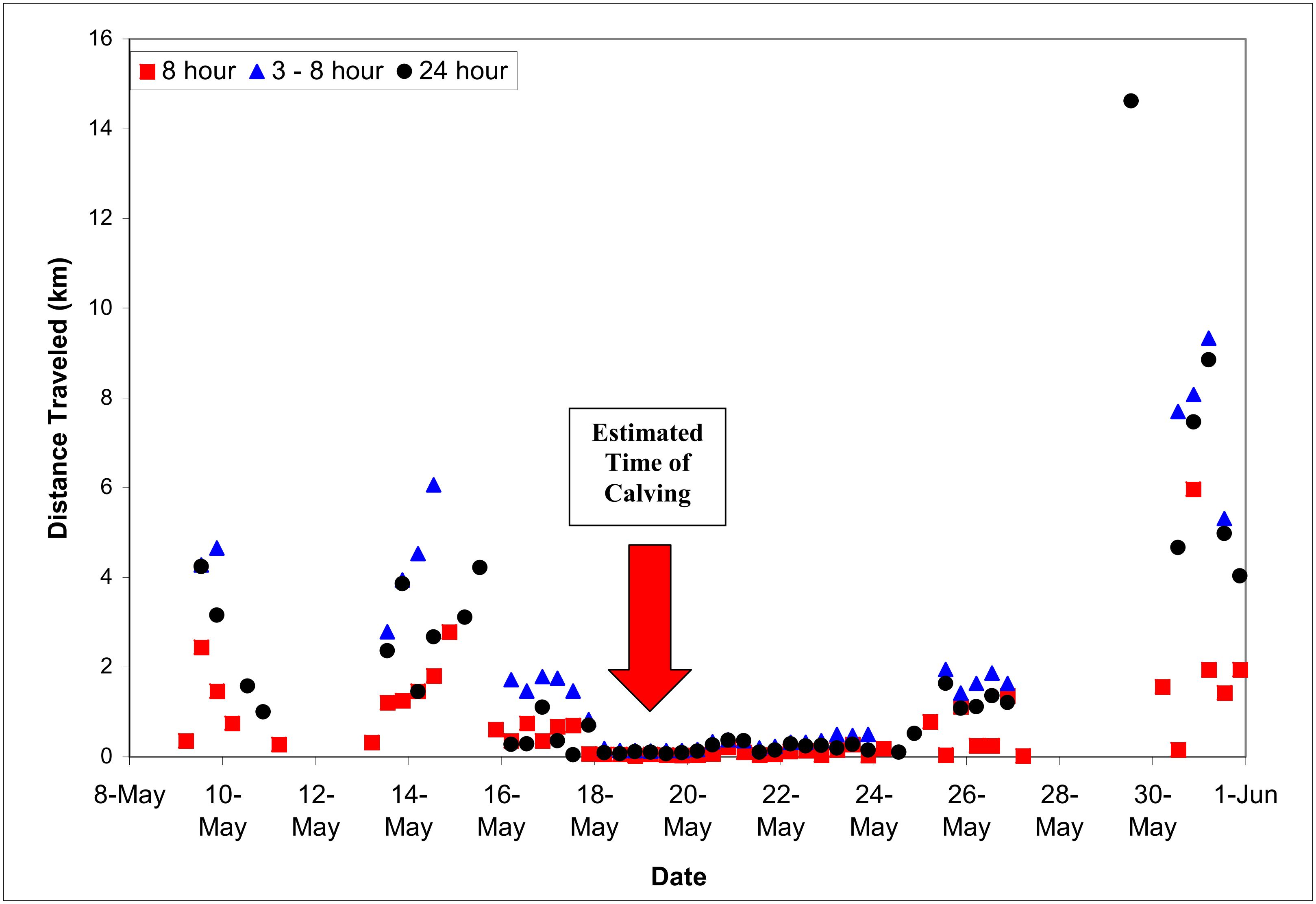


Figure 24. Use of generalized vegetation classes by month.

