HABITAT USE, WINTER FEEDING ECOLOGY AND POPULATION STATUS OF WOODLAND CARIBOU IN WEST-CENTRAL BRITISH COLUMBIA

West-central B.C. Caribou Research Project

Final Report

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by

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SUMMARY

1. Tweedsmuir Park and the area adjacent to the east supports two populations of woodland caribou (*Rangifer tarandus caribou*): the Tweedsmuir-Entiako population, and the Itcha-Ilgachuz-Rainbow population. The area was identified as a high priority management area for woodland caribou in British Columbia (Stevenson and Hatler 1985). Increasing concern over population status, winter habitat disturbance through logging and increasing accessibility, prompted the initiation of the West Central B.C. Caribou Research Project. The objectives of the study were to determine seasonal movements, habitat use and food habits of the caribou, especially during winter, and to determine population size, calf production, calf survival and adult survival to assess population status and limiting factors.

2. Data collected was based on radiocollared caribou. Seasonal movements and habitat use were monitored by aerial radiotelemetry, weekly from December to March and every 2-3 weeks from April to November. Winter food habits were determined by following caribou tracks and identifying feeding site types in different habitats. Calf production, calf survival and adult survival were based on the radiocollared sample and on caribou seen opportunistically during June, October and March censuses. Population size was estimated for the Itcha-Ilgachuz-Rainbow population during June censuses and for the Tweedsmuir-Entiako population during October censuses.

3. Tweedsmuir-Entiako caribou migrated north across Tetachuck Lake in early May, then moved through low elevation forested and meadow habitats to calving areas throughout northern Tweedsmuir Park and the mountains west of the park. Caribou

were widely distributed during the summer and habitat use ranged from Coastal Western Hemlock forests at 500 meters to alpine habitats at 2000 meters. In October, caribou began moving east towards the Quanchus Mountains and Tetachuck Lake. Rutting occurred throughout the park, but major rutting aggregations were found in alpine habitat near Wells Gray Peak and in forest/meadow complexes east of the Quanchus Mountains. By early December, caribou had moved south across Tetachuck Lake and used primarily low elevation pine or pine/spruce forests throughout the winter. Some years, between mid February and mid March, up to 25% of the population used alpine and subalpine habitats in the Fawnie Mountains. In March, caribou at lower elevations concentrated near the mouth of the Entiako River where they used pine and pine/spruce forests, before moving to the south side of Tetachuck Lake.

4. In May, Itcha-Ilgachuz caribou moved from late winter ranges to high elevation forested and meadow habitats at the base of the Itcha and Ilgachuz Mountains and in the pass between the two ranges. In early June, calving occurred at high elevations in alpine habitat. Radiocollared caribou summered primarily in alpine habitat in the Itcha-Ilgachuz Mountains but also in forested and meadow habitats adjacent to the mountains. During October, radiocollared caribou used mostly alpine habitat and subalpine or forested-meadow complexes. Caribou began moving to winter ranges in November, and during early winter used both pine forests and high elevation, fescue-lichen meadows. During winter radiocollared caribou were found primarily in low elevation pine forests, although 5-15% of the caribou remained in the alpine on the north side of the Ilgachuz Mountains.

5. Radiocollared Rainbow caribou concentrated on the north side of the Rainbow Mountains in May. Caribou were widely distributed throughout alpine habitat in the Rainbow Mountains during summer and early fall. Caribou that remained in the Rainbow

Mountains during the winter were found primarily in alpine habitat on the north slopes. Some of the radiocollared caribou moved to the north side of the Ilgachuz Mountains in November and followed the same habitat use patterns as the Itcha-Ilgachuz caribou that wintered there. Caribou that wintered in the Ilgachuz Mountains returned to the Rainbow Mountains by May.

6. During winter, caribou in both Tweedsmuir-Entiako and Itcha-Ilgachuz low elevation winter ranges used predominantly mature pine forest cover types on low and poor quality sites, and mature Dry Lichen/Lichen Moss and Lichen Moss caribou habitat types. In early winter, Itcha-Ilgachuz caribou selected Fescue-Lichen meadows but stopped using them by February due to snow accumulation. By late winter, Tweedsmuir-Entiako caribou were found near the mouth of the Entiako River using mature Moss/Seepage Forest - Aspen Forest caribou habitat types and selected mature pine and pine/spruce forest cover types on medium quality sites. In the Itcha-Ilgachuz winter range during late winter, Dry Lichen/Kinnikinnick sites in the SBPSxc biogeoclimatic subzone south of Punkutlaenkut Creek were also heavily used.

7. Snow depth affected habitat selection by caribou. In early winter Itcha-Ilgachuz caribou used both Fescue-Lichen meadows and pine forests. When snow depth and predicted caribou sinking depth approached 50 and 40 centimeters respectively in the Moore Creek wetland snow station, use of Fescue-Lichen meadows ceased and caribou were found primarily in forested habitats.

8. In low elevation winter ranges in both areas, caribou foraged primarily by cratering for terrestrial lichens in pine forests. Within forested habitats feeding site selection was related to terrestrial lichen abundance. Snow depth did not appear to affect feeding site selection. Snow depth was often greater at crater sites than at non-

crater sites, likely because sites with high terrestrial lichen abundance had more open canopies which intercepted less snow. Snow penetrability did not appear to influence crater site selection in 1987/88; however, data suggested that snow penetrability may have a greater influence during years with deeper snowpacks and lower snow penetrability. Arboreal lichen feeding also occurred in pine forests but arboreal lichen feeding was more prevalent in pine/spruce or spruce forests and forested wetlands. In the Itcha-Ilgachuz area, caribou cratered for water in wetlands and to a lesser extent on creeks, and in the Tweedsmuir-Entiako area, caribou cratered for water on lakes and creeks.

9. The Tweedsmuir-Entiako population consisted of about 500 caribou and was apparently declining due to high adult mortality (22.6%) and low calf recruitment (7.8 calves/100 adults). Although data were insufficient to determine the major limiting factor for the population, predation by wolves and bears appeared to be important mortality factors.

10. The Itcha-Ilgachuz-Rainbow population consisted of about 1500 caribou and was increasing or stable due to moderate-high calf recruitment (16.9 calves/100 adults) and low-moderate adult mortality (15.2%). Wolf predation appeared to be the major limiting factor of the population.

11. Calf counts for adult female caribou found in alpine habitat were greater than calf counts for adult female caribou found below treeline. Most calf mortality occurred during summer months; calves that survived until fall had generally high survival over the winter. Early calf mortality factors included both predator-related and non-predator-related factors.

12. Reliability of calf recruitment estimates derived from surveys of alpine habitat during June, October and March was variable. In the Itcha-Ilgachuz-Rainbow area, the October survey yielded the most reliable calf recruitment estimate. In the Tweedsmuir-Entiako area, although October was the only practical time to conduct a survey, the calf recruitment estimates were not representative of actual calf recruitment of the total population..

13. Management recommendations were proposed to maintain caribou habitat and caribou numbers for both areas.

i) Dry Lichen and Lichen Moss are the most important caribou habitat types to protect. These stands contain the greatest quantities of terrestrial lichens and are relatively poor growing sites for timber production.

ii) Access control within winter ranges would decrease potential disturbance, displacement and poaching of caribou.

iii) Wolf control may be necessary to reduce high caribou mortality rates, especially in the Tweedsmuir-Entiako area.

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INTRODUCTION

Decreasing woodland caribou (*Rangifer tarandus caribou*) numbers (Bergerud 1978) and increasing logging activity on caribou ranges precipitated the need for a better understanding of relationships between caribou and their habitat in British Columbia. Tweedsmuir Park and the area adjacent to the east, was identified as a high priority management area for woodland caribou in British Columbia (Stevenson and Hatler 1985). Two populations of woodland caribou exist in that area, the Tweedsmuir-Entiako population of about 500 caribou, and the Itcha-Ilgachuz-Rainbow population of about 1500 caribou. Because caribou in both these areas wintered primarily in low elevation forested habitat, potential conflicts with logging were anticipated. Increasing concern over current population status, habitat disturbance through logging, and increased accessibility, prompted the initiation of studies on radiocollared caribou. Between 1982 and 1984, caribou in both the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas were radiocollared and basic information on habitat use, seasonal movements and population parameters was collected (Marshall 1984, Smith and Hebert 1987).

In April 1985, the West Central B.C. Caribou Study was initiated to investigate potential effects of logging on caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas. The original studies were expanded to include more intensive investigations of winter range and population parameters.

The objectives of the study were:

1. To determine seasonal movements, habitat use and food habits of caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, especially during winter. This information was necessary to develop logging guidelines compatible with caribou winter habitat use.

2. To determine population size, calf production, calf survival and adult survival, so that current population status and major limiting factors could be determined.

OBJECTIVE I: Seasonal movements, habitat use and food habits.

During the first year of study (April 1985 - March 1986) preliminary data on habitat use and feeding sites were collected. These data indicated that in winter, caribou used primarily mature lodgepole pine (*Pinus contorta*) forests where they foraged primarily on terrestrial lichens (Cichowski 1986). Little evidence of foraging was found in non-forested areas and arboreal lichen feeding appeared to be minimal. Based on this information suggesting that terrestrial lichens were important winter forage for these caribou, the British Columbia Ministry of Forests developed Caribou Habitat Maps for both winter ranges, with habitat units based on terrestrial lichen abundance (B.C.M.O.F. 1987a, B.C.M.O.F. 1987b).

The preliminary information on habitat use and foraging habits was used to formulate hypotheses for selection of winter habitat types and feeding sites by caribou.

Hypothesis 1:

During the winter months, caribou select forest stands containing abundant terrestrial lichens and avoid stands where lichens are uncommon.

Terrestrial lichens are poor competitors against vascular plants; they are most abundant on nutrient-poor, dry, open sites where competition from vascular plants is minimal or nonexistent (Hale 1983, Johnson 1981, Kershaw 1977, Rowe 1984). Because terrestrial lichens are abundant on poor quality growing sites, trees growing on those sites are usually slow growing and of poor quality and low timber value. Lichens also have slow growth rates and are associated with late successional stages (Carroll and Bliss 1982, Hale 1983, Klein 1982). Mature pine stands in the study area contain greater amounts of terrestrial lichens than immature stands (Clement 1987).

Hypothesis 2:

During the winter months, caribou select mature timber types on poor quality forest growing sites and avoid immature stands and timber types on good growing sites.

Hypotheses 1 and 2 were tested by determining caribou habitat types and forest cover types most frequently used by caribou, and comparing habitat use to habitat availability.

Caribou selection of habitat types during winter could also be influenced by snow conditions. In non-forested areas, snow accumulation may impede caribou movements and cratering. In forested areas, snow interception by coniferous trees should result in less snow accumulation than in unforested areas, making locomotion and cratering easier in the forested areas. Snow depth was measured over the winter in open habitat,

and in immature pine and mature pine stands to determine whether snow conditions differed between the 3 habitat types, thus potentially affecting habitat use by caribou.

Within each habitat type, selection of feeding sites likely depends on microhabitat characteristics. On treeless Arctic ranges, barren-ground caribou crater where snow depth and hardness are relatively low (Duquette 1988, Henshaw 1968, Laperriere and Lent 1977, Miller 1976, Pruitt 1959). Within forested winter ranges, woodland caribou in southeastern Manitoba and west-central Alberta selected crater sites based on terrestrial lichen availability and snow conditions (Darby and Pruitt 1984, Edmonds and Bloomfield 1984). From this information, hypotheses on feeding site selection by woodland caribou in west-central B.C. were formulated.

Hypothesis 3:

> Caribou crater in areas where terrestrial lichens are abundant, and avoid cratering where terrestrial lichens are absent or present in low quantities.

Hypothesis 4:

> Caribou crater in areas where snow conditions (snow depth, snow penetrability) allow easier digging and locomotion (i.e., shallow snow packs, greater snow penetrability).

Hypotheses 3 and 4 were tested by comparing snow conditions and lichen cover at feeding craters used by caribou, to snow conditions and lichen cover in areas where caribou travelled without cratering.

Food habits were determined by examination of feeding craters in winter, and by analysis of fecal samples collected throughout the year.

OBJECTIVE II: Population size, calf production, calf survival and adult survival.

Population parameters were monitored to determine the current status of the two populations. Population status was determined by comparing calf survival and adult mortality. Calf survival was documented in the Itcha Mountains during calving, and calves associated with radiocollared female caribou were monitored throughout the year to identify seasonal patterns of calf mortality. Causes and rates of adult mortality were determined to identify important limiting factors of the population.

Information obtained on both resource selection and population status are used to evaluate possible effects of logging on caribou populations. From this information, management recommendations for logging practices compatible with caribou winter habitat use are proposed.

STUDY AREA

The study area was located in the western part of central British Columbia (Fig.1), almost entirely within the Interior Plateau physiographic region (Holland 1976). The southern section of the study area extended from the Rainbow Mountains in Tweedsmuir Park, east to 20 kilometers east of the Chilcotin River, and northeast to the Blackwater River. Most of this area lies between 1200 and 1650 meters on the Fraser Plateau region of the Interior Plateau. Three dome-shaped shield volcanos rise from the flat or gently rolling upland, up to 2350 meters in the Itcha Mountains, 2400 meters in the Ilgachuz Mountains and 2475 meters in the Rainbow Mountains (Holland 1976). This southern part of the study area consisted predominantly of the Very Dry Central Montane Spruce biogeoclimatic subzone (MSd) (B.C.M.O.F. 1989a). The Sub-Boreal Pine-

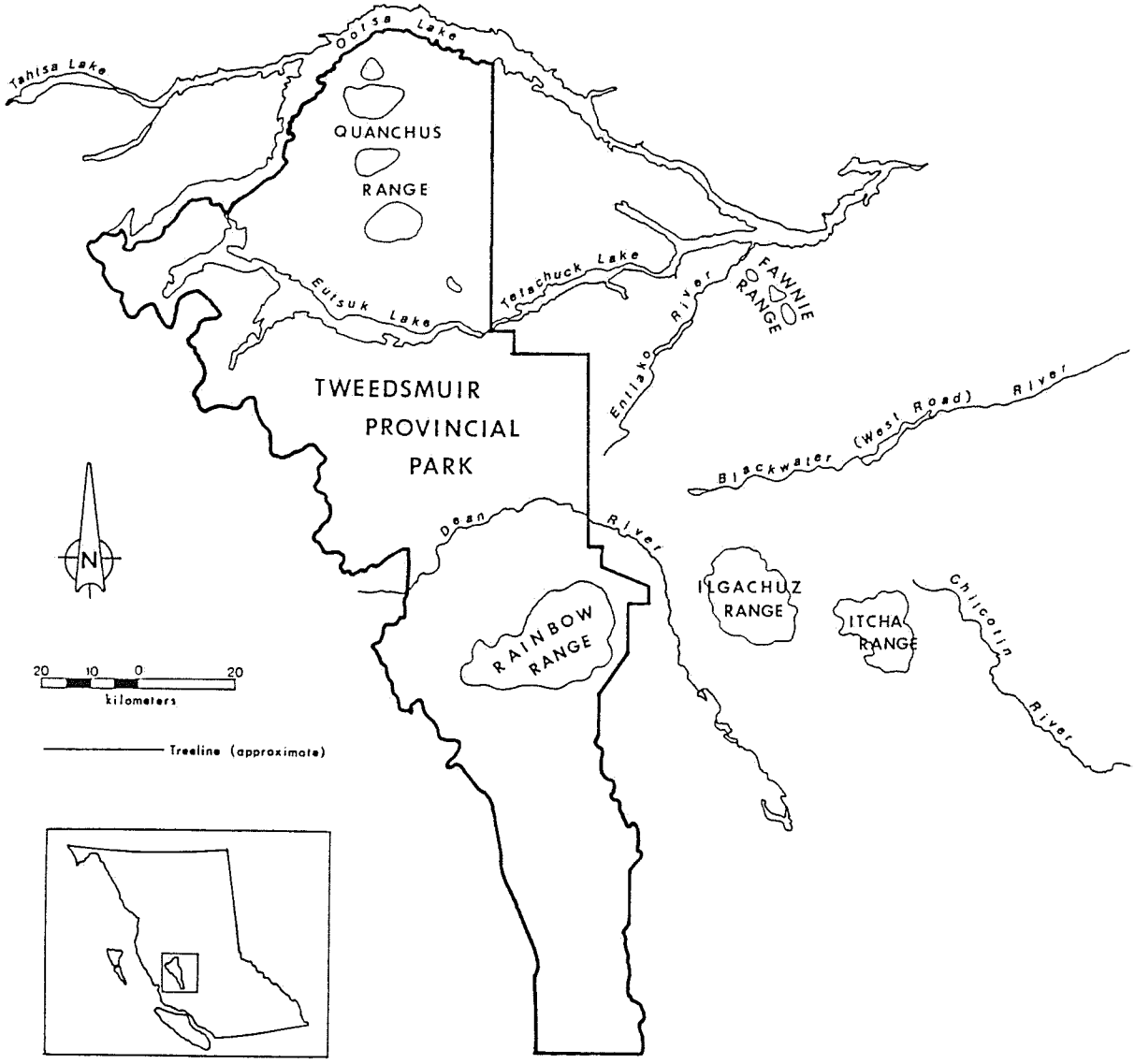

Fig.1. Location of the study area in west-central British Columbia.

Spruce (SBPS) zone occurred at lower elevations (<1300 - 1500 meters) and the Engelmann Spruce Subalpine Fir zone (ESSF) occurred at higher elevations (>1650m) (B.C.M.O.F. 1989b). Alpine tundra was present in the Itcha, Ilgachuz and Rainbow Mountains above the ESSF. The MSd and SBPS were dominated by lodgepole pine (*Pinus contorta*) stands. Interior spruce (*Picea glauca* X *engelmannii*) occurred adjacent to wetland sites in pure stands or in mixed pine/spruce stands. The shrub layer was limited primarily to soapberry (*Shepherdia canadensis*); ground cover and herb layer consisted of mosses, terrestrial lichens (*Cladina* spp., *Cladonia* spp. *Stereocaulon* spp., *Peltigera* spp.) and kinnikinnick (*Arctostaphylos uva-ursi*). Large dry, grass-lichen (fescue-lichen) meadows were present in areas of cold air ponding and wet sedge fens and shrub-carrs occurred along drainages and in areas where the watertable was at or near the surface (Clement 1987). *Festuca altaica* was the dominant grass in fescue-lichen meadows, and scrub birch (*Betula glandulosa*) and willows (*Salix* spp.) were associated with shrub-carrs and interfaces between open areas and forest stands. Lodgepole pine, interior spruce and subalpine fir (*Abies lasiocarpa*) were the major components of stands in the ESSF. Arboreal lichens, almost exclusively *Bryoria* spp., were found in all stand types. The alpine tundra zone was dominated by dry alpine communities such as alpine grasslands and dwarf scrub. Vegetation consisted of terrestrial lichens, grasses, and dwarf scrub (*Cassiope* spp., *Arctostaphylos uva-ursi*, *Phyllodoce* spp., *Empetrum nigrum*, *Vaccinium* spp., *Dryas* spp., *Salix* spp., *Betula glandulosa*) (Pojar 1983).

The northern part of the study area extended from the area in and to the west of northern Tweedsmuir Park, east and southeast to the Fawnie Mountains and to the Blackwater River. Most of this area lies on the Nechako Plateau region of the Interior Plateau; however, the westernmost part of Tweedsmuir Park and the area to the west are part of the Coast Mountains physiographic region (Holland 1976). The Coast

Mountains adjacent to northern Tweedsmuir Park are typically round-topped mountains with peaks ranging from 2000-2300 meters. Rivers transecting the ranges result in relief of 1500-2000 meters. The Nechako Plateau lies between 850 and 1300 meters and is characterized by flat or gently rolling terrain. The round topped Quanchus Mountains and Fawnie Mountains rise up from the Nechako Plateau to 2250 meters and 1920 meters respectively. Most of the Nechako Plateau consisted of the Sub-Boreal Spruce (SBS) and SBPS biogeoclimatic zones (Lewis et al. 1986). The ESSF zone occurred at higher elevations (>1200m) and alpine tundra occurred above the ESSF in the Fawnie Mountains and in the mountains of northern Tweedsmuir Park. Lower elevation forested areas consisted of lodgepole pine or mixed lodgepole pine/spruce stands. Spruce also occurred in bands along lakes and wetlands as well as in wetlands (forested wetlands). Lakes and sedge fens were common and often occurred in mosaics of lakes, fens, and fringe forests of spruce. Shrubs and ground cover were similar to that of the Itcha-Ilgachuz-Rainbow area but included a greater variety of species. Arboreal lichens occurred throughout the forested habitats but were especially abundant in forested wetlands and spruce fringes surrounding lakes and fens. The western part of northern Tweedsmuir Park and the area to the west consisted of the Coastal Western Hemlock (CWH) biogeoclimatic zone at low elevations, and the Mountain Hemlock (MH) or ESSF zone at higher elevations, below the alpine tundra zone. Forest stands in this area were generally mixed stands of amabalis fir (*Abies amabalis*), western red cedar (*Thuja plicata*), hemlock (*Tsuga* spp.), spruce (*Picea* spp.) and Douglas-fir (*Pseudotsuga menziesii*). Alpine tundra in the Quanchus Mountains and Fawnie Mountains was dominated by dry alpine communities. In western Tweedsmuir Park and the Coast Mountains, the alpine tundra zone was dominated by moister dwarf scrub and herb meadow communities (Pojar 1983).

Most of the study area lies within the rainshadow of the Coast Mountains and is characterized by a dry continental climate. Summers are typically cool, short, and dry, and winters are very cold, long, and dry. The weather station at Tautri Lake, 40 km southeast of the study area (SBPS biogeoclimatic zone, 1200 meters above sea level) reports mean annual precipitation and winter snow accumulation of 420 mm and 50 cm respectively (Annas and Coupe 1979). Soils throughout the winter ranges are predominantly Brunisolic Gray Luvisols and Dystric Brunisols on morainal deposits (B.C.M.O.F. 1989a,1989b, Lewis et al. 1986).

METHODS

CARIBOU CAPTURE AND MARKING

Caribou were captured using 3 methods. In the Itcha-Ilgachuz-Rainbow area, caribou were captured during late fall (October-November) or late winter (March-April) by netgunning them from a helicopter, or by herding them with a helicopter into drive nets. In the Tweedsmuir-Entiako area, caribou were caught from boats as they crossed Tetachuck Lake during fall migration in November 1983 and November 1984 (Marshall 1984). In February 1987, caribou found in alpine habitat in the Fawnie Mountains were netgunned from a helicopter. A total of 52 adult female caribou were radiocollared (Tweedsmuir-Entiako-25, Itcha-Ilgachuz-Rainbow-27). Each female caribou was fitted with a radiocollar and unique eartag/collar colour combination which permitted identification of individual caribou. Thirty-eight of the 52 radiocollars were equipped with motion sensitive devices which aided in the early detection of mortality. When possible, total length, chest girth and hind foot length were measured and blood samples were

taken. A summary of capture information and mean body measurements is presented in Appendix I.

SEASONAL MOVEMENTS AND HABITAT USE

During the 3 year study (April 1985 - March 1988), radiocollared caribou were located by telemetry from aircraft approximately every 2-3 weeks from April to November, and weekly from December to March. Locations were plotted onto 1:100 000 scale map sheets and habitat, aspect and elevation of each location were recorded. Coordinates of each location were recorded to the nearest 0.5 kilometer and plotted by the HOME program on UBC MTS (Harestad 1981).

Winter locations were also plotted onto 1:50 000 scale B.C. Forest Service forest cover maps and caribou habitat maps (B.C.M.O.F. 1987a, 1987b). Locations that were not plotted directly onto forest cover maps or caribou habitat maps after each telemetry flight were not used in the analyses. Therefore, locations from winter 1985/86 were not used. Data from the winters of 1986/87 and 1987/88 were combined for the analyses.

Forest cover types were grouped according to dominant tree species present. Each group was divided into immature (age classes 1-4, 0-80 years) and mature (age classes 5-9, >80 years) age classes and further divided into low, poor and medium productivity types. Low productivity sites were lower quality sites than poor sites, which in turn were lower than medium sites. Availability of each forest cover type in the Itcha-Ilgachuz winter range was determined by plotting 1449 random points onto forest cover maps of the study area and calculating the proportion of the total random points occurring in each forest cover type. A 95% confidence interval was calculated for each forest cover type available using the Bonferroni z statistic (Neu et al. 1974). Availability of forest cover

types in the Tweedsmuir-Entiako winter range was determined as a proportion of the total area using the B.C. Ministry of Forests GEOMAP database.

Caribou habitat type polygons (individually labelled map units) were grouped according to abundance of terrestrial lichens as described in Tables 1 and 2. A more detailed description of individual habitat units can be obtained from the B.C. Ministry of Forests (Williams Lake; Smithers). In general, in the SBPSmc (previously SBSa2), SBS and MSd biogeoclimatic subzones, dry lichen (DL) sites contained the most terrestrial lichen. Lichen moss (LM) sites contained less terrestrial lichen and more moss than DL sites. Moss (M), seepage forest (SF) and aspen forest (AF) sites contained very little or no terrestrial lichen. All forested habitat types contained arboreal lichens but moister types (M,SF) appeared to contain larger quantities of arboreal lichens than drier types (DL,LM). Wetlands (W), non-forested wetlands (NW), and forested wetlands (FW) were wet, generally open areas containing primarily grasses, sedges and shrubs. Fescue-lichen (FL) meadows were dry open areas containing grasses (primarily *Festuca altaica*) and terrestrial lichens. In the SBPSxc (previously SBSa1) subzone, dry lichen and kinnikinnick (K) sites contained the most terrestrial lichen. All other habitat types in the SBPSxc subzone contained little terrestrial lichen. Each group was divided into immature (age classes 1-3, 0-80 years) and mature (age classes 4-5, >80 years) age classes. Availability of each caribou habitat type in the Tweedsmuir-Entiako winter range was determined as a proportion of the total area using the Ministry of Forests GEOMAP database. Availability of each caribou habitat type in the Itcha-Ilgachuz winter range was determined by plotting 1932 random points onto caribou habitat maps of the study area.

Caribou use of forest cover types and caribou habitat types was calculated as the proportion of radiocollared caribou locations in each type for winter (December - March),

Table 1. Description of Caribou Habitat Types in the Tweedsmuir-Entiako study area.

Caribou Habitat Type	Description and associated polygon units
DLLM	Dry Lichen / Lichen Moss -includes dry lichen / lichen moss combinations and dry lichen leading and dominant over moss DL, DL/LM, DL//LM, LM/DL, LM//DL, DL//M, DL/M
LM	Lichen Moss -lichen moss leading and dominant over moss LM, LM//M, LM/M
DLLM MOSAIC	Dry Lichen / Lichen Moss Ecomosaic -combinations of dry lichen or lichen moss with adjacent wetlands or seepage forests DL/SF, DL/W, W/DL, SF/DL, DL//SF, DL//W, W//DL, SF//DL LM/SF, LM/W, W/LM, SF/LM, LM//SF, LM//W, W//LM, SF//LM
MDLLM	Moss - Dry Lichen / Lichen Moss -moss leading and dominant over dry lichen or lichen moss; includes dry lichen or lichen moss as a 3rd unit with combinations of moss and seepage forest as the first 2 units M//DL, M//LM, M/DL, M/LM, M/SF/DL, M//SF/DL, M/SF//DL, M//SF//DL, SF/M/DL, SF//M/DL, SF/M//DL, SF//M//DL, M/SF/LM, M//SF/LM, M/SF//LM, M//SF//LM, SF/M/LM, SF//M/LM, SF/M//LM, SF//M//LM
MSF/AF	Moss / Seepage Forest - Aspen Forest combinations -combinations of moss and seepage forest and aspen forest without dry lichen or lichen moss as the 3rd unit; aspen forest leading or dominant over any other habitat M, M/SF, M/AF, M//SF, M//AF, SF, SF/M, SF/AF, SF//M, SF//AF, AF//, AF/
W/FW	Wetlands / Moss - Seepage Forest Wetlands -wetlands; includes wetlands with fringe forests of moss or seepage forest W, W//M, W//SF, W//AF, W/M, W/SF, W/AF, M/W, SF/W, M//W, SF//W
LAKE	Lake

Symbols
A/B A leading over B (Amount of A = amount of B, in polygon)
A//B A dominant over B (Amount of A > amount of B, in polygon)
W = Nonforested wetland (NW) or Forested wetland (FW)

Table 2. Description of Caribou Habitat Types in the Itcha-Ilgachuz study area.

Caribou Habitat Type	Description and associated polygon units
DLLM	Dry Lichen / Lichen Moss combinations DL, DL/LM, DL//LM, LM/DL, LM//DL
LM	Lichen Moss -lichen moss pure and lichen moss dominant over moss LM, LM//M
DLLM MOSAIC	Dry Lichen / Lichen Moss Ecomosaic -combinations of dry lichen or lichen moss with adjacent wetlands or seepage forests DL/SF, DL/W, W/DL, SF/DL, DL//SF, DL//W, W//DL, SF//DL LM/SF, LM/W, W/LM, SF/LM, LM//SF, LM//W, W//LM, SF//LM
MDLLM	Moss / Dry Lichen / Lichen Moss -lichen moss, dry lichen, moss, leading but not dominant DL/M, M/DL, LM/M, M/LM
MSF	Moss / Seepage Forest combinations -includes moss dominant over lichen moss and dry lichen M, M/SF, M//SF, SF, SF/M, SF//M, M//DL, M//LM
W/FW	Wetlands / Forested Wetlands -includes wetlands with fringe forests of seepage forest or moss W, W//M, W//SF, W/M, W/SF, M/W, SF/W, M//W, SF//W
FL	Fescue Lichen meadows -includes fescue-lichen meadows with fringe forests of dry lichen or lichen moss and fescue-lichen / wetland combinations FL, FL//W, FL/W, W//FL, W/FL, FL//DL, FL//LM, FL/DL, FL/LM
SBPS-DLK	SBPSxc - Dry Lichen / Kinnikinnick combinations -includes dry lichen and kinnikinnick dominant over other SBPSxc units DL, DL/K, DL//K, K, K/DL, K//DL, DL//R, DL//M,
SBPS-OTHER	SBPSxc - units other than SBPS-DLK units

Symbols

A/B A leading over B (Amount of A = amount of B, in polygon)

A//B A dominant over B (Amount of A > amount of B, in polygon)

W = Nonforested wetland (NW) or Forested wetland (FW)

early winter (December - mid-January), mid winter (mid-January - mid-March) and late winter/early spring (mid-March - April). Differences between the pattern of caribou use, and availability of forest cover types and caribou habitat types, were tested by the chi-squared technique (Neu et al. 1974) at α=.05. Differences between caribou use and the availability of individual forest cover types and caribou habitat types were tested by using the Bonferroni z statistic (Neu et al. 1974) to calculate 95% confidence intervals (winter) or 90% confidence intervals (early winter, mid winter, late winter/early spring) for caribou use of each habitat type.

A summary of all altitudinal movements, habitat use, forest cover type use and caribou habitat type use data for each area by year and season is presented in appendix II.

Seasonal home ranges

Winter and summer home range sizes were calculated for individual radiocollared caribou for each year of the study. For the purposes of this study, home range is defined as the area used by an animal during a specified period of time based on radiotelemetry locations. It does not imply any periodicity of movements or intensity of use. Home range size was determined using the minimum convex polygon method with the HOME program on UBC MTS (Harestad 1981). Winter home ranges included locations from early December until the onset of spring migration in April/May and summer home ranges included locations from calving time until the onset of fall migration in October or November. Home ranges with less than 5 locations were not used in the analysis. Distances moved between summer and winter ranges were measured as the straight-line distance between calving sites and the visually estimated center of the winter home range of the following winter.

SNOW MEASUREMENTS

Snow stations were set up in the Itcha-Ilgachuz caribou winter range near Moore Creek (10 kilometers east of the Chilcotin River; 1500 meters above sea level; MSd biogeoclimatic subzone) during the winters of 1986/87 and 1987/88. Snow depth, observer sinking depth, and snow penetrability (1987/88 only) were measured biweekly from December to March in 3 habitat types (mature pine, immature pine, meadow). Snow penetrability was measured as the distance that a 1 kilogram weight penetrated the snowpack after being dropped from a height of 1 meter above the snow; divided by the snow depth at the site. A total of 30 measurements were taken in each habitat type; 5 measurements, at 6 stations, which were 25 meters apart.

When very fresh caribou tracks were encountered, caribou sinking depth, observer sinking depth and snow depth immediately adjacent to the caribou track were measured. Caribou sinking depth was regressed against observer sinking depth and the equation from the regression was then applied to the mean observer sinking depth at the snow stations to predict caribou sinking depths in all 3 habitat types over the winter.

WINTER FEEDING ECOLOGY

During the winter months, feeding sites of caribou in forested areas were investigated. The winter range of each caribou population was visited by snowmobile biweekly following radiotelemetry flights. When fresh caribou tracks were encountered in areas being used by radiocollared caribou, tracks were followed or backtracked to locate feeding sites. Very fresh tracks were backtracked to avoid displacing the caribou. Feeding site type (cratering, arboreal lichen feeding, browsing) was noted at each

feeding site, and the proportion of cratering sites versus arboreal lichen feeding sites was calculated for each habitat type. The proportion of cratering and arboreal lichen feeding in all forest types combined (pine, spruce and pine/spruce), was calculated by weighting the amounts of each feeding type in each forest type by the proportion of telemetry locations in each forest type:

$$\frac{\text{\# locations in forested habitat x}}{\text{\# locations in all forested habitat types combined}} \times \frac{\text{\# craters in habitat x (or arboreal lichen sites)}}{\text{total \# feeding sites in habitat x}}$$

The weighted proportions were then added to determine the overall proportion of craters and arboreal lichen feeding sites in all forested habitats combined.

In the winter of 1985/86, vegetation present in each crater was identified. During the winters of 1986/87 and 1987/88, crater sites (C) were compared to pits dug at 100 step intervals where caribou had travelled but not cratered (non-crater sites (NCS)). Snow conditions (snow depth, snow penetrability (1987/88 only)), canopy closure (1987/88 only) and presence and % ground cover of vegetation were measured at each crater and non-crater site. Percent ground cover of vegetation types was grouped into 5 classes; absent (0%), trace (<1%), low (2-14%), medium (15-39%) and high (>40%). Canopy cover in an area 10 meters in diameter around the crater was visually estimated as very open (<5% canopy cover), open (6-10%), moderately open (11-15%), moderately open - moderately closed (16-20%) and moderately closed (>20%).

A chi-squared contingency table was used to test the difference between the proportion of craters that contained terrestrial lichens and the proportion of non-crater sites that contained terrestrial lichens at $\alpha=.05$ (Mendenhall 1983). Differences between percent terrestrial lichen cover classes in craters and in non-crater sites, and differences

between percent canopy cover classes at craters and at non-crater sites were also tested using the chi-squared technique at α=.05.

Differences between mean snow depth at craters and at non-crater sites, and differences between mean snow penetrability at craters and at non-crater sites, were tested using paired t-tests for each sampling session at α=.05 (Mendenhall 1983).

FECAL ANALYSES

Food habits and diet quality were determined through analyses of fecal pellet groups. Fecal samples were collected monthly during the winter (December-March) for each area and opportunistically during the rest of the year. General trends in food habits were determined through fecal fragment analysis (Davitt and Nelson 1980). Pellets from 10 fecal samples collected during each sampling session were pooled and sent to the Wildlife Habitat Laboratory, Washington State University for analysis. Percent fecal nitrogen for each of 10 samples collected during each sampling session were analyzed using the microkjeldhal technique by the Faculty of Agriculture, UBC (A.O.A.C. 1984).

Annual patterns of food habits and percent fecal nitrogen were based on fecal samples collected in 1985/86 in the Itcha-Ilgachuz-Rainbow study area. Because fecal samples were collected opportunistically during spring, summer and fall, 1985/86 samples were supplemented with samples from April, May and December 1987 to demonstrate seasonal trends.

POPULATION PARAMETERS

Population size

Population censuses of the Itcha-Ilgachuz-Rainbow caribou were conducted in June when most caribou cows were present in the alpine in post-calving aggregations. All caribou in alpine habitat were counted and classified during an intensive search from a helicopter. A correction factor accounting for the caribou cows not present in the alpine during the census was calculated as:

$$\frac{\text{number of radiocollared caribou cows}}{\text{number of radiocollared caribou cows seen in alpine during the census}}$$

The total count of caribou cows in the alpine was multiplied by the correction factor to estimate the total number of caribou cows in both alpine and non-alpine habitats. Few bull caribou were present above treeline during the June census; therefore, a bull:cow ratio was determined from fall counts during the rut and applied to the number of cows present in June to obtain a total population estimate of bulls.

Less than 50% of the radiocollared caribou in the Tweedsmuir-Entiako area were present above treeline at any one time during the year. An estimate of the population size was attempted during the fall counts when approximately half the radiocollared cows were present in rutting areas above treeline. Thus, caribou were counted during an intensive helicopter search of alpine areas in the Quanchus range in October. The count was multiplied by a correction factor:

$$\frac{\text{number of radiocollared caribou}}{\text{number or radiocollared caribou counted in alpine habitat}}$$

to account for caribou in non-alpine habitat. Population estimates were calculated for the October 1986 and October 1987 surveys.

Adult mortality

Adult mortality rate was calculated as the proportion of radiocollared caribou dying between April and March of the following year. Causes of adult mortality were determined by necropsying radiocollared caribou that had died.

Adult harvest

Adult bull harvest rates were estimated by dividing the number of adult bulls harvested into the estimated number of adult bulls in the population. In the Itcha-Ilgachuz-Rainbow population, the estimated number of adult bulls was calculated by multiplying the bull:cow ratio (in October) by the corrected number of cows from the June census and adding the number of bulls harvested. In the Tweedsmuir-Entiako area, the number of adult bulls was calculated by multiplying the radiocollared caribou cow correction factor by the number of bulls counted in the Quanchus Mountains above treeline and adding the number of bulls harvested.

Calf production and recruitment

Pregnancy rates of the Itcha-Ilgachuz-Rainbow and Tweedsmuir- Entiako caribou were determined from a sample of 41 adult female caribou. Blood samples collected from caribou captured during late winter were analyzed for serum progesterone levels to determine pregnancy status (B.C. Biomedical Lab, Burnaby).

Calf production for both radiocollared and unmarked cows was determined by helicopter survey in mid-June. A calf count was conducted in October to determine

survival over the summer and another calf count was conducted in mid March to determine calf recruitment into the population for the year. During all 3 surveys, each radiocollared cow was located to determine if it had a surviving calf. Uncollared cows and calves seen during the counts were also recorded. Trends in calf survival were based on calves associated with the radiocollared female sample. The calf:cow ratio of the radiocollared caribou for each survey was corrected to account for adult mortality by dividing the number of radiocollared caribou cows with calves during the survey, into the number of radiocollared caribou cows known to be alive in June. Calves associated with radiocollared female caribou that died were presumed to have died also.

For each survey, uncorrected calf:cow ratios of radiocollared caribou cows and calf:cow ratios of all caribou seen were calculated for caribou found above treeline, and caribou found below treeline. Data from all 3 years were combined for June, October and March surveys. Differences between calf:cow ratios above and below treeline were tested using a chi-squared contingency table at α=.05 (Mendenhall 1983).

Population status

Population status of the two populations was determined by comparing the annual adult mortality rate of the radiocollared caribou sample with the March recruitment rate (calves/100 adult caribou, based on caribou counted both above and below treeline). Both adult mortality rate and recruitment rate were averaged over the 3 years. To compare recruitment rate to mortality rate, the denominator used in these rates had to be based on the number of caribou present in the population at the start of the year (April). The mortality rate was based on the number of adult radiocollared caribou present at the start of the year, but the recruitment rate was based on the number of adults present at the end of the year (March). Therefore, for the two rates to

be comparable, the recruitment rate was adjusted to take into account the adult mortality incurred during the year. Calf recruitment was adjusted for adult mortality by multiplying the number of adults counted during the March survey (for all 3 years combined) by 1/average adult survival rate. Confidence intervals for recruitment and mortality rates were calculated using the large sample normal approximation to the binomial distribution (Mendenhall 1983).

CALVING BEHAVIOUR

Calving sites

Radiocollared caribou locations from June calving surveys were plotted onto 1:500 000 base maps to identify important calving areas for each population. Calving site fidelity of individual caribou was determined by examining distances between locations of individual caribou during successive June survey flights.

Cumulative distance moved during summer was compared between radiocollared caribou with calves and radiocollared caribou without calves. Caribou with calves were defined as those caribou found with a calf during both June and October surveys. Caribou without calves were defined as those caribou found without a calf during both June and October surveys. Caribou that lost calves between June and October, or that were not seen during either June or October surveys, were not included in the analysis.

Calving ground observations

Ground surveys were conducted on the calving grounds in the Itcha Mountains from June 5 - July 24, 1985, June 3 - July 10, 1986 and May 25 - June 12, 1987. Alpine areas were surveyed by 2 observers over 2 or 3 day sessions. All caribou groups observed were counted and classified. Locations of each group were plotted onto 1:125 000 maps and elevations were recorded. When encountered, calf carcasses were necropsied. Ratios of calves/100 cows were calculated for each sampling session for each of the 3 years. Data from corresponding sampling intervals were combined for the three years of fieldwork and mean group size, typical group size, percentage of all groups consisting of a single cow or one cow and one calf, and percentage of all cows observed that were alone or with a calf were calculated. Typical group size is the mean size of the group in which the average individual finds itself and was calculated as the sum of squares of each group divided by the total number of individuals (Jarman 1982).

RESULTS

SEASONAL MOVEMENTS AND HABITAT USE

Seasonal movements and habitat use are described for Tweedsmuir-Entiako, Itcha-Ilgachuz, and Rainbow caribou separately. These three groupings were based on use of different calving grounds by the caribou.