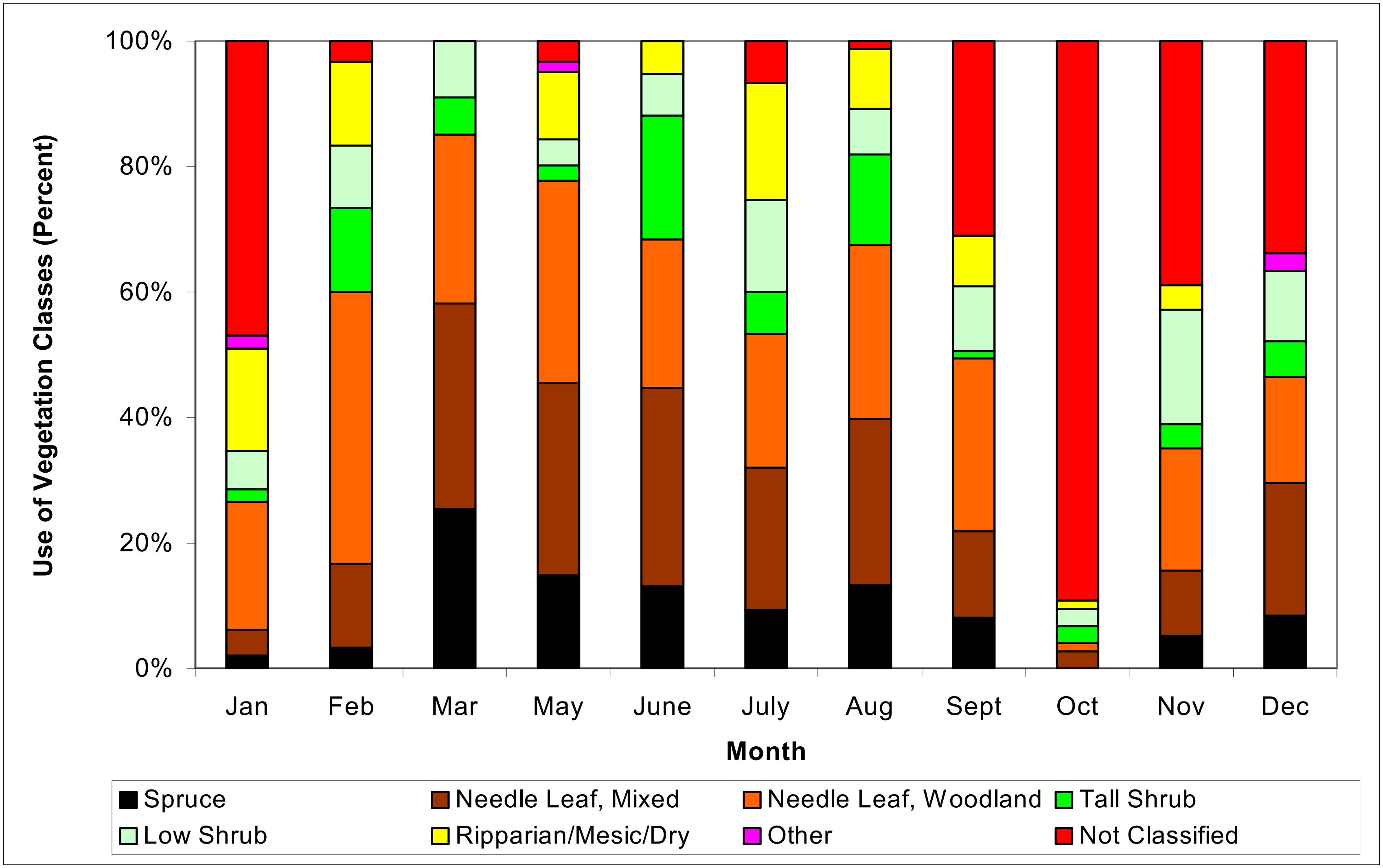


Figure 25. **Open needle leaf (black spruce dominated)/woodland needle leaf (black spruce and paper birch dominated) stand used by caribou 35983 during the calving period (20 to 23 May 2002).**

Figure 26. **Open needle leaf (black spruce dominated) stand used by caribou 36182 during the calving period (18 to 20 May 2002)**

Figure 27. **Typical sites where boreal woodland caribou were located during reconnaissance and capture surveys. A mixed group of 16 caribou were located in this area.**

Figure 28. **Typical crater sites in forested areas were caribou appeared to be foraging on reindeer lichens.**

Figure 29. **Craters located along shoreline of lake. The caribou had cratered through approximately 122 cm (1 foot) of hard crusted snow to get at the forage below (horsetail stalks and moss).**

Appendix A. Lower Mackenzie Field Form Used During Aerial Classification of Vegetation (Ducks Unlimited Canada, July 2002).

Rev 7/3/01

Lower Mackenzie Field Form

2001- MACK -____-________ Yr Project Crew Site Number	___/___/___ Observers	Obs. Date: ___/___/___ Mo Day Year	1 2 3 4 Obs. Level	Obs.Time:____:____ Hr Min
Digital Photo_____.________ Session # Photo #	LAT (GPS)________.________ Decimal Degrees		LONG (GPS)________.________ Decimal Degrees	
	Drainage Class: Rapidly Well Imperfectly Poorly Inundated			
%Slope (Avg)	Elev	Aspect: N NE E SE S SW W NW Flat		
Average Distance Between Stems: (Open or Woodland Needleaf Only)	10-15' 15-20' 20-25' 25-30' 30-35' 35-40'			

Physiognomic Type: (Circle Lichen where present)

Forest	Forest	Shrub	Herbaceous	Herbaceous	Aquatic/Water	Barren	Comment
Closed Needleleaf	Closed Deciduous	Closed Tall	Lichen	Dry Sedge	Aquatic Bed	Sparse Veg	Bog
Open Needleleaf	Open Deciduous	Open Tall	Moss	Dry Graminoid	Emergent	Rock/Gravel	Fen
Wdlnd Needleleaf	Closed Mixed	SA/AL Low	Wet Sedge/Gram	Dry Grass	Snow/Ice	Mud/Silt/Sand	Marsh
Wdlnd Ndllf-Lichen	Open Mixed	Tussock Low	Wet Forb	Dry Forb	Turbid Water		Beav Pd
Forest Modifiers	**Forest Modifiers**	Other Low-Lichn	Tussock-Lichen		Clear Water	**Other**	Lake
Lichen / Moss	Wet Gram / Other	Dwarf - Lichen				Other	River/Strm

%Cov	Height	TREES	
		White/ Black	Picea glauca / mariana
		Birch	Betula papyrifera
		Larch, Tamarack	Larix laricina
		Balsam Poplar	Populus balsamifera
		Spring Birch	Betula occidentalis
		Balsam Fir	Abies balsamea
		Aspen	Populus tremuloides

%Cov	Height	SHRUBS	
		Willow	Salix spp.
		Alder	Alnus crispus / spp.
		Bog Birch	Betula glandulosa
		Blueberry	Vaccinium uliginosum
		Labrador tea	Ledum descum/ groenlandicum
		Rose	Rosa acicularis
		Azalea	Rhododendrn lapponicum
		Kinnikinnick	Arctostaphylos uva-ursi
		Leatherleaf	Chamaedaphne calyculata
		Laurel, pale	Kalmia polifolia
		Lowbush cranberry	Vaccinium vitis-idaea
		Bog rosemary	Andromeda polifolia
		Manzanita, alpine	Arctostaphylos alpina
		Bearberry	Arctostaphylos rubra
		Cinquefoil, shrubby	Potentilla fruticosa

%Cov	HERBACEOUS	
	Graminoid	
	Grass	Grass spp.
	Sedge	Carex spp.
	Cotton Grass	Eriophorum spp
	Subtotal % Cover	

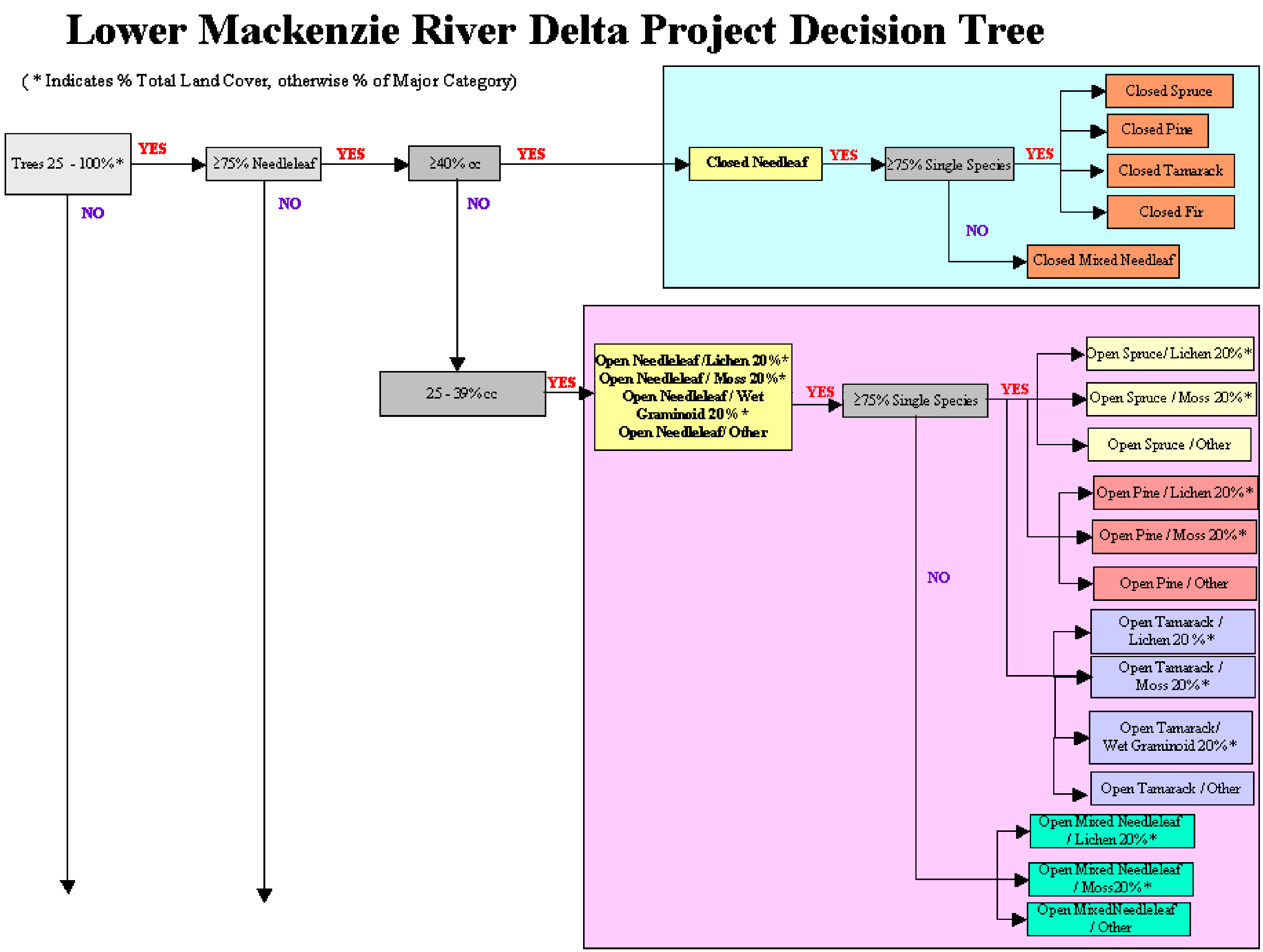
%Cov	HERBACEOUS con't	
	Forbs	
	Horsetails	Equisetum spp.
	Fireweed	Epilobium angustifolium
	Spikerush, Least	Eleocharis acicularis
	Crowberry	Empetrum nigrum
	Cloudberry	Rubus chamemorous
	Arctic Lupine	Lupinus arcticus
	Coltsfoot	Petasites palmatus
	Wintergreen	Pyrola spp.
	Bryoid	
	Moss	
	Lichen	

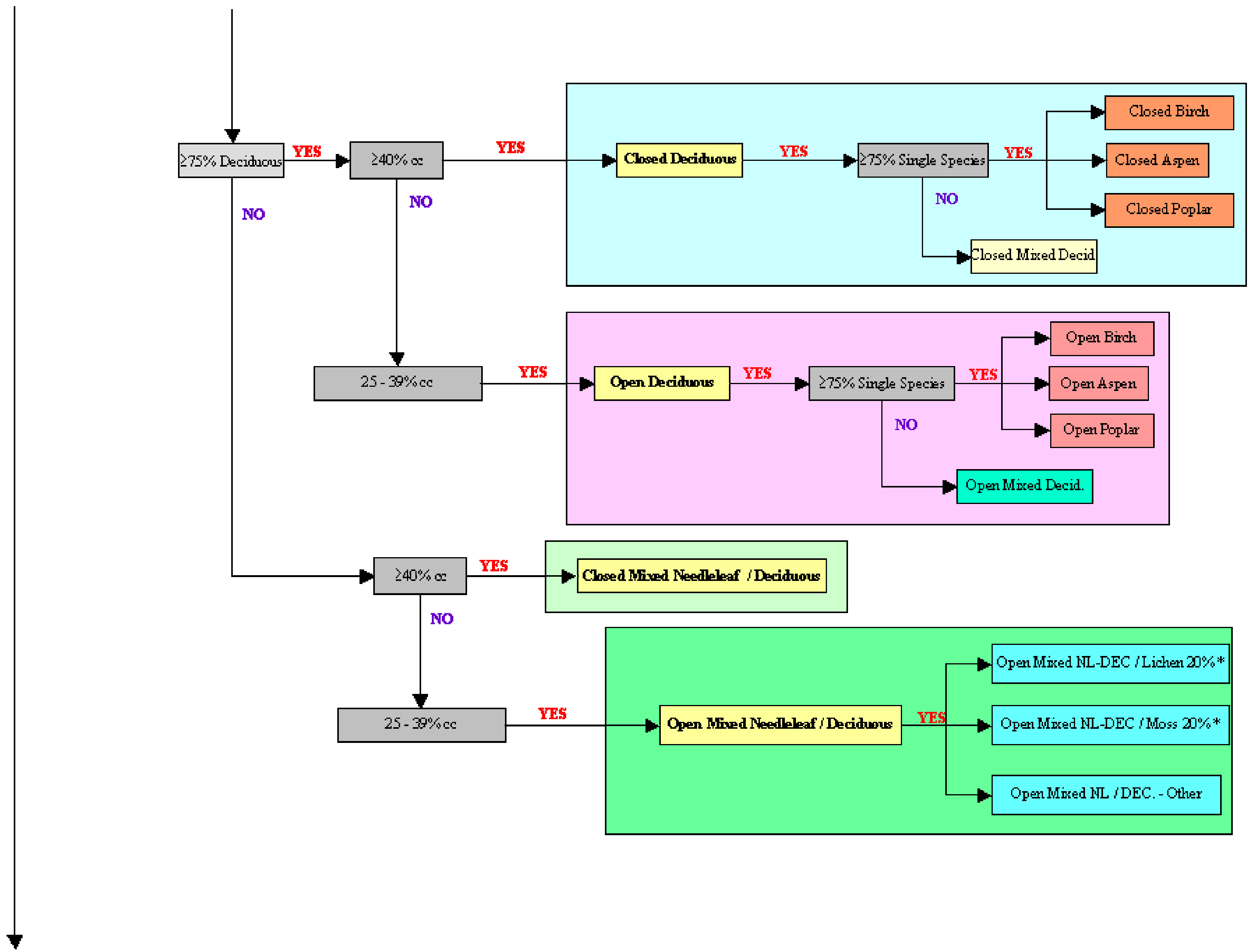
%Cov	AQUATIC / EMERGENT	
	Wet Sedge	Carex spp.
	Spikerush, creeping	Eleocharis palustris
	Water horsetail	Equisetum fluviatile
	Pondweed	Potomogeton spp.
	Butter-cup, water	Ranunculus aquaticus
	Mare's Tail	Hippuris vulgaris