Tweedsmuir-Entiako

In April, radiocollared caribou were located primarily in low elevation pine and pine/spruce forests on the south side of Tetachuck Lake (Figs.2,3,4). By early May, all

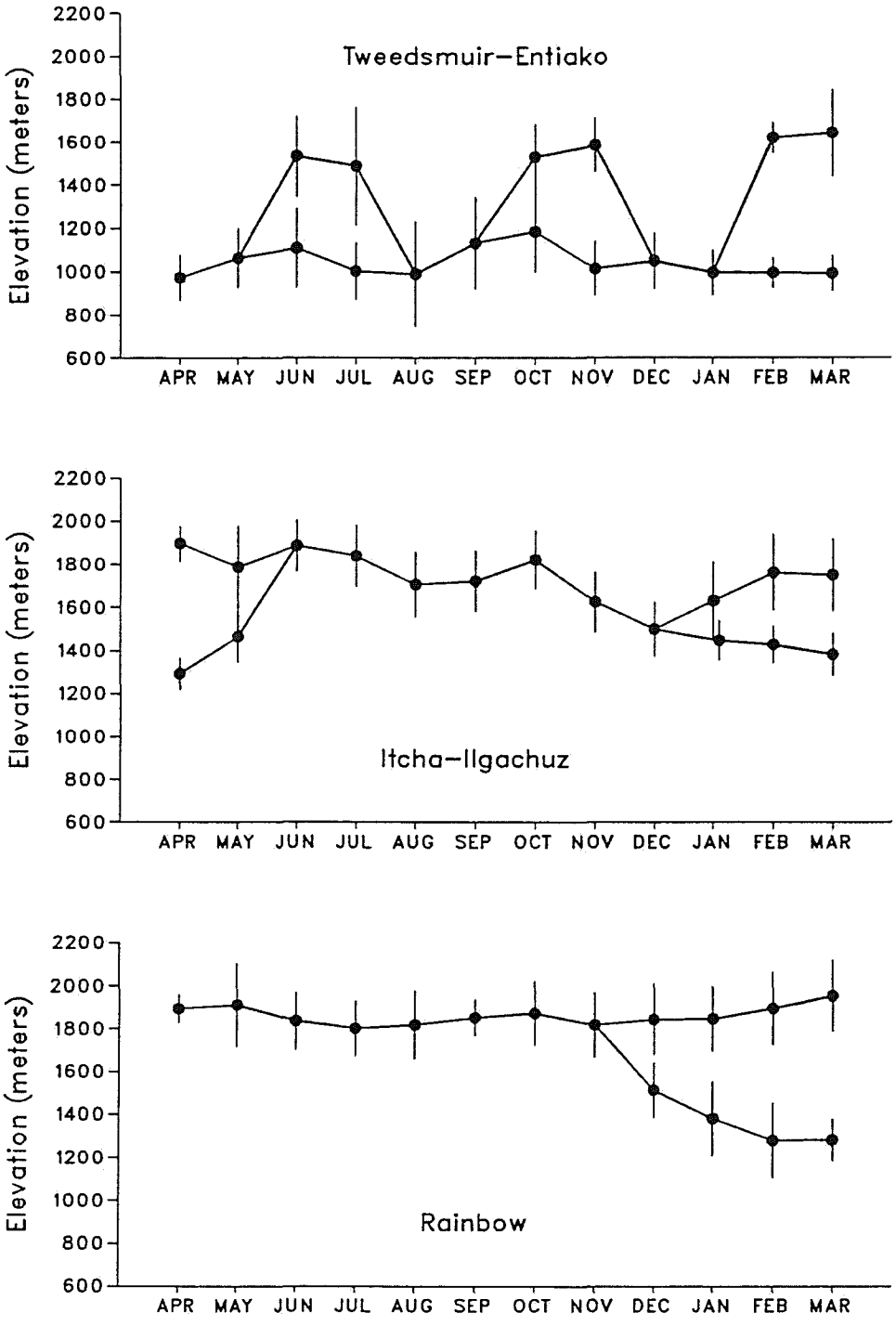

Fig.2. Mean elevation of radiocollared caribou locations (±1 standard deviation) in the Tweedsmuir-Entiako, Itcha-Ilgachuz and Rainbow areas, April - March, 1985/86, 1986/87 and 1987/88 combined. Upper lines represent caribou using alpine/subalpine habitat; lower lines represent caribou using lower elevation habitat.

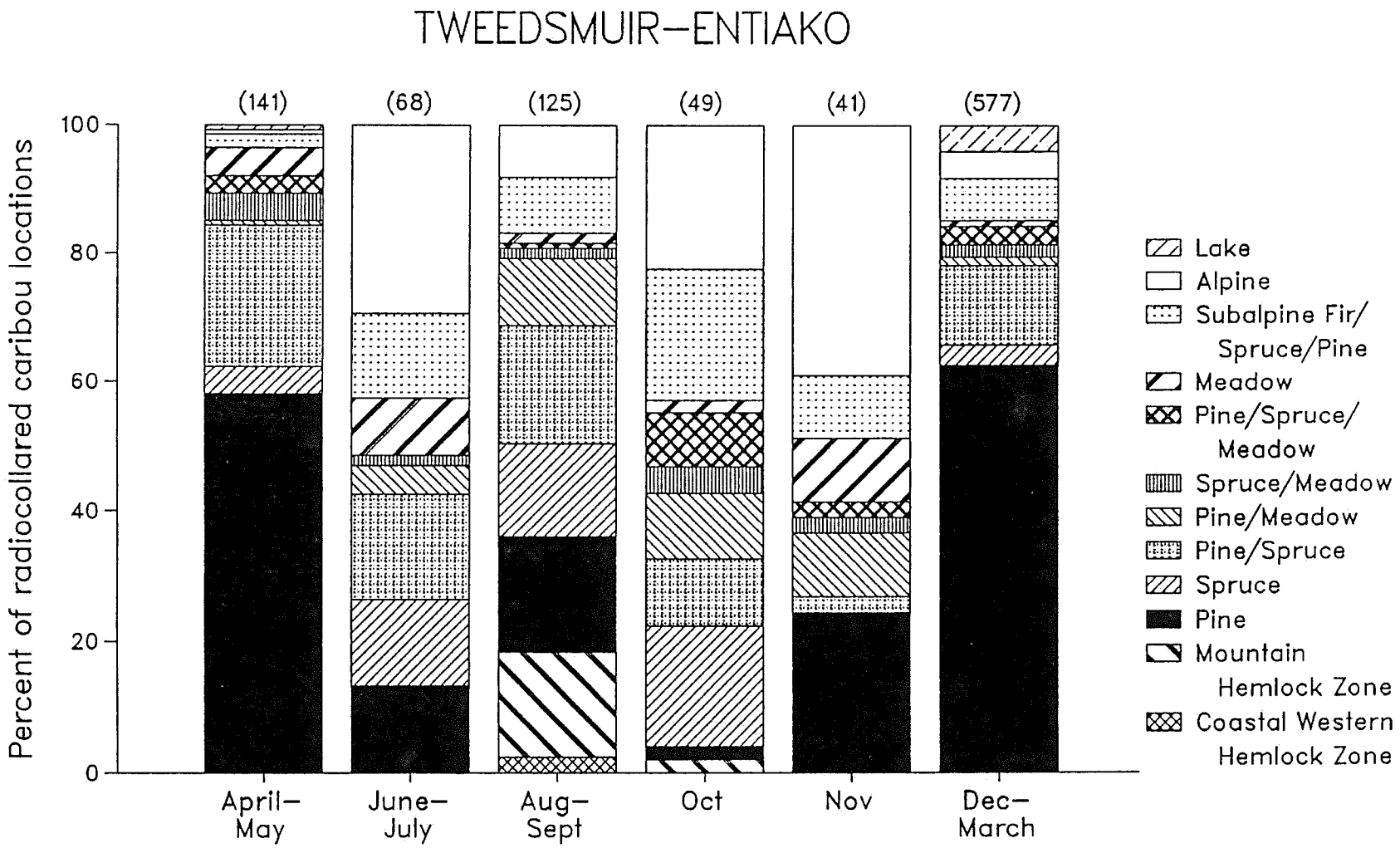

Fig.3. Proportion of radiocollared caribou locations in each habitat type in the Tweedsmuir-Entiako area, 1985/86, 1986/87 and 1987/88 combined. (N) = number of locations.

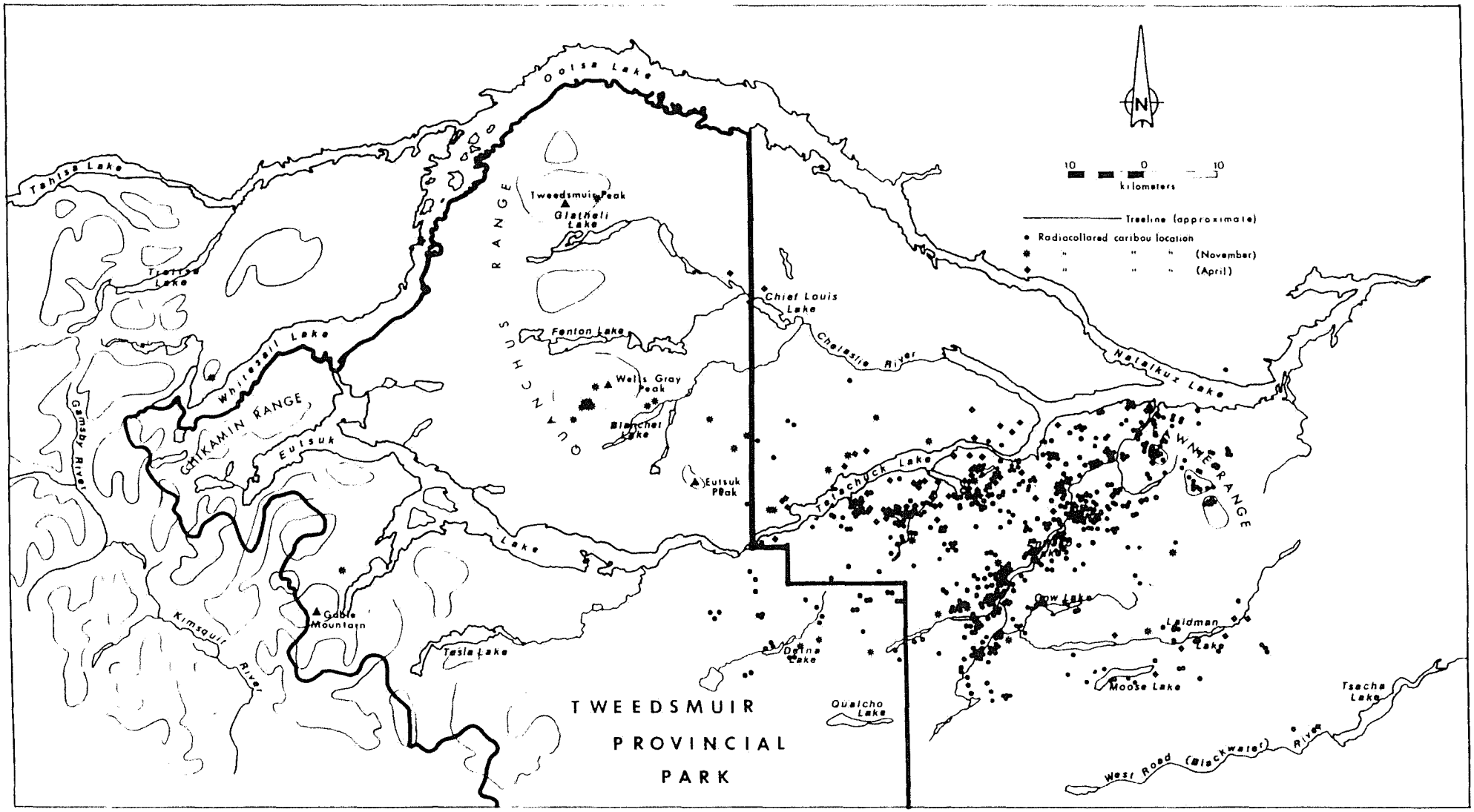

Fig.4. Radiocollared female caribou locations in the Tweedsmuir-Entiako area from November - April, 1985/86, 1986/87, and 1987/88 combined.

radiocollared caribou had moved north across Tetachuck Lake (Fig.5). During migration from winter to summer ranges, about 85% of the radiocollared caribou were found in low elevation forested habitats along the Chelaslie River drainage (Fig.6). Those caribou moved through the Quanchus Mountains at low elevations in the Glatheli Lake and Fenton Lake areas enroute to calving areas to the west and southwest near Tahtsa Lake, Whitesail Lake, Eutsuk Lake and the Gamsby River (Fig.5). About 15% of the radiocollared caribou moved along the north shore of Eutsuk Lake enroute to calving areas near the west end of Eutsuk Lake.

During calving and early summer (June-July), about 40% of the radiocollared caribou cows were found in alpine or subalpine habitat. These caribou were found mostly in the Chikamin Mountains, the mountains to the west and northwest of the Tweedsmuir Park boundary, and the mountains at the west end of Eutsuk Lake. Few caribou calved in the alpine or subalpine in the Quanchus Mountains. The other radiocollared caribou were found throughout northern Tweedsmuir Park (northeast of Eutsuk Lake) in low elevation forested habitat types. From July to September, caribou were widely distributed throughout the park and used a wide variety of habitats ranging from Coastal Western Hemlock forests at 500 meters to alpine habitat at 2000 meters. Movements during the summer and early fall consisted primarily of movements from high elevation alpine/subalpine habitat to lower elevation forested habitats. In August and September, over 80% of all radiocollared caribou locations were in low elevation forested areas. By October, up to 50% of the radiocollared caribou moved to rutting areas in the Quanchus Mountains. Almost half of the radiocollared caribou locations in October and early November were in alpine and subalpine habitat in the Quanchus Mountains. In addition, up to 20% of the radiocollared caribou used meadow and forest/meadow complexes east of the Quanchus Mountains. Other radiocollared caribou cows were found throughout the park in lower elevation forested habitat on the north side of

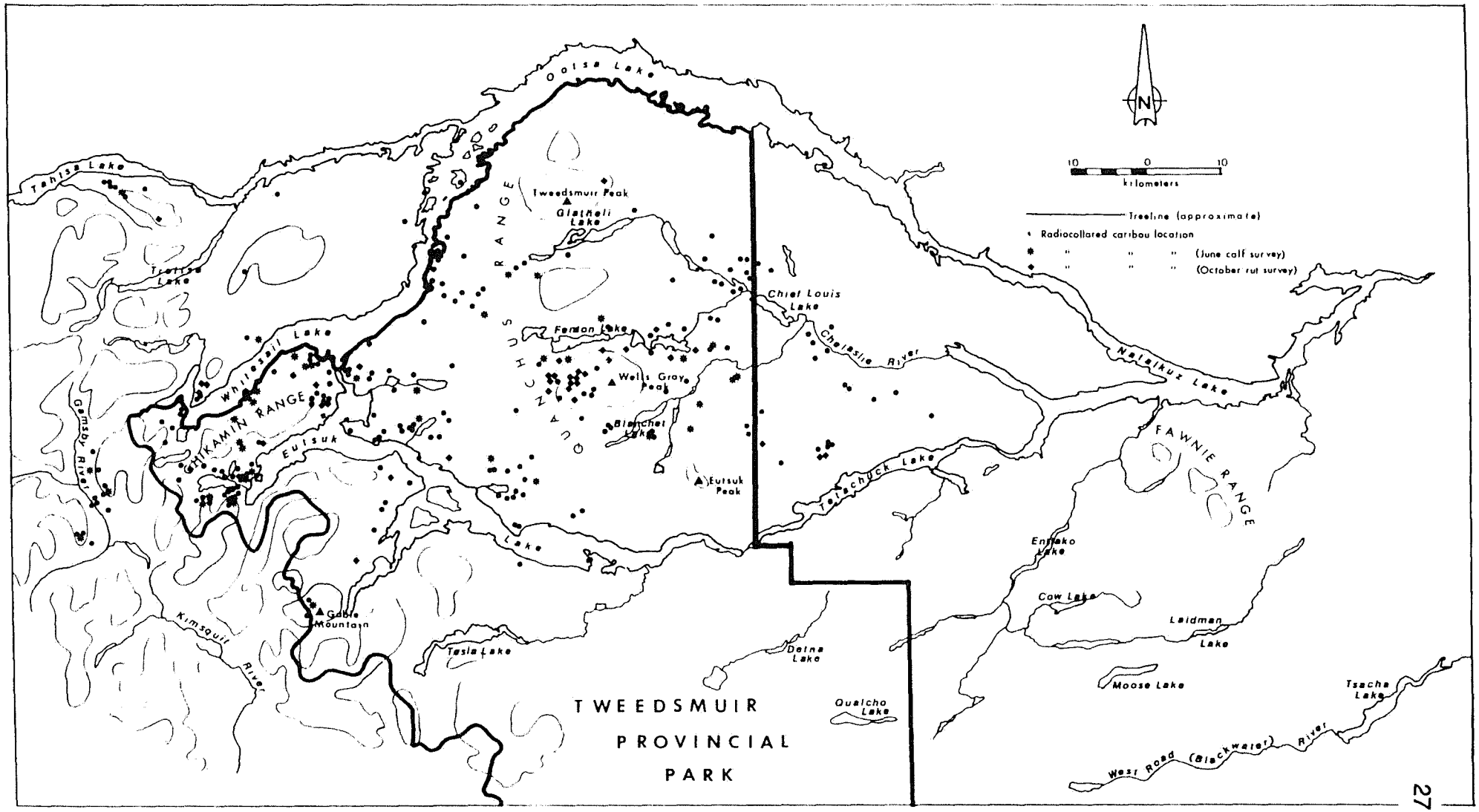

Fig.5. Radiocollared female caribou locations in the Tweedsmuir-Entiako area from May - October, 1985, 1986, and 1987 combined.

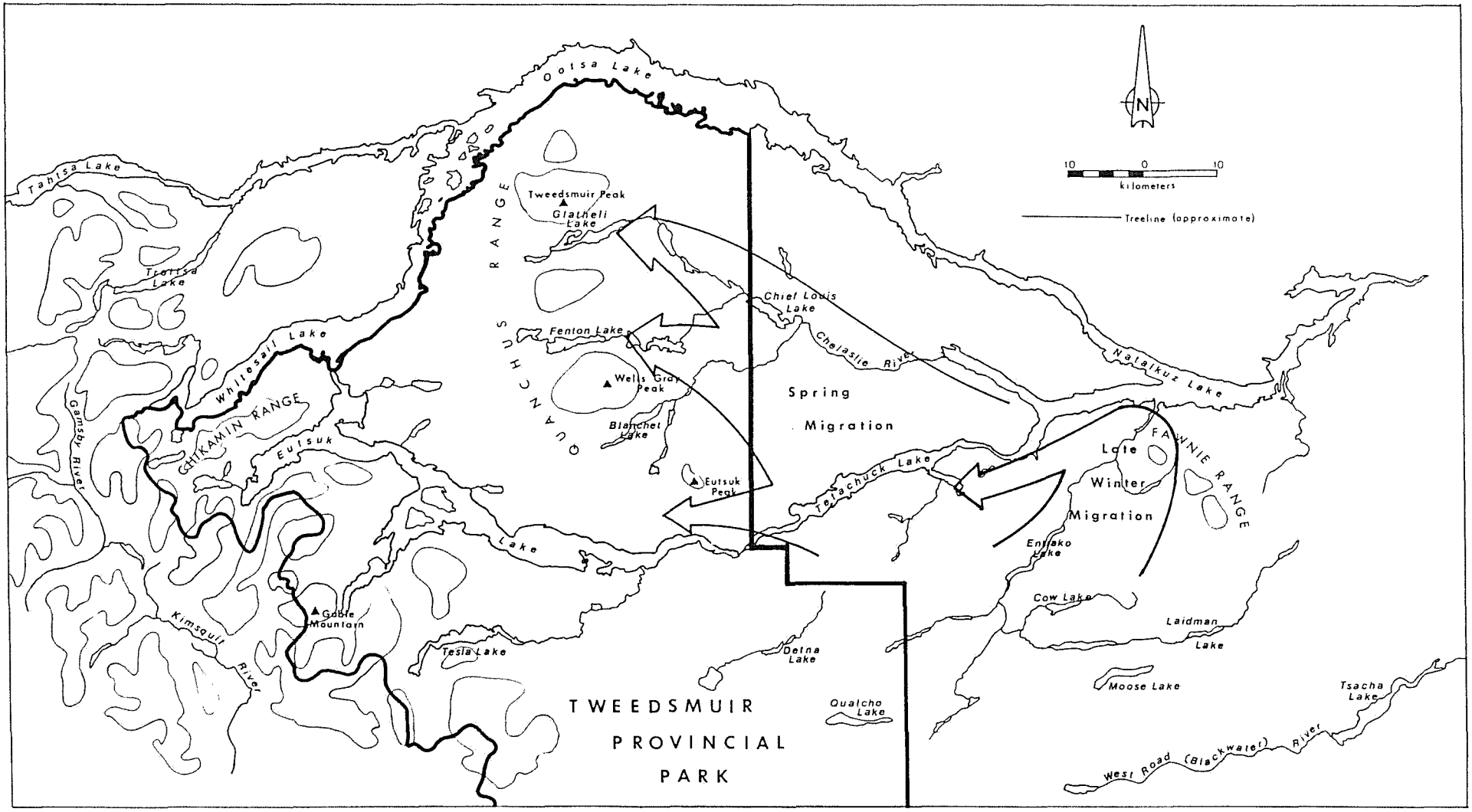

Fig.6. Late winter and spring migration routes of radiocollared female caribou in the Tweedsmuir-Entiako area.

Tetachuck Lake during the rut in October, and prior to crossing the lake in mid-November.

By late November, almost all radiocollared animals had moved south across Tetachuck Lake to the Entiako Lake area (Fig.4). The only exception occurred during the winter of 1987/88 when one radiocollared caribou remained in the Eutsuk peak area until mid-January, before moving south across Tetachuck Lake. During fall migration caribou did not appear to use specific crossing areas on Tetachuck Lake, but rather crossed anywhere along the lake.

Between early December and mid-February, caribou were distributed primarily throughout the Entiako River drainage. Some animals were also found near Laidman Lake, Moose Lake, and Tsacha Lake. During this time, almost 80% of the locations occurred in low elevation pine or pine/spruce forests (Fig.3). By late February up to 25% of the radiocollared caribou had moved into alpine habitat in the Fawnie Mountains. Use of alpine areas during late winter was variable during the 3 year study. In 1985/86 and 1986/87, 1 out of 12, and 3 out of 11 radiocollared caribou respectively were found in alpine areas in the Fawnie Mountains. In 1987/88 however, none of the 14 radiocollared caribou used alpine habitat any time during the winter. Caribou sign was absent from alpine areas in the Fawnie Mountains that year. Alpine habitat was used until mid-late March. In mid-March, radiocollared caribou concentrated at the mouth of the Entiako River and in the area to the east in pine/spruce and pine forests. Caribou exhibited a definite shift from the Entiako Lake area in early and mid-winter to the area near the mouth of the Entiako River in late winter (Fig.6). By late March caribou had moved to the south side of Tetachuck Lake before crossing the lake and migrating to summer range.

Some caribou did not undergo movements made by radiocollared caribou from summer range in northern Tweedsmuir Park to winter range south of Tetachuck Lake. A band of 10-20 caribou was reported to have wintered in northern Tweedsmuir Park along the south shore of Ootsa Lake in 1986/87 (Rick Marshall pers. comm.). Also, caribou were seen during summer and fall months south of Tetachuck Lake in the Moose Lake area (John Blackwell pers. comm.). Although some caribou are found north of Tetachuck Lake during winter, and others are found south of Tetachuck Lake during summer, the majority of the caribou in the Tweedsmuir-Entiako area move from summer ranges in northern Tweedsmuir Park to winter ranges south of Tetachuck Lake.

Itcha-Ilgachuz

In April, about 80% of the radiocollared caribou locations were in low elevation pine forest habitat in the Chilcotin River, Punkutlaenkut Creek and Coglistiko River drainages (Figs.2,7,8). The other caribou locations were on the north side of the Ilgachuz Mountains in alpine and subalpine habitat. Movements to summer range in the Itcha and Ilgachuz Mountains began in late April. By mid-May, caribou used forested habitats and meadows at the base of the Itcha and Ilgachuz Mountains and in the area between the two mountain ranges (Figs.9,10).

During calving in June, and up to mid-July, radiocollared caribou cows used primarily high elevation alpine or subalpine habitat in the Itcha and Ilgachuz Mountains (Fig.2,7,9). Alpine and subalpine were also the most heavily used habitats in August and September. Movements by radiocollared caribou between the Itcha and Ilgachuz Mountains occurred occasionally throughout the summer. Caribou located at lower elevations in the summer and early fall used pine forests or meadows in the vicinity of the Itcha and Ilgachuz Mountains.

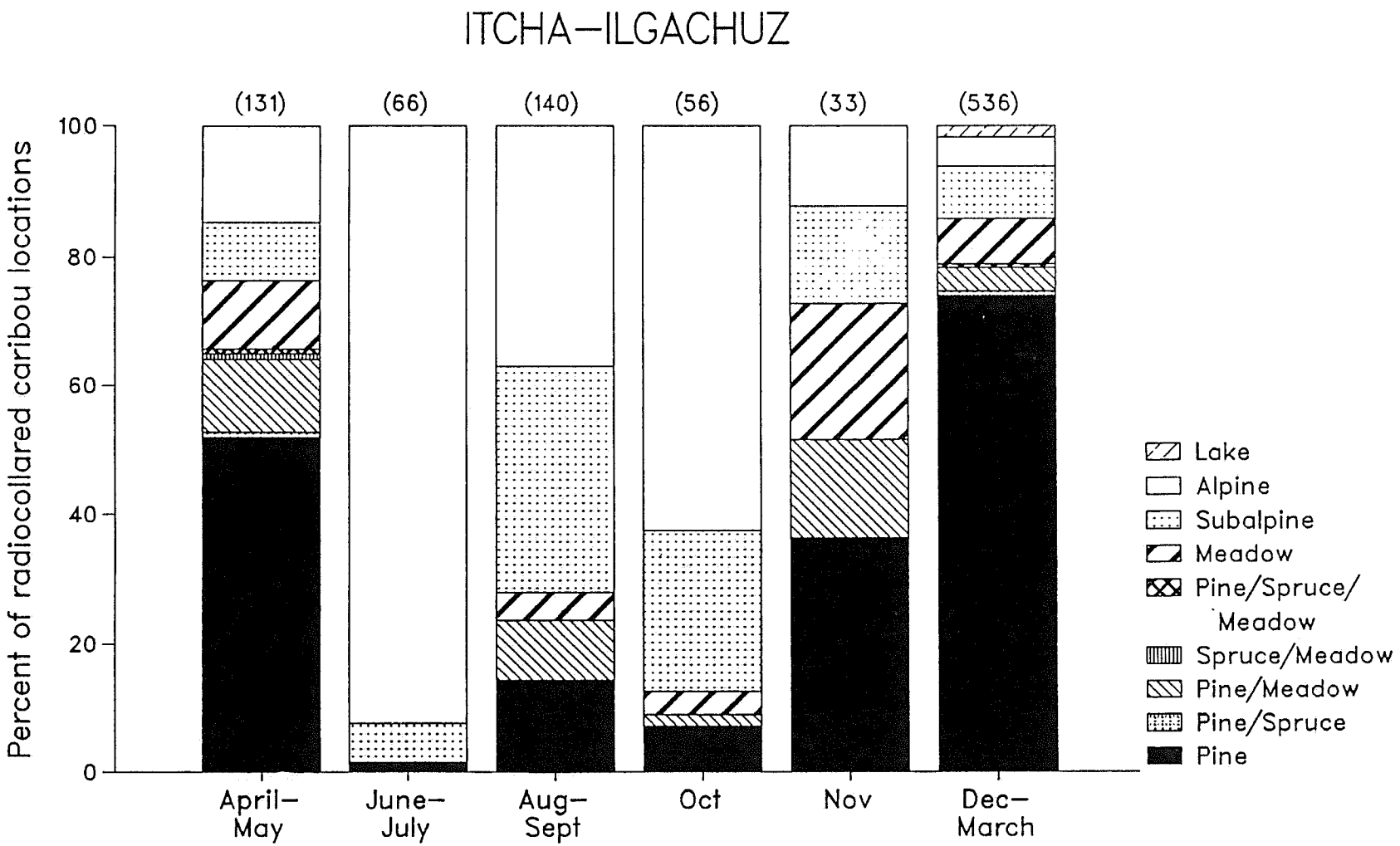

Fig.7. Proportion of radiocollared caribou locations in each habitat type in the Itcha-Ilgachuz area, 1985/86, 1986/87 and 1987/88 combined. (N) = number of locations.

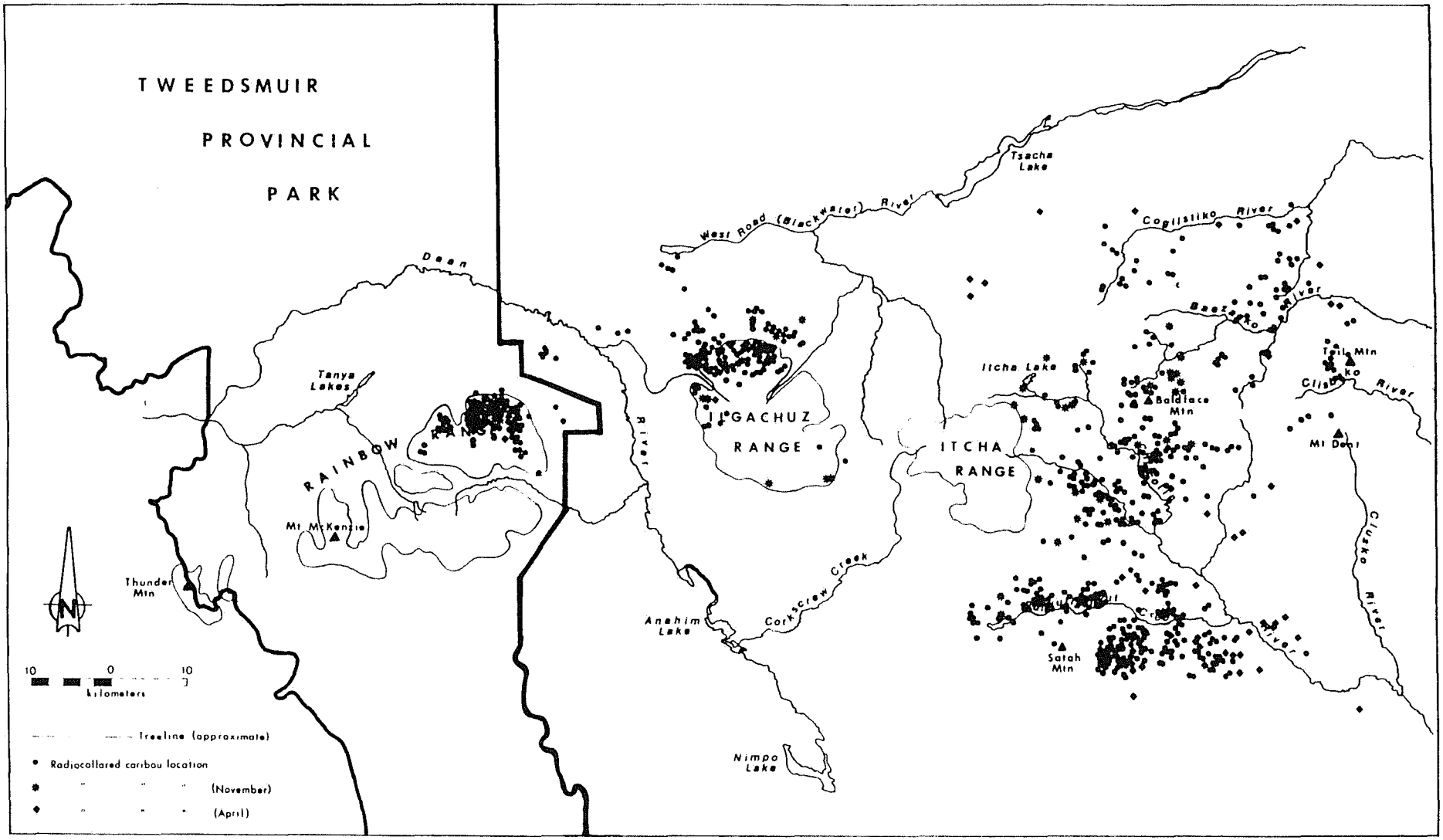

Fig.8. Radiocollared female caribou locations in the Itcha-Ilgachuz-Rainbow area from November - April, 1985/86, 1986/87, and 1987/88 combined.

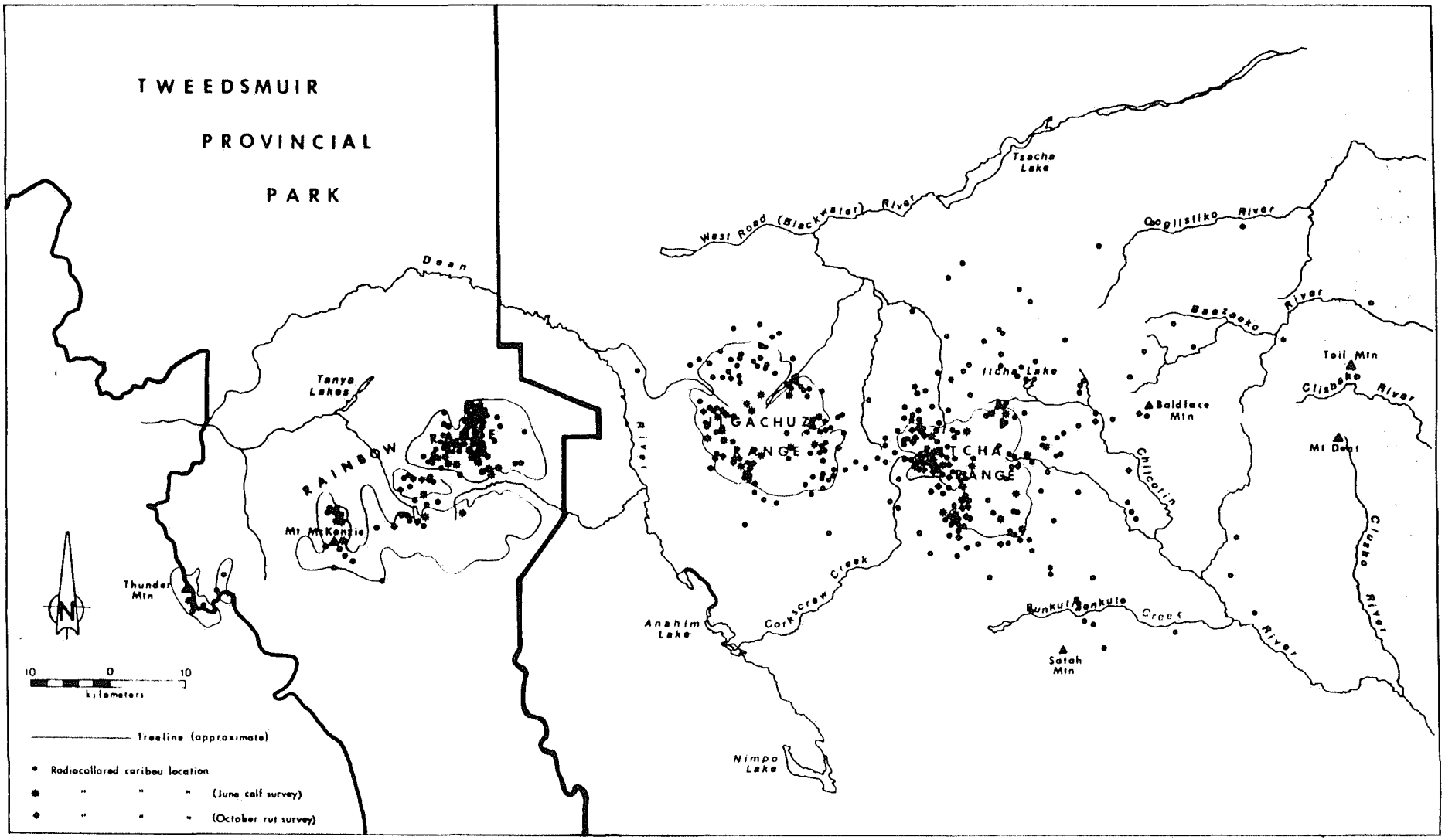

Fig.9. Radiocollared female caribou locations in the Itcha-Ilgachuz-Rainbow area from May - October, 1985, 1986, and 1987 combined.

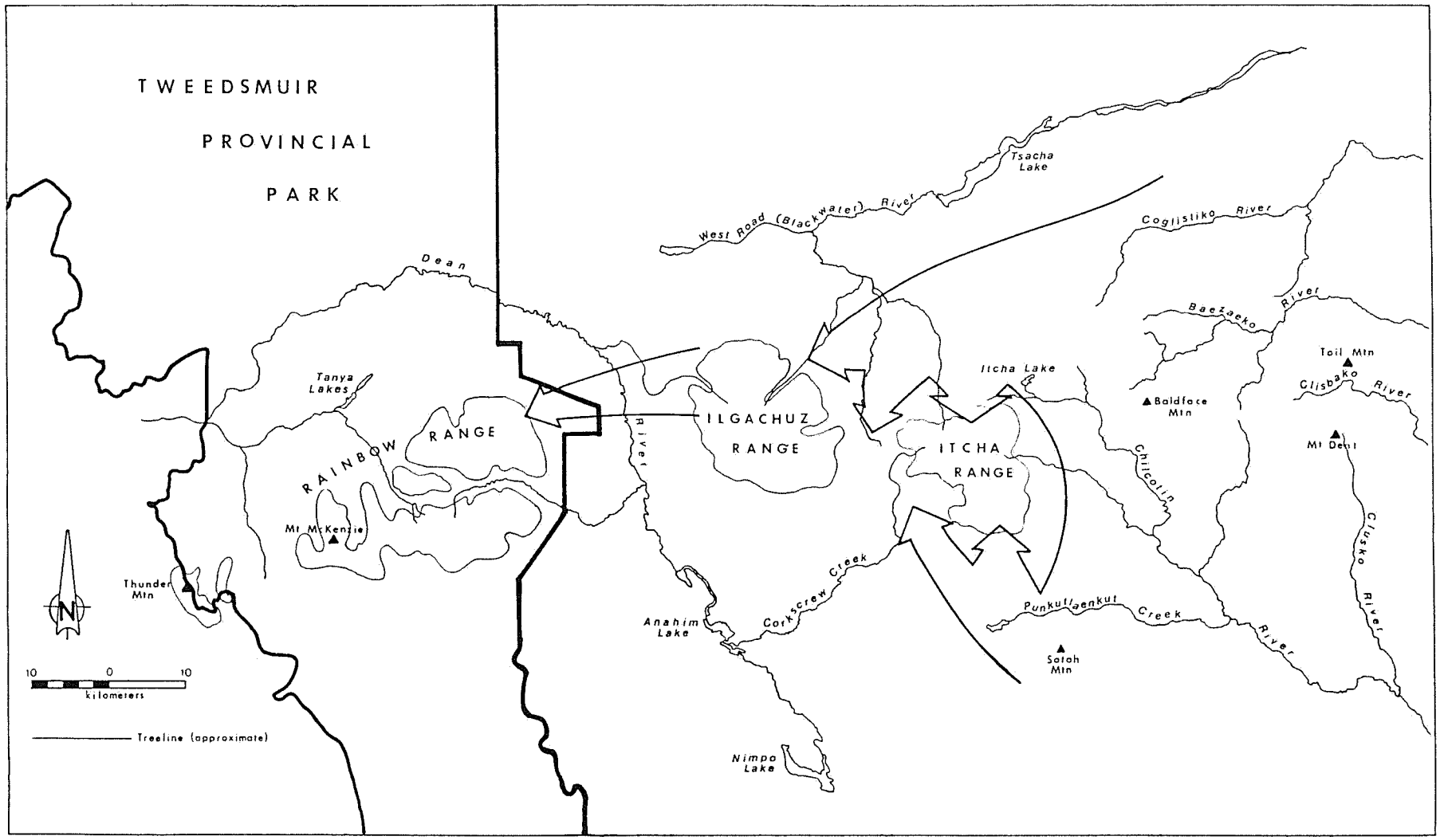

Fig.10. Spring migration routes of radiocollared female caribou in the Itcha-Ilgachuz-Rainbow area.

During the rut in October, almost 90% of radiocollared caribou locations were in alpine or subalpine habitat in the Itcha and Ilgachuz Mountains (Fig.7). By November, caribou began moving to large fescue-lichen meadows and pine forests east of the Itcha and Ilgachuz Mountains (Fig.7). During early winter (mid November - early January), caribou used large meadows at the headwaters of the Chilcotin and Baezaeko Rivers and pine forests throughout the Chilcotin River, Punkutlaenkut Creek, Baezaeko River and Coglistiko River drainages (Fig.8). In the winters of 1985/86 and 1986/87, caribou moved out of these large meadows by mid-December, but during the winter of 1987/88, they used this habitat type until mid-late January. From January to March, caribou were primarily found in lower elevation pine forests throughout the Chilcotin River, Punkutlaenkut Creek, Baezaeko River and Coglistiko River areas.

Each winter, 5-15% of the radiocollared Itcha-Ilgachuz caribou were found on windswept slopes on the north side of the Ilgachuz Mountains (Fig.7,8). The proportion of radiocollared caribou using alpine (20%) was similar to the proportion of the total population using alpine (300/1500) indicating that the radiocollared caribou were a good representation of the population. These animals remained in high elevation alpine or subalpine habitat until early-mid December, then moved to lower elevation forested or subalpine habitat north of the Ilgachuz Mountains until mid-late January. From late January to the end of March, these caribou were again found in high elevation alpine or subalpine habitat on the north slopes of the Ilgachuz Range. Some radiocollared caribou that spent the winter in the Ilgachuz Mountains during some years, were found in lower elevation pine forests to the east of the Itcha Mountains during other years.

Rainbow

Radiocollared Rainbow Mountain caribou cows almost exclusively used high elevation alpine habitats from April to November (Fig.2,11). In May, all radiocollared caribou were found on the north side of the Rainbow Range prior to dispersing throughout the range for calving in June (Fig.9). During the three year study, only once did a radiocollared caribou move out of the Rainbow Mountains during the summer. In late August 1987, one radiocollared caribou moved from the Rainbow Mountains to the Itcha Mountains before moving to the Ilgachuz Mountains in late September, where she remained throughout the winter. During the rut in October, caribou concentrated on the north side of the Rainbow Mountains but some were also found scattered throughout the range. By November, some of the radiocollared caribou moved to the north side of the Ilgachuz Mountains. The proportion of radiocollared caribou that moved varied between 1/7 and 3/4 for the three years of the study. Radiocollared Rainbow caribou that were found in the northern Rainbow Mountains during winter, were found mostly in alpine habitat. Radiocollared Rainbow caribou that were found in the northern Ilgachuz Mountains during winter, followed the same habitat use patterns as the Itcha-Ilgachuz caribou that spent the winter in the northern Ilgachuz Mountains. During winter 1987/88, one radiocollared Rainbow caribou used low elevation forested habitat east of the Itcha Mountains.