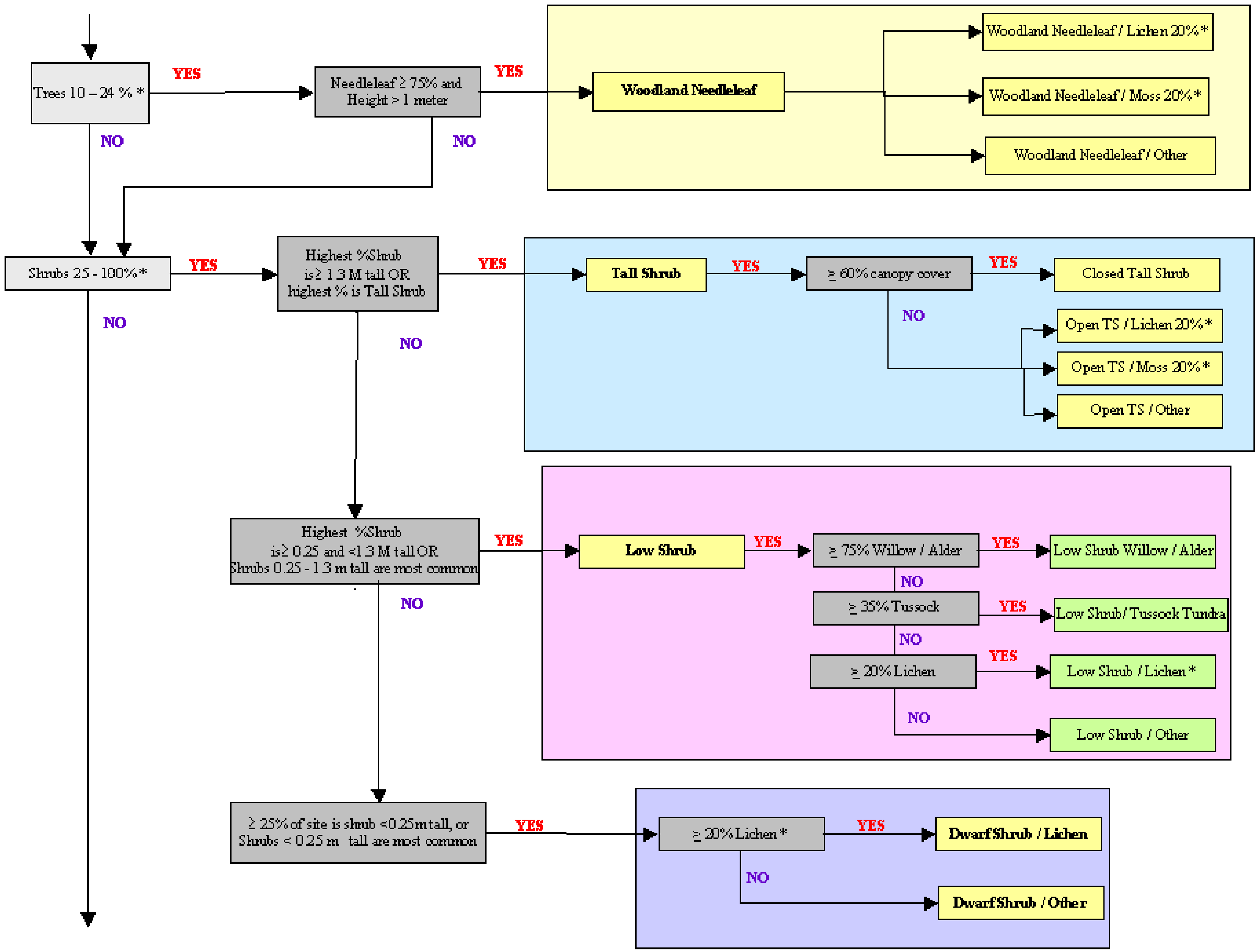
%Cov	NON-VEGETATED	
	Clear/Turbid Water	(circle one)
	Mud/Silt/Sand	(circle one)
	Gravel/Rock	(circle one)
	Litter	
	Standing Dead	
	Subtotal % Cover	
	GRAND TOTAL % COVER	

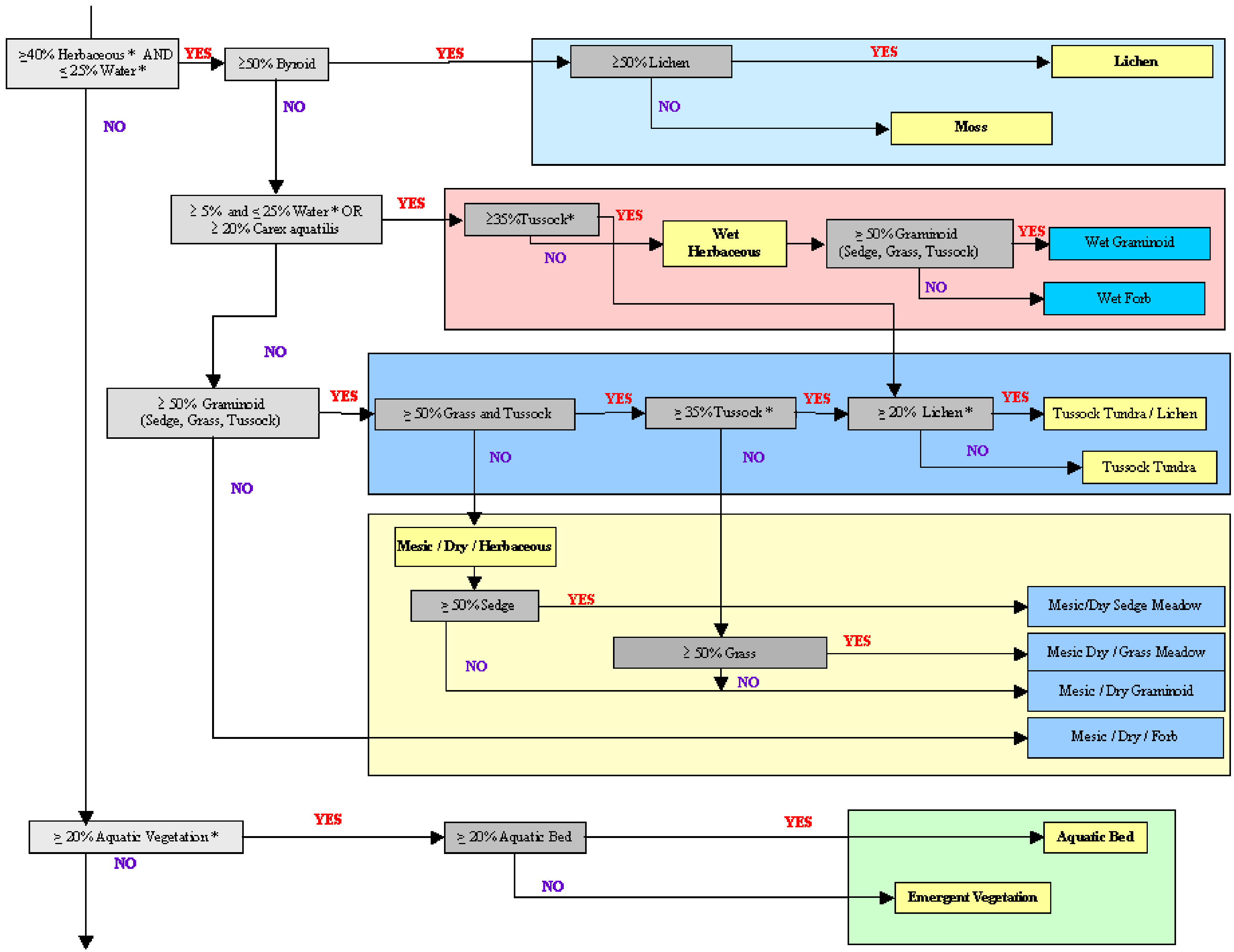
COMMENTS

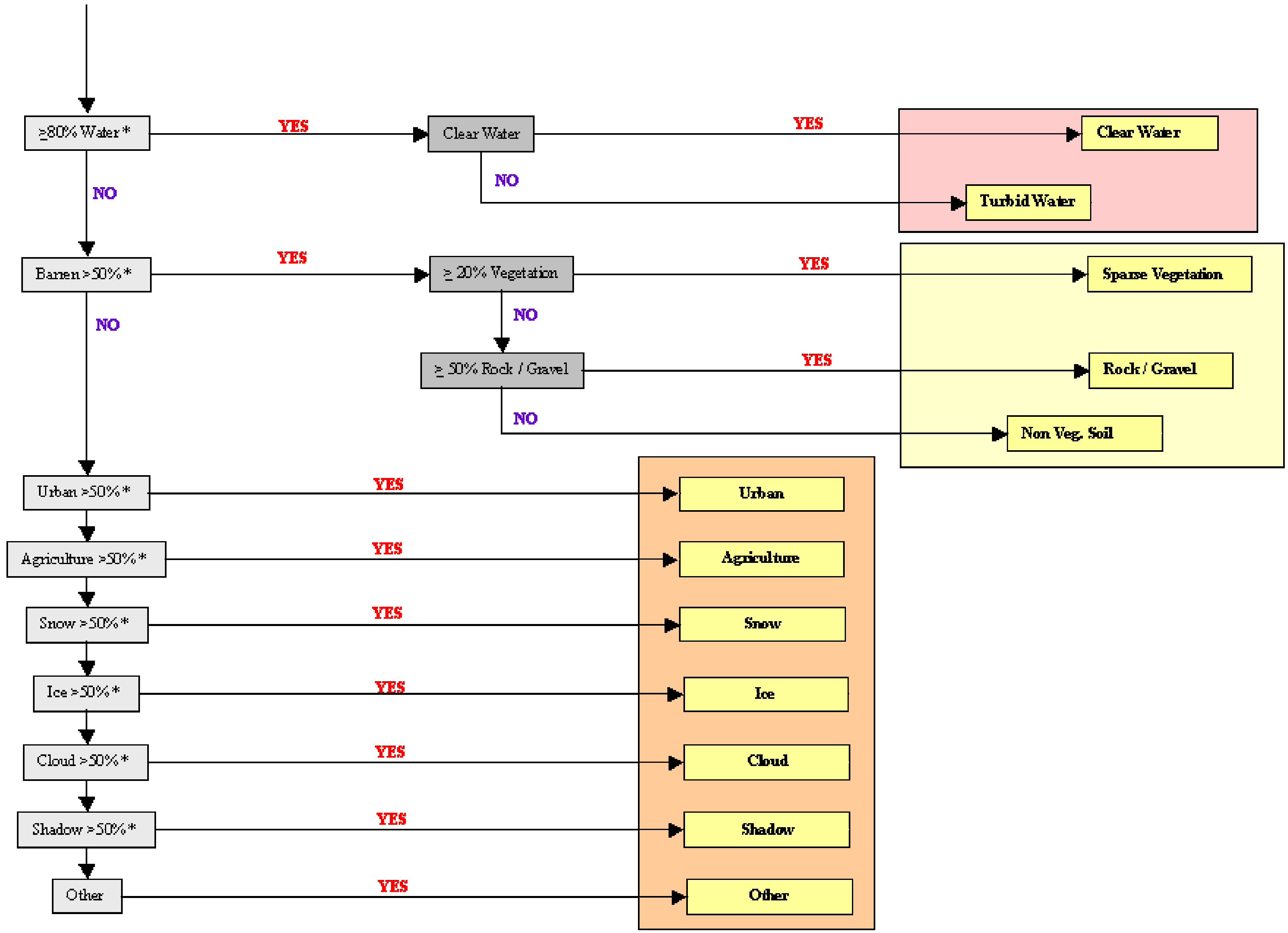
Appendix B. **Lower Mackenzie River Delta Classification Decision Tree (Ducks Unlimted Canada, July 2002).**