Seasonal Home Ranges

Tweedsmuir-Entiako: Variability in the size of the area used by radiocollared adult female caribou was high in both winter and summer (Table 3). The mean size of winter home ranges (527 km^2) was twice as large as the mean size of summer home ranges (246 km^2). On average radiocollared female caribou travelled a straight line

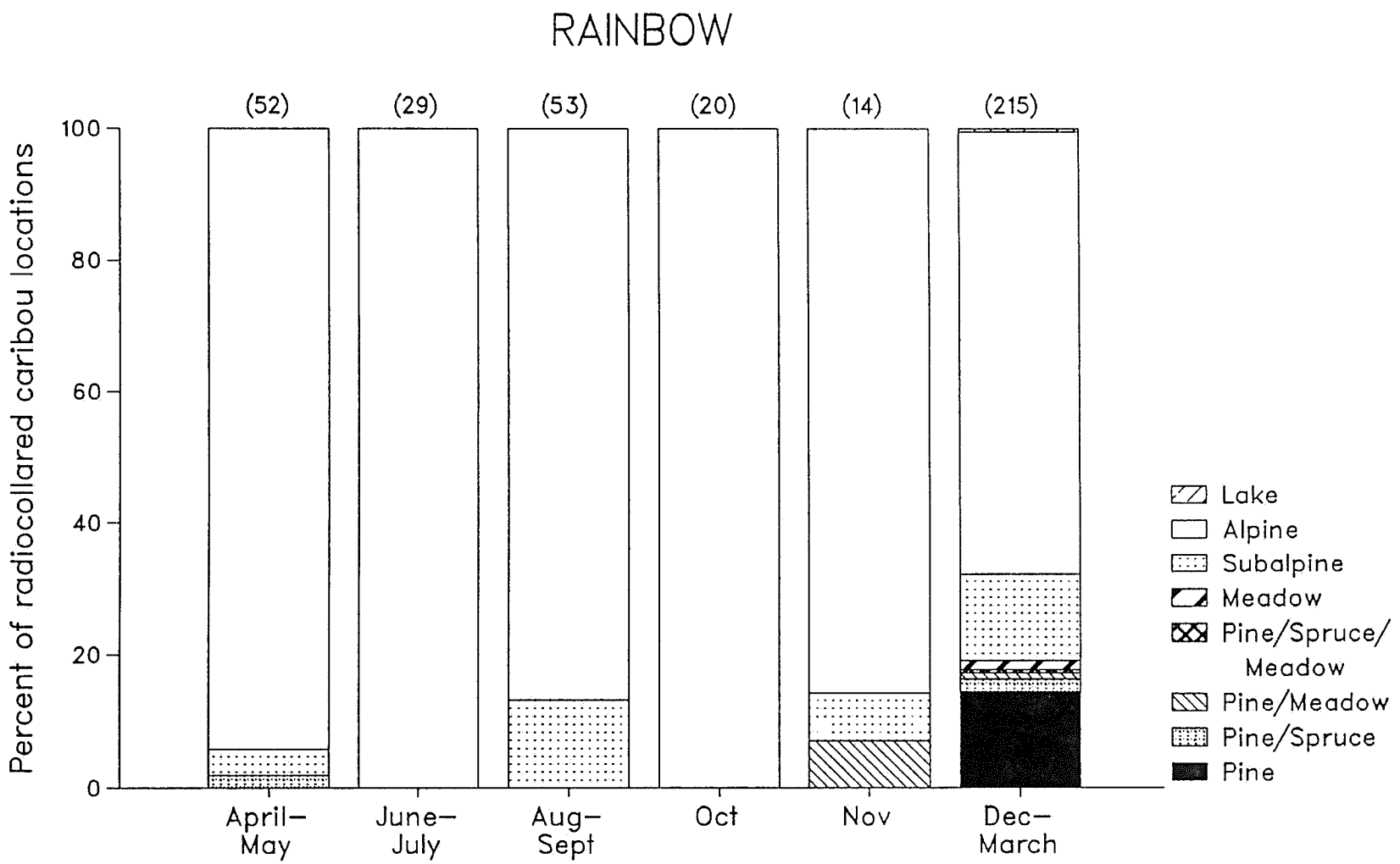

Fig.11. Proportion of radiocollared caribou locations in each habitat type in the Rainbow area, 1985/86, 1986/87, and 1987/88 combined. (N) = number of locations.

Table 3. Mean winter and summer home range sizes (in square kilometers) of adult radiocollared female caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas.

	N	Mean home range size (km^2)	Range
Tweedsmuir-Entiako			
Winter	37	527.0	68.1-1206.9
Summer	25	246.1	4.8- 731.4
Itcha-Ilgachuz-Rainbow			
Winter			
Alpine (Ilgachuz/Rainbow)	18	56.5	7.9-143.6
Forest	35	192.9	35.1-513.8
Summer	46	171.7	3.5-554.8

Table 4. Mean distance travelled (in kilometers) by adult radiocollared female caribou between the calving site and the centre of the winter home range in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas.

	N	Mean distance travelled (km)	Range
Tweedsmuir-Entiako	37	95.1	34.9-134.4
Itcha-Ilgachuz-Rainbow			
Calving site / wintering area in same mountain range	11	10.8	5.9-14.6
Calving site / wintering area in different mountain ranges	39	41.0	18.5-87.4

distance of 95 km between calving areas and winter ranges (Table 4). If travel routes are taken into account, some caribou travelled up to 160 km between calving sites and winter ranges.

Itcha-Ilgachuz-Rainbow: Radiocollared adult female caribou in the Itcha-Ilgachuz-Rainbow study area were divided into two groups; caribou that wintered in low elevation forests east of the Itcha Mountains, and caribou that wintered in alpine/subalpine areas in the Ilgachuz and Rainbow Mountains (Table 3). Caribou that wintered in low elevation forests used larger areas than caribou that wintered in the mountains (Table 3). Summer home ranges were similar in size to home ranges of caribou wintering in forested habitat. Caribou that wintered and calved in the same mountain range moved an average of 11 km between calving sites and winter range (Table 4). Caribou that calved and wintered in different mountain ranges, or caribou that wintered east of the Itcha Mountains moved an average of 41 km between calving site and winter range.

WINTER FOREST COVER TYPE USE

Tweedsmuir-Entiako

During winter, caribou using forested habitat were found primarily in mature pine stands on low and poor quality growing sites (Fig.12,Table 5). Use of immature pine stands decreased over winter whereas use of mature pine stands on medium quality sites increased (Fig.13,Table 5). During late winter, mature pine/spruce stands on medium sites were also heavily used.

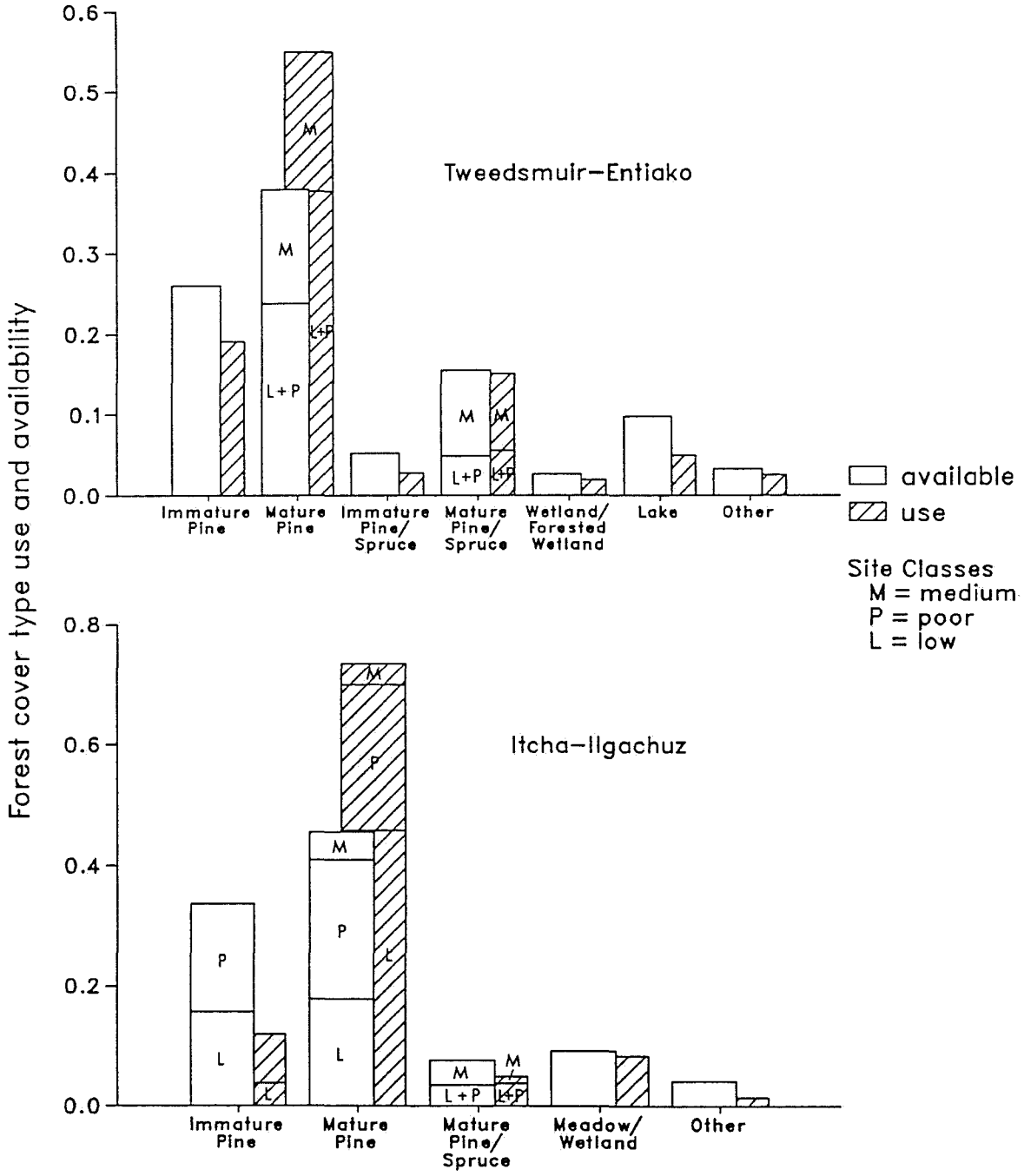

Fig.12. Proportion of each forest cover type available, and proportion of radiocollared caribou locations in each forest cover type during winter (December - March) in the Tweedsmuir-Entiako (N=366), and Itcha-Ilgachuz (N=369) winter ranges, December 1986 - March 1988.

Table 5. Percent of forest cover types available and percent of radiocollared caribou locations in each forest cover type in the Tweedsmuir-Entiako study area during winter (December - March), early winter (December - mid-January), mid winter (mid-January - mid-March), and late winter/early spring (mid-March - April) for 1986/87 and 1987/88 combined. Significance at α=.05 (winter) or α=.10 (early, mid and late winter).

Forest Cover Type	Available	Use Winter	Use Early Winter	Use Mid Winter	Use Late Winter
	%	%	%	%	%
PINE					
Immature	26.0	19.1 -	25.3	19.6	12.4 -
Mature					
L+P	23.8	37.7 +	40.7 +	39.1 +	23.6
M	14.1	17.2	11.0	17.8	28.1 +
PINE/SPRUCE					
Immature	5.2	2.7 -	4.4	2.2 -	2.3
Mature					
L+P	4.8	5.5	3.3	4.9	7.9
M	10.7	9.6	7.7	7.1	20.2
WETLAND/ FORESTED-WETLAND	2.6	1.9 -	3.3	1.8	3.4
LAKE	9.7	4.9 -	2.2 -	6.2	2.3 -
OTHER	3.2	2.5	2.2	1.3	0.0 -
N		366	91	225	89

N = number of radiocollared caribou locations

AGE CLASS Immature (0-80 years)
Mature (>80 years)

SITE CLASS L = Low
P = Poor
M = Medium

OTHER Nonproductive(NP) pine, NP pine/spruce, NP spruce, NP brush, Rock, Mature spruce

\+ use > availability
\- use < availability

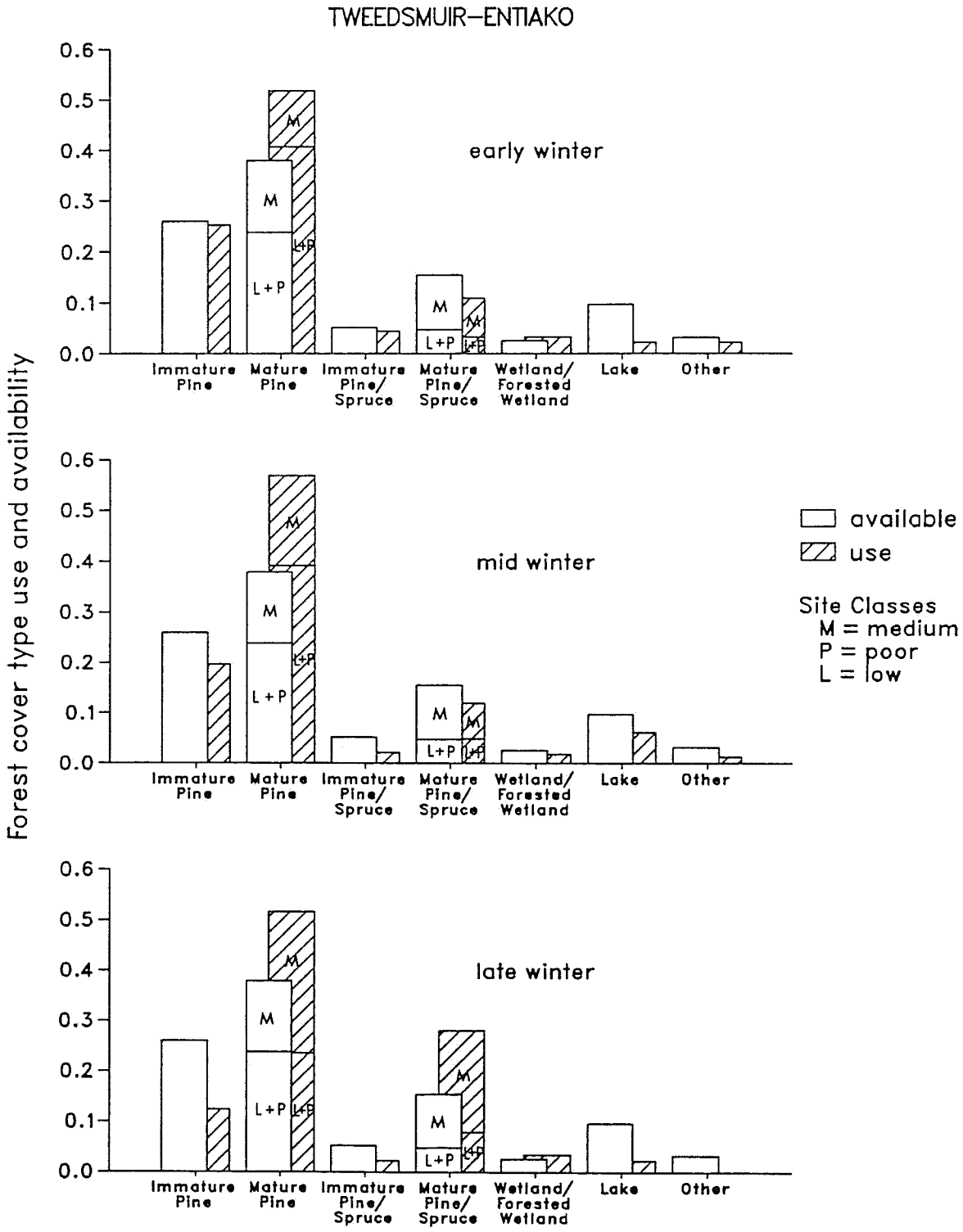

Fig.13. Proportion of each forest cover type available, and proportion of radiocollared caribou locations in each forest cover type in the Tweedsmuir-Entiako winter range during early winter (N=91), mid winter (N=225), and late winter (N=89), December 1986 - April 1988.

Use of forest cover types by radiocollared caribou was different from availability during winter (X^2=54.5, p<.05), early winter (X^2=20.5, p<.05), mid winter (X^2=41.2, p<.05) and late winter (X^2=35.9, p<.05) (Table 5). Use of mature pine stands on low and poor quality sites exceeded availability during winter, early winter and mid winter. In late winter, pine/spruce stands on medium quality growing sites were heavily used, and use of mature pine stands on medium sites exceeded availability. Use of immature stands, wetlands and forested wetlands was less than availability during winter. Lakes were also used less than were available during winter, early winter, and late winter.

Itcha-Ilgachuz

Caribou that wintered in forested habitat, almost exclusively used mature pine forests on low and poor quality growing sites and seldom used pine and pine/spruce stands on medium sites (Figs.12,14). Meadow/wetlands decreased in importance from being heavily used during early winter to not being used in late winter.

Use of forest cover types was different from availability during winter (X^2=231.5, p<.05), early winter (X^2=57.1, p<.05), mid winter (X^2=185.3, p<.05) and late winter (X^2=58.9, p<.05). Use of mature pine stands on low quality sites exceeded availability and use of immature pine stands was less than availability throughout the winter (Table 6). During early winter, mature pine stands on medium quality growing sites were used less than were available, and during winter, mid-winter and late winter, mature pine/spruce stands on medium sites were used less than were available. Use of mature pine/spruce stands on low and poor quality growing sites during late winter also was less than availability. Use of meadow/wetlands was greater than availability during early winter and less than availability during mid and late winter (Table 6).

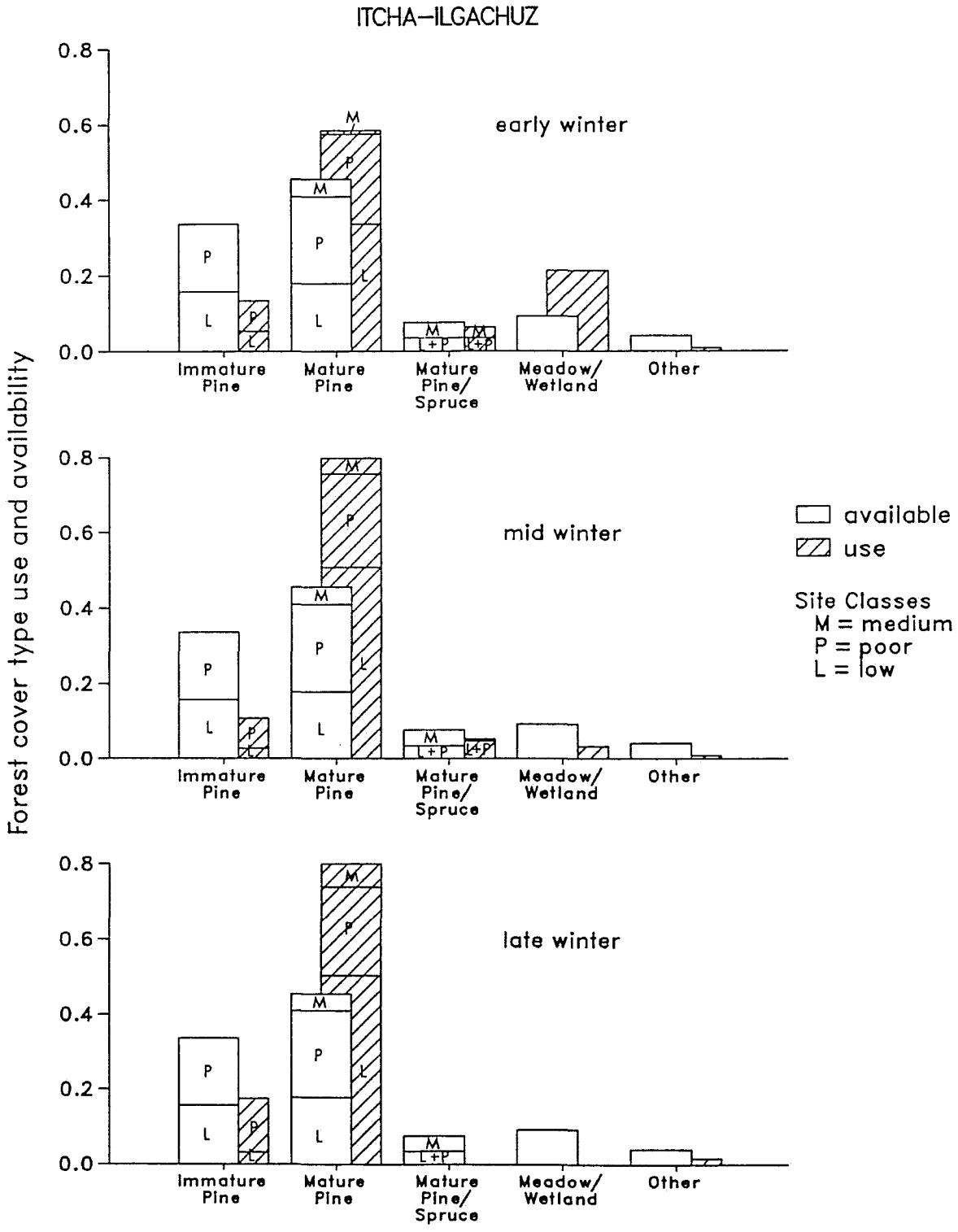

Fig.14. Proportion of each forest cover type available, and proportion of radiocollared caribou locations in each forest cover type in the Itcha-Ilgachuz winter range during early winter (N=113), mid winter (N=213), and late winter (N=63), December 1986 - April 1988.

Table 6. Percent of forest cover types available and percent of radiocollared caribou locations in each forest cover type in the Itcha-Ilgachuz study area during winter (December - March), early winter (December - mid-January), mid winter (mid-January - mid-March), and late winter/early spring (mid-March - April) for 1986/87 and 1987/88 combined. Significance at α=.05 (winter) or α=.10 (early, mid and late winter).

Forest Cover Type	Available	Use Winter	Use Early Winter	Use Mid Winter	Use Late Winter
	%	%	%	%	%
PINE					
Immature					
L	15.7	3.8 -	5.3 -	2.8 -	3.2 -
P	17.9	8.1 -	8.0 -	8.0 -	14.3
Mature					
L	17.8	45.8 +	33.6 +	50.7 +	50.8 +
P	23.1	24.1	23.9	24.9	23.8
M	4.6	3.5	0.9 -	4.2	6.3
PINE/SPRUCE					
Mature					
L+P	3.5	3.8	3.6	4.7	0.0 -
M	4.1	1.1 -	2.7	0.5 -	0.0 -
MEADOW/ OPEN RANGE/ WETLAND	9.2	8.4	21.2 +	3.3 -	0.0 -
OTHER	4.1	1.4	0.9	0.9 -	1.6
N		369	113	213	63

N = number of radiocollared caribou locations

AGE CLASS Immature (0-80 years)
Mature (>80 years)

SITE CLASS L = Low
P = Poor
M = Medium

OTHER Nonproductive(NP) pine, NP pine/spruce, NP spruce, NP brush, Rock, Immature pine (medium sites), Immature pine/spruce, Mature spruce

\+ use > availability
\- use < availability

WINTER CARIBOU HABITAT TYPE USE

Tweedsmuir-Entiako

During winter, radiocollared caribou used a variety of caribou habitat types (Figs.15,16). Between December and March, caribou used dry sites, primarily mature stands of Dry Lichen/Lichen Moss and Lichen Moss, and to a lesser extent, Moss - Dry Lichen/Lichen Moss and Moss/Seepage Forest - Aspen Forest. In early and mid winter (December - mid-March), both immature and mature stands of Dry Lichen/Lichen Moss, Lichen Moss, Dry Lichen/Lichen Moss Ecomosaic and Moss - Dry Lichen/Lichen Moss were extensively used. By late winter/early spring (mid-March - April) radiocollared caribou used predominantly moister sites consisting of Moss/Seepage Forest - Aspen Forest, Moss - Dry Lichen/Lichen Moss and Lichen Moss.

Caribou use of caribou habitat types was different from availability for winter (X^2=261.1, $p<.05$), early winter (X^2=101.8, $p<.05$), mid winter (X^2=251.2, $p<.05$) and late winter/early spring (X^2= 38.9, $p<.05$). Mature Dry Lichen/Lichen Moss sites were used more than were available during winter, early winter and mid winter; and use of mature Lichen Moss sites exceeded availability during winter and mid winter (Table 7). Mature Lichen Moss sites also were heavily used in early winter and late winter. Use of immature Dry Lichen/Lichen Moss sites exceeded availability during mid winter. In winter and mid winter, mature and immature Moss/Seepage Forest - Aspen Forest types were used less than were available. Mature Moss/Seepage Forest - Aspen Forest sites were also used less than were available during early winter, but were heavily used during late winter. Use of forested wetland habitat was less than availability during winter, mid winter and late winter and use of open wetland habitat was less than was availability during late winter. Other habitat types used less than their availability

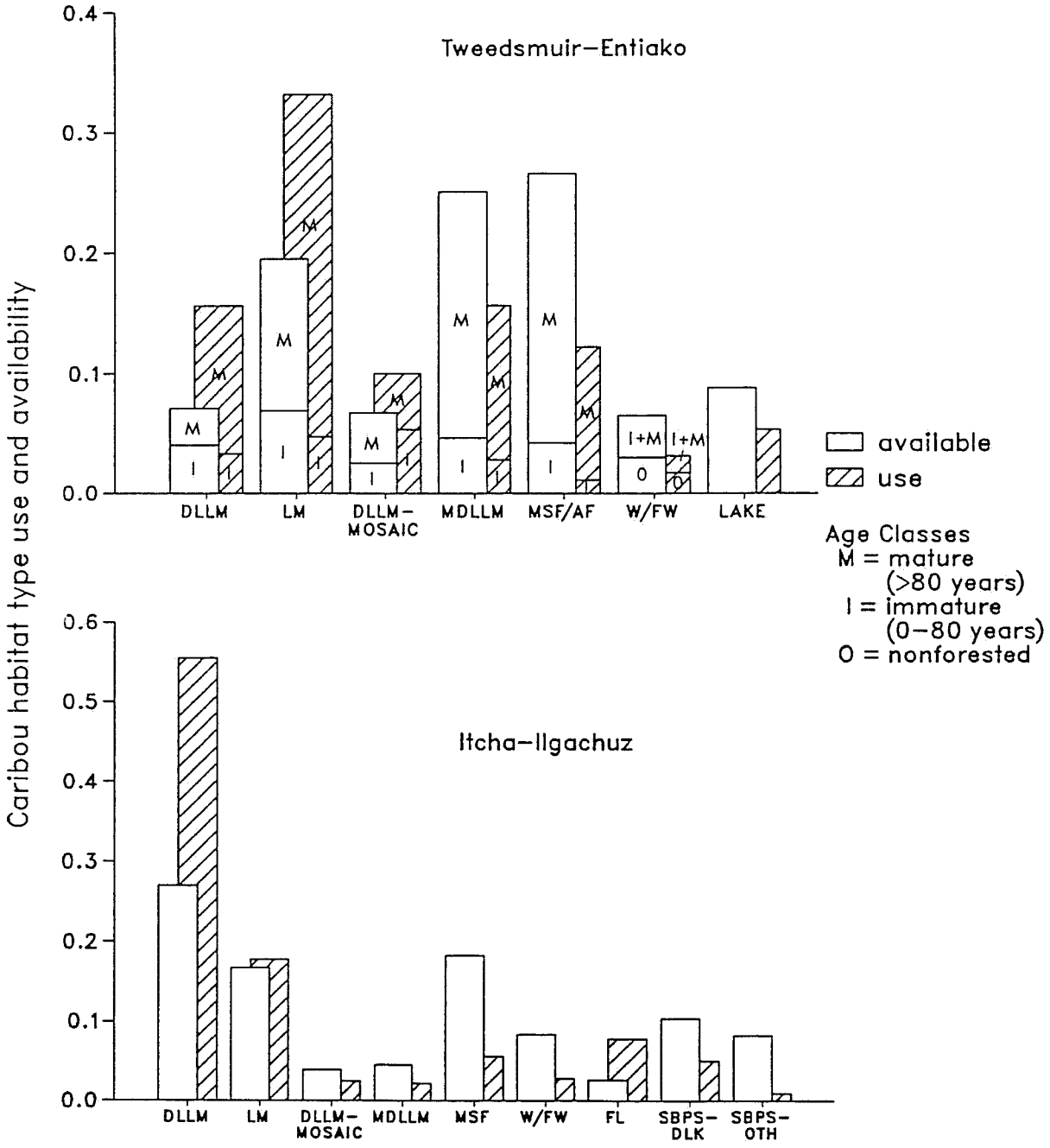

Fig.15. Proportion of each caribou habitat type available, and proportion of radiocollared caribou locations in each caribou habitat type during winter (December - March), in the Tweedsmuir-Entiako (N=355), and Itcha-Ilgachuz (N=321) winter ranges, December 1986 - April 1988.

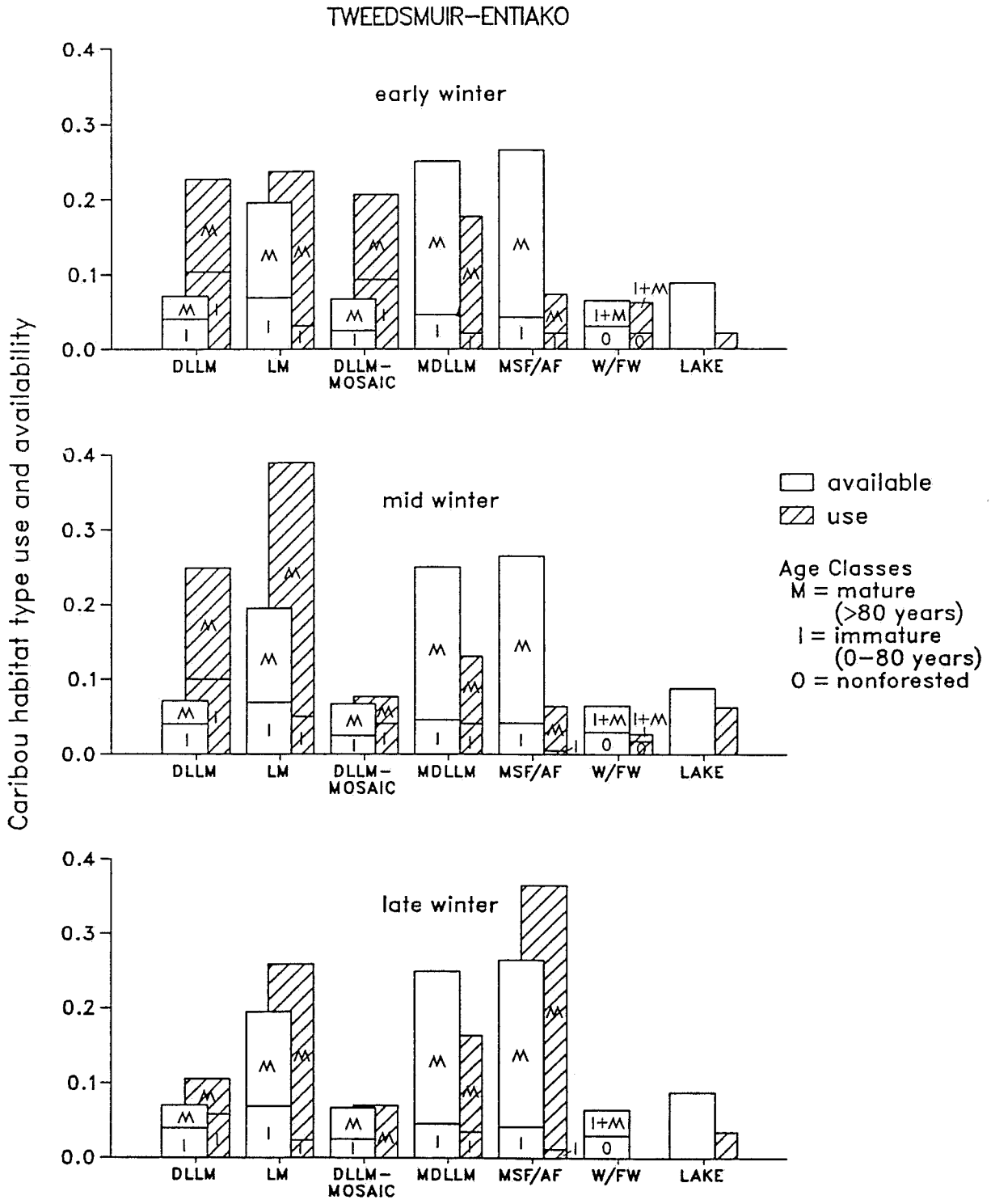

Fig.16. Proportion of each caribou habitat type available, and proportion of radiocollared caribou locations in each caribou habitat type in the Tweedsmuir-Entiako winter during early winter (N=97), mid winter (N=221), and late winter (N=85), December 1986 - April 1988.

Table 7. Percent of caribou habitat types available and percent of radiocollared caribou locations in each caribou habitat type in the Tweedsmuir-Entiako study area during winter (December - March), early winter (December - mid-January), mid winter (mid-January - mid-March), and late winter/early spring (mid-March - April) for 1986/87 and 1987/88 combined. Significance at α=.05 (winter) or α=.10 (early, mid and late winter).

Caribou Habitat Type	Available	Use Winter	Use Early Winter	Use Mid Winter	Use Late Winter
	%	%	%	%	%
DLLM (I)	4.0	3.3	10.3	10.0 +	5.9
(M)	3.1	12.3 +	12.4 +	14.9 +	4.7
LM (I)	6.9	4.7	3.1	5.0	2.4
(M)	12.6	28.4 +	20.6	33.9 +	23.5
DLLM-MOSAIC (I)	2.5	5.3	9.3	4.1	0.0 -
(M)	4.2	4.7	11.3	3.6	7.1
MDLLM (I)	4.6	2.8	2.1	4.1	3.5
(M)	20.4	12.8 -	15.5	9.0 -	12.9
MSF/AF (I)	4.2	1.1 -	2.1	0.5 -	1.2
(M)	22.3	11.1 -	5.2 -	5.9 -	35.3
W/FW (0)	3.0	1.7	2.1	1.8	0.0 -
(I+M)	3.5	1.4 -	4.2	0.9 -	0.0 -
Lake	8.8	5.3 -	2.1 -	6.3	3.5
N		355	97	221	85

N = number of radiocollared caribou locations

I = Immature (0-80 years)
M = Mature (>80 years)
0 = No age class

\+ use > availability
\- use < availability

included mature Moss - Dry Lichen/Lichen Moss in winter and mid winter, and immature Dry Lichen/Lichen Moss Ecomosaic in late winter.

Overall, mature Dry Lichen/Lichen Moss and Lichen Moss caribou habitat types were selected throughout the winter. In early winter, caribou used a variety of habitats equally, and by late winter, Moss/Seepage Forest - Aspen Forest had increased in importance.

Itcha-Ilgachuz

Use of caribou habitat types in immature stands was less than availability (X^2=75.3, p<.05) (Table 8). Use/availability analysis was therefore performed only on mature and open habitat types. Radiocollared caribou used primarily Dry Lichen/Lichen Moss and Lichen Moss habitat types in the MSd biogeoclimatic zone during winter (Fig.15). In early winter Fescue-Lichen sites were heavily used and in late winter/early spring, Dry Lichen/Kinnikinnick sites in the SBPSxc subzone were heavily used (Fig.17, Table 9).

Caribou use of caribou habitat types was different from availability for winter (X^2=214.6, p<.05), early winter (X^2=158.4, p<.05), mid winter (X^2=251.8, p<.05) and late winter/early spring (X^2=58.0, p<.05). Dry Lichen/Lichen Moss was heavily used during early winter, and use of Dry Lichen/Lichen Moss exceeded availability during winter, mid winter and late winter (Table 9). Moss/Seepage Forest types were used less than were available throughout winter. Use of Fescue-Lichen types exceeded availability during winter and early winter, and was less than availability during late winter/early spring. Conversely, SBPSxc biogeoclimatic zone types were used less than were available in winter and early winter, but in late winter/early spring, use of Dry Lichen/Kinnikinnick in

Table 8. Percent of caribou habitat type age classes available and percent of radiocollared caribou locations in caribou habitat type age classes in the Itcha-Ilgachuz study area during winter, for 1986/87 and 1987/88. Significance at α=.05.

Age Class	Available	Use - Winter
	%	%
0 (no age class)	4.3	4.1
1-3 (0-80 years)	26.6	6.1 -
4-5 (>80 years)	69.1	89.8 +

\+ use > availability
\- use < availability

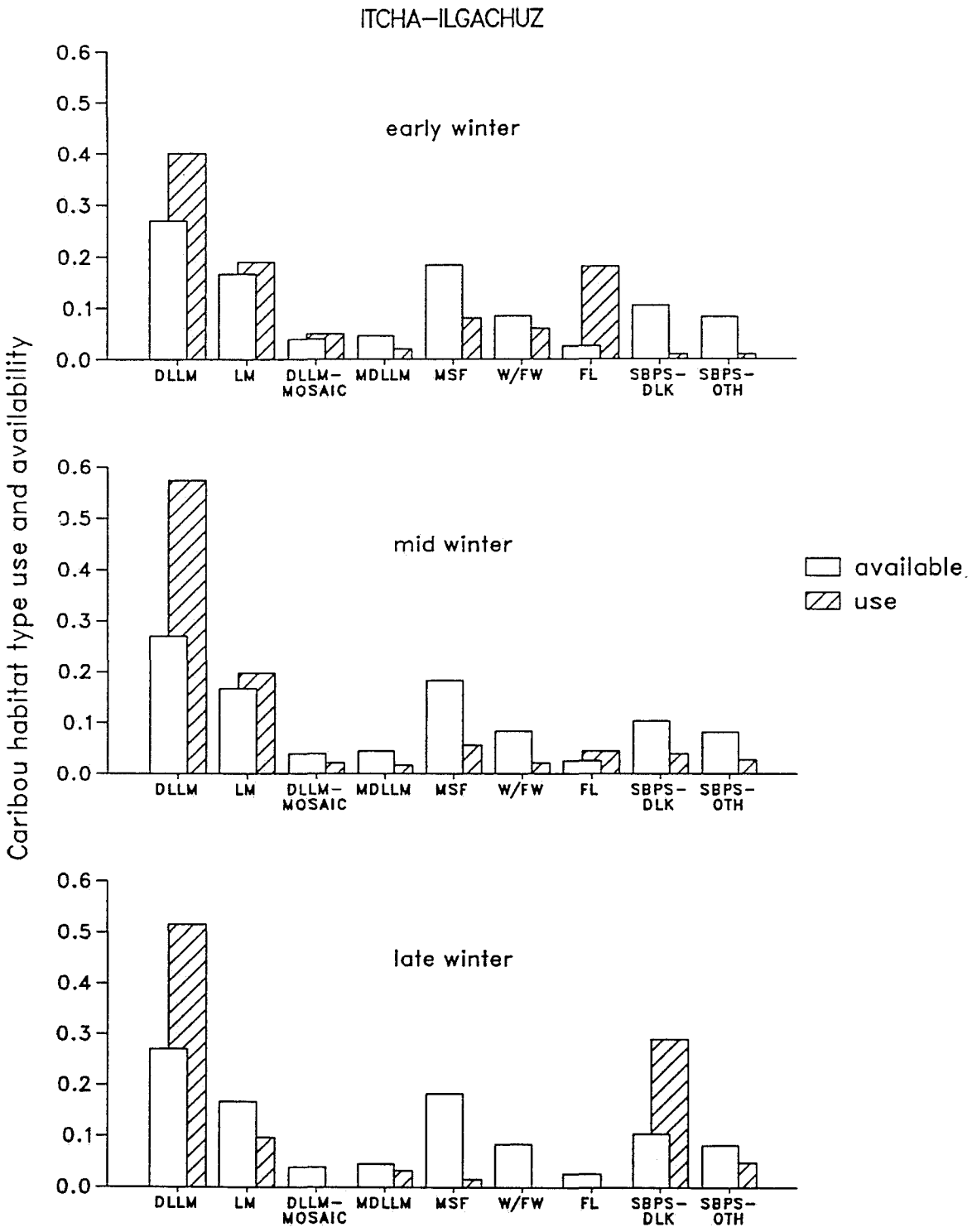

Fig.17. Proportion of each caribou habitat type available, and proportion of radiocollared caribou locations in each caribou habitat type in the Itcha-Ilgachuz winter range during early winter (N=100), mid winter (N=178), and late winter (N=62), December 1986 - April 1988.

Table 9. Percent of caribou habitat types available and percent of radiocollared caribou locations in each caribou habitat type in the Itcha-Ilgachuz study area during winter (December - March), early winter (December - mid-January), mid winter (mid-January - mid-March), and late winter/early spring (mid-March - April) for 1986/87 and 1987/88 combined. Significance at α=.05 (winter) or α=.10 (early, mid and late winter).

Caribou Habitat Type	Available	Use Winter	Use Early Winter	Use Mid Winter	Use Late Winter
	%	%	%	%	%
DLLM	27.0	55.5 +	40.0	57.3 +	51.6 +
LM	16.7	17.8	19.0	19.7	9.7
DLLM-MOSAIC	3.9	2.5	5.0	2.2	0.0 -
MDLLM	4.5	2.2	2.0	1.7	5.7
MSF	18.3	5.6 -	8.0 -	5.6 -	1.6 -
W/FW	8.4	2.8 -	6.0	2.2 -	0.0 -
FL	2.6	7.8 +	18.0 +	4.5	0.0 -
SBPS-DLK	10.4	5.0 -	1.0 -	3.9 -	29.0 +
SBPS-OTHER	8.2	0.9 -	1.0 -	2.8 -	4.8
N		321	100	178	62

N = number of radiocollared caribou locations

\+ use > availability
\- use < availability

the SBPSxc subzone was greater than availability. Use of wetlands and forested wetlands in mid and late winter, and Dry Lichen/Lichen Moss Ecomosaics were less than availability.

Overall, mature Dry Lichen/Lichen Moss and Lichen Moss were the most heavily used caribou habitat units during winter. In early winter Fescue-Lichen meadows were important, and in late winter Dry Lichen/Kinnikinnick sites in the SBPSxc subzone were heavily used.

WINTER SNOW ACCUMULATION AND SINKING DEPTH

Snow accumulation in all 3 habitat types (open wetland, immature pine, and mature pine) increased between December and February then remained relatively constant through February and March in both 1986/87 and 1987/88 (Fig.18). Snow depths in the mature and immature pine stands were approximately equal and between 10 and 15 centimeters less than in the open wetland. Less snow accumulated in the winter of 1987/88 than in the winter of 1986/87. On average, snow accumulation at the snow stations in the wetland in 1987/88 was about 25 centimeters less than in 1986/87 for the same time period. Maximum mean snow depth in 1987/88 (March 1988) was lower than minimum mean snow depth in 1986/87 (December 1986).