≥75% Deciduous
YES
≥40% cc
YES
Closed Deciduous
YES
≥75% Single Species
YES
Closed Birch
Closed Aspen
Closed Poplar
NO
Closed Mixed Decid
NO
NO
25 - 39% cc
YES
Open Deciduous
YES
≥75% Single Species
YES
Open Birch
Open Aspen
Open Poplar
NO
Open Mixed Decid.
≥40% cc
YES
Closed Mixed Needleleaf / Deciduous
NO
25 - 39% cc
YES
Open Mixed Needleleaf / Deciduous
YES
Open Mixed NL-DEC / Lichen 20%*
Open Mixed NL-DEC / Moss 20%*
Open Mixed NL / DEC. - Other


Trees 10 – 24 % *
YES
NO
Needleleaf ≥ 75% and Height > 1 meter
YES
NO
Woodland Needleleaf
Woodland Needleleaf / Lichen 20%*
Woodland Needleleaf / Moss 20%*
Woodland Needleleaf / Other
Shrubs 25 - 100%*
YES
NO
Highest %Shrub is ≥ 1.3 M tall OR highest % is Tall Shrub
YES
NO
Tall Shrub
YES
≥ 60% canopy cover
YES
NO
Closed Tall Shrub
Open TS / Lichen 20%*
Open TS / Moss 20%*
Open TS / Other
Highest %Shrub is ≥ 0.25 and <1.3 M tall OR Shrubs 0.25 - 1.3 m tall are most common
YES
NO
Low Shrub
YES
≥ 75% Willow / Alder
YES
NO
Low Shrub Willow / Alder
≥ 35% Tussock
YES
NO
Low Shrub/ Tussock Tundra
≥ 20% Lichen
YES
NO
Low Shrub / Lichen *
Low Shrub / Other
≥ 25% of site is shrub <0.25m tall, or Shrubs < 0.25 m tall are most common
YES
≥ 20% Lichen *
YES
NO
Dwarf Shrub / Lichen
Dwarf Shrub / Other


≥40% Herbaceous * AND ≤ 25% Water *
YES
NO
≥50% Byroid
≥50% Lichen
Lichen
Moss
≥ 5% and ≤ 25% Water * OR ≥ 20% Carex aquatilis
≥35%Tussock*
Wet Herbaceous
≥ 50% Graminoid (Sedge, Grass, Tussock)
Wet Graminoid
Wet Forb
≥ 50% Graminoid (Sedge, Grass, Tussock)
≥ 50% Grass and Tussock
≥ 35% Tussock *
≥ 20% Lichen *
Tussock Tundra / Lichen
Tussock Tundra
Mesic / Dry / Herbaceous
≥ 50% Sedge
≥ 50% Grass
Mesic/Dry Sedge Meadow
Mesic Dry / Grass Meadow
Mesic / Dry Graminoid
Mesic / Dry / Forb
≥ 20% Aquatic Vegetation *
≥ 20% Aquatic Bed
Aquatic Bed
Emergent Vegetation


≥80% Water*
YES
Clear Water
YES
Clear Water
NO
Turbid Water
NO
Barren >50%*
YES
≥ 20% Vegetation
YES
Sparse Vegetation
NO
≥ 50% Rock / Gravel
YES
Rock / Gravel
NO
Non Veg. Soil
NO
Urban >50%*
YES
Urban
Agriculture >50%*
YES
Agriculture
Snow >50%*
YES
Snow
Ice >50%*
YES
Ice
Cloud >50%*
YES
Cloud
Shadow >50%*
YES
Shadow
Other
YES
Other

Appendix C. Lower Mackenzie River Delta Earth Cover Classification Class Descriptions (Ducks Unlimited Canada, July 2002).

1.0 Forest

Needleleaf and Deciduous Trees-
The needleleaf species generally found were white spruce (*Picea glauca*) and black spruce (*P. mariana*). White spruce tended to occur on warmer sites with better drainage, while black spruce dominated poorly drained sites.

The deciduous tree species generally found were paper birch (*Betula papyfera*), aspen (*Populus tremuloides*) and Balsam Poplar (*P. balsamifera*). Under some conditions willow (*Salix* spp.) and alder *(Alnus rubra)* formed a significant part of the tree canopy. Deciduous stands were found in major river valleys, on alluvial flats, surrounding lakes, or most commonly, on the steep slopes of small hills. Mixed deciduous/coniferous stands were present in the same areas as pure deciduous stands. While needleleaf stands were often extensive, deciduous and mixed decidous/needleleaf stands were generally limited in size.