Caribou sinking depth increased linearly with observer sinking depth (Fig.19). The relationship was used to predict caribou sinking depth in each habitat type by using observer sinking depth measurements at the snow stations. Predicted caribou sinking depth in open habitat exceeded predicted caribou sinking depth in both immature pine and mature pine forests during both years (Fig.20). Trends in predicted caribou sinking depth reflected trends in snow depth in that predicted caribou sinking depth averaged

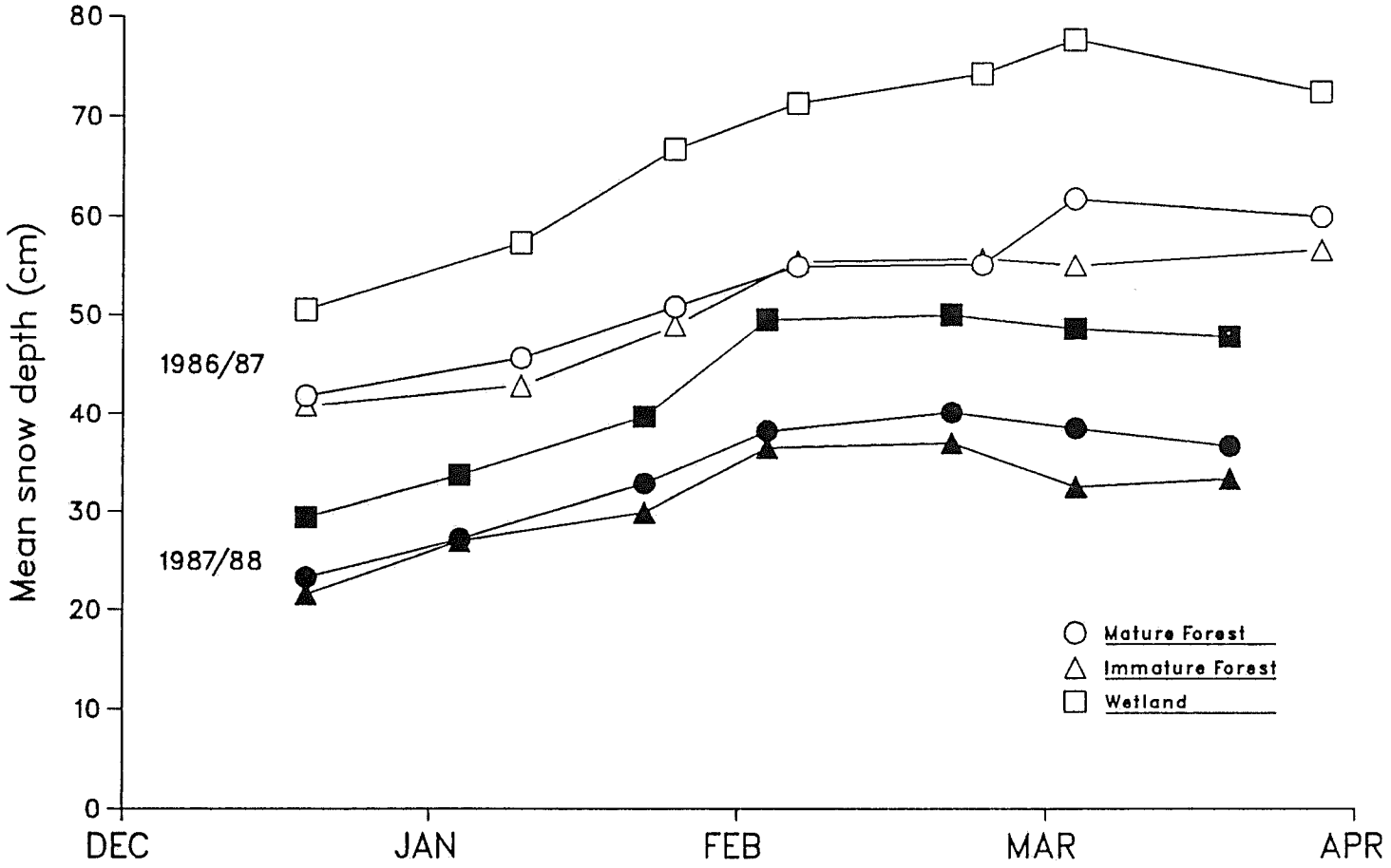

Fig.18. Mean snow depth at snow stations in 3 habitat types (wetland, mature and immature pine stands) at Moore Creek, in the Itcha-Ilgachuz winter range, December 1986 - March 1987, December 1987 - March 1988.

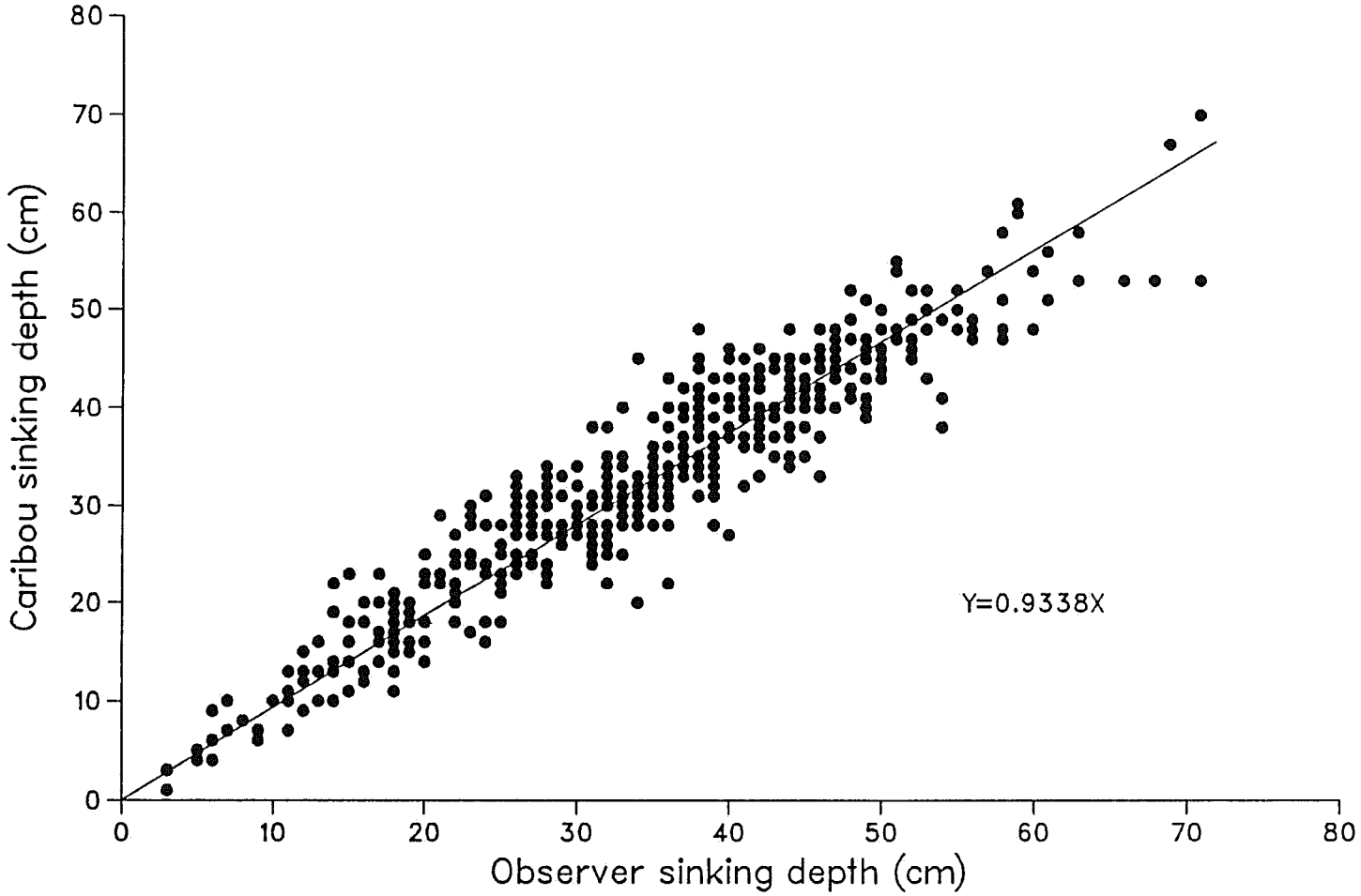

Fig.19. Caribou sinking depth versus observer sinking depth in the Tweedsmuir-Entiako and Itcha-Ilgachuz winter ranges in 1985/86, 1986/87 and 1987/88 combined ($F=39082$, $p<.05$, $r^2.90$).

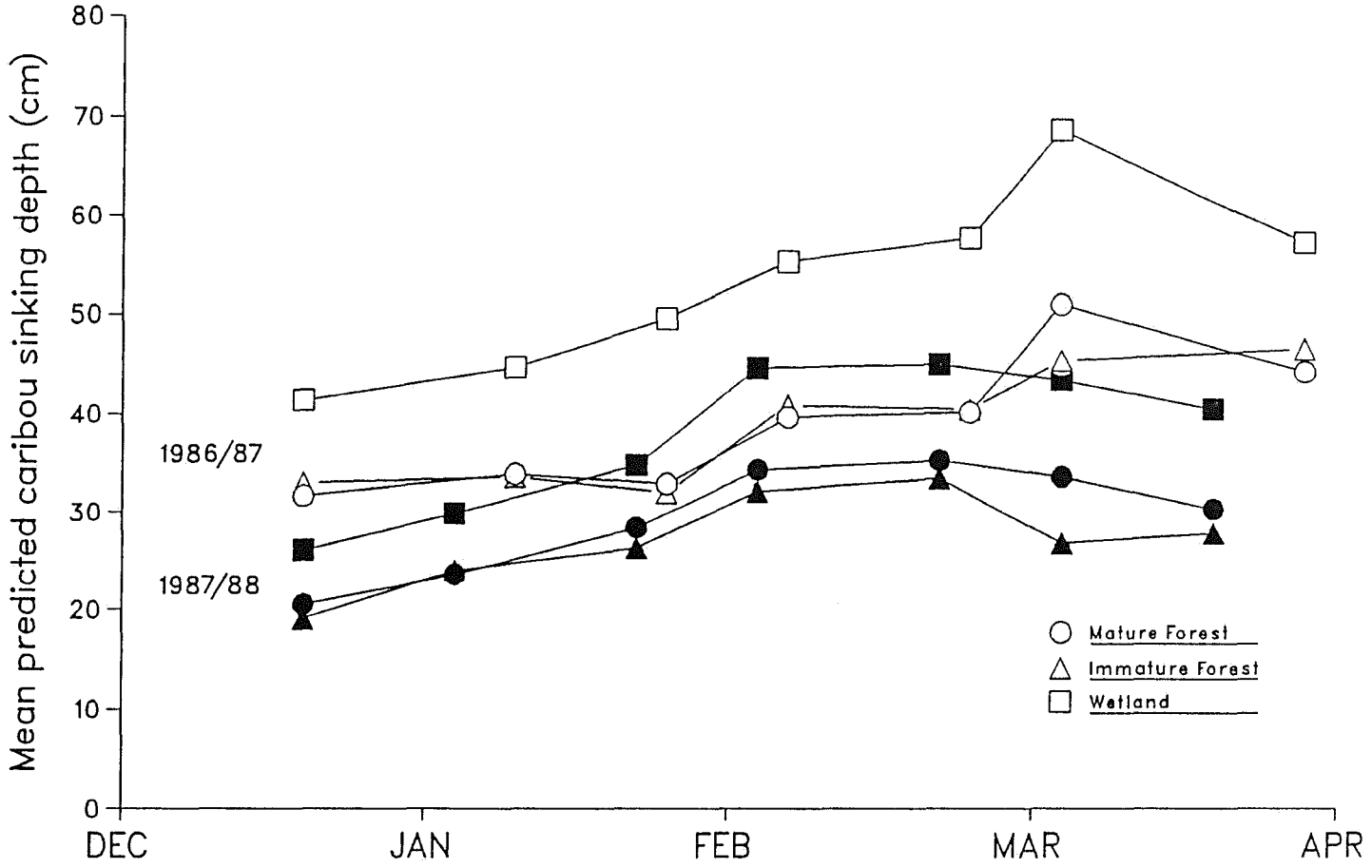

Fig.20. Predicted caribou sinking depth at snow stations in 3 habitat types (wetland, mature and immature pine stands) at Moore Creek, in the Itcha-Ilgachuz winter range, December 1986 - March 1987, December 1987 - March 1988.

15-30 centimeters greater in 1986/87 than in 1987/88. In 1987/88 predicted caribou sinking depth in open habitat did not exceed 45 cm. In summary, snow depth and predicted sinking depth were greater in open rather than forested habitat, but did not differ between mature and immature forests.

WINTER FEEDING ECOLOGY

Cratering versus arboreal lichen feeding

Cratering was the primary feeding activity in pine forests on both the Tweedsmuir-Entiako and Itcha-Ilgachuz winter ranges (Table 10). Pine/spruce stands were used predominantly for arboreal lichen feeding on both winter ranges; however more cratering occurred in pine/spruce stands on the Tweedsmuir-Entiako winter range than on the Itcha-Ilgachuz winter range. Spruce stands in Tweedsmuir-Entiako were used primarily for arboreal lichen feeding. In all forested habitat types combined (weighted for the proportion of telemetry locations in each forested type), craters made up 78% of feeding site types in the Itcha-Ilgachuz-Rainbow winter range and 63% of feeding site types in the Tweedsmuir-Entiako winter range (Table 10). Feeding sites in open habitats such as wetlands, lakes and fescue-lichen meadows consisted mostly of cratering sites. Arboreal lichen feeding was the predominant feeding activity in forested wetlands. Only 2 incidents of browsing on shrubs were observed during the 3 winter field seasons.

In all forested habitats combined, caribou in the Tweedsmuir-Entiako area used arboreal lichens to a greater extent than caribou in the Itcha-Ilgachuz area throughout the winter (Table 11). Arboreal lichen use was greater during March than during January and February on both winter ranges. The December sample in Tweedsmuir-Entiako was

Table 10. Percent of feeding site types investigated (cratering vs. arboreal lichen feeding) in the winter ranges of the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou, for January-March 1986, December 1986-March 1987, December 1987- March 1988 combined.

Tweedsmuir-Entiako caribou winter range

Habitat	% cratering	% arboreal feeding	# sites investigated
Pine	72	28	816
Spruce	15	85	52
Pine/Spruce	32	68	228
Total Forest	63	37	1096
Forested Wetland	21	79	58
Wetland	0	100	3
Lake/Creek	100	0	52

Itcha-Ilgachuz caribou winter range

Habitat	% cratering	% arboreal feeding	# sites investigated
Pine	79	21	1044
Pine/Spruce	10	90	20
Total Forest	78	22	1064
Forested Wetland	10	90	10
Wetland	100	0	120
Fescue-Lichen	100	0	84
Lake/Creek	100	0	14
Alpine	100	0	26

Table 11. Percent of feeding site types investigated (cratering vs. arboreal lichen feeding) in forested habitats in the winter ranges of the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou, by month, for January-March 1986, December 1986-March 1987, December 1987- March 1988 combined.

Tweedsmuir-Entiako caribou winter range

	% cratering	% arboreal feeding	# sites investigated
December	19	81	30
January	65	35	624
February	68	32	150
March	53	47	225

Itcha-Ilgachuz caribou winter range

	% cratering	% arboreal feeding	# sites investigated
December	81	19	21
January	82	18	183
February	89	11	443
March	66	34	406

based on only one set of tracks in pine/spruce habitat and was possibly not representative of feeding site types chosen during December.

Feeding site selection

Terrestrial lichen abundance:

Terrestrial lichens were the most frequently occurring vegetation type found in craters in forested habitats (Table 12). At least one of the terrestrial lichen genera (*Cladonia* spp., *Cladina* spp. and *Stereocaulon* spp.) was found in 99-100% of all craters in forested habitats. Of the terrestrial lichens present, *Cladina* spp. were most common. Terrestrial lichens were less prevalent in non-crater sites. Of non-crater sites in forested habitat, 33% contained terrestrial lichens in the Tweedsmuir-Entiako caribou winter range, and 70% contained terrestrial lichens in the Itcha-Ilgachuz caribou winter range. The proportion of craters containing terrestrial lichens was greater than the proportion of non-crater sites containing terrestrial lichens in both Tweedsmuir-Entiako (X^2=483.9, $p<.05$) and Itcha-Ilgachuz (X^2=196.8, $p<.05$) areas. Terrestrial lichens were found in moderate to high quantities in craters, whereas in non-crater sites, terrestrial lichens were absent or found in low to moderate quantities (Fig.21). The abundance of terrestrial lichens in craters was greater than the abundance of terrestrial lichens in non-crater sites (Tweedsmuir Entiako X^2=384.4, $p<.05$; Itcha-Ilgachuz X^2=279.2, $p<.05$). Overall, caribou cratered in areas where terrestrial lichens were more abundant.

On the Itcha-Ilgachuz caribou winter range, fescue-lichen meadows were heavily used during early winter. The most frequently occurring vegetation types in craters in those meadows were terrestrial lichens (contained in 100% of the craters) and grasses (contained in 99% of the craters) (Table 12). As winter progressed, use of wetlands and

Table 12. Frequency of occurrence of vegetation in craters (C) and in non-crater sites (*NCS*) in the winter ranges of the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou, from January- March 1986, December 1986-March 1987, December 1987-March 1988 combined.

Tweedsmuir-Entiako

	PINE		SPRUCE		PINE/ SPRUCE		TOTAL FOREST		WETLAND/ FOR.WET.		LAKE/ CREEK	
	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*
No. C / *NCS*	**589**	***127***	**8**	***23***	**73**	***63***	**670**	***213***	**12**	***22***	**52**	***20***
Vegetation present												
Arctostaphylos uva-ursi	.40	*.42*	.25	*.13*	.45	*.22*	.41	*.33*				
Betula glandulosa		*.01*						*.005*		*.09*		
Carex spp.				*.04*	.01		.001	*.005*		*.55*		
Cornus canadensis		*.01*		*.04*	.03		.003	*.01*				
Empetrum nigrum	.005	*.03*		*.04*	.03	*.02*	.007	*.17*				
Equisetum spp.												
Forbes	.005	*.06*	.25	*.09*	.03		.01	*.04*				
Grasses	.04	*.06*	.13	*.22*	.10	*.06*	.05	*.08*	1.00	*.78*	.08	
Ice/Slush										*.23*	.92	*1.00*
Juniperus spp.		*.01*			.01	*.05*	.001	*.02*				
Ledum groenlandicum	.002				.07	*.02*	.01	*.005*		*.14*		
Linnaea borealis	.002	*.01*		.04		*.03*	.001	*.02*				
Lycopodium spp.				*.04*				*.02*				
Mosses	.25	*.50*	.63	*.78*	.30	*.73*	.26	*.60*	.50	*.50*		
Pinus contorta	.01	*.01*				*.02*	.01	*.005*				
Rosa spp.				*.04*				*.005*				
Salix spp.		*.01*						*.005*		*.36*		
Shepherdia canadensis	.04		.13	*.09*	.01		.04	*.01*				
Terrestrial lichens												
Cladonia spp.	.55	*.19*			.36	*.08*	.52	*.12*				
Cladina spp.	.83	*.16*			.97	*.23*	.91	*.17*				
Stereocaulon spp.	.03					*.02*	.02	*.005*				
Cladonia/Cladina/Ster	.99	*.37*	.75	*.17*	.95	*.30*	1.00	*.33*				
Peltigera spp.	.04	*.20*	.13	*.09*	.19	*.10*	.06	*.15*				
Vaccinium spp.	.003						.003					
Frozen ground		*.05*			.01	*.13*	.001	*.07*				

Itcha-Ilgachuz

	PINE		PINE/ SPRUCE		TOTAL FOREST		WETLAND/ FOR.WET.		FESCUE-LICHEN		LAKE/ CREEK		ALPINE	
	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*	C	*NCS*
No. C / *NCS*	**827**	***187***	**2**	***5***	**829**	***192***	**120**	***20***	**84**	***0***	**14**	***3***	**26**	***0***
Vegetation present														
Arctostaphylos uva-ursi	.15	*.17*	.50		.16	*.16*							.38	
Betula glandulosa		*.01*		*.20*		*.02*	.09	*.35*	.04				.15	
Carex spp.		*.01*	1.00		.002	*.01*	.24	*.70*	.02					
Cornus canadensis		*.01*	.50	*.20*	.001	*.02*								
Empetrum nigrum	.18	*.26*		*.40*	.18	*.26*								
Equisetum spp.	.004				.004				.04					
Forbes	.006				.006									
Grasses	.33	*.25*	.50	*.20*	.34	*.20*	.08	*.30*	.99				.88	
Ice/Slush							.85	*.10*			1.00	*1.00*		
Juniperus spp.	.04	*.09*		*.20*	.04	*.09*								
Linnaea borealis	.02	*.005*			.02	*.005*		*.05*						
Lycopodium spp.		*.005*				*.005*								
Mosses	.21	*.38*		*.60*	.21	*.39*	.03						.77	
Pinus contorta	.01	*.01*			.01	*.01*								
Rosa spp.														
Salix spp.	.001	*.005*			.001	*.005*	.05	*.15*						
Shepherdia canadensis	.03				.03									
Terrestrial lichens														
Cladonia spp.	.63	*.50*		*.60*	.63	*.51*			.15					
Cladina spp.	.77	*.31*		*.20*	.76	*.31*	.02		.98					
Stereocaulon spp.	.11	*.09*			.08	*.09*			.35					
Cladonia/Cladina/Ster	.99	*.70*		*.80*	.99	*.70*	.02		1.00				1.00	
Peltigera spp.	.06	*.17*			.06	*.17*								
Vaccinium spp.	.08	*.10*		*.20*	.08	*.10*								
Frozen ground		*.005*				*.005*								

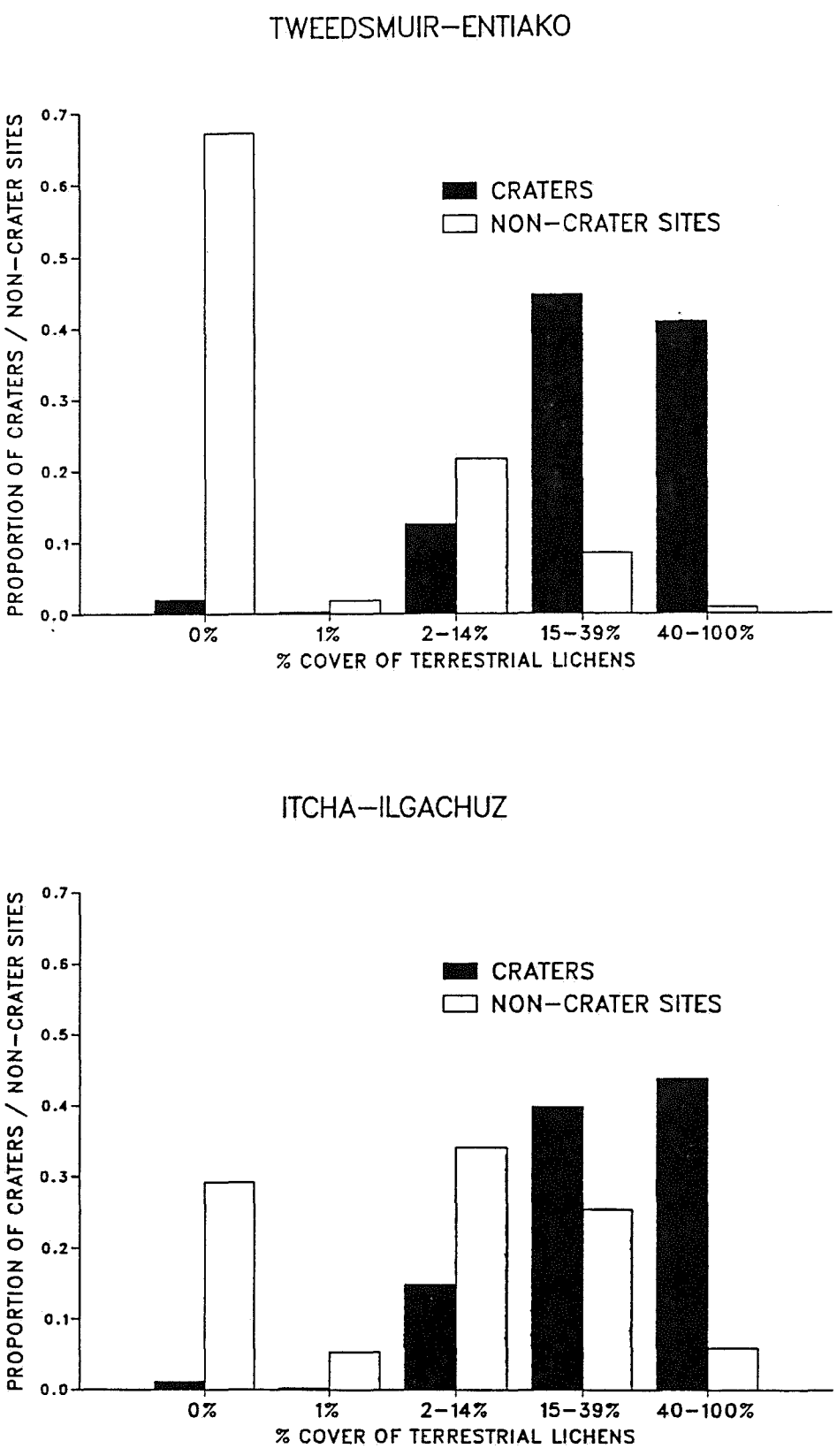

Fig.21. Proportion of craters (C) and non-crater sites (NCS) containing % ground cover classes (0%, 1%, 2-14%, 15-39%, 40-100%) of terrestrial lichens (*Cladina* spp., *Cladonia* spp., *Stereocaulon* spp. combined) in all forested habitat types combined in the Tweedsmuir-Entiako (C=351, NCS=213), and Itcha-Ilgachuz (C=570, NCS=185) winter ranges (December - March, 1986/87, 1987/88).

forested wetlands increased and use of fescue-lichen meadows decreased. Ice and/or water were present in 85% of craters in wetlands on the Itcha-Ilgachuz winter range. The proportion of craters containing sedges was lower than the proportion of non-crater sites containing sedges (X^2=40.0, p<.05), and the proportion of craters containing ice was greater than the proportion of non-crater sites containing ice (X^2=39.3, p<.05), suggesting that in wetlands, caribou were probably not cratering for food but for water. Caribou also cratered on or along lakes and creeks in both Itcha-Ilgachuz and Tweedsmuir-Entiako winter areas (Table 12). These craters almost exclusively contained ice or water only. In summary, Caribou use of open areas included use of fescue-lichen for terrestrial lichen feeding during early winter, and use of wetlands for obtaining water throughout the winter.

Canopy cover:

The distribution of canopy cover classes at craters was different from non-crater sites in Tweedsmuir-Entiako (X^2=42.8, p<.05) and Itcha-Ilgachuz (X^2=34.9, p<.05) winter ranges (Fig.22). Craters occurred most often in forested areas with very open (<5% canopy cover) and open (6-10%) canopies. Conversely, non-crater sites occurred more often than craters in forested areas with more closed canopies (11-15%, 16-20%, >20% canopy cover). An interaction between canopy closure and percent ground cover of terrestrial lichens was apparent in crater site selection (Table 13). Crater sites were found primarily in stands with both open canopies and abundant terrestrial lichens; whereas areas where caribou had not cratered occurred in less open stands with lower quantities of terrestrial lichens.

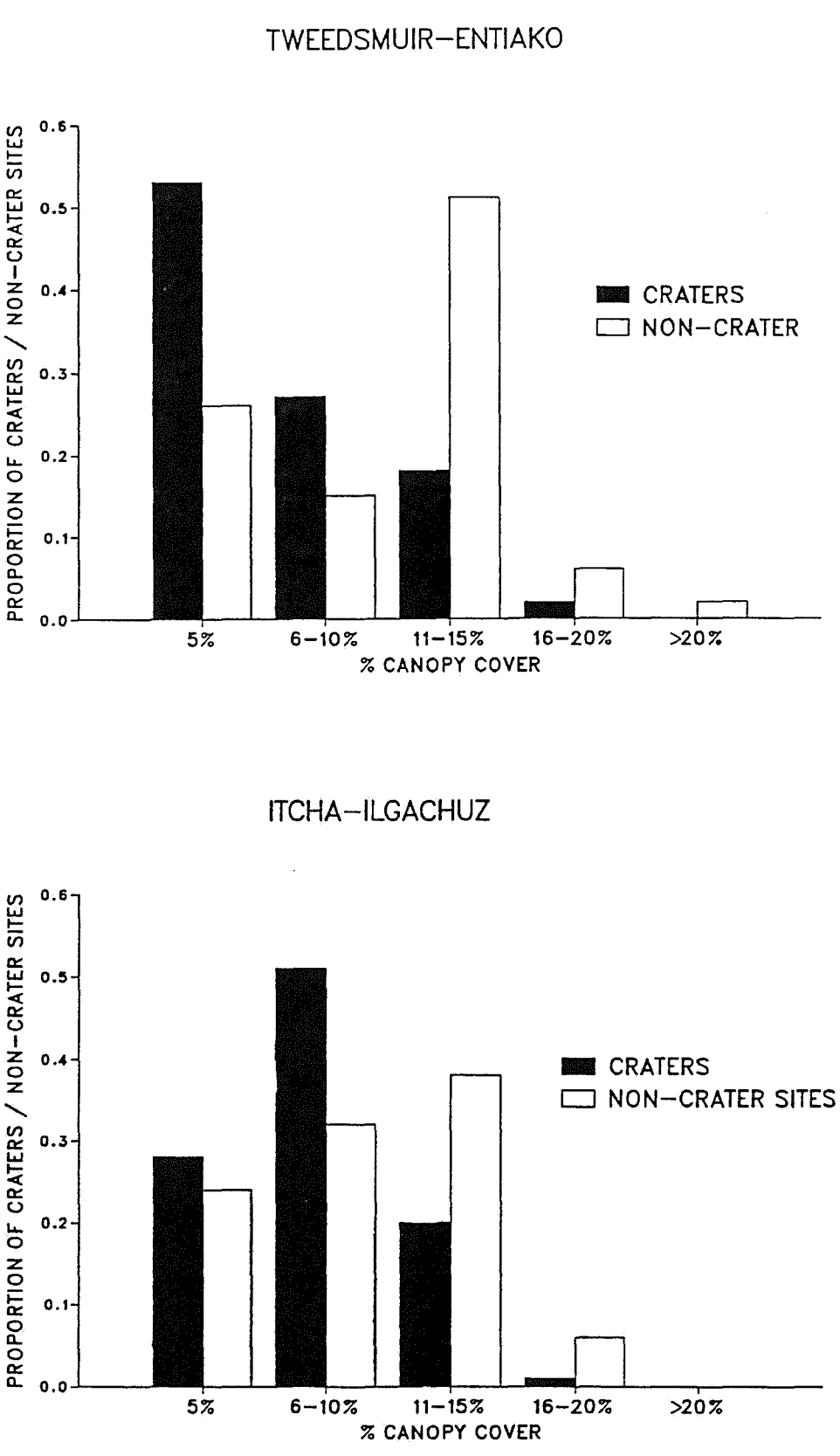

Fig.22. Proportion of craters (C) and non-crater sites (NCS) in % canopy cover classes (<5%, 6-10%, 11-15%, >20% canopy cover) in all forested habitats combined in the Tweedsmuir-Entiako (C=293, NCS=65) and Itcha-Ilgachuz (C=446, NCS=105) winter ranges (December 1986 - March 1987, December 1987 - March 1988).

Table 13. Percentage of craters (C) and non-crater sites (*NCS*) found in different canopy closure / terrestrial lichen availability classes in all forested habitat types combined in the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou winter ranges, December 1987 - March 1988.

		% ground cover of terrestrial lichens					
% canopy closure		**0%**	**1%**	**2-14%**	**15-39%**	**40-100%**	**Total**
Tweedsmuir-Entiako							
1-5%	C	0.3	0	5.8	23.5	23.5	156
	NCS	*17.2*	*1.6*	*3.1*	*4.7*	*0*	*17*
6-10%	C	0	0	3.4	13.0	10.6	79
	NCS	*10.9*	*3.1*	*0*	*1.6*	*0*	*10*
11-15%	C	0	0.3	3.4	7.5	6.5	52
	NCS	*40.6*	*1.6*	*7.8*	*1.6*	*0*	*33*
16-20%	C	0	0	0.3	0.3	1.4	6
	NCS	*6.3*	*0*	*0*	*0*	*0*	*4*
Total	C	1	1	38	130	123	293
	NCS	*48*	*4*	*7*	*5*	*0*	*64*
Itcha-Ilgachuz							
1-5%	C	0.2	0	3.4	10.3	14.6	127
	NCS	*3.8*	*2.9*	*8.6*	*6.7*	*1.9*	*25*
6-10%	C	0.4	0	6.7	23.8	20.0	227
	NCS	*12.4*	*3.8*	*6.7*	*8.6*	*1.0*	*34*
11-15%	C	0.4	0	3.4	9.4	7.0	90
	NCS	*14.3*	*2.9*	*11.4*	*9.5*	*0*	*40*
16-20%	C	0	0.2	0	0.2	0	2
	NCS	*1.9*	*0*	*2.9*	*1.9*	*0*	*6*
Total	C	4	1	60	195	185	446
	NCS	*34*	*10*	*31*	*27*	*3*	*105*

Snow conditions:

Both snow depth and snow penetrability at craters and non-crater sites varied over the winter (Figs.23,24,25). On the Itcha-Ilgachuz winter range, snow depth was greater at craters than at non-crater sites during the early February sampling session in 1987 ($t=3.5$, $p<.05$) and during the early March sampling session in 1988 ($t=3.5$, $p<.05$) (Fig.23). Snow penetrability at craters was greater than snow penetrability at non-crater sites during the early February ($t=2.2$, $p<.05$) and early March ($t=2.8$, $p<.05$) sampling sessions in 1988 (Fig.24).

On the Tweedsmuir-Entiako winter range, snow depth was greater at crater sites than at non-crater sites during mid-January 1987 ($t=7.4$, $p<.05$) but not during February and March (Fig.25). In 1988, snow depths of craters and non-crater sites were similar in January, but snow depth at craters exceeded snow depth at non-crater sites during the late February ($t=6.0$, $p<.05$), early March ($t=6.3$, $p<.05$) and late March ($t=2.1$, $p<.05$) sampling sessions. Snow penetrability decreased in both non-crater sites and craters throughout the winter in Tweedsmuir-Entiako (Fig.24). Snow penetrability at cratering sites was greater than snow penetrability at non-crater sites during both early March ($t=5.7$, $p<.05$) and late March ($t=3.1$, $p<.05$) sampling sessions in 1988. Overall, snow depth was regularly greater at craters than at non-cratering sites and snow penetrability tended to be greater at craters than at non-crater sites later in the winter.

A summary of data from winter feeding site figures is presented in Appendix III.

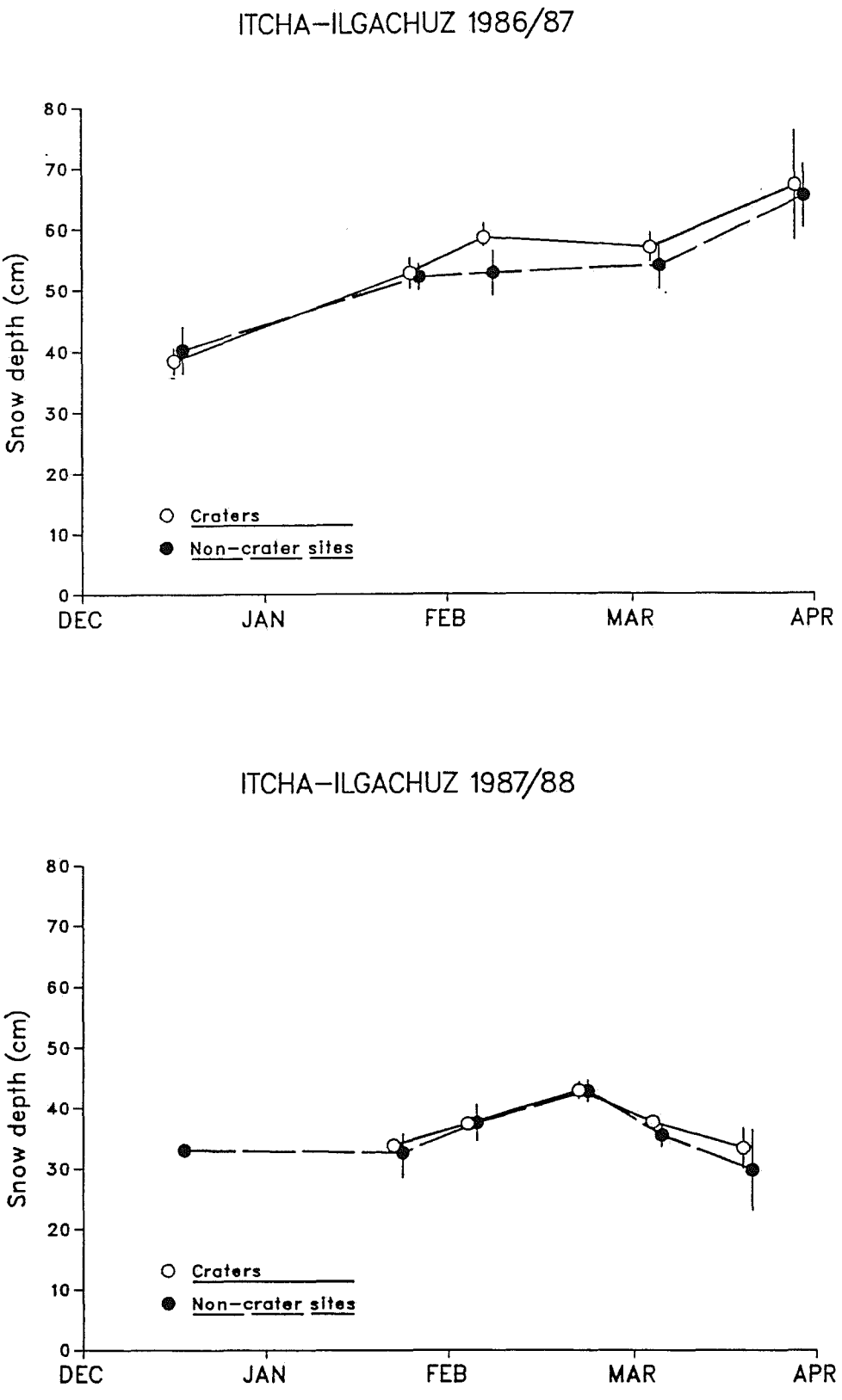

Fig.23. Mean snow depths of craters and non-crater sites in all forested habitat types combined, during sampling sessions conducted on the Itcha-Ilgachuz winter range, December 1986 - March 1987, December 1987 - March 1988. Error bars are 95% confidence limits.

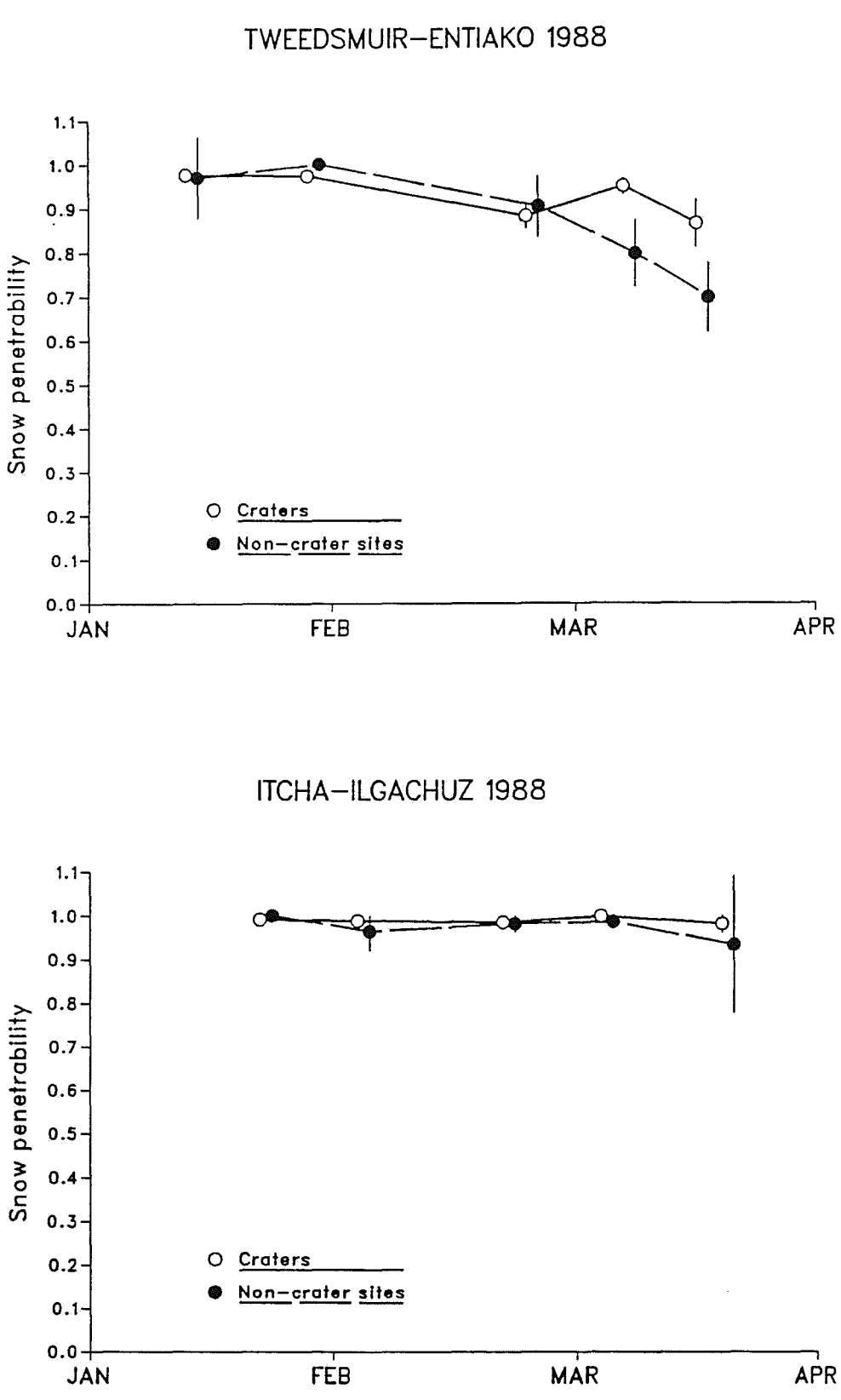

Fig.24. Mean snow penetrability (weight sinking depth÷ snow depth) of craters and non-crater sites in all forested habitat types combined, during sampling sessions conducted on the Tweedsmuir-Entiako and Itcha-Ilgachuz winter ranges, December 1987 - March 1988. Error bars are 95% confidence limits.