1.1 Closed Needleleaf

At least 40% of the cover was trees, and ≥75% of the trees were needleleaf trees. Closed needleleaf sites were rare because even where stem densities were high, the crown closure remained low. Closed needleleaf sites are often found along major rivers.

1.2 Open Needleleaf

From 25-39% of the cover was trees, and ≥75% of the trees were needleleaf. This class was very common throughout the project area. A wide variety of understory plant groups were present, including low and tall shrubs, forbs, grasses, sedges, horsetails, mosses and lichens.

1.21 Open Needleleaf Lichen

From 25-39% of the cover was trees, ≥75% of the trees were needleleaf, and ≥ 20% of the site cover was lichen.

1.22Open Needleleaf Moss

From 25-39% of the cover was trees, ≥75% of the trees were needleleaf, and ≥20% of the site cover was moss.

1.3 Woodland Needleleaf

From 10-24% of the cover was trees, and ≥75% of the trees were needleleaf trees taller than 1 meter. Woodland understory was extremely varied and included most of the shrub, herbaceous, or graminoid types present in the study area.

1.31 Woodland Needleleaf Lichen

From 10-24% of the cover was trees, ≥75% of the trees were needleleaf trees taller than 1 meter, and ≥ 20% of the understory was lichen. The lichen often occurred in small patches between trees.

1.32 Woodland Needleleaf Moss
From 10-24% of the cover was trees, ≥75% of the trees were needleleaf trees taller than 1 meter, and ≥ 20% of the understory was moss.

1.33 Woodland Needleleaf Other
From 10-24% of the cover was trees, ≥75% of the trees were needleleaf trees taller than 1 meter, and a mixture of lichen, moss and herbs with no predominant understory species.

1.4 Closed Deciduous (Mixed Deciduous Species 1.44)
At least 40% of the cover was trees, and ≥75% of the trees were deciduous. Occurred in stands of limited size, generally on the floodplains of major rivers, but occasionally on hillsides, riparian gravel bars, or bordering small lakes. This class included Paper Birch, and Balsam Poplar.

1.41 Closed Aspen
At least 40% of the cover was trees,≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Aspen (*Populus Tremuloides*).

1.42 Closed Birch
At least 40% of the cover was trees, ≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Paper Birch (*Betula Papyfera).* This class was very limited.

1.43 Closed Poplar
At least 40% of the cover was trees, ≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Balsam Poplar. This class was rarely found in pure stands, but was more commonly mixed with other deciduous species.

1.5 Open Deciduous (Mixed Deciduous Species 1.54)
From 25-39% of the cover was trees, and ≥75% of the trees were deciduous. There was generally a needleleaf component to this class though it was less than 25%. This was a relatively uncommon class.

1.51 Open Birch
From 25-39% of the cover was trees, ≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Paper Birch. This class was very rare.

1.52 Open Aspen
From 25-39% of the cover was trees, ≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Aspen (*Populus Tremuloides*).

1.53 Open Poplar
From 25-39% of the cover was trees, ≥75% of the trees were deciduous, and ≥75% of the deciduous trees were Aspen. This class was very rare.

1.6 Closed Mixed Needleleaf/Deciduous
At least 40% of the cover was trees, but neither needleleaf nor deciduous trees made up ≥75% of the tree cover. This class was found mainly within the delta region and south of the Mackenzie River.

1.7 Open Mixed Needleleaf/Deciduous
From 25-39% of the cover was trees, but neither needleleaf nor deciduous trees made up ≥75% of the tree cover. This class occurred throughout the scene, but was more prevalent on the Fort McPherson plateau.

2.0 Shrub
The tall and low shrub classes were dominated by willow species, dwarf birch (*Betula nana* and *Betula glandulosa*) and blueberry (*Vaccinium)* species*,* with alder being somewhat less common. However, the proportions of willow to birch and the relative heights of the shrub species varied widely, which created difficulties in determining whether a site was made up of tall or low shrub. As a result, the height of the shrub species making up the largest proportion of the site dictated whether the site was called a low or tall shrub. The shrub heights were averaged within a genus, as in the case of a site with both tall and low willow shrubs. Dwarf shrub was usually composed of dwarf ericaceous shrubs and *Dryas* species, but often included a variety of forbs and graminoids. The species composition of this class varied widely from site to site and included rare plant species. It is nearly always found on hilltops or mountain plateaus, and may have included some rock.

2.1 Tall Shrub
Shrubs made up 25-100% of the cover, with the majority of shrubs being ≥1.3 meters in height. This class generally had a major willow component that was mixed with dwarf birch and/or alder, but could also have been dominated by nearly pure stands of alder. It was found most often in wet drainages, at the head of streams, or on slopes.

2.11 Closed Tall Shrub
Shrubs made up 60-100% of the cover, with the majority of shrubs being ≥1.3 meters in height.

2.121 Open Tall Shrub / Lichen
Shrubs made up 25-59% of the cover, with the majority of shrubs being ≥1.3 meters in height, and ≥20% of the cover was made up of lichen.

2.122 Open Tall Shrub / Moss
Shrubs made up 25-59% of the cover, with the majority of shrubs being ≥1.3 meters in height, and ≥20% of the cover was made up of moss.

2.123 Open Tall Shrub Other
Shrubs made up 25-59% of the cover, with the majority of shrubs being ≥1.3 meters in height, and the understory was mixed.

2.21 Low Shrub Willow / Alder
Shrubs made up 25 – 100% of the cover, with the majority of shrubs being .25-1.29 meters in height, and willow/alder species constituted ≥75% of the shrub cover.

2.22 Low Shrub/ Tussock Tundra
Shrubs made up 25 – 100% of the cover, with the majority of shrubs being .25-1.29 meters in height, and a total of ≥35% cover was tussock tundra.

2.23 Low Shrub/Lichen
Shrubs made up 25-100% of the cover, with the majority of shrubs being .25-1.29 meters in height, and ≥20% of the cover was made up of lichen. The shrub species in this class were normally either dwarf birch or tussock tundra.