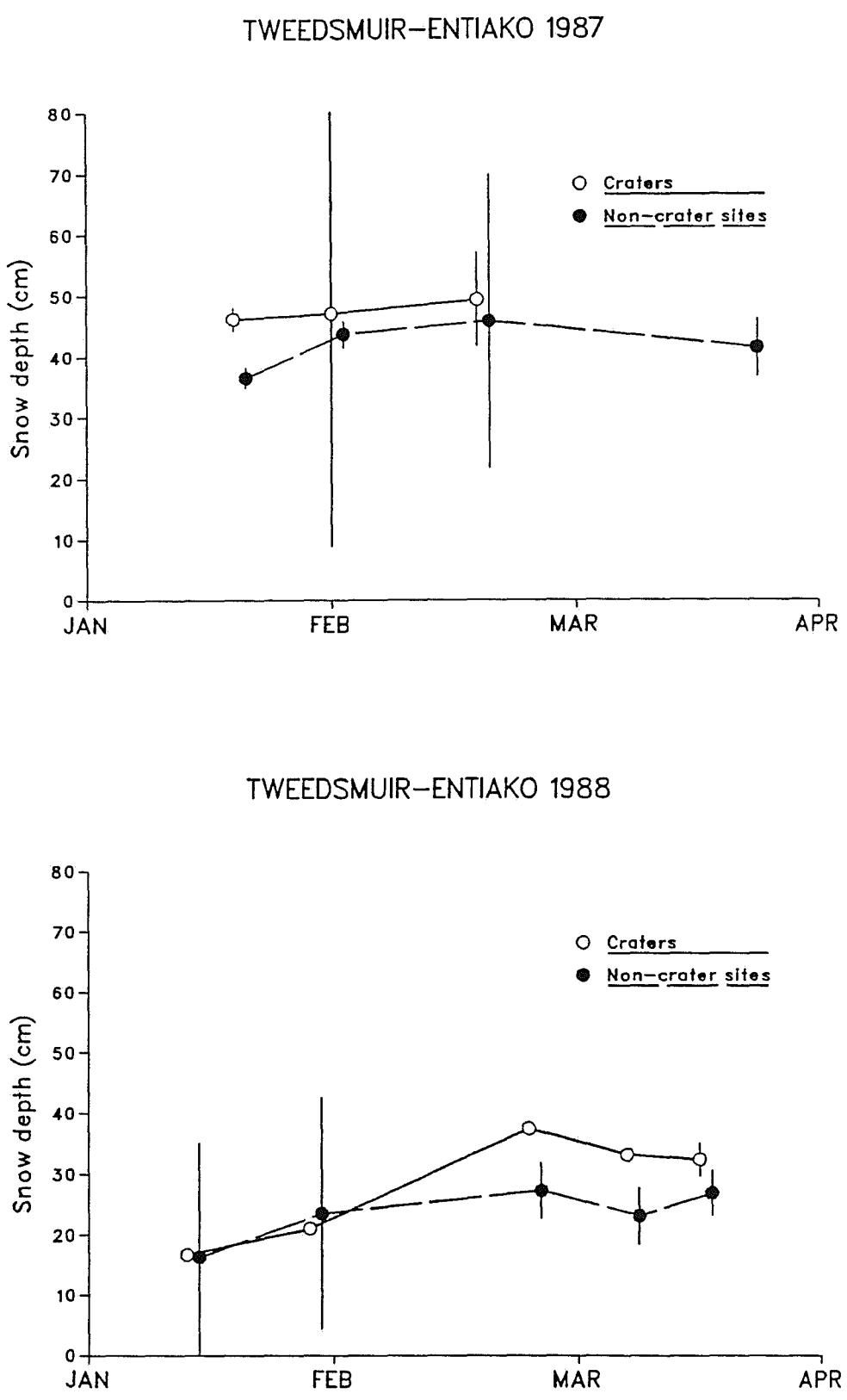

Fig.25. Mean snow depths of craters and non-crater sites in all forested habitats combined, during sampling sessions conducted on the Tweedsmuir-Entiako winter range, January - March 1987, January - March 1988. Error bars are 95% confidence limits.

FECAL FRAGMENT ANALYSES AND FECAL NITROGEN

Terrestrial and arboreal lichens were the predominant food types in fecal samples during winter months (Fig.26). In early spring, forbs comprised 20% of the vegetation found in fecal samples. In the summer, lichen use decreased and grasses, sedges and forbs made up more than 50% of vegetation in fecal pellet groups. Conifers, shrubs and mosses were present in low quantities throughout the year. By October, terrestrial and arboreal lichens made up over 80% of vegetation in fecal pellets. Terrestrial and arboreal lichens were the most heavily used food items during the fall.

Fecal nitrogen values were relatively constant at about 1.5% during fall, winter and spring and increased in the summer to about 2.5% (Fig.27). Low fecal nitrogen during calving in early June indicates female migrated before new vegetation was available on the calving grounds.

There was little monthly or year to year variation in diet composition or nitrogen content of winter fecal samples from both winter ranges (Figs.28,29). In general, terrestrial and arboreal lichens were the most abundant vegetation types in fecal samples collected during winter months. Terrestrial lichen was more abundant than arboreal lichen and combined they made up 50-75% of vegetation types found in fecal samples. Terrestrial lichens were more frequent in fecal groups collected in the Itcha-Ilgachuz area than in the Tweedsmuir-Entiako area. Conifers and mosses were the next most abundant vegetation types. The percentage of grasses, sedges and forbs in fecal samples collected in the Tweedsmuir-Entiako area increased from 7% in early winter to 27% in late winter in 1986/87. A summary of all fecal sample data is presented in Appendix IV.

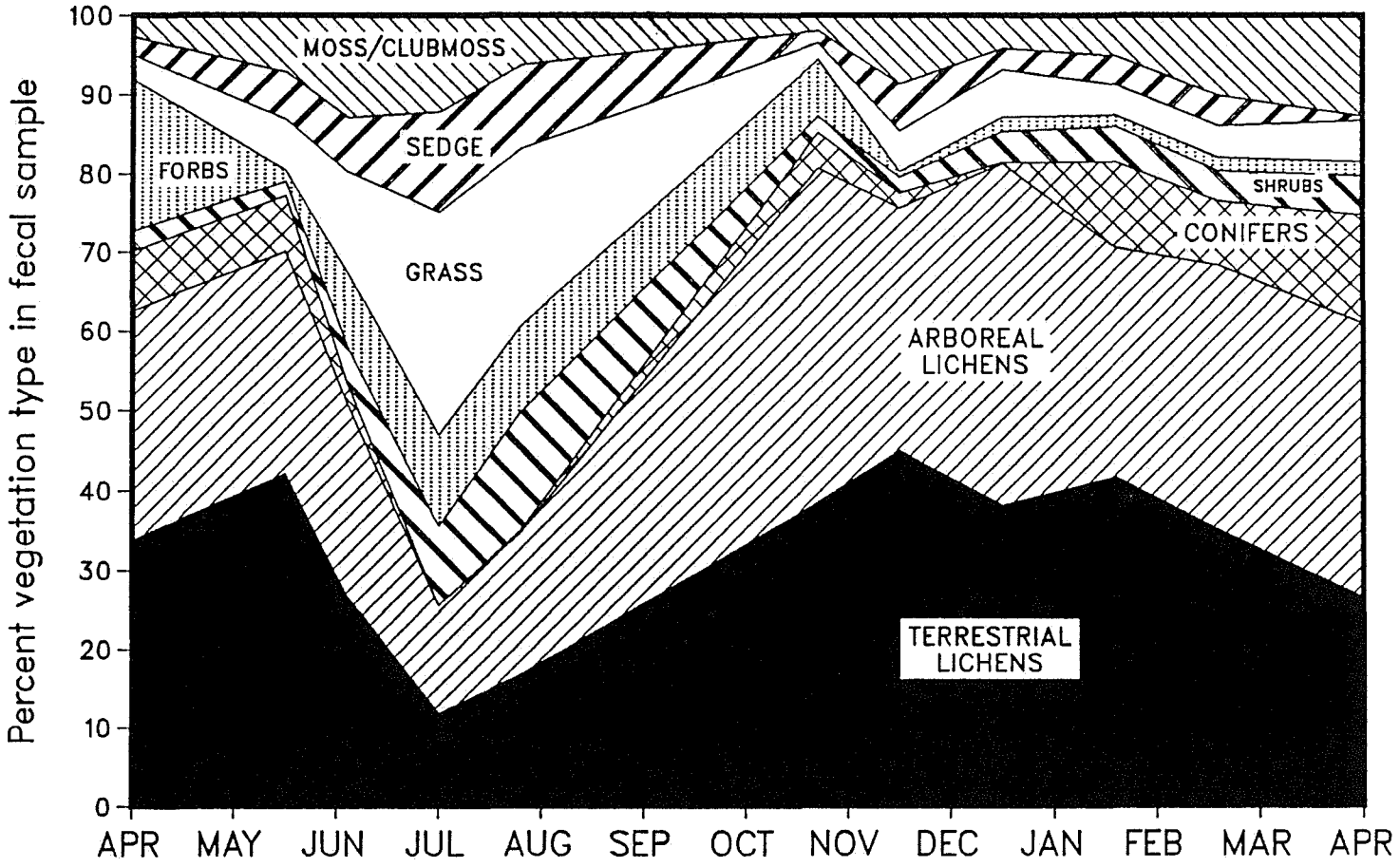

Fig.26. Percent of vegetation types found in fecal samples collected in the Itcha-Ilgachuz area in 1985/86. Samples from April, May and December were collected in 1987.

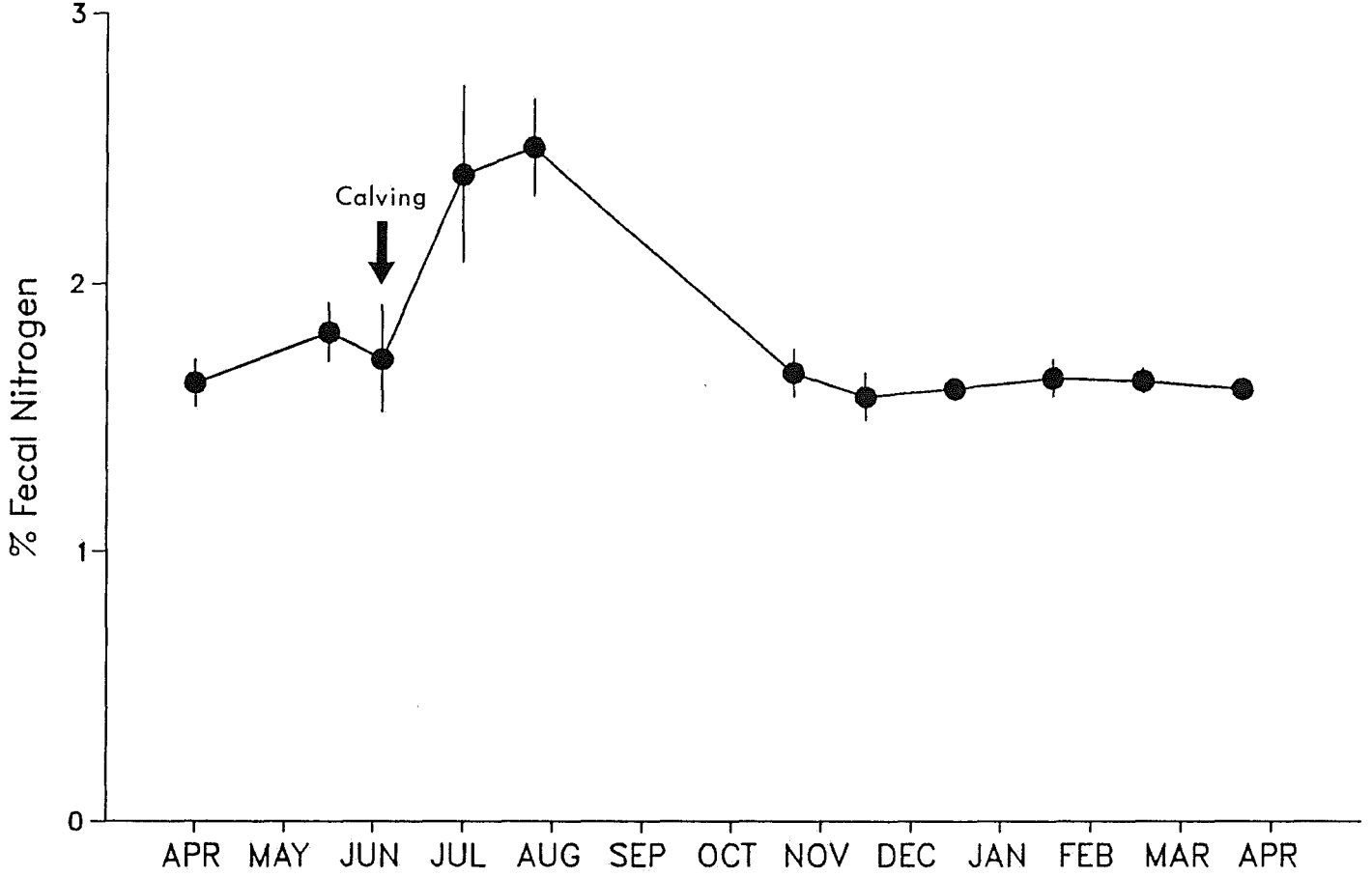

Fig.27. Percent fecal nitrogen levels in fecal samples collected in the Itcha-Ilgachuz in 1985/86. Samples from April, May and December were collected in 1987. Error bars are 95% confidence limits.

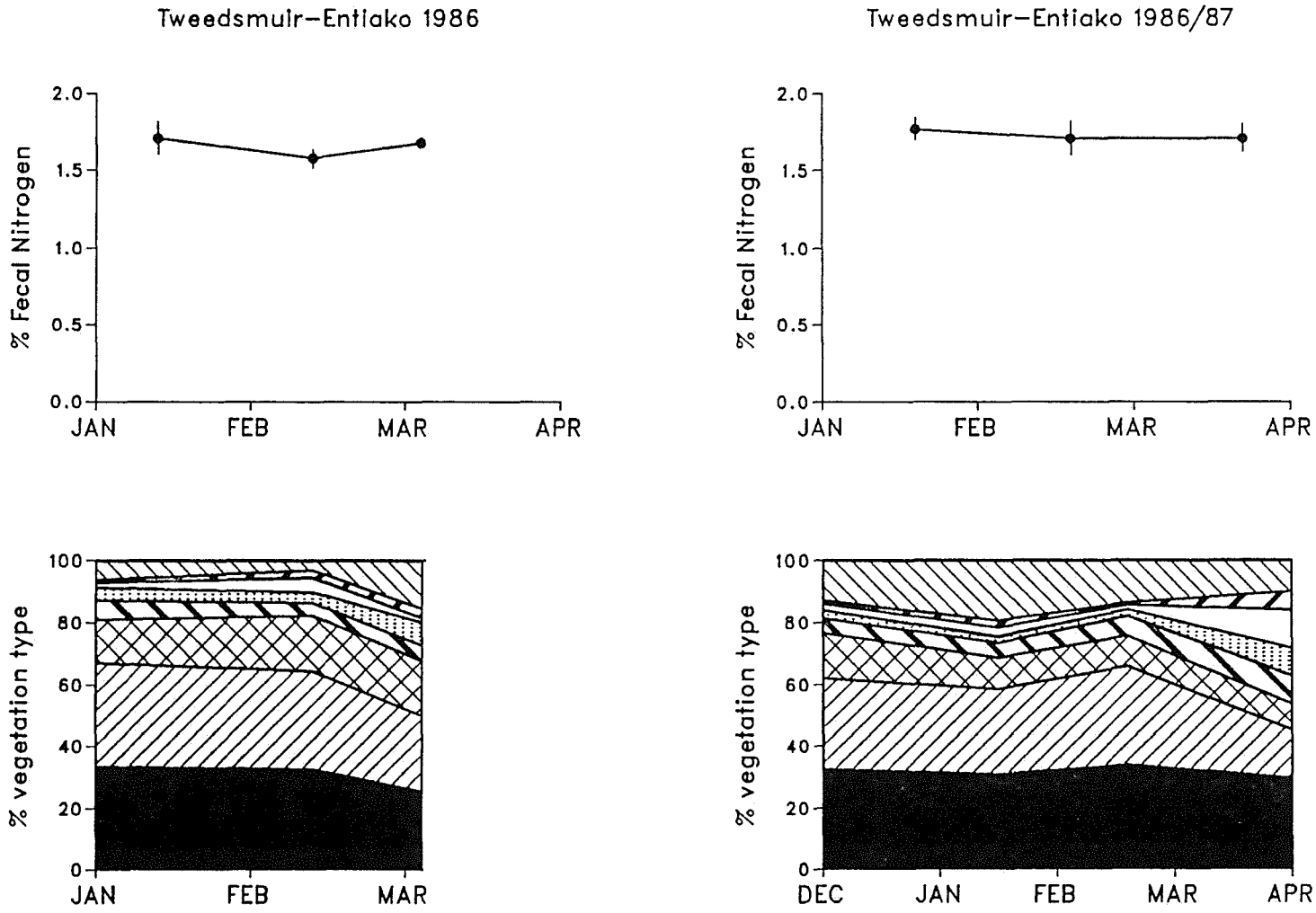

Fig.28. Percent fecal nitrogen levels and percent of vegetation types found in fecal samples collected in the Tweedsmuir-Entiako winter range in 1985/86 and 1986/87. Error bars are 95% confidence limits. (Vegetation type key on Fig.26.).

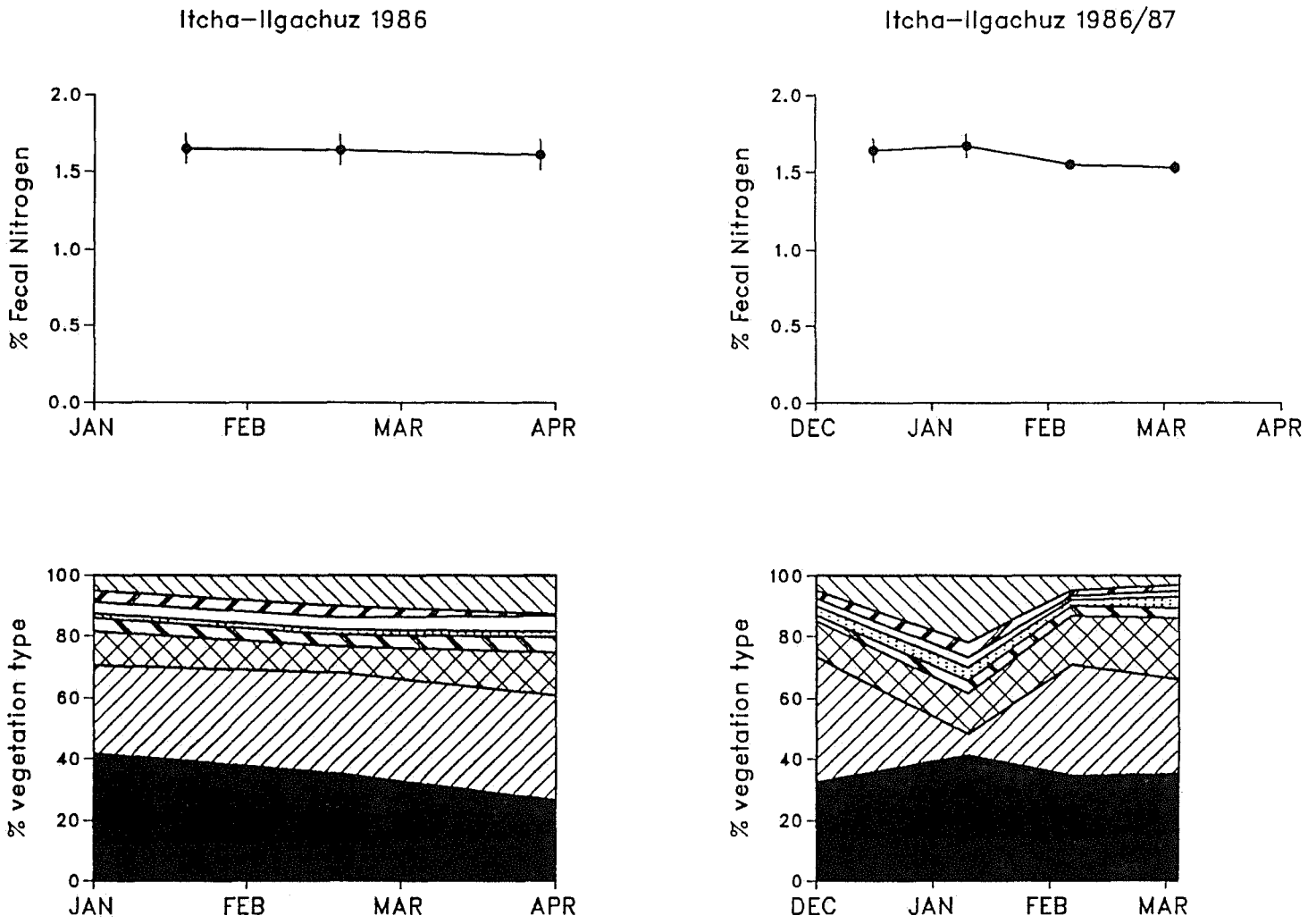

Fig.29. Percent fecal nitrogen levels and percent of vegetation types found in fecal samples collected in the Itcha-Ilgachuz winter range in 1985/86 and 1986/87. Error bars are 95% confidence limits. (Vegetation type key on Fig.26.).

POPULATION PARAMETERS

Population size

Tweedsmuir-Entiako: A total of 104 and 202 caribou were counted in alpine areas in the Quanchus Mountains during the October 1986 and 1987 calf surveys respectively. In 1986, 3 of 12 radiocollared caribou, and in 1987, 7 of 14 radiocollared caribou were present in alpine habitat in the Quanchus Range. Application of the correction factor to account for animals below treeline, to the total number of caribou counted in the alpine, yielded population estimates of 416 for October 1986 and 404 for October 1987 in the Tweedsmuir-Entiako area. Total caribou counted (both above and below treeline) during October surveys yielded a minimum population of 155 in 1985, 137 in 1986 and 245 in 1987 (Table 14).

Itcha-Ilgachuz-Rainbow: Correcting for caribou (cows and calves) not seen during the June censuses of the Itcha, Ilgachuz and Rainbow Mountains, and adding the estimated number of bulls in the population resulted in June population estimates of 1349 in 1985, 1433 in 1986, and 1484 in 1987 for the Itcha-Ilgachuz-Rainbow caribou (Table 15). The estimate for 1987 was probably low because the Rainbow Mountains were not intensively surveyed.

The population estimate for caribou in the Rainbow Mountains was derived from a survey conducted on the north side of the Rainbow Mountains in March 1987. A total of 165 caribou were counted during the survey, including 6 of the 7 radiocollared caribou. Correcting for the proportion of caribou not present on the north side of the Rainbow Mountains during the survey, yielded an estimate of 193 caribou in March 1987.

Table 14. Number of caribou of each sex/age class counted (both above and below treeline) during aerial surveys in June, October and March in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas (April 1985 - March 1988).

Date	Calves	Cows	Bulls	Total
Tweedsmuir-Entlako				
June 16,1985	9	28	0	37
October 6, 1985	10	114	31	155
March 19, 1986	8	81		89
June 23, 1986	6	20	0	26
October 7, 1986	13	102	22	137
March 15, 1987	15	135		150
June 16, 1987	14	20	0	34
October 20, 1987	20	192	33	245
March 11, 1988	12	123		135
Itcha-Ilgachuz-Rainbow				
June 18-19, 1985	287	721	58	1063
October 18, 1985	46	187	30	263
March 18, 1986	83	277	51	411
June 25-26, 1986	302	706	61	1069
October 10, 1986	105	407	87	599
March 14-15, 1987	85	407		492
June 18-19, 1987	273	620	78	971
October 21, 1987	82	483	92	657
March 10, 1988	47	338		385

Table 15. Estimated number of caribou present in the Itcha, Ilgachuz and Rainbow Mountains in June 1985, 1986 and 1987.

		1985	1986	1987
A.	Number of cows, calves and yearlings counted in alpine habitat	1002	986	884
B.	Proportion of radiocollared cows in alpine habitat	15/17	16/20	14/20
C.	Sightability correction factor (1/B)	1.13	1.25	1.43
D.	Estimated number of cows, calves, and yearlings (AxC)	1136	1233	1263
E.	Estimated number of bulls	213	200	221
F.	Total Population Estimate (D+E)	1349	1433	1484

Adult Mortality

From April 1985 to March 1988, 12 radiocollared caribou mortalities occurred in the Tweedsmuir-Entiako area and 9 mortalities occurred in the Itcha-Ilgachuz-Rainbow area (Table 16). Of the 7 known causes of mortality in the Itcha-Ilgachuz-Rainbow area, 6 were due to wolf (*Canis lupus*) predation, and 1 was due to poaching. In the Tweedsmuir-Entiako area, only 3 of the 12 causes of mortality were identified due to lack of mortality sensors in most of those radiocollars. Of the 3 known causes of mortality, two were predator related and one was caused by an accident. Ten of the 12 mortalities in the Tweedsmuir-Entiako area, and 8 of the 9 mortalities in the Itcha-Ilgachuz-Rainbow area occurred between May and October when caribou were on summer ranges (Fig.30). Seven of the 8 summer mortalities in the Itcha-Ilgachuz-Rainbow area and 2 of the 10 summer mortalities in the Tweedsmuir-Entiako area occurred in alpine or subalpine habitat.

In the Tweedsmuir-Entiako area, the annual adult mortality rate was 29.4% in 1985/86, 8.3% in 1986/87, 30.0% in 1987/88 and averaged 22.6% for the 3 year period. The annual adult mortality rate in the Itcha-Ilgachuz-Rainbow area was 5.6% in 1985/86, 20% in 1986/87 and 20% in 1987/88, and averaged 15.2% for the 3 year period.

Adult Harvest

In the Tweedsmuir-Entiako area, hunting was restricted to adult males and a maximum of 35 licences were sold in 1985, 1986 and 1987. The limited number of licences and poor access into the area contributed to the low harvest during those 3 years (Table 17).

Table 16. Causes of mortality of adult female radiocollared caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas between April 1985 and March 1988.

Date	Habitat type	Elevation (meters)	Cause of Death
Tweedsmuir/Entiako			
April 1985	Pine/spruce	980	unknown
May 1985	Pine	850	unknown (wolf sign present)
June 1985	Pine/spruce	1220	unknown (wolf/bear sign present)
September 1985	Spruce	870	unknown
October 1985	Subalpine	1400	unknown
July 1986	Pine/meadow	1050	unknown
April 1987	Spruce/wetland	920	unknown (possible wolf kill)
June 1987	Mtn. hemlock	910	wolf kill
June 1987	Pine	980	bear kill/scavenge
July 1987	Alpine	1430	unknown
October 1987	Coastal western hemlock	640	accident
August 1987	Pine	850	unknown
Itcha/Ilgachuz/Rainbow			
June 1985	Pine	1460	unknown (bear scavenge)
June 1986	Subalpine	1750	wolf kill
July 1986	Alpine	1950	unknown (previously limping)
September 1986	Alpine	1750	wolf kill
March 1987	Pine	1310	wolf kill
July 1987	Alpine	1700	wolf kill
July 1987	Alpine	1800	wolf kill
September 1987	Alpine	1740	wolf kill
October 1987	Subalpine	1750	poached

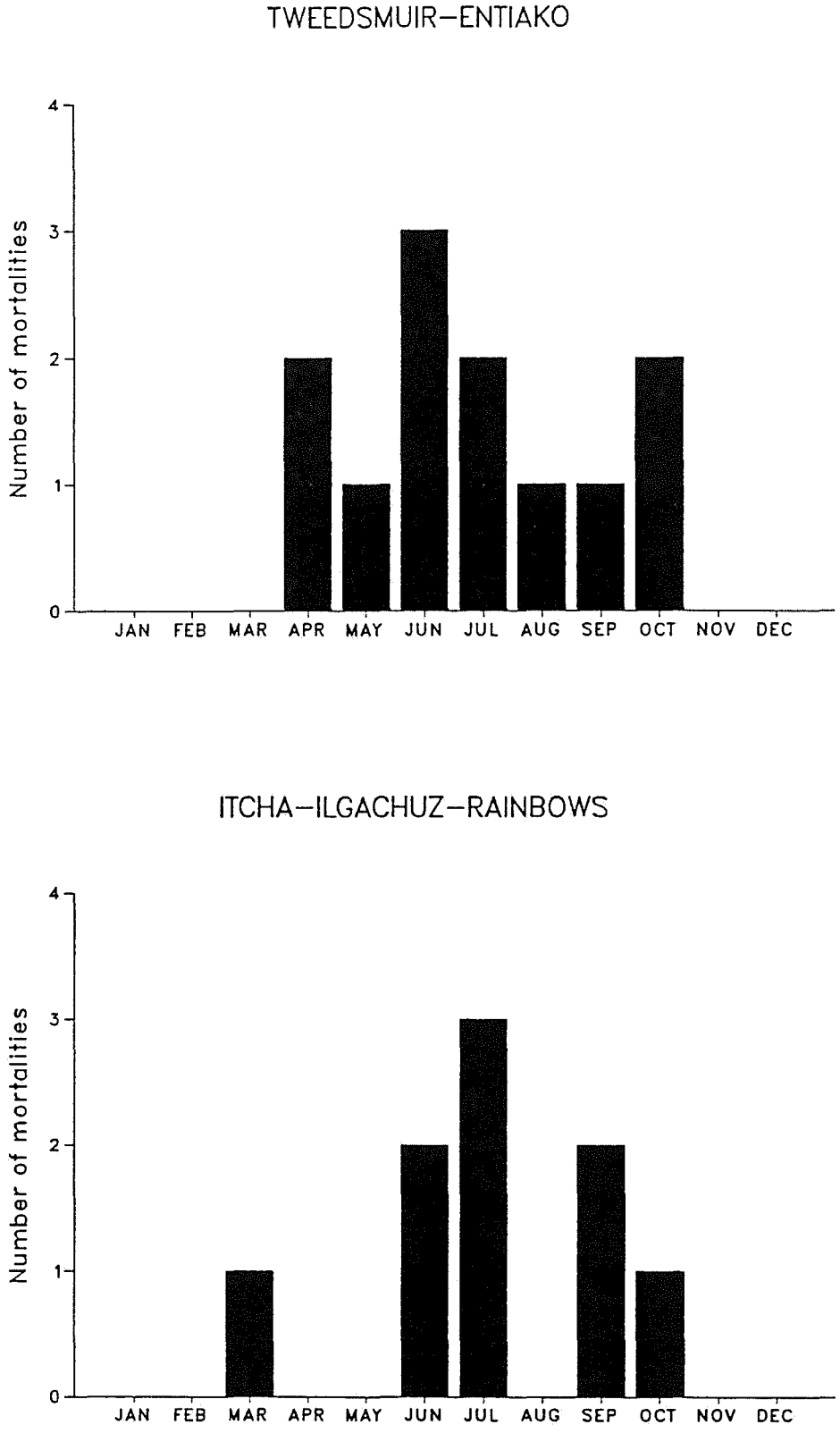

Fig.30. Seasonal distribution of adult female radiocollared caribou mortalities in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas.

Table 17. Estimated adult male harvest rates in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas from 1985-1987.

	# of adult bulls harvested	estimated # of bulls	harvest rate
Tweedsmuir-Entiako			
October 1985	0	-	0
October 1986	1	88	1.1
October 1987	0	66	0
Itcha-Ilgachuz-Rainbow			
October 1985	19	213	8.9
October 1986	8	200	4.0
October 1987	30	221	13.6

Table 18. Percent of female radiocollared caribou that were pregnant in the Itcha-Ilgachuz-Rainbow area and in the Tweedsmuir-Entiako area based on serum progesterone levels. Samples from April 1986 (16), March 1987 (21), and March 1988 (13).

Age Group	% Pregnant	Sample size
Itcha-Ilgachuz-Rainbow		
Adults (>22 months)	97	34
Yearlings (22 months)	25	4
Calves (10 months)	0	5
Tweedsmuir-Entiako		
Adults (>22 months)	86	7

In the Itcha-Ilgachuz-Rainbow area, hunting was open for all adult male caribou in 1985, but in 1986 and 1987 hunting was limited to adult male caribou with antlers with at least 5 points that were greater than 5 centimeters in length, or total antler length greater than 75 centimeters. The estimated harvest rate of adult males varied between 4% and 14% from 1985 to 1987 (Table 17). In 1987, 20 licences were sold for adult female caribou. Four female caribou were harvested resulting in an adult female harvest rate of less than 0.5%.

Calf Production and Survival

In the Tweedsmuir-Entiako area, 5 of 7 adult female caribou in March 1987 were pregnant (Table 18). In June, 30%-65% of the radiocollared caribou cows had surviving calves but by October only 0-30% of adults had surviving calves (Fig.31). No radiocollared female caribou had a surviving calf in March 1986 and March 1987; but, 2 of the 14 radiocollared caribou had surviving calves in March 1988.

Pregnancy rate of adult female caribou in the Itcha-Ilgachuz-Rainbow Mountains was 97% (Table 18). In June, 45-80% of the radiocollared cows had calves, and in October, 6-45% of the radiocollared caribou had surviving calves (Fig.31). Most calf mortality occurred between June and October and relatively little mortality occurred between October and March. In March, the percentage of adult radiocollared female caribou with calves varied between 6% and 35%.

Calf survival: alpine vs. low elevation

The percentage of radiocollared caribou in alpine habitat varied over the 3 survey periods (Fig.32). In the Itcha-Ilgachuz-Rainbow area, an average of 84%, 75% and 27%

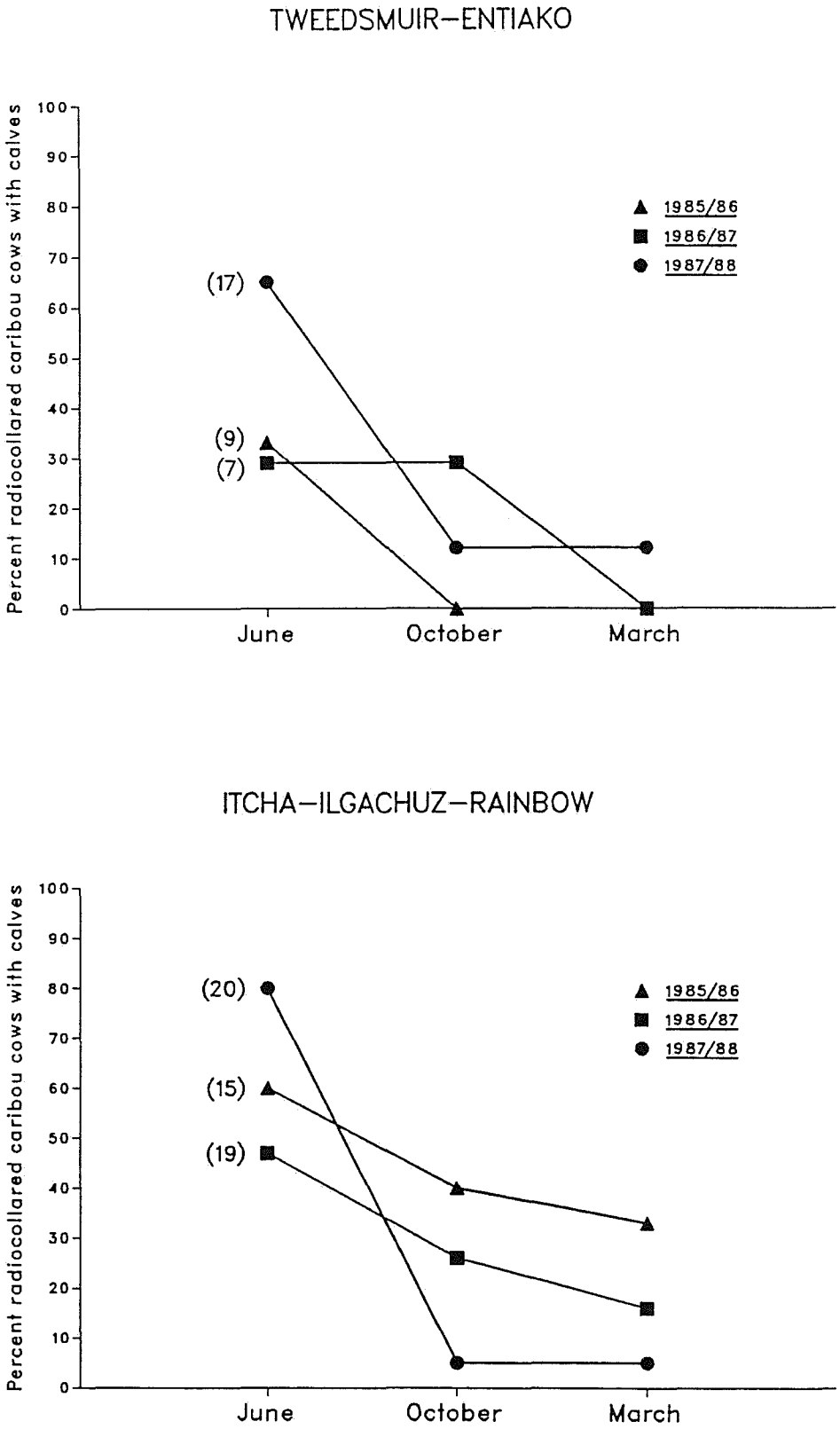

Fig.31. Corrected calf/cow ratios of radiocollared caribou during June, October and March calf surveys in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, April 1985 - March 1988.

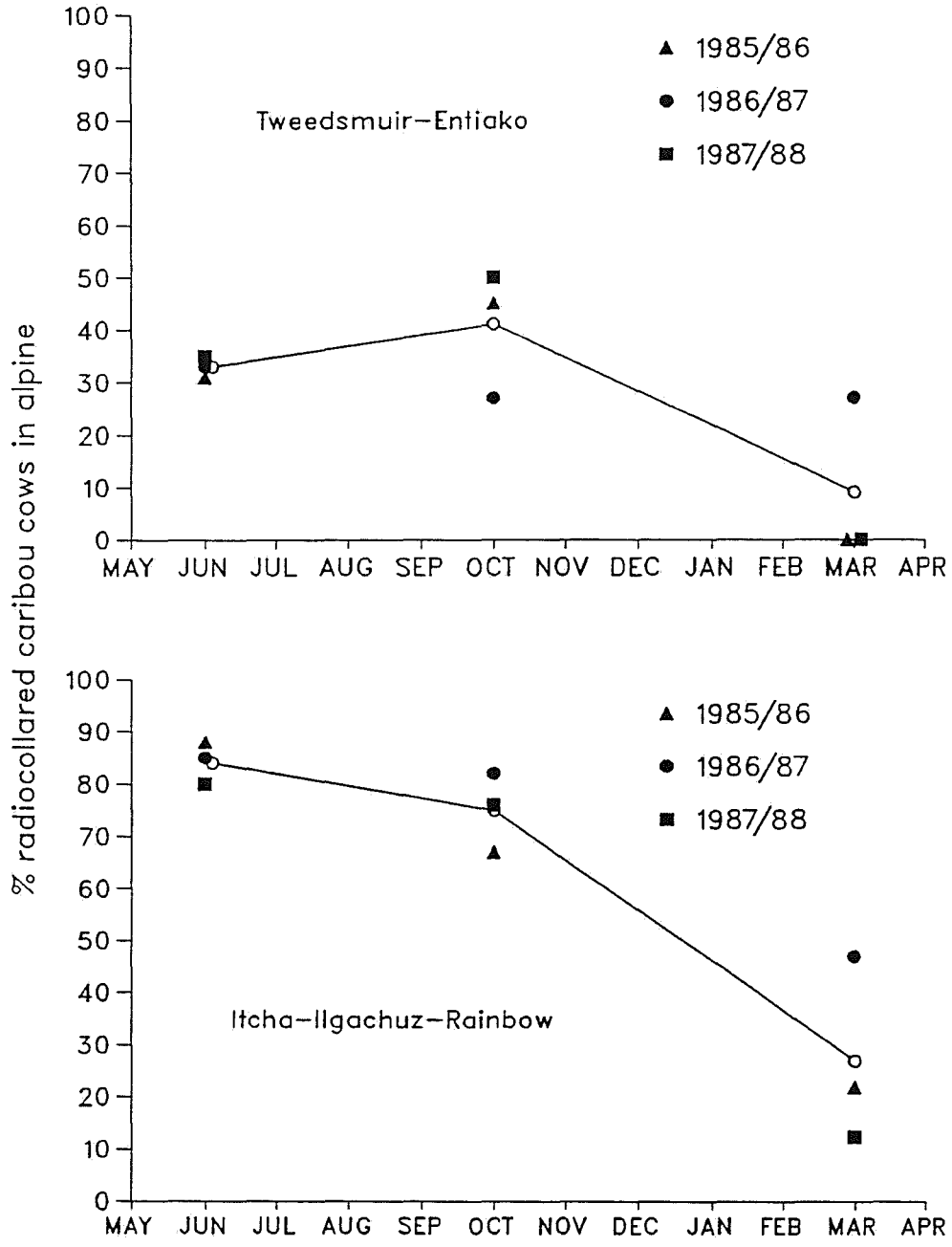

Fig.32. Percent of radiocollared caribou cows in alpine habitat during calf survival surveys in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas.

of radiocollared caribou cows used alpine habitat during June, October and March respectively. Less than 50% of the radiocollared caribou cows in the Tweedsmuir-Entiako area were found above treeline during surveys. Greatest use of alpine habitat occurred in October when an average of 41% of the radiocollared caribou were in alpine habitat.

The proportion of adult female caribou (collared and uncollared) with calves counted during June censuses was greater for cows that were found in the alpine than for cows found below treeline, in both the Tweedsmuir-Entiako (X^2=22.4, $p<.05$) and Itcha-Ilgachuz-Rainbow (X^2=4.4, $p<.05$) areas (Table 19). In the Tweedsmuir-Entiako area, the proportion of radiocollared caribou with calves in June was also greater in the alpine than below treeline (X^2= 14.3, $p<.05$). The percentage of radiocollared caribou with calves in the Chikamin Mountains and in the area west of Ootsa and Eutsuk Lakes (80%) was greater than the percentage of radiocollared caribou with calves at lower elevations in northern Tweedsmuir Park east of Ootsa and Eutsuk Lakes (24%) (X^2=14.7, $p<.05$) (Fig.33). In the Rainbow Mountains, calving success was high (88%) for all 3 years combined (Fig.34).