2.24 Other Low Shrub
Shrubs made up 25-100% of the cover, with the majority of shrubs being .25-1.29 meters in height. This was the most common low shrub class. It was generally composed of dwarf birch, willow species, *Vaccinium* species, and ledum species.

2.31 Dwarf Shrub/Lichen
Shrubs made up 25-100% of the cover, with the majority of shrubs being <.25 meters in height, and ≥20% of the cover was made up of lichen. This class was generally made up of dwarf ericaceous shrubs and *Dryas* species, but often included a variety of forbs and graminoids. It was nearly always found at higher elevations on hilltops, mountain slopes and plateaus.

2.32 Other Dwarf Shrub
Shrubs made up 25-100% of the cover, with the majority of shrubs being <.25 meters. This class was generally made up of dwarf ericaceous shrubs and *Dryas* species, but often included a variety of forbs and graminoids, and some rock. It was nearly always found at higher elevations on hilltops, mountain slopes, and plateaus.

3.0 Herbaceous
The classes in this category included bryoids, forbs, and graminoids. Bryoids and forbs were present as a component of most of the other classes but rarely appeared in pure stands. Graminoids such as *Carex* spp., *Eriophorum* spp., or bluejoint grass (*Calamagrostis canadensis*) may have dominated a community.

3.11 Lichen
Composed of ≥40% herbaceous species, ≤25% water, ≥50% of the herbaceous species are Bryoids (lichen or moss species), with lichen making up the majority of the moss/lichen component.

3.12 Moss
Composed of ≥40% herbaceous species, ≤25% water, and ≥50% of the herbaceous species are Bryoids (lichen or moss species), with moss making up the majority of the moss/lichen component.

3.21 Wet Graminoid
Composed of ≥40% herbaceous species, >5% and ≤25% water or ≥20% *Carex aquatilis*, and where ≥50% of the herbaceous cover was graminoid. This class represented wet or seasonally flooded sites.

3.22 Wet Forb
Composed of ≥40% herbaceous species, >5% and ≤25% water or ≥20% *Carex aquatilis*, and where <50% of the herbaceous cover was graminoid. This class represented wet or seasonally flooded sites.

3.31 Tussock Tundra / Lichen
Composed of ≥40% herbaceous species, ≤25% water, and ≥50% of herbaceous species are Graminoid and ≥35 of these are Tussock. Lichen is present in the site with ≥20% cover.

3.32 Tussock Tundra
Composed of ≥40% herbaceous species, ≤25% water, and ≥50% of herbaceous species are Graminoid and ≥35 of these are Tussock.

3.33 Mesic/Dry Sedge Meadow
Composed of ≥40% herbaceous species, ≤5% water, with ≥50% sedges. This class was not common and had only one occurrence among sampled sites

3.34 Mesic/Dry Grass Meadow
Composed of ≥40% herbaceous species, ≤5% water, with ≥50% graminoids excluding tussock forming cotton grass and *Carex aquatilis*. This class was not common and had only one occurrence among sampled sites

3.35 Mesic/Dry Graminoid
Composed of ≥40% herbaceous species, ≤5% water, with <50% sedge. This class was not common and had only once occurrence among sampled sites.

3.36 Mesic/Dry Forb
Composed of ≥40% herbaceous species, ≤5% water, with <50% graminiods. Regenerating burn areas dominated by fireweed *(Epilobium angustifolium)* fell into the mesic/dry forb category.

4.0 Aquatic Vegetation
The aquatic vegetation was divided into Aquatic Bed and Emergent classes. The Aquatic Bed class was dominated by plants with leaves that float on the water surface, generally pond lilies (*Nuphar polysepalum*). The Emergent Vegetation class was composed of species that were partially submerged in the water, and included freshwater herbs such as Horsetails (*Equisetum* spp.), Marestail (*Hippuris* spp.), and Buckbean (*Menyanthes trifoliata*).

4.1 Aquatic Bed
Aquatic vegetation made up ≥20% of the cover, and ≥20% of this vegetation was composed of plants with floating leaves. This class was generally dominated by pond lilies.

4.2 Emergent Vegetation
Aquatic vegetation made up ≥20% of the cover, and ≥20% of this vegetation was composed of plants other than pond lilies. Generally included freshwater herbs such as Horsetails, Marestail, or Buckbean.

5.1 Snow
Composed of ≥50% snow.

5.2 Ice
Composed of ≥50% ice.

5.3 Clear Water
Composed of ≥80% clear water.

5.4 Turbid Water
Composed of ≥80% turbid water.

6.0 Barren
This class included very sparsely vegetated sites, e.g., riparian gravel bars, along with non-vegetated sites, e.g., barren mountaintops or glacial till.

6.1 Sparse Vegetation
At least 50% of the area was barren, but vegetation made up ≥20% of the cover. This class was often found on riparian gravel bars, on rocky or very steep slopes and in abandoned gravel pits. The plant species were generally herbs, graminoids and bryoids.

6.2 Rock/Gravel
At least 50% of the area was barren, ≥50% of the cover was composed of rock and/or gravel, and vegetation made up less than 20% of the cover. This class was most often found on mountaintops or on barren riparian gravel bars.

6.3 Non-vegetated Soil
At least 50% of the area was barren, ≥50% of the cover was composed of mud, silt or sand, and vegetation made up less than 20% of the cover. This type was generally along shorelines or rivers.

7.0 Urban
At least 50% of the area was urban. This class is limited to developed areas around Inuvik, Aklavik Ft. McPherson and the Dempster highway.

8.0 Agriculture
At least 50% of the area was agriculture. This class was not found in the study area.

9.1 Cloud
At least 50% of the cover was cloud or haze.

9.2 Shadow

At least 50% of the cover was made up of cloud or terrain shadows.

<u>10.0 Other</u>

Sites that did not fall into any other category were assigned to Other. For example, sites containing 25%-79% water, <25% shrub and <20% aquatic vegetation were classed as Other. Sites classed as Other may have also included extensive areas of vegetative litter, such as downed wood. These sites were assessed individually and generally treated as the land cover that they most closely resembled