During October surveys, there were no differences between the proportion of cows with calves above treeline and the proportion of cows with calves below treeline in either the radiocollared caribou sample or the total caribou sample in the Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas at α=.05 (Table 19). At α=.10, the proportion of radiocollared cows with calves below treeline was greater than the proportion of radiocollared cows with calves above treeline in Tweedsmuir-Entiako.

Table 19. Proportion of caribou cows with calves in the alpine and below treeline in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas from 1985 - 1988 combined. (N) = number of cows counted.

DATE	PROPORTION COWS IN ALPINE WITH CALVES	PROPORTION COWS BELOW TREELINE WITH CALVES	SIGNIFICANCE α=.05	SIGNIFICANCE α=.10
RADIOCOLLARED CARIBOU				
Tweedsmuir-Entiako				
June	.933 (15)	.238 (21)	SIG	SIG
October	.063 (16)	.222 (18)	NS	SIG
March	(0)	.056 (36)		
Itcha-Ilgachuz-Rainbow				
June	.625 (48)	.667 (9)	NS	NS
October	.275 (40)	.167 (12)	NS	NS
March	.308 (13)	.135 (37)	NS	NS
TOTAL CARIBOU				
Tweedsmuir-Entiako				
June	.800 (25)	.209 (43)	SIG	SIG
October	.096 (343)	.154 (65)	NS	NS
March	.151 (86)	.087 (253)	NS	SIG
Itcha-Ilgachuz-Rainbow				
June	.424 (2017)	.233 (30)	SIG	SIG
October	.211 (960)	.256 (117)	NS	NS
March	.281 (519)	.137 (503)	SIG	SIG

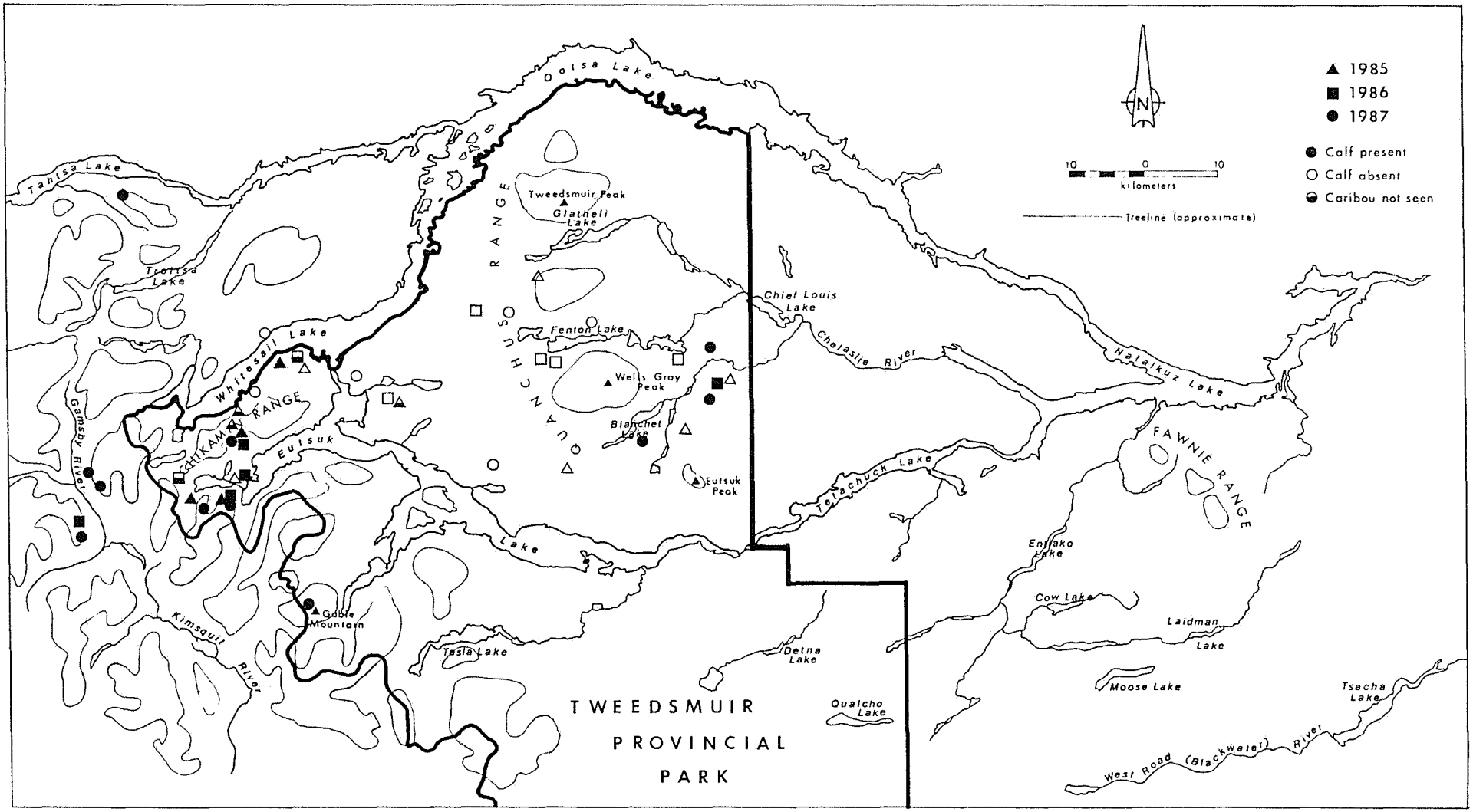

Fig.33. Locations of radiocollared female caribou in northern Tweedsmuir Park during calving surveys in June 1985, 1986 and 1987.

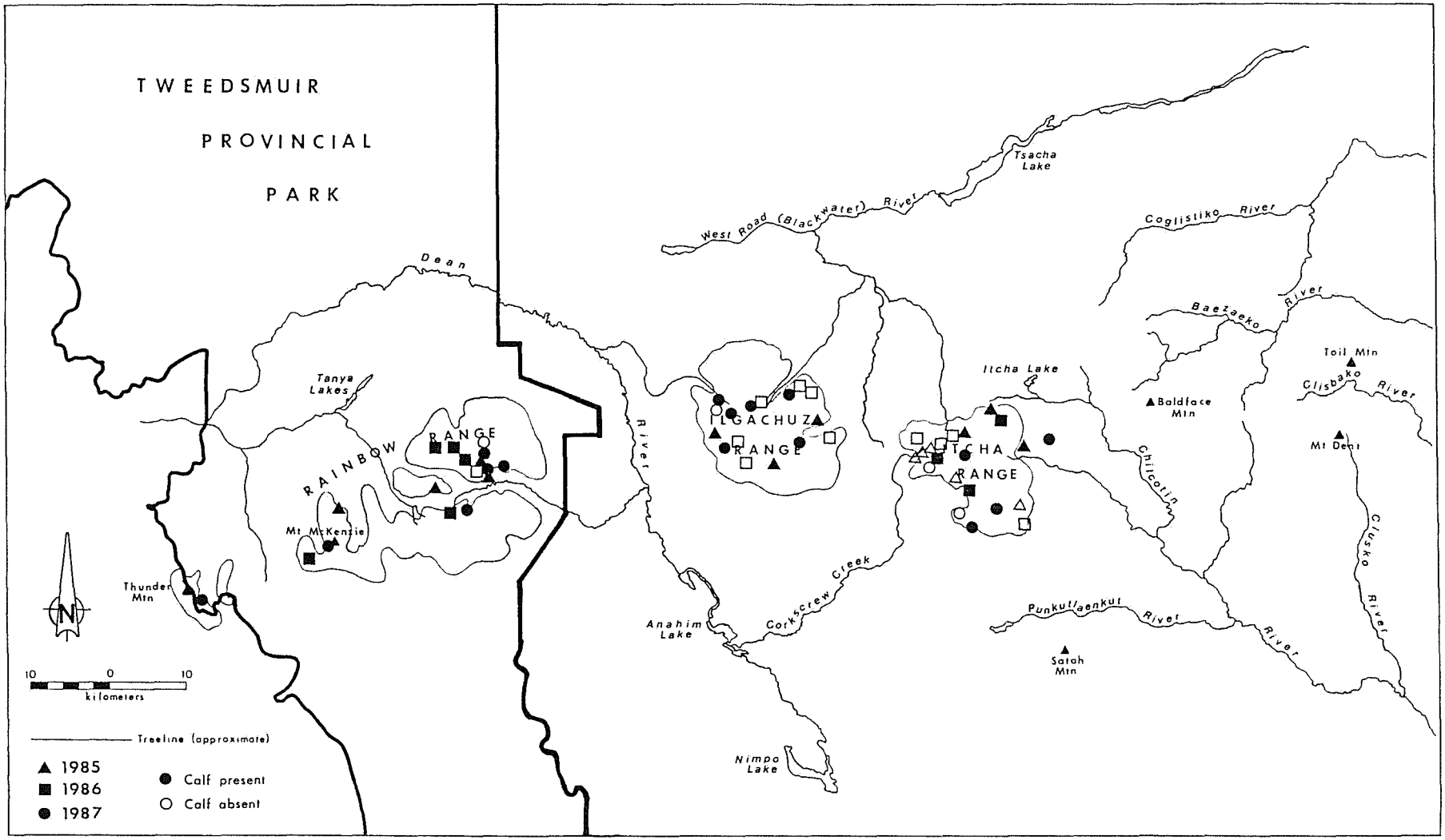

Fig.34. Locations of radiocollared female caribou in the Itcha, Ilgachuz, and Rainbow Mountains during calving surveys in June 1985, 1986 and 1987.

In March, the total counts indicated that the proportion of cows with calves in the alpine was greater than the proportion of cows with calves below treeline in both Itcha-Ilgachuz-Rainbow (X^2=31.9, p<.05) and Tweedsmuir-Entiako (X^2=2.86, p<.10) areas.

Population Status

Over the 3 year study, average adult mortality rate exceeded average March calf recruitment for the Tweedsmuir-Entiako caribou, suggesting a declining population (Table 20). For the Itcha-Ilgachuz-Rainbow caribou, average adult mortality rate and average March calf recruitment were similar indicating a stable or growing population.

CALVING BEHAVIOUR

Calving sites

Calving site locations of individual radiocollared caribou varied little between years. In both the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, 43% of calving sites of radiocollared caribou found during successive years were within 5 km from the previous year's calving site, and about 70% were within 10 km (Fig.35). In the Itcha-Ilgachuz-Rainbow area, 14 of 17 radiocollared caribou were found in the same mountain range during both or all 3 June surveys.

Over the summer, radiocollared caribou without calves travelled greater distances than radiocollared caribou with calves (Fig.36). The difference was more pronounced in the Tweedsmuir-Entiako area than in the Itcha-Ilgachuz-Rainbow area.

Table 20. Average adult mortality rate and average calf recruitment rate (calves/100 adults) in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas, 1985/86 - 1987/88. Adult mortality rate based on radiocollared caribou sample; calf recruitment rate based on total counts (alpine and below treeline) in March. (N) = number of adult radiocollared caribou (mortality); total number of adult caribou (recruitment).

	Adult mortality rate	95% confidence limits	Calf recruitment rate	95% confidence limits
Tweedsmuir-Entiako				
1985/86	29.4(17)		9.9(081)	
1986/87	8.3(12)		11.1(135)	
1987/88	30.0(20)		9.8(123)	
Average	22.6(49)	10.9-34.3	10.3(339)	
Average March recruitment rate corrected for average adult mortality			7.8(448)	5.3-10.3
Itcha-Ilgachuz-Rainbow				
1985/86	5.6(18)		25.3(328)	
1986/87	20.0(20)		20.9(407)	
1987/88	20.0(20)		13.9(338)	
Average	15.2(58)	6.0-24.4	20.0(1073)	
Average March recruitment rate corrected for average adult mortality			16.9(1270)	15.7-19.0

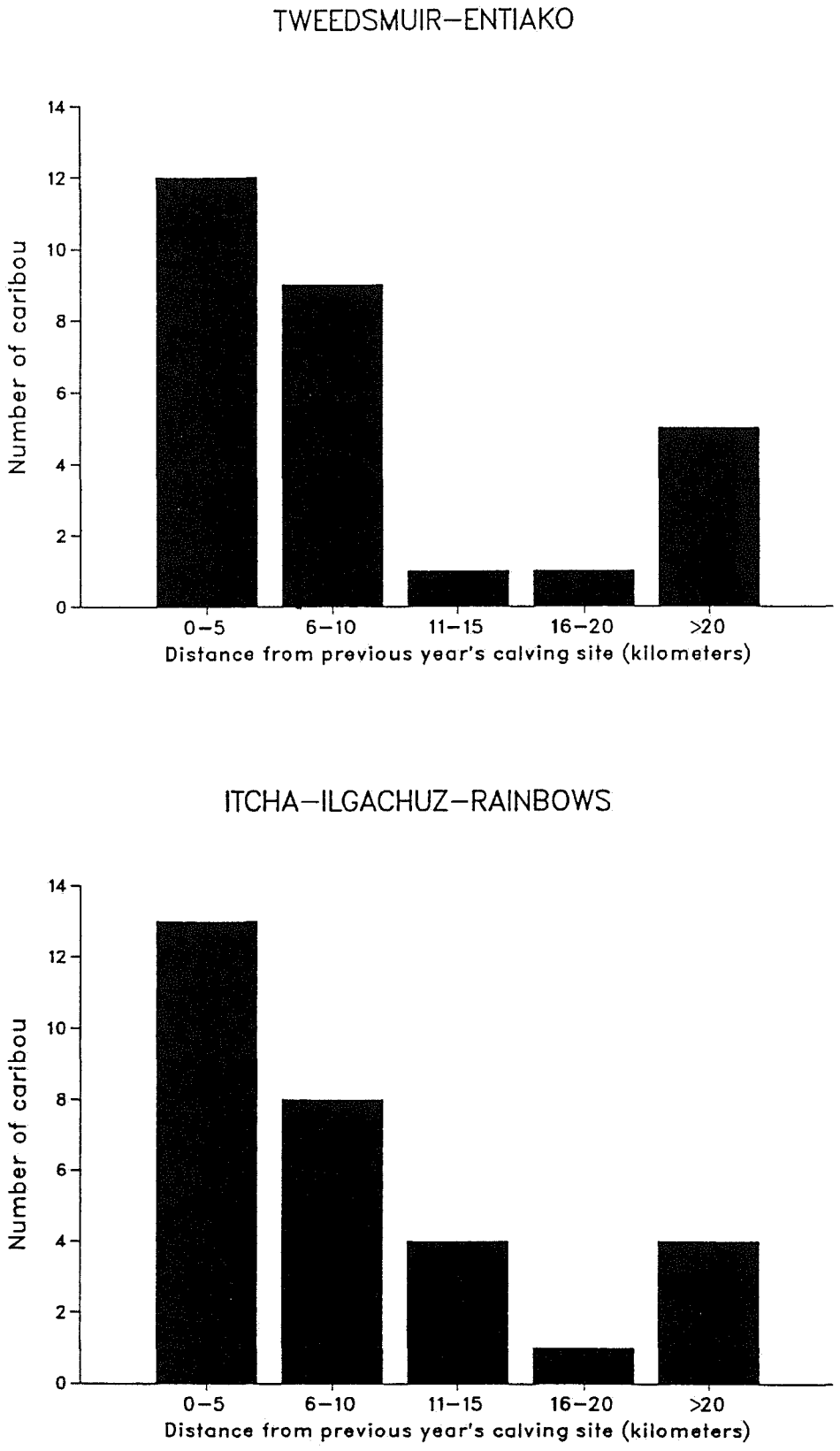

Fig.35. Distance between calving sites of successive years of radiocollared caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas.

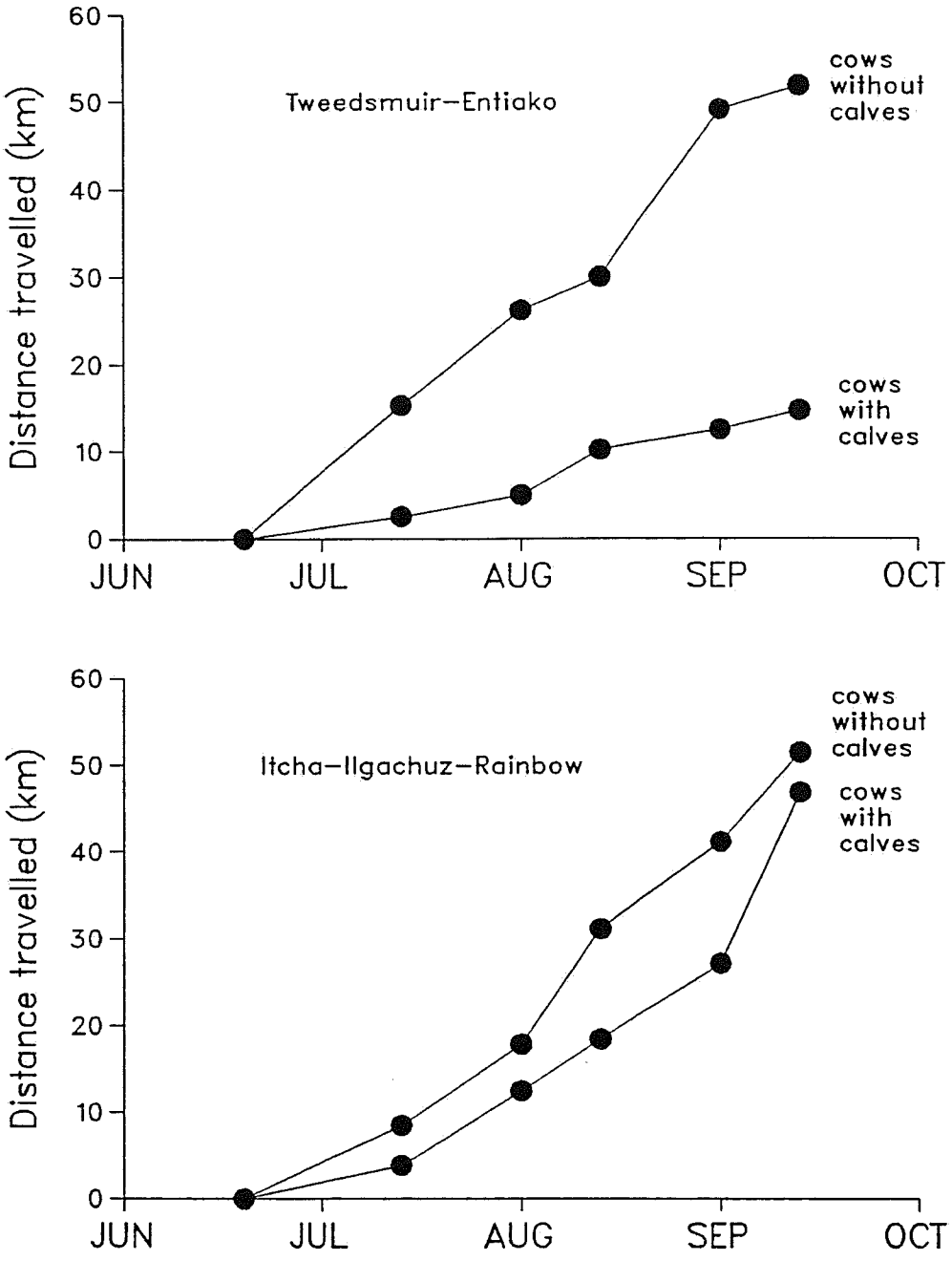

Fig.36. Mean cumulative distance travelled between radiotelemetry locations by adult female radiocollared caribou with calves, and adult female caribou without calves, during the summer in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas.

Calving ground observations

The percentage of caribou cows with calves in the Itcha Mountains increased from 2% in late May to a peak of 60-73% in early June (Fig.37). The calf/cow ratio then decreased slowly after the peak of calving, and stabilized in late July at about 35 calves/100 cows.

Group size varied over the summer. From late May to June 15, mean group size varied between 3 and 4 caribou and typical group size varied between 5 and 7 caribou (Fig.38). During the peak of calving, 62% of all groups observed consisted of either 1 adult female or 1 adult female and a calf, and of all caribou cows observed, 35% were observed alone or alone with a calf (Fig.39). Mean group size increased to 64 caribou and typical group size increased to a peak of 164 caribou in mid-July before decreasing to 13 and 25 caribou respectively in late July (Fig.38). The proportion of lone cows declined to close to zero following calving (Fig.39). The average elevation that caribou groups were found at gradually decreased from 2052 meters in early June to 1950 meters in late July (Fig.40).

A total of 10 dead calves were found during June and July in 1985, 1986 and 1987 (Table 21). Of the 5 known causes of mortality, 2 mortalities were wolf kills, 2 were nutritionally related and one mortality was birth related. Eagles were found scavenging 6 of the 10 calf carcasses. Although eagles were never observed killing caribou calves, on one occasion a golden eagle was observed to attack a calf that was separated from its mother. Because it was easier to find dead calves that were only partly consumed, and that were being scavenged by eagles and ravens, the above results were biased against mortalities in which calves were quickly consumed or removed.

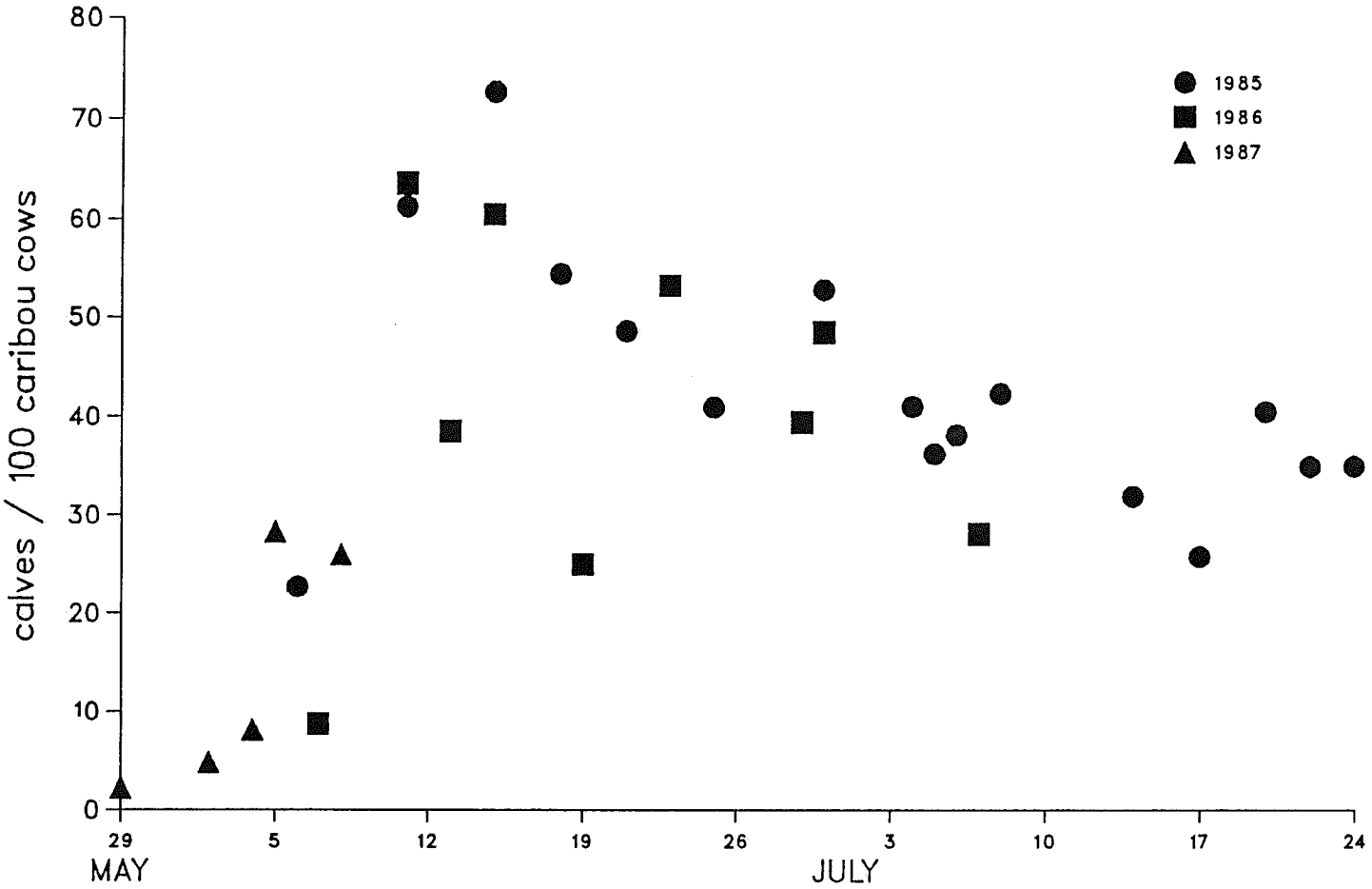

Fig.37. Calves/100 caribou cows counted during individual ground surveys in alpine areas in the Itcha Mountains during June and July, 1985, 1986 and 1987.

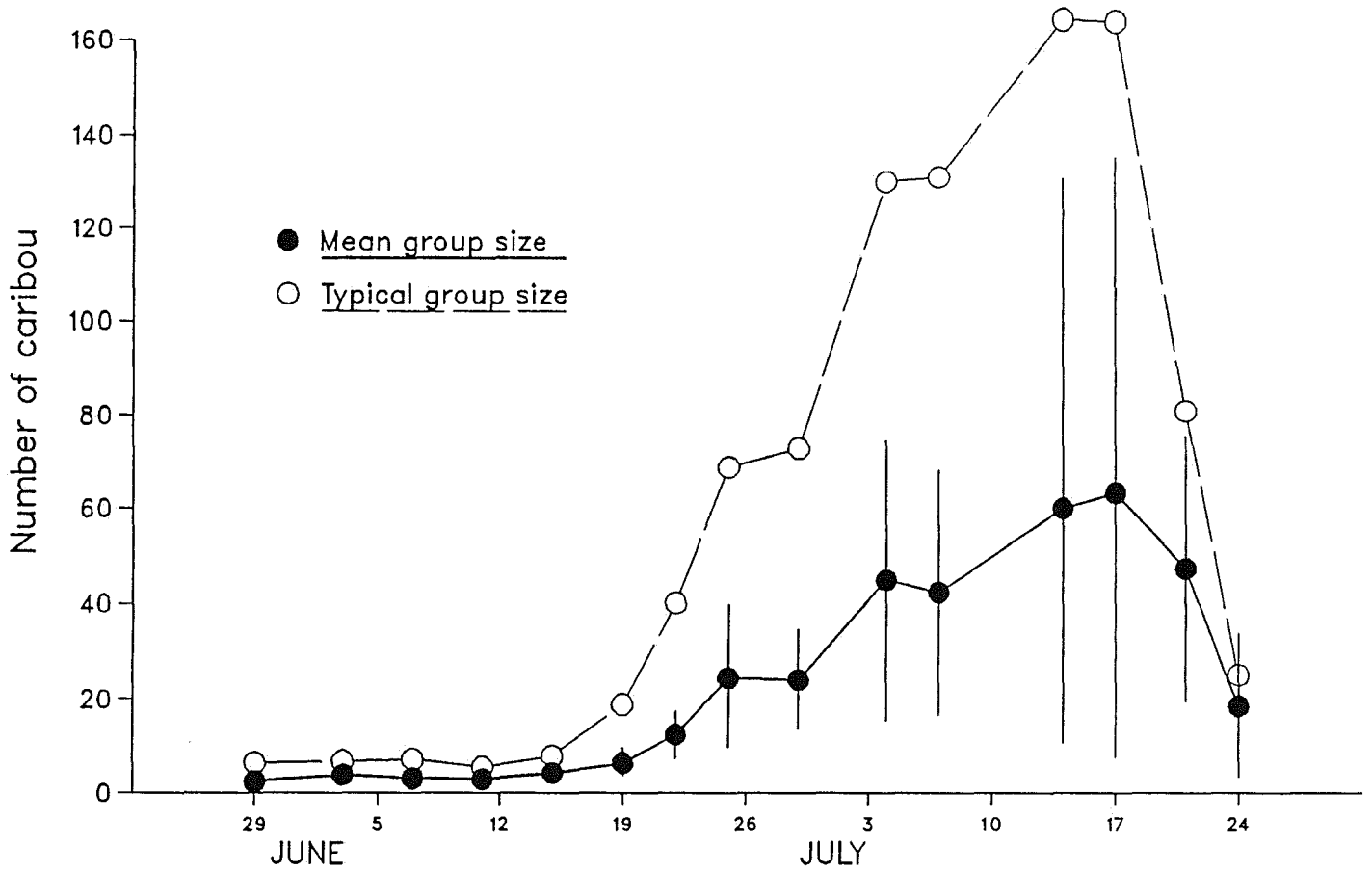

Fig.38. Mean group size (±1 standard deviation) and typical group size of caribou during ground surveys in alpine areas in the Itcha Mountains during June and July for 1985, 1986 and 1987 combined.

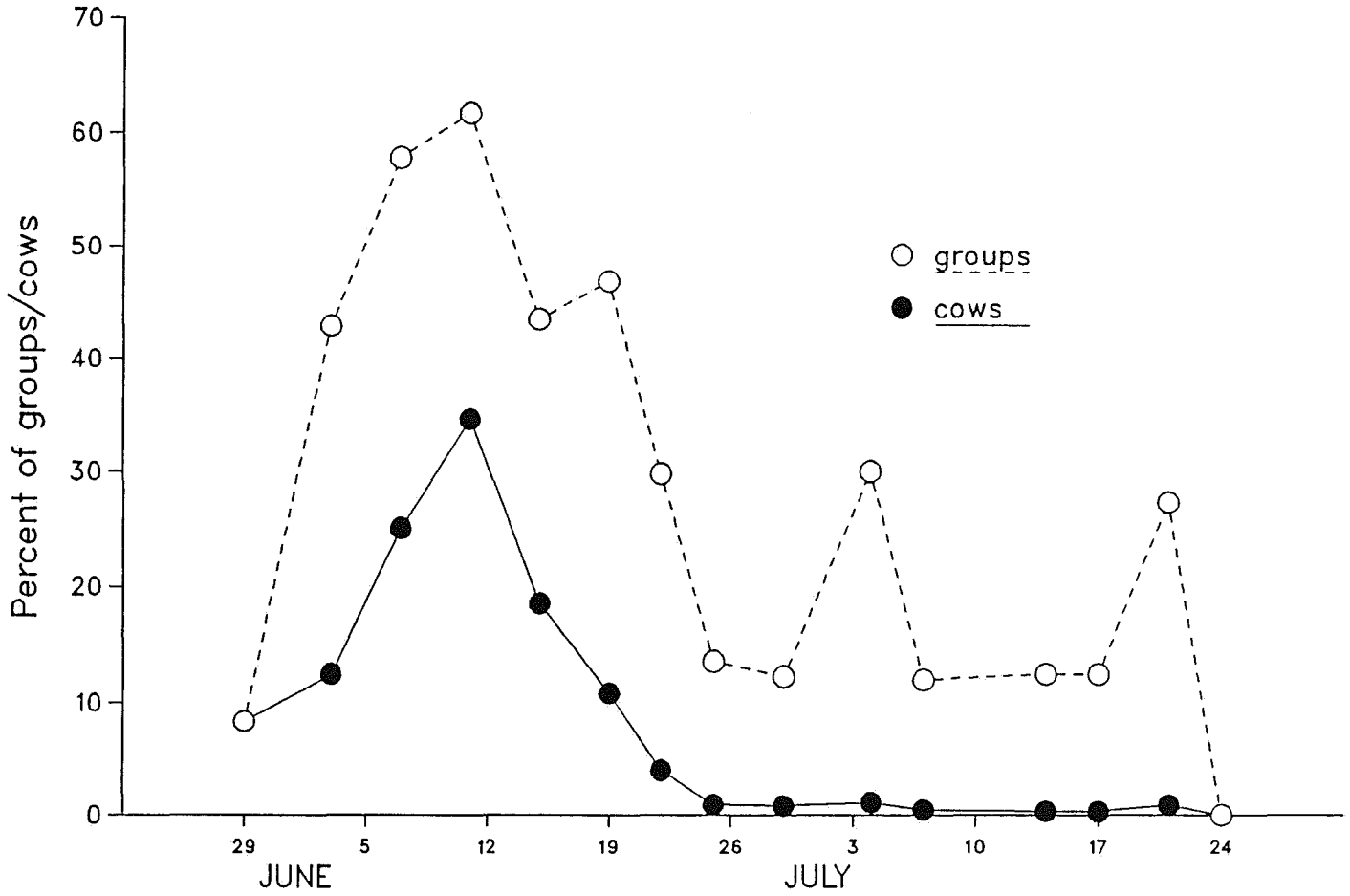

Fig.39. Percent of total groups observed consisting of a single cow or one cow and one calf, and percent of all cows observed that were alone or only with a calf during calving ground surveys in the Itcha Mountains for 1985, 1986 and 1987 combined.

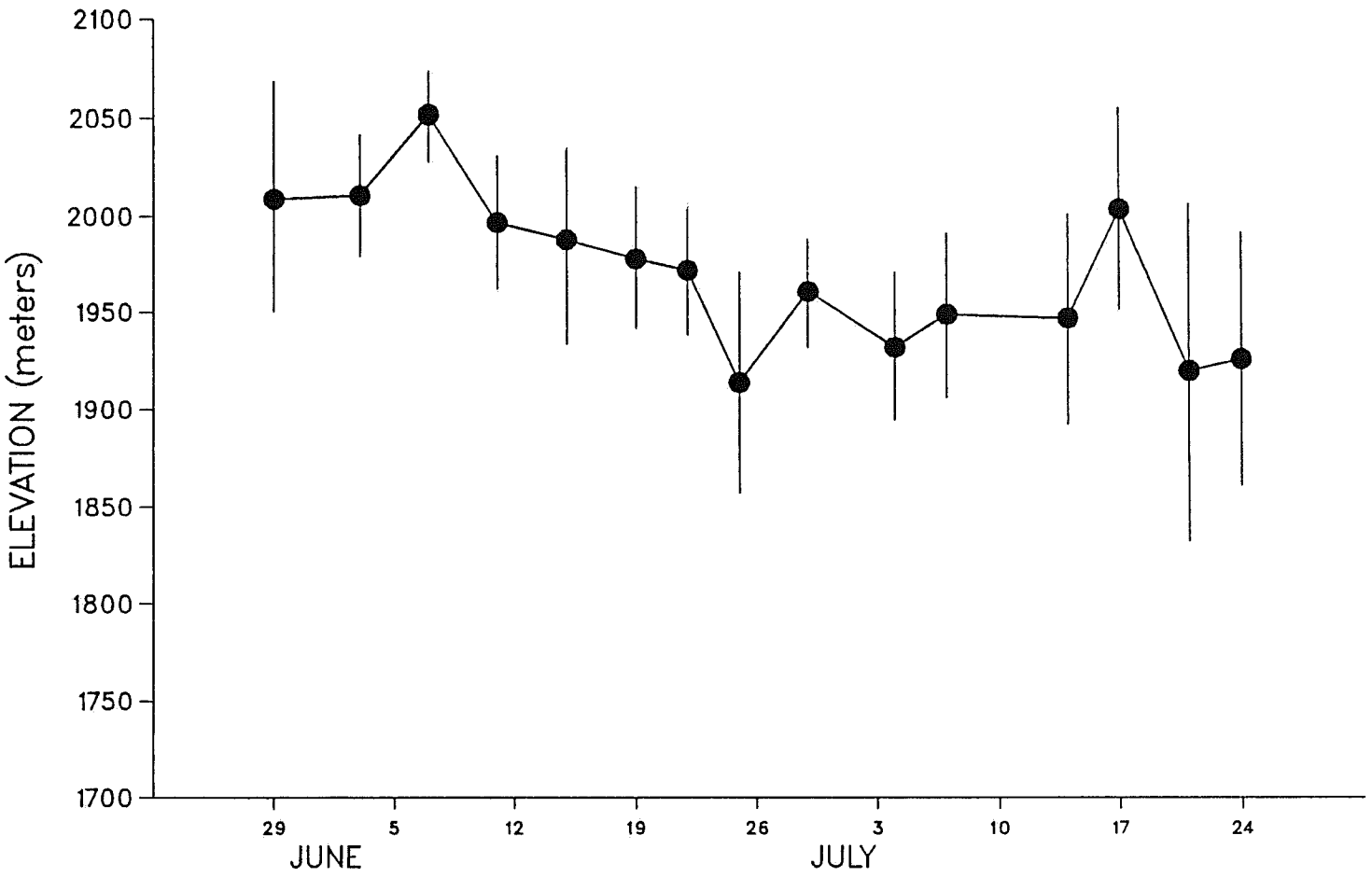

Fig.40. Mean elevation (±1 standard deviation) of caribou groups counted during ground surveys in alpine areas in the Itcha Mountains during June and July for 1985, 1986 and 1987 combined.

Table 21. Causes of caribou calf mortality during summer calving ground observations in the Itcha Mountains (June - July) 1985, 1986, 1987.

Date Found	Cause of Death	Comment
June 25, 1985	Unknown	extensively scavenged by eagles, -no mammalian carnivore sign present
June 26, 1985	Wolf kill	actual kill observed
June 27, 1985	Unknown	possible eagle kill -calf found alone previous day -scavenged by eagles
June 27, 1985	Weak calf	emaciated condition -no sign of scavenging -no visible puncture marks -no carnivore sign present
June 27, 1985	Unknown	scavenged by eagles -little left of the carcass
July 6, 1985	Unknown	scavenged by eagles
June 25, 1986	Weak calf	emaciated condition -no sign of scavenging -no visible puncture marks -no carnivore sign present
June 30, 1986	Unknown	scavenged by eagles -head missing
June 18, 1987	Probable wolf kill	wolf found feeding on carcass -calf found with broken leg which occurred while still alive -break most likely occurred when chased by wolf
June 19, 1987	Birth related	found beside female -the umbilical cord was wrapped around its waist

DISCUSSION

SEASONAL MOVEMENTS AND HABITAT USE

Caribou in the Tweedsmuir-Entiako area spent the winter south of Tetachuck Lake in low elevation forested habitat in the Entiako Lake area and migrated to summer ranges in northern Tweedsmuir Park and the adjacent mountains to the west. Itcha-Ilgachuz caribou spent the summer in the Itcha and Ilgachuz Mountains. In winter, most moved to low elevation forested habitat to the east of the Itcha Mountains although some remained in the alpine on the north side of the Ilgachuz Mountains. Rainbow Mountain caribou were found primarily in the Rainbow Mountains during summer and winter although some used the north side of the Ilgachuz Mountains during winter.

Spring migration

Caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas displayed generally consistent movement patterns between winter and summer ranges. Spring migration occurred along low elevation routes where snow was minimal or absent. Some Tweedsmuir-Entiako caribou moved up to 40 kilometers off the most direct route to summer ranges, to follow low elevation areas along the Chelaslie River. In the Tweedsmuir-Entiako area, distance between winter ranges and summer ranges averaged 95 km; although some caribou travelled up to 160 km during spring migration. Caribou in the Itcha-Ilgachuz-Rainbow area travelled lesser distances (average = 41 km) during spring migration between low elevation winter range and calving areas. Habitat use by caribou during spring migration was restricted primarily to those habitats occurring at low elevations. Snowfree areas were also reported to be important during

spring migration for barren-ground caribou in northern Yukon (Surrendi and DeBock 1976) and woodland caribou in west-central Alberta (Edmonds and Bloomfield 1984).

In the Tweedsmuir-Entiako area, caribou moved north across Tetachuck Lake during spring migration. Although crossing occurred along the length of the lake, the main crossing points appeared to be along the east half of the lake and at the Tetachuck River (between Tetachuck Lake and Natalkuz Lake). Movements of Rainbow caribou from the Ilgachuz to the Rainbow Mountains were inferred from caribou locations before and after migration since the frequency of flights was insufficient to detect actual routes used. It appeared that most movement occurred north of Lessard Lake.

Rainbow caribou crossed the Dean River Road when moving between the Rainbow and Ilgachuz Mountains. The road currently supports little traffic and does not appear to hinder caribou movements. Roads with low traffic volume do not appear to act as barriers to caribou and reindeer movement (Bergerud et al. 1984b, Gauthier et al. 1976, Russell and Martell 1976, Skogland 1986), but increased traffic may interfere with movements. Currently there are no roads transecting spring migration routes of the Itcha-Ilgachuz and Tweedsmuir-Entiako caribou.

Calving grounds

By calving time in early June, adult female caribou had returned to summer ranges. Most calving sites were within 10 kilometers of the previous year's calving site. In the Itcha-Ilgachuz-Rainbow area, most adult female radiocollared caribou were found in alpine habitat in the Itcha, Ilgachuz and Rainbow Mountains. In the Itcha Mountains, caribou cows were found throughout the alpine during calving but were primarily found alone on ridgetops. By the end of June, cows and calves in the Itcha-Ilgachuz-Rainbow

Mountains formed post-calving aggregations and by late June/early July, were joined by bulls. Dispersion in mountains is considered to be an antipredator strategy of woodland caribou (Bergerud et al. 1984a, Seip 1989). Adult female caribou often forgo superior forage quality available at lower elevations to calve high in mountains. Adult female caribou moved to alpine habitat before emergence of new vegetative growth, as indicated by low fecal nitrogen values. This strategy spaces caribou away from alternate prey such as moose (*Alces alces*) which occupy lower elevation habitats at this time, and increases predator searching time for calves, making it difficult for predators to subsist on a diet of caribou calves (Bergerud and Page 1987, Seip 1989). In eastern Canada where alpine ridges are not available, caribou often calve alone on islands in lakes to avoid predators (Bergerud and Page 1987, Shoesmith and Storey 1977). Dispersion by caribou in the Itcha, Ilgachuz and Rainbow Mountains during calving was consistent with the antipredator strategy described by Bergerud et al. (1984a).

In northern Tweedsmuir Park, caribou were widely dispersed during calving, but only 30% were found above treeline (50% were at low elevations). Caribou cows in Spatsizi Provincial Park displayed similar behaviour as they were also found below treeline during calving (Hatler 1986).

Although no bull caribou were radiocollared for this study, ground observations during calving in the Itcha Mountains indicated that bulls were not abundant in alpine areas until late June. Woodland caribou bulls in Spatsizi Park (Hatler 1986) and west-central Alberta (Edmonds and Bloomfield 1984) were also absent from alpine areas until late June/early July. Barren-ground caribou bulls in the Porcupine caribou herd moved northward to summer ranges following plant phenology and snowmelt whereas female caribou returned to summer ranges much earlier (Martell et al. 1986). Bulls in the Itcha Mountains apparently also followed plant phenology to summer range in the alpine,

further indicating that females which occupy these areas earlier during the calving season do so at the expense of better forage quality found at lower elevations. Bulls became abundant in alpine habitat by late June when fecal nitrogen values of cows had increased, indicating that improved forage quality was available at that time. The presence of bulls below treeline during early June also suggests that cows were not forced into alpine areas by insect harassment; otherwise, bulls would also have been found in alpine habitat during the calving period.

Summer range

Caribou habitat use during summer (mid-July - September), reflected abundant and nutritious forage available at the time and lack of barriers to movement (i.e. snow). Radiocollared caribou cows were found in a variety of habitat types between 500 and 2200 meters in northern Tweedsmuir Park, reflecting the diverse topography and vegetation. Itcha-Ilgachuz caribou similarly used a variety of habitat types whereas Rainbow caribou dispersed throughout the Rainbow Mountains in alpine habitat only.

Summer home ranges ranged in size from 4.8-731.4 km^2 in the Tweedsmuir-Entiako area, and from 3.5-554.8 km^2 in the Itcha-Ilgachuz-Rainbow area. Although on average, females without calves moved longer distances during summer than females with calves, no difference in home range size between females with calves and without calves was detected. Summer home ranges of adult female caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas were larger than those reported for other woodland caribou populations (Edmonds 1988, Fuller and Keith 1981, Shoesmith and Storey 1977).

Fall / rutting habitat

By October, use of alpine habitat increased in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas. In northern Tweedsmuir Park, between 100 and 200 caribou aggregated during the rut in alpine habitat near Wells Gray Peak in the Quanchus Mountains. Rutting groups were also often found in meadows or forest/meadow complexes in the eastern part of northern Tweedsmuir Park. Although up to 40% of radiocollared caribou cows did not join these aggregations and remained dispersed throughout northern Tweedsmuir Park, the high pregnancy rate for the population indicates that females bred even though they did not join large rutting aggregations. Caribou used primarily alpine or subalpine habitat during the rut in the Itcha-Ilgachuz-Rainbow Mountains although some caribou were found in the Itcha Lake meadows and adjacent forests. Rutting aggregations of between 4 and 89 caribou occurred throughout the three mountain ranges.

Caribou that rutted in the Quanchus Mountains remained there until they commenced movement to winter ranges in November. Several studies have shown that caribou initiate movements to winter ranges in response to snow accumulation (Edmonds 1988, Hatler 1983, Marshall 1985). In 1985/86 and 1986/87, all radiocollared caribou were found in the wintering area south of Tetachuck Lake by late November. However, in winter 1987/88, snow accumulation was 40-50% of what it was during the other years of the study and fall movements were initiated 2-3 weeks later. One radiocollared caribou remained on the north side of Tetachuck Lake until early January and another moved back north across Tetachuck Lake for 2 weeks in December before returning to winter range south of Tetachuck lake.

Specific crossing areas were not identified, but in the fall, caribou apparently crossed Tetachuck Lake along the length of the lake as well as in the vicinity of Redfern Rapids at the west end of Tetachuck Lake. In the Itcha-Ilgachuz-Rainbow area, fall migration routes were not as well defined as in the Tweedsmuir-Entiako area and appeared to be the shortest routes between summer and winter ranges.

Winter range

For most of the winter, caribou in the Tweedsmuir-Entiako and Itcha-Ilgachuz areas were found primarily in low elevation pine forests. Use of predominantly low elevation forested areas during winter was also documented for woodland caribou in northern British Columbia (Hatler 1986), west-central Alberta (Edmonds and Bloomfield 1984) and the southern Yukon (Farnell and McDonald 1987, Farnell and McDonald 1989). Between 100 and 300 of the approximately 1500 Itcha-Ilgachuz caribou wintered in the northern Ilgachuz Mountains. Rainbow caribou also wintered on windswept slopes in the northern Ilgachuz or northern Rainbow Mountains. In the Tweedsmuir-Entiako area in some years, alpine areas in the Fawnie Mountains were used by some caribou from mid-February to mid-late March. An increase in use of alpine habitat in late winter in Spatsizi Wilderness Park was attributed to less favourable snow conditions at lower elevations (Hatler 1986). Hatler (1986) suggested that during winters of deep snow accumulation, caribou were restricted to using windswept alpine slopes. During the present study, there were no apparent reasons for the difference in use of alpine habitat between years.

During winter, home ranges of female caribou using low elevation forested areas were larger than home ranges of female caribou using alpine habitat. Caribou using alpine habitat were confined to windswept slopes on the north side of the Ilgachuz and

Rainbow Mountains thus reducing potential home range size. Large winter home ranges in low elevation forested habitat were the result of movements between areas used during different stages of the winter. Winter home ranges of female caribou in the Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas were comparable in size to woodland caribou winter home ranges in eastern Alberta (Edmonds 1988, Fuller and Keith 1981).

HABITAT SELECTION ON LOW-ELEVATION WINTER RANGES

Terrestrial lichen abundance

The results support hypothesis 1: that in winter, caribou which were found in low elevation forests selected stands where lichens were most abundant and avoided stands with low lichen abundance. In general, caribou selected mature stands on poor quality growing sites and avoided immature stands, especially on relatively good quality growing sites, since lichens were not abundant in immature stands. During winter months, caribou selected and were found most frequently in Dry Lichen/Lichen Moss and Lichen Moss caribou habitat types on the Tweedsmuir-Entiako winter range, and in the mature Dry Lichen/Lichen Moss caribou habitat type on the Itcha-Ilgachuz winter range. The mature Lichen Moss caribou habitat type was also heavily used in the Itcha-Ilgachuz winter range but was not selected disproportionately to its availability. Conversely, the moister Moss - Dry Lichen/Lichen Moss and Moss/Seepage Forest (/Aspen Forest) caribou habitat types in both Tweedsmuir-Entiako and Itcha-Ilgachuz areas were used less frequently than were available. Of all forested caribou habitat units available, terrestrial lichens were most abundant in drier Dry Lichen/Lichen Moss and Lichen Moss units (Clement 1987, B.C.M.O.F. 1989a, 1989b). Consequently, caribou selected caribou habitat types (Dry Lichen/Lichen Moss and Lichen Moss) with the greatest abundance of terrestrial lichens.

Forest stand characteristics

Selection of forest cover types by caribou on both Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow winter ranges supports hypothesis 2: that caribou select mature timber types on poor quality growing sites. Terrestrial lichens are slow-growing and are most abundant in mature forests (Hale 1983, Rowe 1984). In both Tweedsmuir-Entiako and Itcha-Ilgachuz winter ranges, caribou selected mature stands and avoided immature stands. Because terrestrial lichens are poor competitors against vascular plants (Hale 1983, Johnson 1981, Kershaw 1977, Rowe 1984), they grow best on low and poor quality growing sites. These poor quality growing sites include sites with poor soils and areas of cold air ponding, which impair growth potential of trees. On the Itcha-Ilgachuz winter range, caribou selected mature pine forest cover types on low quality growing sites, and on the Tweedsmuir-Entiako winter range caribou selected mature pine forest cover types on low and poor quality sites . Mature pine forest cover types on poor quality sites were also heavily used in the Itcha-Ilgachuz winter range, but were not selected disproportionately to availability. Mature pine/spruce stands on medium quality growing sites were used less frequently than were available. In general, caribou selected stands on the lowest quality growing sites (low and poor sites) and seldom used stands on higher quality sites (medium sites).

Seasonal variation

Although caribou were found most often in forest stands on low quality growing sites and with abundant terrestrial lichens, habitat selection varied as the winter progressed.

Tweedsmuir-Entiako:

In the Tweedsmuir-Entiako area, caribou shifted from using mature pine forests on poor and medium sites in early winter to using mature pine and pine/spruce stands on medium sites in late winter/early spring. Use of immature pine stands decreased over the winter. Lodgepole pine is an early seral species and can occupy dry open sites whereas interior spruce is more shade tolerant and prefers moister habitats (Hosie 1979, Krajina et al. 1982). The shift from open dry sites in winter to moister sites in late winter/early spring was also evident in the use of caribou habitat types. During early winter mature Dry Lichen/Lichen Moss, Lichen Moss and Moss - Dry Lichen/Lichen Moss and Dry Lichen/Lichen Moss Ecomosaic units were most heavily used. In late winter mature Moss/Seepage Forest - Aspen Forest and Lichen Moss were most heavily used. This shift in habitat use and selection coincided with a shift in range to the area at and east of the mouth of the Entiako River, and with an increase in the amount of sedges, grasses and forbs in the diet. The area near the mouth of the Entiako River is 100-200 meters lower in elevation than the areas used by caribou in mid winter. Snow cover there was usually patchy and less than snow cover in the rest of the winter range during late winter. Woodland caribou in Alberta (Fuller and Keith 1981, Edmonds and Bloomfield 1984), northern British Columbia (Hatler 1986) and Manitoba (Darby and Pruitt 1984) also sought out green vegetation at lower elevations during late winter/early spring. In Tweedsmuir-Entiako, caribou continued to use arboreal and terrestrial lichens during late winter/early spring, but to a lesser extent since terrestrial lichen availability was limited to eskers and drier sites within the area.

Itcha-Ilgachuz:

Although Itcha-Ilgachuz caribou did not exhibit the same trend in increasing use of moister habitat types over winter, there was a definite shift in elevation. Snow conditions influenced habitat selection during winter. During late fall/early winter in the Itcha-Ilgachuz area, caribou using low elevation winter range selected Fescue-Lichen meadows for terrestrial lichen foraging. Terrestrial lichens were more abundant in fescue-lichen meadows than in any other caribou habitat type (Clement 1987). Caribou that used Fescue-Lichen habitats during early winter shifted from those areas to forested areas when snow depth at the Moore Creek open habitat snow station exceeded 50 centimeters and predicted caribou sinking depths in the open exceeded 40 centimeters. Data from snow stations indicated that snow depths in forested habitats were about 15 centimeters less than in open areas. In 1986/87, use of Fescue-Lichen habitat was almost nil even in December at which time snow depth and predicted caribou sinking depth exceeded the above thresholds. In 1987/88, caribou extensively used Fescue-Lichen habitat in December apparently due to the low snow accumulation. Use of this habitat decreased as snow accumulation increased. By February, when snow depth in the open snow station exceeded 40 centimeters, caribou no longer used Fescue-Lichen meadows.

In late winter/early spring, caribou used lower elevation forested habitats in the SBPSxc biogeoclimatic subzone in the area south of Punkutlaenkut Creek. By this time caribou were presumably foraging on bare patches to obtain green vegetation.

WINTER FEEDING ECOLOGY

Cratering versus arboreal lichen feeding

Caribou in both Tweedsmuir-Entiako and Itcha-Ilgachuz winter ranges fed primarily by cratering to obtain terrestrial lichens. Within forested habitat, terrestrial lichen feeding sites made up 78% of feeding sites in the Itcha-Ilgachuz area and 63% of the feeding sites in the Tweedsmuir-Entiako area. In general, caribou appeared to obtain more forage from craters than from arboreal lichen feeding. Data from feeding sites therefore probably underestimated the importance of terrestrial lichens. Fecal fragment data also suggested that terrestrial lichens were used more than arboreal lichen; however, the difference between the two types of foraging is not as apparent as with the feeding site data. Fecal fragment analysis assumes that plant fragments present in feces are proportional to the forages ingested (Holechek et al. 1982); however, different forage items are digested at different rates (Person et al. 1980, Thomas et al. 1984). Because of the problems associated with fecal fragment analysis, it was used only to describe general seasonal trends in diet.

Arboreal lichen feeding was more pronounced in stands on moister sites (pine/spruce, spruce, forested wetlands) where arboreal lichens were more abundant than in stands on drier sites (pine). In pine stands, caribou incidentally grazed some arboreal lichen while travelling, whereas at other sites, especially in forested wetlands, caribou fed extensively on arboreal lichen-loaded trees. Arboreal lichens were used to a greater extent in the Tweedsmuir-Entiako area (39% of forest feeding sites) than in the Itcha-Ilgachuz area (21% of forest feeding sites). This difference may be the result of a combination of fewer habitat units containing abundant terrestrial lichens (i.e. Dry Lichen sites) and more habitat containing abundant arboreal lichens (i.e. fringe spruce forests

around lakes and wetlands) in Tweedsmuir-Entiako. Use of arboreal lichens in Tweedsmuir-Entiako and Itcha-Ilgachuz was higher than that reported in west-central Alberta even during winters of extreme snow accumulation (Edmonds and Bloomfield 1984). Fecal data also indicated a greater degree of use of arboreal lichen in the Tweedsmuir-Entiako and Itcha-Ilgachuz areas than in west-central Alberta. Arboreal lichens were used most heavily in both Tweedsmuir-Entiako and Itcha-Ilgachuz areas during late winter (March). Arboreal lichen use by caribou and reindeer increases in importance as winter progresses or during winters of deep snowpack (Bergerud 1974b, Edmonds and Bloomfield 1984, Helle 1981, Sulkava and Helle 1975). The increase in importance of arboreal lichen during late winter was more pronounced in the Tweedsmuir-Entiako winter range than in the Itcha-Ilgachuz winter range. This increase was possibly due to a combination of less habitat with abundant terrestrial lichens and more frequent melt/freeze conditions which impair digging conditions in the lower elevation Entiako area.

Although it might appear that walking between trees to feed on arboreal lichen would be energetically favourable over digging through snow to obtain terrestrial lichens, the energetic cost of cratering in loose or thinly crusted snow is less than the energetic cost of a slow walk on a treadmill (Fancy and White 1985). The energetic expenditure of travelling from tree to tree in soft snow would therefore be greater than that of cratering. Caribou cratering in loose or thinly crusted snow expend the same amount of energy as caribou foraging in snowfree areas during summer (Thing 1977). Cratering during late winter in harder, more crusted snow requires greater energy expenditure than during early and mid winter (Fancy and White 1985, Thing 1977). By late winter, walking over hard snow and feeding on arboreal lichens may become energetically favourable over cratering for terrestrial lichens. Greater use of arboreal lichens in Tweedsmuir-Entiako

than Itcha-Ilgachuz suggests that snow conditions in Tweedsmuir-Entiako may be less favourable for cratering than in Itcha-Ilgachuz area.

Crater selection

Within forested habitats, crater site selection by caribou supported hypothesis 3: caribou cratered where terrestrial lichens were abundant and seldom cratered where terrestrial lichens were absent or present in low quantities. Terrestrial lichens were more abundant at craters than where caribou had travelled but not cratered. In Finland, Helle (1981) found that reindeer could smell lichens in up to 70 centimeters of snow. In the Tweedsmuir-Entiako and Itcha-Ilgachuz areas, caribou likely also selected crater sites by smell.

Crater sites also had more open canopies than non-crater sites, probably because they were poor growing sites for trees, allowing better growth of terrestrial lichens. Consequently, less snow was intercepted and snow depth at craters was often greater than at non-crater sites. Within forested habitat, snow depth data did not support hypothesis 4: that caribou crater where snow depth is lower and/or snow penetrability is greater. During most of the winter, snow depth and snow penetrability in forested areas were similar at craters and non-crater sites. When snow depth and penetrability did differ between crater and non-crater sites, snow depth and snow penetrability were greater at craters than at non-crater sites. On other woodland caribou, reindeer and barren-ground caribou winter ranges, snow depth at non-crater sites exceeded snow depth at craters (Adamczewski et al. 1988, Bergerud 1974b, Henshaw 1968, Laperriere and Lent 1977, Pruitt 1959, Skogland 1978).

Snow accumulation did not prevent caribou cratering in forested habitats. Caribou cratered in up to 75 centimeters of snow. In 1986/87, almost all craters on the Itcha-Ilgachuz winter range during February and March were greater than 50 centimeters deep. Stardom (1975) suggested a threshold of 65 centimeters for caribou cratering in forested winter habitats. However, woodland caribou in west-central Alberta cratered in up to 100 centimeters of snow during a heavy snow year 1981/82 (Edmonds and Bloomfield 1984). Helle (1981) reported crater depths up to 88 centimeters for reindeer in Finland and Bergerud (1974b) observed craters in up to 74 centimeters of snow for caribou in Newfoundland. Pruitt (1959) suggested a threshold of 60 centimeters for barren-ground caribou on tundra range and Henshaw (1968) observed that barren ground caribou would not dig for food in more than 70 centimeters of snow and only rarely dug in more than 50 centimeters of snow. Barren-ground caribou occupying tundra ranges would encounter greater snow density and hardness than woodland caribou using forested habitats since forested areas are protected from wind action. Also, woodland caribou are larger animals and would be able to crater in deeper snow than barren-ground caribou. Bergerud (1974b) also reported that woodland caribou did not use areas with snowpacks of greater than 90 centimeters. During the present study, snow depth exceeded 90 centimeters only in open habitat, but caribou had ceased using those habitats when snow depth exceeded 50 centimeters.

Snow penetrability also had little effect on crater site selection; however, snowpack was unusually low the year snow penetrability was examined. On barren-ground caribou ranges, snow penetrability had a much greater effect on crater site selection at deeper snow depths (Henshaw 1968, Pruitt 1959). In Tweedsmuir-Entiako as snow depth increased and snow penetrability decreased in late winter, caribou selected crater sites with greater snow penetrability, suggesting that snow penetrability

may potentially play a greater role in crater site selection during winters of greater snow accumulation.

POPULATION PARAMETERS

Adult mortality

The annual adult mortality rate averaged 22.6% for the Tweedsmuir-Entiako caribou and 15.2% for the Itcha-Ilgachuz-Rainbow caribou over the 3 year study. In the Itcha-Ilgachuz-Rainbow area, the major cause of adult mortality was wolf predation. Eight of the 9 mortalities occurred during summer months (May-October) suggesting that mortality from poor nutrition in winter was not significant. Similarly, 10 of the 12 mortalities in the Tweedsmuir-Entiako area occurred during the summer when caribou were in northern Tweedsmuir Park. Causes of adult mortality were difficult to determine in the Tweedsmuir-Entiako area due to lack of radiocollars equipped with mortality sensors; however, 2 of the 3 identified causes of mortality were predator related. Hunting in both areas had little impact on the populations. Other studies have also found wolf predation to be the major cause of adult mortality for woodland caribou (Seip 1989, Edmonds 1988, Farnell and MacDonald 1987).

Calf survival and recruitment

The calf recruitment rate averaged 7.8 calves/100 adults for the Tweedsmuir-Entiako caribou and 16.9 calves/100 adults for the Itcha-Ilgachuz-Rainbow caribou over the 3 year study. Pregnancy rates for both populations were high, indicating that low calf recruitment rates were due to high calf mortality rates.

Like adult mortality, most calf mortality occurred between May and October while caribou were on summer ranges. Neonatal mortality in both areas was high. Although 97% of the female caribou older than 2 years in the Itcha-Ilgachuz-Rainbow were pregnant, usually less than 50% of females counted in alpine areas at the end of the calving period had calves. Data from calving ground observations in the Itcha Mountains indicated that the peak of calving occurred around June 12. At this time, caribou cows were typically alone at about 2000 meters in elevation. As summer progressed, cows moved to lower plateaux where they formed large post-calving aggregations. Calf mortality appeared to be important during the first 1-2 months of life as the percent of cows with calves decreased from 74% at the peak of calving to 35% by the end of July. Calves died from both predation (wolves, possibly eagles) and non-predator related causes; however, the relative importance of each factor was not determined. At least 2 of the mortalities appeared to be nutritionally related and many of the calves scavenged by eagles may have been calves that had died from nutritional stress or abandonment. Although calf mortality was high during the summer months, calves that survived until fall (October) generally survived through the winter (March).

In other woodland and barren-ground caribou studies, causes of early calf mortality included predation (wolf, bear, eagle), abandonment, birth related deaths, disease, and accidents (Miller and Broughton 1974, Miller et al. 1983, Page 1985, Thing and Clausen 1980, Whitten et al. 1985). In the Itcha-Ilgachuz-Rainbow area, predation on young calves was likely due primarily to wolf predation; whereas in the Tweedsmuir-Entiako area, predation was likely due to both wolves and bears.

Population status

Tweedsmuir-Entiako;

During the 3 year study, in the Tweedsmuir-Entiako area, the average annual adult mortality rate (22.6%) exceeded the average annual calf recruitment rate (7.8 calves/100 adults). Consistently low calf recruitment appeared inadequate to balance high adult mortality, suggesting that the population was declining.

The population size during the 3 year study was estimated at about 400-500 caribou. Historically, caribou numbers were higher in Tweedsmuir-Entiako and the population occupied a larger area (Hatter 1979, Stevenson and Hatler 1985). During the present study, less than 50 caribou were found in alpine habitat in the Quanchus Mountains during flights in the summer; however, in the mid 1960's, over 400 caribou were found in alpine in the Quanchus Mountains in June (Low 1964). Similarly, in the early 1960's, caribou wintered in the Quanchus Mountains and in low elevation forests on the north side of Ootsa Lake, as well as in the Entiako Lake area. Presently, caribou winter predominantly in the Entiako Lake area, although a group of less than 30 caribou has been reported to winter in forested habitat just south of Ootsa Lake and north of Mt. Wells. Increasing caribou populations tend to increase the size of the area which they occupy in order to maintain low densities (Bergerud 1974a). Conversely, reduction of use of ranges would indicate that a population is declining. In Tweedsmuir-Entiako, reduction of use of historical winter ranges, and reductions in numbers of caribou suggest that the population had declined since the mid 1960's to the present level.

Itcha-Ilgachuz-Rainbow:

In the Itcha-Ilgachuz-Rainbow area, the average annual adult mortality rate (15.2%) was similar to the average annual calf recruitment rate (16.9 calves/100 adults) during the 3 year study. Overall, calf recruitment appeared to balance adult mortality suggesting the population was approximately stable.

During each of the three years, calf recruitment differed from adult mortality. In the first year, calf recruitment exceeded adult mortality indicating that the population was increasing. During the second and third years, calf recruitment decreased and adult mortality increased. Caribou numbers in the Itcha-Ilgachuz-Rainbow area had increased from the mid 1970's until the start of the present study (Smith and Hebert 1987). Population growth during the 1970's and early 1980's appeared to have been halted or reversed during those 3 years as calf recruitment decreased and adult mortality increased. During the present study, the caribou population size in the Itcha-Ilgachuz-Rainbow area was estimated at about 1500 caribou (Itcha-Ilgachuz:1300, Rainbow:200).

Calf recruitment as an indicator of population status:

Bergerud (1978) suggested that for caribou, calf recruitment less than 10% indicates a declining population, and calf recruitment greater than 15% indicates an increasing population. Calf recruitment between 10% and 15% indicates that the population is most likely stable but may be slightly increasing or decreasing. Results from the present study were consistent with Bergerud's predictions. For the Tweedsmuir-Entiako population which appeared to be decreasing, calf recruitment averaged 7.8 calves/100 adults. For the Itcha-Ilgachuz-Rainbow population which appeared to be increasing or stable, calf recruitment averaged 16.9 calves/100 adults.

Population limitation

Wolf predation appeared to be the most important factor limiting the Itcha-Ilgachuz-Rainbow caribou population. In the Tweedsmuir-Entiako area, wolf predation also appeared to be important in limiting the caribou population; however, not enough evidence was available to fully support this conclusion. Wolf predation has been implicated as the major factor limiting woodland caribou populations in western Alberta, the Yukon, Alaska and southeastern B.C. (Edmonds 1988, Farnell and MacDonald 1987, Gasaway et. al. 1983, Seip 1989).

Bergerud (1974a) hypothesized that declines of woodland caribou populations in B.C. were the result of increased wolf predation due to an increase in alternate prey, moose. Prior to the 1860's, moose were limited primarily to the northeastern part of B.C. (B.C. Ministry of Environment 1979). In the late 1800's and early 1900's moose expanded their range south and west, and by the 1950's were relatively abundant throughout north and central B.C. Moose colonization of areas inhabited by woodland caribou provided wolves with an alternative food source. The increase in prey base (moose) for wolves resulted in increased wolf numbers and consequently increased predation pressure on woodland caribou (Bergerud 1974a).

Woodland caribou populations that migrate and disperse in alpine habitat away from moose and wolves have higher adult survival and calving success than populations that do not have access to extensive alpine areas (Bergerud *et al.* 1984a, Seip 1989). This appears to be true for woodland caribou in west-central B.C. Habitat use patterns indicate that Tweedsmuir-Entiako caribou probably overlapped more with wolves and moose than did Itcha-Ilgachuz-Rainbow caribou. In the Tweedsmuir-Entiako area,

where less than 35% of the adult female caribou used alpine areas during calving and summer, adult mortality was higher and summer calf survival was lower than in the Itcha-Ilgachuz-Rainbow area where over 80% of the adult female caribou used alpine areas during calving and summer. Calf survival was greatest in the Rainbow Mountains where all of the radiocollared caribou were found in alpine habitat during calving and summer. In both Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, caribou cows found in alpine habitat during calving had more calves than caribou cows found below treeline. Within the Tweedsmuir-Entiako area, those caribou that calved in the mountainous region in the western part of Tweedsmuir Park had higher calving success than those caribou that calved in less rugged terrain at lower elevation throughout the rest of Tweedsmuir Park. Presumably, in both Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas, calving success was greater for caribou using mountainous terrain where calves had little or no contact with predators. Seip (1989) also found that caribou which migrated to high elevation rugged mountainous habitats for calving had high calf survival whereas caribou that calved in lower elevations had high adult and calf mortality, primarily due to wolf predation.

The decline of the Tweedsmuir-Entiako population was potentially associated with the extensive use of low elevation forested habitats during summer where they encountered wolves and bears. Of the 11 mortalities that occurred between May and October, 9 occurred below treeline and 2 occurred in alpine/subalpine habitat. If these trends continue, the portion of the population which use low elevation forested habitats in summer may be eliminated leaving only those that summer in the alpine.

The recent growth of the Itcha-Ilgachuz-Rainbow caribou population may have been associated with the migration of most adult females to alpine areas for calving, where they became separated from moose. Radiocollared adult female moose in the

area calved in lower elevation forested habitat (B. Baker, pers. comm.). Although wolves periodically moved into alpine habitat to hunt caribou, bears were largely absent from the alpine. Absence of alternate prey for wolves in the alpine probably reduced wolf use of the alpine, especially prior to the late 1970's when the Itcha-Ilgachuz-Rainbow population was low. Recent increases in caribou numbers may have made it profitable for wolves to hunt in the alpine resulting in a reversal of population growth during the latter years of the study. Although no information was collected on wolves in the study area, wolf trapping and illegal wolf control in the area may have also been important in restraining the growth of the wolf population and in keeping the predation rate on caribou low.

Census Reliability

Recently, Hatler (1987) challenged the reliability of calf recruitment estimates derived from woodland caribou surveys conducted in alpine or open habitat. He suggested that calf/cow ratios of animals counted in alpine habitat may not be representative of calf/cow ratios of the entire population. In Spatsizi Wilderness Park, cows without calves were overrepresented in rutting aggregations resulting in erroneous low calf/cow ratios.

In the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, the proportion of cows with calves differed between forested and alpine habitat during some surveys. Censuses of alpine areas during those times would result in incorrect estimation of calf recruitment. For this study, calf recruitment was based on surveys conducted in March. Although most caribou used forested areas during March, radiocollared caribou were easily located and caribou associated with radiocollared caribou were counted. Therefore, both caribou above and below treeline were counted resulting in an unbiased

estimate of recruitment. However, without radiocollared caribou, surveys will be limited primarily to open areas so the reliability of surveys is of concern.

Tweedsmuir-Entiako:

In the Tweedsmuir-Entiako area, use of alpine habitat in March was inconsistent between years and did not occur at all during some years. During June, although over 30% of the caribou used alpine habitat, at this time of year caribou were widely distributed throughout Tweedsmuir Park. Surveys at this time of year were costly and since most calf mortality occurred during summer, the calf/cow ratio obtained in June was not representative of calf recruitment. In addition, alpine counts were biased towards cows with calves during June. Consequently, surveys of alpine areas in the Tweedsmuir-Entiako area during June or March would not be reliable estimators of calf recruitment.

Caribou in the Tweedsmuir-Entiako area were most abundant in alpine areas during surveys in October. At that time they were found in rutting aggregations in the Quanchus Mountains. Although alpine rutting surveys in Spatsizi Wilderness Park were biased toward cows without calves, the results in the Tweedsmuir-Entiako area were less conclusive. The radiocollared caribou sample suggested that the proportion of cows with calves in rutting groups in the Quanchus Mountains was less than the proportion of cows with calves below treeline or in alpine/subalpine habitat elsewhere. On the other hand, the total caribou samples indicated no difference. During October, 10% of the total female caribou and 0% of the radiocollared female caribou had calves in the survey area (alpine habitat in the Quanchus Mountains),. In the non-survey area (forested habitat or alpine habitat not in the Quanchus Mountains), 15% of the total female caribou and 26% of the radiocollared female caribou had calves. Adult female caribou found in

alpine habitat in the Quanchus Mountains in October represented less than half (27-45%) of the total female population.

In summary, although October is the only survey period in which a significant number of caribou are found in alpine habitat, because less than half of the adult female are observed in the alpine in the Quanchus Mountains, and because the calf/cow ratio is lower in the alpine than below treeline, the October count in the Quanchus Mountains is biased against cows with calves and should be interpreted with caution.

Itcha-Ilgachuz-Rainbow:

In the Itcha-Ilgachuz-Rainbow area, more than two thirds of the adult female caribou were found in alpine habitat during June and October; whereas in March, less than 45% of the adult female caribou used alpine habitat.

In June, on average 84% of the adult female caribou were found in alpine habitat in the Itcha, Ilgachuz and Rainbow Mountains. In the alpine, 42% of the total female caribou counted had calves, and 63% of radiocollared caribou had calves. Below treeline 23% of the total female caribou counted had calves and 67% of the radiocollared females had calves. Because most of the adult female caribou were above treeline during the June surveys, the calf/cow ratio of caribou counted above treeline was likely representative of the total population even though it was slightly biased towards cows with calves. However, the calf/cow ratio from June surveys did not take into account summer or winter mortality and therefore, was not representative of actual calf recruitment.

In October, between 67% and 82% of the adult female caribou used alpine habitat in the Itcha, Ilgachuz and Rainbow Mountains. At this time, in the alpine, 28% of the radiocollared female caribou and 21% of all female caribou counted had calves. Below treeline, 17% of the radiocollared female caribou and 26% of all female caribou counted had calves. Because more than two thirds of the female population was in alpine habitat in October and no difference was detected between the calf/cow ratio in the alpine and below treeline, the calf/cow ratio derived from counts in alpine habitat in October was representative of the total population. Although the calf/cow ratio from October surveys did not take into account calf mortality during winter, because calf mortality during winter was low, the October calf/cow ratio may be a reasonable estimator of calf recruitment.

During March surveys, less than 47% and as few as 12% of the adult radiocollared female caribou were found in alpine habitat. At this time, the calf/cow ratio of radiocollared caribou in alpine (31%) was greater than the calf/cow ratio of radiocollared caribou below treeline (14%) Similarly, the ratio of calves to total caribou in alpine habitat (28%) was greater than the ratio of calves to total caribou below treeline (14%). Because a low proportion of the population was in alpine habitat in March, and because the calf/cow ratio was greater in the alpine than below treeline, calf recruitment derived from surveys conducted only in alpine habitat during March would overestimate actual calf recruitment.

In summary, for the Itcha-Ilgachuz-Rainbow population, October surveys of alpine habitat yielded the most reliable estimate of calf recruitment. In October, over two thirds of the population was found in alpine habitat and the proportion of calves in the alpine was representative of the total population. In June and March, calf/cow ratios of surveys conducted in alpine habitat were not representative of actual calf recruitment.

IMPLICATIONS TO FOREST MANAGEMENT

Summer range

Although some calving occurred in the mountains west of northern Tweedsmuir Park and some rutting occurred east of the northern Tweedsmuir Park boundary, summer ranges (including calving and rutting areas) of Tweedsmuir-Entiako and Rainbow Mountain caribou occurred almost exclusively within Tweedsmuir Park. Outside of the park, calving occurred in alpine habitat, and rutting occurred in forest/meadow/lake complexes immediately adjacent to northeastern Tweedsmuir Park. These calving and rutting areas are not directly threatened by logging due to the nature of the habitats used; however, undisturbed calving habitat is important for calving success. In the Itcha-Ilgachuz area, caribou summer in the Itcha and Ilgachuz Mountains in alpine habitat and adjacent forests. Currently, a proposal has been submitted to make this area into a Wildlife Management Area. Because caribou use primarily alpine habitats in summer, logging will have little direct impact on caribou summer habitat; however, logging roads could increase access to and disturbance on calving grounds.

Winter range

Logging has a much greater potential impact on caribou winter ranges than on summer ranges. During winter, caribou selected low elevation forested habitats where snow accumulated at a slower rate than in open habitats or at higher elevations. Mature pine forests were most frequently selected. Within these pine forests, feeding sites were chosen on the basis of terrestrial lichen availability and abundance. Arboreal lichens

were also used during winter but to a lesser extent than terrestrial lichens. Lichens are slow growing and are most abundant in mature forests (Hale 1983, Rowe 1984). Caribou selected mature stands and avoided immature stands. Consequently, normal forest rotations are incompatible with maintaining caribou winter habitat and adequate amounts of habitat must be protected if caribou are to be maintained. Characteristics of high quality caribou winter habitat would therefore include: mature forested stands (primarily pine stands); well drained soils and open canopy supporting abundant terrestrial lichen communities while providing sufficient snow interception; moderate to high quantities of arboreal lichens; and moderate quantities of other vegetation.

Recently, logging activity has increased in the peripheries of the Itcha-Ilgachuz and Tweedsmuir-Entiako winter ranges. Most of both winter ranges however, remain pristine with occasional seismic lines transecting the Itcha-Ilgachuz area. Timber harvest affects woodland caribou habitat directly by destroying terrestrial and arboreal lichens. Preferred terrestrial lichen species such as *Cladina* spp. are late successional species (Ahti 1977, Carroll and Bliss 1982, Johnson 1981, Rowe 1984, Appendix V). Regeneration of lichens to pre-logging levels would take at least 50-100 years due to succession and to slow lichen growth rates (Hale 1983, Rowe 1984). In terms of lichen supply, logged areas would be unavailable to caribou for at least 50 years. Therefore, sufficient mature forested habitat must be maintained to provide an adequate winter food supply. During winter, caribou in both Tweedsmuir-Entiako and Itcha-Ilgachuz areas primarily used mature pine stands on low or poor quality growing sites where terrestrial lichens were most abundant. In terms of caribou habitat types, Dry Lichen/Lichen Moss and Lichen Moss were most frequently used. Timber on these sites would be of lower merchantable value than on moister and more productive sites that were seldom used by caribou. Much of the best caribou habitat therefore, occurred on poor growing sites with low timber values such as Dry Lichen/Lichen Moss sites. However, Lichen Moss sites,

which have higher timber values, were also important caribou habitat and should be managed as high quality caribou winter habitat.

During winters of above average snowfall, arboreal lichens may become more important than terrestrial lichens as winter forage. Arboreal lichens occurred throughout forested areas but were most abundant (especially in Tweedsmuir-Entiako) surrounding lakes and wetlands. In Tweedsmuir-Entiako, spruce/wetland/lake ecomosaics were an example of such habitats. The combination of high arboreal lichen abundance and less snow accumulation due to denser canopies probably make these valuable habitats during periods of adverse snow conditions.

Wetlands in the Itcha-Ilgachuz winter range and lakes in the Tweedsmuir-Entiako winter range were heavily used for obtaining water. Maintaining lichen bearing buffers surrounding lakes and wetlands would both provide abundant arboreal lichen forage during winters of high snowfall, and maintain visual barriers between roads and wetlands.

During late winter/early spring, caribou in both Itcha-Ilgachuz and Tweedsmuir-Entiako winter ranges used snowfree areas at lower elevations in which to forage. Clearcuts in those areas may provide green vegetation and early snowfree areas. Similarly, during spring migration caribou used low elevation forested areas relatively free of snow. Small clearcuts may be used by caribou in spring. Tweedsmuir-Entiako caribou were found bedded down less than 10 meters away from clearcuts on the north side of Natalkuz Lake during late winter/early spring. Itcha-Ilgachuz caribou were found in clearcuts as well as bedded down close to them in late winter/early spring when clearcuts were free of snow, suggesting that caribou may have been using those areas. Caribou avoided immature forest stands, and large tracts of dense second-growth stands

may impede migration. Therefore, timber harvests should be scheduled so that there is always a continuum of mature forests along migration routes.

Indirect effects of logging may be more detrimental to caribou populations than the direct result of destruction of winter food supply. New logging roads provide improved access into wilderness areas. Although the physical presence of roads themselves is not detrimental to caribou (Bergerud et al. 1984b, Gauthier et al. 1976, Russell and Martell 1976, Skogland 1986), improved access generally results in increased human use of an area. In well roaded caribou ranges in west-central Alberta (Edmonds and Bloomfield 1984) and southeastern British Columbia (Simpson et al. 1987), poaching accounted for a large proportion of caribou mortality (Bergerud 1974a). Because caribou are gregarious and use open habitat, increased access can result in a substantial increase in hunting and poaching mortality (Bergerud et al. 1984b). Logging can therefore indirectly affect caribou numbers through increased access and poaching.

Another indirect effect of logging on caribou numbers is the decreased amount of mature forest which caribou can occupy, thereby increasing the density of caribou in the remaining mature stands. An antipredator strategy of woodland caribou is to exist at low densities; that is to space themselves out so that it is harder for predators to find them (Bergerud et al. 1984b, Bergerud and Page 1987). When caribou populations grow, they use a larger area to maintain low densities instead of increasing the density in the area already occupied (Bergerud et al. 1984b). In Ontario, logging in woodland caribou winter ranges effectively restricted animals to using remaining mature stands (Darby and Duquette 1986). By concentrating caribou into smaller areas of mature forests, logging may increase predator efficiency.

Logging, like fire, reverts mature forest into early successional stages, creating habitat favoured for moose (Peek 1974). A corresponding increase in moose numbers can support a larger predator population and increase predation pressure on caribou. Darby and Duquette (1986) suggested that in Ontario, woodland caribou use of only unlogged portions of their winter range may have resulted indirectly from increased deer numbers (alternate prey for wolves) in logged areas.
In the Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas, increased predation rates could potentially result from changes in prey-predator interactions due to habitat disturbance from logging.

In summary, effects of logging on caribou in Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas will be manifested both directly and indirectly. A decrease in the food supply, increased access, decreased space and potentially disturbed predator-prey relationships combined will generally affect the caribou populations negatively. Forestry practices must be consistent with caribou winter food and spatial requirements. Access control will become increasingly important as logging approaches caribou rutting areas in large open habitats, where caribou are vulnerable to hunting. Finally predator-prey relationships may need to be managed to ensure adequate caribou survival rates.

Currently the B.C. Ministry of Forests Research Branch (Smithers) in conjunction with Fish and Wildlife is developing a habitat management strategy for the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow caribou winter ranges by integrating caribou habitat values and timber values using the PAMAP Geographic Information System. Management options for the caribou winter range will be assessed for impacts on the woodland caribou populations and on the timber supply. Further recommendations will be made based on those results.

MANAGEMENT RECOMMENDATIONS

1. Large undisturbed areas should be maintained for calving and summer ranges throughout which caribou may distance themselves from each other and from predators. Undisturbed areas such as Tweedsmuir Park and the proposed Itcha-Ilgachuz Wildlife Management Area will be important for maintaining this objective.

2. In the Chelaslie River drainage it is important to maintain the low elevation spring migration routes of the caribou. Large clearcuts and/or extensive tracts of dense second-growth may inhibit migration.

3. The prime winter range areas where habitat protection is most important include:

   Tweedsmuir-Entiako:

   - -the Entiako River drainage, southwest of Capoose Creek
   - -the area at the southeast end of Bryan Arm of Tetachuck Lake

   Itcha-Ilgachuz-Rainbow

   - -the east side of the Chilcotin River, south of Baldface Mountain to the junction with Downton Creek
   - -the Downton Creek drainage
   - -the north side of Punkutlaenkut Creek, just north of Satah Mountain
   - -the south side of Punkutlaenkut Creek east of Satah Mountain
   - -low elevation forests north of the Ilgachuz Mountains

4. Because caribou require abundant lichens which are not provided during normal forest rotations, sufficient mature forest must be protected from logging if caribou are to be maintained. The habitat types that are most important to protect are:

   - -Dry Lichen/Lichen Moss and Lichen Moss caribou habitat types

-mature pine forest cover types on low and poor quality sites

5. Effects of logging on terrestrial lichens should be determined for both summer and winter logging. If no difference is found, most logging should occur during summer months to minimize human contact with caribou. If winter logging reduces destruction of terrestrial lichens, the potential of clearcuts and young stands for winter use by caribou must be assessed before recommending winter logging.

6. Controlling access within winter ranges would reduce potential disturbance, displacement and poaching of caribou.

7. Productivity and reforestation problems on these poor growing sites should be re-evaluated. Given the low productivity of these sites in the Tweedsmuir-Entiako and Itcha-Ilgachuz areas, caribou winter habitat values may exceed timber harvest values.

8. In the Itcha-Ilgachuz-Rainbow area, calf recruitment estimates derived from surveys of alpine areas in October may be sufficient for monitoring population status by using Bergerud's (1978) rule of thumb.

9. In the Tweedsmuir-Entiako area, calf recruitment estimates from surveys conducted in alpine habitat should be interpreted cautiously. Management actions such as predator control may be considered to prevent further population decline.

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APPENDIX I

SUMMARY OF CAPTURE AND MARKING INFORMATION, AND PHYSICAL CHARACTERISTICS OF CARIBOU CAPTURED IN THE TWEEDSMUIR-ENTIAKO AND ITCHA-ILGACHUZ-RAINBOW AREAS

Table 1. Mean body measurements of woodland caribou captured in the Itcha-Ilgachuz-Rainbow study area (September 1982 - March 1988). All yearling and calf measurements were taken in late winter (March-April).

	N	Mean (cm)	Range
Total Length			
Adult female	25	196.6	173.0-215.0
Yearling male	1	178.0	
Yearling female	3	184.0	178.0-188.0
Calf male	5	162.5	153.0-172.0
Calf female	14	161.9	153.0-170.5
Calf total	19	162.5	153.0-172.0
Chest Girth			
Adult female	28	126.2	108.0-138.5
Yearling male	1	108.0	
Yearling female	3	121.3	115.0-127.0
Calf male	5	104.3	99.0-109.5
Calf female	14	103.3	93.0-109.0
Calf total	19	103.6	93.0-109.5
Hind Foot Length			
Adult female	19	57.0	48.0-63.5
Yearling female	1	59.0	
Calf male	3	54.5	54.0-55.0
Calf female	14	52.7	48.0-56.0
Calf total	19	53.0	48.0-56.0
Neck circumference			
Adult female	12	56.4	53.0-58.5
Shoulder height			
Adult female	10	127.5	115.0-134.0

Table 2. Summary of capture and marking information of woodland caribou caught in the Tweedsmuir-Entiako study area, November 1983 - March 1988.

Capture Date	Area	Method	Collar Frequency	Collar Colour	Eartags[1] Left	Eartags[1] Right	Sex[2]	Fate	Serum Prog.[3] (ng/ml)	Total Length (cm)	Chest Girth (cm)	Hind Foot Length (cm)	Neck Circ. (cm)	Shoulder Height (cm)
05/11/83	Tetachuck Lk	Boat	148.980	White		Y-13	AF	Lost contact-06/84						
05/11/83	Tetachuck Lk	Boat	148.240	White		Y-32	AF	Mortality-04/87						
05/11/83	Tetachuck Lk	Boat				Y-35	AM	-						
08/11/83	Tetachuck Lk	Boat	148.580	White		Y-2	AF	J88[4]						
08/11/83	Tetachuck Lk	Boat	148.710	White		Y-3	AF	Mortality-04/85						
09/11/83	Tetachuck Lk	Boat	148.740	White		Y-4	AF	J88						
09/11/83	Tetachuck Lk	Boat			Y-30	Y-33	AM	-						
09/11/83	Tetachuck Lk	Boat			Y-34	Y-39	AM	-						
10/11/83	Tetachuck Lk	Boat	148.780	White		Y-5	AF	Mortality-07/86						
10/11/83	Tetachuck Lk	Boat	148.810	White		Y-6	AF	Mortality-10/85						
10/11/83	Tetachuck Lk	Boat	148.830	White		Y-7	AF	J88						
10/11/83	Tetachuck Lk	Boat	148.840	White		Y-8	AF	Mortality-05/85						
10/11/83	Tetachuck Lk	Boat	148.860[5]	White		Y-9	AF	Mortality-09/85						
11/11/83	Tetachuck Lk	Boat	148.930	White		Y-10	AF	Mortality-09/84						
11/11/83	Tetachuck Lk	Boat	148.940	White		Y-11	AF	Mortality-05/85						
11/11/83	Tetachuck Lk	Boat	148.960	White		Y-12	AF	Mortality-10/87						
05/11/84	Tetachuck Lk	Boat	148.270	White			AF	Collar failure 03/88						
05/11/84	Tetachuck Lk	Boat	148.290	White			AF	J88						
05/11/84	Tetachuck Lk	Boat	148.320	White			AF	J88						
05/11/84	Tetachuck Lk	Boat	148.340	White			AF	Mortality-06/87						
05/11/84	Tetachuck Lk	Boat	148.690	White			AF	J88						
05/11/84	Tetachuck Lk	Boat	148.760	White			AF	J88						
25/02/87	Mt Swannell	Net-gun	148.066	Blue	Y		AF	Mortality-07/87	0.4					
25/02/87	Mt Swannell	Net-gun	148.075	Blue		Y	AF	Mortality-06/87						
27/02/87	Tutiai Mt	Net-gun	148.095	Orange	Y		AF	J88	6.0					
27/02/87	Mt Swannell	Net-gun	148.026	Orange		Y	AF	J88						
27/02/87	Mt Swannell	Net-gun	148.036	Green	Y		AF	J88	7.7					
28/02/87	Mt Swannell	Net-gun	148.056	Blue	Y	Y	AF	Mortality-10/87	8.1					
28/02/87	Mt Swannell	Net-gun	148.016	Orange	Y	Y	AF	J88	9.8					
28/02/87	Mt Swannell	Net-gun	148.140	White		Y	AF	J88	3.8					
28/02/87	Mt Swannell	Net-gun	148.006	Green		Y	AF	Mortality-06/88	5.4					

[1] Eartag colours: B=blue, Bk=Black, G=green, O=orange, P=purple, R=red, Y=yellow, W=white
[2] Sex/age classes: AF=adult female, AM=adult male, YF=yearling female, YM=yearling male, CF=calf female, CM=calf male
[3] Serum progesterone levels >1.0 ng/ml indicate pregnancy
[4] J88 indicates animal had a functioning radiocollar and was alive June 1988
[5] collar ceased functioning October 1984; animal recaptured November 1984 and fitted with radiocollar 148.620

Table 3. Summary of capture and marking information of woodland caribou caught in the Itcha-Ilgachuz-Rainbow study area, September 1982 - March.

Capture Date	Area	Method	Collar Frequency	Collar Colour	Eartags[1] Left	Eartags[1] Right	Sex[2]	Fate	Serum Prog.[3] (ng/ml)	Total Length (cm)	Chest Girth (cm)	Hind Foot Length (cm)	Neck Circ. (cm)	Shoulder Height (cm)
02/09/82	Ilgachuz Mts	Net-gun	151.237	Yellow			AF	J88[4]						
23/02/83	Moore Creek	Net-gun	150.460	White	G-6		AF	J88						
14/04/83	Ilgachuz Mts	Net-gun	151.115	Black	G	G	AF	Collar failure 06/85						
14/04/83	Ilgachuz Mts	Net-gun	151.510	White		P-26	AF	Mortality-09/86						
14/04/83	Moore Creek	Net-gun	151.006	Black	O	O	AF	Mortality-06/86						
03/10/84	Ilgachuz Mts	Net-gun	151.340	White	R	Y	AF	Mortality-11/87		178.0	121.0	55.0	57.0	
04/10/84	Itcha Mts	Net-gun	151.310	White	G	B	AF	Mortality-03/86		185.0	122.0	57.0		128.0
05/10/84	Itcha Mts	Net-gun	150.751	White	Y	O	AF	J88		189.0	138.5	60.0	57.5	130.0
05/10/84	Itcha Mts	Net-gun	151.070	White	P	P	AF	J88		192.0	133.5	48.0	58.0	127.0
05/10/84	Ilgachuz Mts	Net-gun	151.290	White	B	O	AF	J88		198.0	133.0	55.0	58.0	128.0
05/10/84	Ilgachuz Mts	Net-gun	151.280	White	R	Y	AF	J88		197.0	130.0	59.0	58.5	115.0
18/10/84	Rainbow Mts	Net-gun	151.080	White	O	G	AF	J88		192.0	122.0	55.0	54.0	125.5
18/10/84	Rainbow Mts	Net-gun	151.251	White	Y	Bk	AF	Mortality-09/87		210.0	121.0	57.0	53.0	127.0
18/10/84	Rainbow Mts	Net-gun	151.390	White	B	W	AF	Mortality-07/87		200.0	120.0	58.0	54.8	128.0
18/10/84	Rainbow Mts	Net-gun	151.260	White	P	O	AF	J88		208.5	135.0	57.0	58.0	132.0
19/10/84	Ilgachuz Mts	Net-gun		Black	B	B	AF	-						
19/10/84	Ilgachuz Mts	Net-gun	151.420	White	Y	O	AF	J88		198.0	129.0	60.0	55.0	134.0
19/11/84	Itcha Flats	Drive n	150.260[5]	White	O		AF	Mortality-06/85			127.0		58.0	
20/11/84	Itcha Flats	Drive n	150.320[5]	White			AF	J88						
20/11/84	Itcha Flats	Drive n	150.240[5]	White			AF	Mortality-07/86						
21/11/84	Itcha Flats	Drive n	151.072[5]	Gray			AF	Collar failure 06/86			127.0		55.0	
02/04/86	Ilgachuz Mts	Drive n	150.449[5]	Green	Y	Y	AF	J88	7.1	203.0	132.0			
02/04/86	Ilgachuz Mts	Drive n	150.490[5]	Green	Bk	Bk	AF	J88	9.3	201.0	126.0			
03/04/86	Ilgachuz Mts	Drive n	150.270	Blue	B	B	AF	J88	10.1	215.0	123.0	55.0		
03/04/86	Ilgachuz Mts	Drive n		Blue	O	G	CF	-	0.1	162.0	105.0	51.0		
06/05/86	Ilgachuz Mts	Net-gun	151.090	Blue	Y	Y	AF	Mortality-07/87	7.5	200.0	122.2	55.0		
06/05/86	Ilgachuz Mts	Net-gun	151.020	White	R	R	AF	Mortality-06/88	5.8	190.0	126.0	54.0		
18/03/87	Whitetop Mt	Net-gun	150.510	Blue	R	R	AF	-	5.1	191.5	122.0	63.5		
18/03/87	Whitetop Mt	Net-gun	150.241	Blue	B	Y	AF	J88	7.0	173.0	116.0	59.0		
18/03/87	Whitetop Mt	Net-gun	151.310	Blue	Y	O	AF	Mortality-06/88	3.8	205.0	135.0	63.5		
18/03/87	Whitetop Mt	Net-gun			B	Y	CF	-		170.5	105.0	56.0		

[1]Eartag colours: B=blue, Bk=Black, G=green, O=orange, P=purple, R=red, Y=yellow, W=white
[2]Sex/age classes: AF=adult female, AM=adult male, YF=yearling female, YM=yearling male, CF=calf female, CM=calf male
[3]Serum progesterone levels >1.0 ng/ml indicate pregnancy
[4]J88 indicates animal had a functioning radiocollar and was alive June 1988
[5]animals which were transplanted but returned to the study area

Table 4. Summary of capture and marking information of woodland caribou caught in the Itcha-Ilgachuz study area and transplanted to the Trumpeter Mountain area, November 1984 - March 1988.

Capture Date	Area	Method	Collar Frequency	Collar Colour	Eartags[1] Left	Eartags[1] Right	Sex[2]		Fate	Serum Prog.[3] (ng/ml)	Total Length (cm)	Chest Girth (cm)	Hind Foot Length (cm)	Neck Circ. (cm)	Shoulder Height (cm)
19/11/84	Itcha Flats	Drive n				Y	AF	-							
19/11/84	Itcha Flats	Drive n				B	AM	-							
19/11/84	Itcha Flats	Drive n			R		AM	-							
20/11/84	Itcha Flats	Drive n			R	O	AF	-							
20/11/84	Itcha Flats	Drive n			W		AF	-							
20/11/84	Itcha Flats	Drive n				R	AF	-							
20/11/84	Itcha Flats	Drive n			Y		CF	-							
20/11/84	Itcha Flats	Drive n				O	AF	-							
20/11/84	Itcha Flats	Drive n				Y	CF	-							
21/11/84	Itcha Flats	Drive n			Y		AF	-				120.0			
02/04/86	Ilgachuz Mts	Drive n	150.470	Green	B	B	YF	-		0.0	178.0	115.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	G	G	AF	-		11.5	193.0	124.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	Y	Y	YF	-		0.2	186.0	122.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	R	R	AF	-		9.7	206.0	125.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	R	Bk	AF	-		5.4	189.0	124.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	B	Y	AF	-		5.1	207.0	129.0			
02/04/86	Ilgachuz Mts	Drive n			P	P	CM	-			162.0	100.0			
02/04/86	Ilgachuz Mts	Drive n		Orange	G	O	YM	-			178.0	108.0			
03/04/86	Ilgachuz Mts	Drive n		Orange	O	B	AF	-		7.7	202.0	124.0	54.0		
03/04/86	Ilgachuz Mts	Drive n		Orange	P	Y	AF	-		11.0	199.0	127.0	57.0		
03/04/86	Ilgachuz Mts	Drive n		Orange	Bk	G	CF	-		0.2	161.0	93.0	50.0		
03/04/86	Ilgachuz Mts	Drive n	150.248	Orange	Y	R	CF	-		0.3	160.0	100.0	48.0		
03/04/86	Ilgachuz Mts	Drive n			P	B	CM	-			168.0	108.0	54.0		
16/03/87	Ilgachuz Mts	Drive n	150.480	Green	Y	Y	CF	-			170.0	105.0	52.5		
16/03/87	Ilgachuz Mts	Drive n	150.540	Green	R	R	CF	-			165.0	96.0	53.5		
16/03/87	Ilgachuz Mts	Drive n		Red	Y	Y	CF	-			155.5	103.5	51.5		
16/03/87	Ilgachuz Mts	Drive n		Red	G	O	CM	-			165.0	99.0			
16/03/87	Ilgachuz Mts	Drive n			G	G	CM	-			153.0	105.0	54.5		
17/03/87	Ilgachuz Mts	Drive n			P	Y	CM	-			172.0	109.5	55.0		
18/03/87	Ilgachuz Mts	Drive n		Red	B	B	CF	-			153.0	103.0	51.0		
18/03/87	Ilgachuz Mts	Drive n		Red	O	O	CF	-			160.0	102.0	52.0		
18/03/87	Ilgachuz Mts	Drive n		Red	Y	R	CF	-			169.5	108.0	54.0		
18/03/87	Ilgachuz Mts	Drive n		Red	Bk	G	CF	-			160.0	105.0	54.0		
18/03/87	Ilgachuz Mts	Drive n		Red	B	Y	CF	-			159.5	106.0	53.0		
14/03/88	Ilgachuz Mts	Drive n	150.300	Yellow	O	O	CF	-		0.1	158.0	106.0	56.0		
14/03/88	Ilgachuz Mts	Drive n	150.282	Yellow	Y	Y	YF	-		1.9	188.0	127.0	59.0		
14/03/88	Ilgachuz Mts	Drive n		Yellow	Y	G	CF	-		0.0	163.0	109.0	55.0		

[1] Eartag colours: B=blue, Bk=Black, G=green, O=orange, P=purple, R=red, Y=yellow, W=white
[2] Sex/age classes: AF=adult female, AM=adult male, YF=yearling female, YM=yearling male, CF=calf female, CM=calf male
[3] Serum progesterone levels >1.0 ng/ml indicate pregnancy

APPENDIX II

SUMMARY OF RADIOCOLLARED CARIBOU LOCATIONS IN EACH HABITAT TYPE, CARIBOU HABITAT TYPE AND FOREST COVER TYPE BY AREA, SEASON AND YEAR

Table 1. Mean monthly elevation (in meters above sea level) of radiocollared caribou locations in the Tweedsmuir-Entiako, Itcha-Ilgachuz and Rainbow study areas.

	N	Mean	Standard Deviation	+/- 1 Standard Deviation
Tweedsmuir-Entiako				
April	78	972	106	866-1078
May	50	1062	136	927-1198
June (Alpine)	22	1533	189	1344-1722
June (Below treeline)	30	1107	181	926-1288
July (Alpine)	19	1486	274	1213-1760
July (Below treeline)	34	1001	130	871-1132
August	40	987	240	747-1227
September	49	1129	212	918-1341
October (Alpine)	26	1529	154	1376-1683
October (Below treeline)	28	1183	186	997-1369
November (Alpine)	15	1584	126	1459-1710
November (Below treeline)	20	1013	123	889-1136
December	110	1048	128	919-1176
January	132	993	104	890-1097
February (Alpine)	9	1619	72	1547-1691
February (Below treeline)	161	993	70	923-1062
March (Alpine)	30	1641	201	1440-1842
March (Below treeline)	136	989	81	908-1070
Itcha-Ilgachuz				
April (Alpine)	7	1897	81	1816-1979
April (Below treeline)	45	1292	73	1219-1365
May (Alpine)	23	1788	193	1595-1981
May (Below treeline)	56	1466	121	1345-1586
June	39	1885	120	1766-2005
July	56	1839	142	1697-1981
August	61	1706	150	1556-1856
September	47	1722	141	1581-1863
October	56	1821	136	1685-1956
November	31	1625	139	1486-1764
December	108	1499	128	1371-1627
January (Alpine)	13	1630	181	1449-1811
January (Below treeline)	105	1447	93	1354-1539
February (Alpine)	14	1761	176	1586-1937
February (Below treeline)	134	1427	86	1342-1513
March (Alpine)	19	1751	168	1583-1918
March (Below treeline)	142	1382	98	1284-1481

Rainbow

April	21	1894	66	1829-1960
May	31	1911	193	1718-2105
June	17	1837	134	1704-1971
July	21	1802	128	1674-1930
August	24	1819	159	1660-1979
September	20	1854	84	1769-1938
October	20	1874	150	1724-2024
November	18	1819	150	1670-1969
December (Alpine)	39	1845	166	1679-2011
December (Below treeline)	7	1514	128	1386-1643
January (Alpine)	34	1848	149	1698-1997
January (Below treeline)	12	1381	172	1209-1553
February (Alpine)	52	1896	170	1727-2066
February (Below treeline)	18	1280	173	1107-1453
March (Alpine)	49	1956	166	1789-2122
March (Below treeline)	7	1283	96	1187-1379

Table 2. Proportion of radiocollared caribou locations in each habitat type in the Tweedsmuir-Entiako study area (April 1985 - March 1988).

Habitat Type	April - May	June - July 14	July 15 - September	October	November	December-March
Pine						
1985/86	.450 (18)	(0)	.333 (4)	.071 (1)	.636 (7)	.565 (78)
1986/87	.750 (18)	.273 (6)	.262 (11)	(0)	(0)	.581 (129)
1987/88	.597 (46)	.091 (3)	.099 (7)	(0)	.214 (3)	.714 (155)
Total	.581 (82)	.132 (9)	.176 (22)	.020 (1)	.244 (10)	.627 (362)
Spruce						
1985/86	.025 (1)	.231 (3)	.250 (3)	(0)	(0)	.073 (10)
1986/87	(0)	.182 (4)	.166 (7)	.286 (6)	(0)	.023 (5)
1987/88	.065 (5)	.061 (2)	.113 (8)	.214 (3)	(0)	.014 (3)
Total	.043 (6)	.132 (9)	.144 (18)	.184 (9)	(0)	.031 (18)
Pine/Spruce						
1985/86	.275 (11)	.154 (2)	(0)	.143 (2)	(0)	.218 (30)
1986/87	.167 (4)	.182 (4)	.143 (6)	.048 (1)	(0)	.081 (18)
1987/88	.208 (16)	.152 (5)	.239 (17)	.143 (2)	.071 (1)	.106 (23)
Total	.220 (31)	.162 (11)	.184 (23)	.102 (5)	.024 (1)	.123 (71)
Pine/Meadow						
1985/86	(0)	(0)	.333 (4)	.143 (2)	.182 (2)	.036 (5)
1986/87	(0)	.136 (3)	.214 (9)	.143 (3)	.125 (2)	.014 (3)
1987/88	.013 (1)	(0)	(0)	(0)	(0)	(0)
Total	.007 (1)	.044 (3)	.104 (13)	.102 (5)	.098 (4)	.014 (8)
Spruce/Meadow						
1985/86	.125 (5)	.077 (1)	(0)	(0)	.091 (1)	.029 (4)
1986/87	(0)	(0)	.024 (1)	.095 (2)	(0)	.014 (3)
1987/88	.013 (1)	(0)	.014 (1)	(0)	(0)	.018 (4)
Total	.043 (6)	.016 (1)	.016 (2)	.041 (2)	.024 (1)	.019 (11)
Pine-Spruce/Meadow						
1985/86	.050 (2)	(0)	(0)	(0)	.091 (1)	.036 (5)
1986/87	.042 (1)	(0)	.024 (1)	.190 (4)	(0)	.054 (12)
1987/88	.013 (1)	(0)	(0)	(0)	(0)	(0)
Total	.028 (4)	(0)	.008 (1)	.082 (4)	.024 (1)	.029 (17)
Meadow						
1985/86	.025 (1)	.308 (4)	(0)	(0)	(0)	.007 (1)
1986/87	(0)	(0)	(0)	.048 (1)	.250 (4)	.009 (2)
1987/88	.065 (5)	.061 (2)	.028 (2)	(0)	(0)	.010 (2)
Total	.043 (6)	.088 (6)	.016 (2)	.020 (1)	.098 (4)	.009 (5)

Subalpine												
1985/86	.025	(1)		(0)	.083	(1)	.286	(4)		(0)	.007	(1)
1986/87		(0)		(0)	.048	(2)		(0)	.062	(1)	.063	(14)
1987/88	.026	(2)	.273	(9)	.113	(8)	.429	(6)	.214	(3)	.106	(23)
Total	.021	(3)	.132	(9)	.088	(11)	.204	(10)	.098	(4)	.066	(38)
Alpine												
1985/86	.025	(1)	.231	(3)		(0)	.357	(5)		(0)		(0)
1986/87		(0)	.227	(5)	.119	(5)	.190	(4)	.563	(9)	.108	(24)
1987/88		(0)	.364	(12)	.070	(5)	.143	(2)	.500	(7)		(0)
Total	.007	(1)	.294	(20)	.080	(10)	.225	(11)	.390	(16)	.042	(24)
Lake												
1985/86		(0)		(0)		(0)		(0)		(0)	.029	(4)
1986/87	.042	(1)		(0)		(0)		(0)		(0)	.054	(12)
1987/88		(0)		(0)		(0)		(0)		(0)	.032	(7)
Total	.007	(1)		(0)		(0)		(0)		(0)	.040	(23)
Coastal Western Hemlock												
1985/86		(0)		(0)		(0)		(0)		(0)		(0)
1986/87		(0)		(0)		(0)		(0)		(0)		(0)
1987/88		(0)		(0)	.042	(3)		(0)		(0)		(0)
Total		(0)		(0)	.024	(3)		(0)		(0)		(0)
Mountain Hemlock												
1985/86		(0)		(0)		(0)		(0)		(0)		(0)
1986/87		(0)		(0)		(0)		(0)		(0)		(0)
1987/88		(0)		(0)	.282	(20)	.071	(1)		(0)		(0)
Total		(0)		(0)	.160	(20)	.020	(1)		(0)		(0)

TOTAL # LOCATIONS						
1985/86	40	13	12	14	11	138
1986/87	24	22	42	21	16	222
1987/88	77	33	71	14	14	217
Total	141	68	125	49	41	577

Table 3. Proportion of radiocollared caribou locations in each habitat type in the Itcha-Ilgachuz study area (April 1985 - March 1988).

Habitat Type	April - May	June - July 14	July 15 - September	October	November	December-March
Pine						
1985/86	.343 (12)	(0)	.103 (3)	.095 (2)	.200 (2)	.817 (116)
1986/87	.522 (23)	(0)	.213 (10)	.091 (2)	.636 (7)	.718 (148)
1987/88	.615 (32)	.038 (1)	.109 (7)	(0)	.250 (3)	.702 (132)
Total	.511 (67)	.015 (1)	.143 (20)	.071 (4)	.363 (12)	.739 (396)
Pine/Spruce						
1985/86	(0)	(0)	(0)	(0)	(0)	.014 (2)
1986/87	.023 (1)	(0)	(0)	(0)	(0)	.010 (2)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	.008 (1)	(0)	(0)	(0)	(0)	.007 (4)
Pine/Meadow						
1985/86	.343 (12)	(0)	.207 (6)	.048 (1)	.400 (4)	.120 (17)
1986/87	.045 (2)	(0)	.128 (6)	(0)	.091 (1)	.010 (2)
1987/88	.020 (1)	(0)	.016 (1)	(0)	(0)	.006 (1)
Total	.114 (15)	(0)	.093 (13)	.018 (1)	.152 (5)	.037 (20)
Spruce/Meadow						
1985/86	(0)	(0)	(0)	(0)	(0)	(0)
1986/87	.023 (1)	(0)	(0)	(0)	(0)	(0)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	.008 (1)	(0)	(0)	(0)	(0)	(0)
Pine - Spruce/Meadow						
1985/86	(0)	(0)	(0)	(0)	(0)	.014 (2)
1986/87	.023 (1)	(0)	(0)	(0)	(0)	.005 (1)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	.008 (1)	(0)	(0)	(0)	(0)	.006 (3)
Meadow						
1985/86	.029 (1)	(0)	.138 (4)	.095 (2)	.400 (4)	.035 (5)
1986/87	.205 (9)	(0)	(0)	(0)	.091 (1)	.034 (7)
1987/88	.077 (4)	(0)	.031 (2)	(0)	.170 (2)	.138 (26)
Total	.107 (14)	(0)	.043 (6)	.036 (2)	.212 (7)	.071 (38)
Subalpine						
1985/86	.114 (4)	.167 (2)	.414 (12)	.381 (8)	(0)	(0)
1986/87	.068 (3)	(0)	.276 (13)	.273 (6)	.182 (2)	.126 (26)
1987/88	.096 (5)	.077 (2)	.375 (24)	(0)	.250 (3)	.085 (16)
Total	.091 (12)	.061 (4)	.350 (49)	.250 (14)	.152 (5)	.078 (42)

Alpine						
1985/86	.171 (6)	0.833(10)	.138 (4)	0.381 (8)	(0)	(0)
1986/87	.068 (3)	1.000(28)	.383 (18)	0.636(14)	(0)	.082 (17)
1987/88	.190 (10)	0.885(23)	.469 (30)	1.000(13)	.330 (4)	.037 (7)
Total	.145 (19)	0.924(61)	.371 (52)	0.625(35)	.121 (4)	.045 (24)
Lake						
1985/86	(0)	(0)	(0)	(0)	(0)	(0)
1986/87	(0)	(0)	(0)	(0)	(0)	.015 (3)
1987/88	(0)	(0)	(0)	(0)	(0)	.032 (6)
Total	(0)	(0)	(0)	(0)	(0)	.017 (9)
Clearcut						
1985/86	(0)	(0)	(0)	(0)	(0)	(0)
1986/87	.023 (1)	(0)	(0)	(0)	(0)	(0)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	.008 (1)	(0)	(0)	(0)	(0)	(0)

TOTAL # LOCATIONS						
1985/86	35	12	29	21	10	142
1986/87	44	28	47	22	11	206
1987/88	52	26	64	13	12	188
Total	131	66	140	56	33	536

Table 4. Proportion of radiocollared caribou locations in each habitat type in the Rainbow study area (April 1985 - March 1988).

Habitat Type	April - May	June - July 14	July 15 - September	October	November	December-March
Pine						
1985/86	(0)	(0)	(0)	(0)	(0)	.275 (11)
1986/87	(0)	(0)	(0)	(0)	(0)	.009 (1)
1987/88	(0)	(0)	(0)	(0)	(0)	.297 (19)
Total	(0)	(0)	(0)	(0)	(0)	.144 (31)
Pine/Spruce						
1985/86	(0)	(0)	(0)	(0)	(0)	.050 (2)
1986/87	.071 (1)	(0)	(0)	(0)	(0)	(0)
1987/88	(0)	(0)	(0)	(0)	(0)	.031 (2)
Total	.019 (1)	(0)	(0)	(0)	(0)	.019 (4)
Pine/Meadow						
1985/86	(0)	(0)	(0)	(0)	.250 (1)	.025 (1)
1986/87	(0)	(0)	(0)	(0)	(0)	.009 (1)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	(0)	(0)	(0)	(0)	.071 (1)	.009 (2)
Pine - Spruce/Meadow						
1985/86	(0)	(0)	(0)	(0)	(0)	.025 (1)
1986/87	(0)	(0)	(0)	(0)	(0)	(0)
1987/88	(0)	(0)	(0)	(0)	(0)	(0)
Total	(0)	(0)	(0)	(0)	(0)	.005 (1)
Meadow						
1985/86	(0)	(0)	(0)	(0)	(0)	.025 (1)
1986/87	(0)	(0)	(0)	(0)	(0)	(0)
1987/88	(0)	(0)	(0)	(0)	(0)	.031 (2)
Total	(0)	(0)	(0)	(0)	(0)	.014 (3)
Subalpine						
1985/86	.200 (2)	(0)	.429 (3)	(0)	.250 (1)	.075 (3)
1986/87	(0)	(0)	.146 (3)	(0)	(0)	.027 (3)
1987/88	(0)	(0)	.042 (1)	(0)	(0)	.344 (22)
Total	.039 (2)	(0)	.132 (7)	(0)	.071 (1)	.130 (28)
Alpine						
1985/86	0.800 (8)	1.000 (4)	.571 (4)	1.000 (4)	0.500 (2)	.525 (21)
1986/87	0.929(13)	1.000(11)	.864 (19)	1.000(12)	1.000 (6)	.955 (106)
1987/88	1.000(28)	1.000(14)	.958 (23)	1.000 (4)	1.000 (4)	.281 (18)
Total	0.942(49)	1.000(29)	.868 (46)	1.000(20)	0.858(12)	.674 (145)

Lake							
1985/86	(0)	(0)	(0)	(0)	(0)		(0)
1986/87	(0)	(0)	(0)	(0)	(0)		(0)
1987/88	(0)	(0)	(0)	(0)	(0)	.016	(1)
Total	(0)	(0)	(0)	(0)	(0)	.005	(1)

TOTAL # LOCATIONS						
1985/86	10	4	7	4	4	40
1986/87	14	11	22	12	6	111
1987/88	28	14	24	4	4	64
Total	52	29	53	20	14	215

Table 5. Number of radiocollared caribou locations in each forest cover type class in the Tweedsmuir-Entiako and Itcha-Ilgachuz study areas during winter (December 1, 1986 - March 31, 1987, November 29, 1987 - March 31, 1988).

Tree Species	*Age Class*	*Site Type*	1986/87	1987/88	Total
Tweedsmuir-Entiako					
Pine	1-4	L + P + M	32	38	70
	5-9	L + P	65	73	138
		M	35	28	63
Pine/	1-4	L + P + M	10	0	10
Spruce	5-9	L + P	12	8	20
		M	17	18	35
Meadow/Open Range/Wetland			3	4	7
Lake			11	7	18
Other			2	3	5
TOTAL			187	179	366
Itcha-Ilgachuz					
Pine	1-4	L	8	6	14
		P	20	10	30
	5-9	L	66	103	169
		P	64	25	89
		M	3	10	13
Pine/	5-9	L + P	14	0	14
Spruce		M	4	0	4
Meadow/Open Range/Wetland			4	27	31
Other			3	2	5
TOTAL			186	183	369

Tree Species PINE = Lodgepole pine
SPRUCE = White spruce + Engelmann spruce + Black spruce

Age Classes 1-4 = 0-80 years (Immature); 5-9 = >80 years (Mature)

Site Types L=Low, P=Poor, M=Medium

Other = Nonproductive (NP) pine, NP pine/spruce, NP spruce, NP brush, Rock, Immature pine (immature sites) (Il), Immature pine/spruce (Il), Mature spruce

Table 6. Number of radiocollared caribou locations in each forest cover type class in the Tweedsmuir-Entiako study area during early winter (December 1, 1986 - January 6, 1987, November 29, 1987 - January 12, 1988), mid winter (January 16 - March 13, 1987, January 16 - March 11, 1988) and late winter / early spring (March 19 - April 22, 1987, March 16 - March 24, 1988).

Tree Species	*Age Class*	*Site Type*	1986/87	1987/88	Total
Early winter					
Pine	1-4	L + P + M	11	12	23
	5-9	L + P	23	14	37
		M	6	4	10
Pine/	1-4	L + P + M	4	0	4
Spruce	5-9	L + P	2	1	3
		M	5	2	7
Meadow/Open Range/Wetland			2	1	3
Lake			2	0	2
Other			1	1	2
TOTAL			56	35	91
Mid winter					
Pine	1-4	L + P + M	19	25	44
	5-9	L + P	38	50	88
		M	20	20	40
Pine/	1-4	L + P + M	5	0	5
Spruce	5-9	L + P	7	4	11
		M	6	10	16
Meadow/Open Range/Wetland			1	3	4
Lake			8	6	14
Other			1	2	3
TOTAL			105	120	225
Late winter					
Pine	1-4	L + P + M	10	1	11
	5-9	L + P	12	9	21
		M	21	4	25
Pine/	1-4	L + P + M	2	0	2
Spruce	5-9	L + P	4	3	7
		M	12	6	18
Meadow/Open Range/Wetland			3	0	3
Lake			1	1	2
Other			0	0	0
TOTAL			65	24	89

Tree Species PINE = Lodgepole pine
SPRUCE = White spruce + Engelmann spruce + Black spruce
Age Classes 1-4 = 0-80 years (Immature); 5-9 = >80 years (Mature)
Site Types L=Low, P=Poor, M=Medium
Other = Nonproductive (NP) pine, NP pine/spruce, NP spruce, NP brush, Rock, Immature spruce, Mature spruce

Table 7. Number of radiocollared caribou locations in each forest cover type class in the Itcha-Ilgachuz study area during early winter (November 29, 1986 - January 6, 1987, November 29, 1987 - January 12, 1988), mid winter (January 15 - March 13, 1987, January 16, - March 10, 1988) and late winter/early spring (March 19 - April 22, 1987, March 18 - March 31, 1988).

Tree Species	*Age Class*	*Site Type*	1986/87	1987/88	Total
Early winter					
Pine	1-4	L	3	3	6
		P	7	2	9
	5-9	L	18	20	38
		P	23	4	27
		M	1	0	1
Pine/	5-9	L + P	4	0	4
Spruce		M	3	0	3
Meadow/Open Range/Wetland			2	22	24
Other			1	0	1
TOTAL			62	51	113
Mid winter					
Pine	1-4	L	3	3	6
		P	9	8	17
	5-9	L	37	71	108
		P	39	14	53
		M	2	7	9
Pine/	5-9	L + P	10	0	10
Spruce		M	1	0	1
Meadow/Open Range/Wetland			2	5	7
Other			1	1	2
TOTAL			104	109	213
Late winter					
Pine	1-4	L	2	0	2
		P	9	0	9
	5-9	L	20	12	32
		P	8	7	15
		M	1	3	4
Pine/	5-9	L + P	0	0	0
Spruce		M	0	0	0
Meadow/Open Range/Wetland			0	0	0
Other			1	0	1
TOTAL			41	22	63

Tree Species PINE = Lodgepole pine
SPRUCE = White spruce + Engelmann spruce + Black spruce
Age Classes 1-4 = 0-80 years (Immature); 5-9 = >80 years (Mature)
Site Types L=Low, P=Poor, M=Medium
Other = Nonproductive (NP) pine, NP pine/spruce, NP spruce, NP brush, Rock, Immature pine (immature sites), Immature pine/spruce, Mature spruce

Table 8. Number of radiocollared caribou locations in each caribou habitat type category in the Tweedsmuir-Entiako and Itcha-Ilgachuz study areas during winter (December 1, 1986 - March 31, 1987, November 29, 1987 - March 31, 1988).

	1986/87			1987/88			Total		
Age Class	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**
Tweedsmuir-Entiako									
DLLM		7	14		23	30		30	44
LM		9	45		8	47		17	102
DLLMMOSAIC		12	10		7	7		19	17
MDLLM		9	27		1	19		10	46
MSF/AF		1	22		3	18		4	40
W/FW	2	2	2	4	0	1	6	2	3
LAKE	12			7			19		
TOTAL	14	40	120	11	42	132	25	82	252
Itcha-Ilgachuz									
DLLM		1	87		5	91		6	178
LM		9	20		2	37		11	57
DLLMMOSAIC		0	3		2	5		2	8
MDLLM		1	6		0	1		1	7
MSF		0	15		0	3		0	18
W/FW	2	0	2	3	0	2	5	0	4
FL	1	0	0	8	1	16	9	1	16
SBPS-DLK		0	15		0	1		0	16
SBPS-OTHER		0	3		0	0		0	3
TOTAL	3	11	151	11	10	156	14	21	307

Age Classes
0 = No age class
1-3 = 0-80 years (Immature)
4-5 = >80 years (Mature)

Table 9. Number of radiocollared caribou locations in each caribou habitat type category in the Tweedsmuir-Entiako study area during early winter (December 1, 1986 - January 12,1987, November 29, 1987 - January 12, 1988), mid winter (January 16 - March 13, 1987, January 16, - March 11, 1988) and late winter / early spring (March 19, 1987 - April 22, 1987, March 16-31, 1988).

	1986/87			1987/88			Total		
Age Class	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**
Early winter									
DLLM		4	6		6	6		10	12
LM		1	10		2	10		3	20
DLLMMOSAIC		4	7		5	4		9	11
MDLLM		2	11		0	4		2	15
MSF/AF		1	3		1	2		2	5
W/FW	1	2	1	1	0	1	2	2	2
LAKE	2			0			2		
TOTAL	3	14	38	1	14	27	4	28	65
Mid winter									
DLLM		5	9		17	24		22	33
LM		5	33		6	42		11	75
DLLMMOSAIC		6	3		3	5		9	8
MDLLM		6	12		3	8		9	20
MSF/AF		0	10		1	3		1	13
W/FW	1	0	1	3	0	1	4	0	2
LAKE	8			6			14		
TOTAL	9	22	68	9	30	83	18	52	151
Late winter									
DLLM		5	4		0	0		5	4
LM		2	15		0	5		2	20
DLLMMOSAIC		0	6		0	0		0	6
MDLLM		3	6		0	5		3	11
MSF/AF		1	18		0	12		1	30
W/FW	0	0	0	0	0	0	0	0	0
LAKE	2			1			3		
TOTAL	2	11	49	1	0	22	3	11	71

Age Classes
0 = No age class
1-3 = 0-80 years (Immature)
4-5 = >80 years (Mature)

Table 10. Number of radiocollared caribou locations in each caribou habitat type category in the Itcha-Ilgachuz study area during early winter (December 1, 1986 - January 6, 1987, November 29, 1987 - January 12, 1988), mid winter (January 15 - March 13, 1987, January 16 - March 10, 1987) and late winter / early spring (March 19, 1987 - April 22, 1987, March 16 - 24, 1988).

	1986/87			1987/88			Total		
Age Class	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**	**0**	**1-3**	**4-5**
Early winter									
DLLM		1	23		1	17		2	40
LM		2	13		0	6		2	19
DLLMMOSAIC		0	3		0	2		0	5
MDLLM		0	1		0	1		0	2
MSF		0	7		0	1		0	8
W/FW	0	0	2	3	0	1	3	0	3
FL	1	0	0	8	1	9	9	1	9
SBPS-DLK		0	1		0	0		0	1
SBPS-OTHER		0	1		0	0		0	1
TOTAL	1	3	51	11	2	37	12	5	88
Mid winter									
DLLM		0	56		4	56		4	112
LM		6	8		2	27		8	35
DLLMMOSAIC		0	0		0	4		0	4
MDLLM		1	3		0	0		1	3
MSF		0	8		0	2		0	10
W/FW	2	0	0	0	0	2	2	0	2
FL	0	0	0	0	0	8	0	0	8
SBPS-DLK		0	6		0	1		0	7
SBPS-OTHER		0	0		0	0		0	0
TOTAL	2	7	81	0	6	100	2	13	181
Late winter									
DLLM		0	14		0	18		0	32
LM		0	2		0	4		0	6
DLLMMOSAIC		0	0		0	0		0	0
MDLLM		0	2		0	0		0	2
MSF		0	1		0	0		0	1
W/FW	0	0	0	0	0	0	0	0	0
FL	0	0	0	0	0	0	0	0	0
SBPS-DLK		0	18		0	0		0	18
SBPS-OTHER		0	3		0	0		0	3
TOTAL	0	0	40	0	0	22	0	0	62

Age Classes
0 = No age class
1-3 = 0-80 years (Immature)
4-5 = >80 years (Mature)

APPENDIX III

SUMMARY OF DATA USED FOR FEEDING SITE FIGURES

Table 1. Number of craters (C) and non-crater sites (NCS) containing abundance classes of terrestrial lichens (0=0%, trace=1%, low=2-14%, medium=15-39%, high=40-100%) in each habitat type in the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou winter ranges, December 1986 - March 1987, December 1987 - March 1988.

	Tweedsmuir-Entiako		**Itcha-Ilgachuz**	
% ground cover	C	NCS	C	NCS
Pine				
0%	2	80	5	53
1%	1	3	1	10
2-14%	35	29	85	59
15-39%	133	13	227	47
40-100%	118	2	250	11
Total	289	127	568	180
Spruce				
0%	2	19		
1%	0	0		
2-14%	2	3		
15-39%	2	1		
40-100%	2	0		
Total	8	23		
Pine/Spruce				
0%	3	44	2	1
1%	0	1	0	0
2-14%	7	14	0	4
15-39%	21	4	0	0
40-100%	23	0	0	0
Total	54	63	2	5
Total Forest				
0%	7	143	7	54
1%	1	4	1	10
2-14%	44	46	85	63
15-39%	156	18	227	47
40-100%	143	2	250	11
Total	351	213	570	185
Fescue-Lichen				
0%			0	0
1%			0	0
2-14%			4	0
15-39%			18	0
40-100%			62	0
Total			84	0

Table 2. Number of craters (C) and non-crater sites (NCS) located in canopy closure classes (1-5%, 6-10%, 11-15%, 16-20%, >20%) in each forested habitat type in the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou winter ranges, December 1986 - March 1987, December 1987 - March 1988.

	Tweedsmuir-Entiako		Itcha-Ilgachuz	
canopy closure	C	NCS	C	NCS
Pine				
1-5%	117	13	127	24
6-10%	79	5	226	34
11-15%	52	12	89	38
16-20%	6	2	2	6
Total	254	32	444	102
Spruce				
1-5%	0	3		
6-10%	0	2		
11-15%	0	2		
16-20%	0	0		
Total	0	7		
Pine/Spruce				
1-5%	39	1	0	1
6-10%	0	3	1	0
11-15%	0	19	1	2
16-20%	0	2	0	0
>20%	0	1	0	0
Total	39	26	2	3
Total Forest				
1-5%	156	17	127	25
6-10%	79	10	227	34
11-15%	52	33	90	40
16-20%	6	4	2	6
>20%	0	1	0	0
Total	293	65	446	105

Table 3. Average snow depth at crater sites (C) and non-crater sites (*NCS*) in all forested habitat types combined in the Tweedsmuir-Entiako caribou winter range, December 1986 - March 1987, December 1987 - March 1988.

		N	Mean	Standard Deviation	95% Confidence Interval
1986/87					
January 18, 1987	(C)	49	46.1	6.8	44.2-48.0
	(NCS)	*63*	*36.5*	*6.8*	*34.8-38.2*
January 30, 1987	(C)	2	47.0	4.2	8.9-85.1
	(NCS)	*58*	*43.6*	*8.6*	*41.4-45.8*
February 18, 1987	(C)	5	49.2	6.2	41.5-56.9
	(NCS)	*3*	*45.7*	*9.7*	*21.6-69.8*
March 21, 1987	(C)	0			
	(NCS)	*19*	*41.3*	*9.7*	*36.6-46.0*
1987/88					
January 13, 1988	(C)	67	16.7	3.6	15.8-17.6
	(NCS)	*3*	*16.3*	*7.6*	*0-35.1*
January 28, 1988	(C)	99	21.0	4.0	20.2-21.8
	(NCS)	*2*	*23.5*	*2.1*	*4.4-42.6*
February 23, 1988	(C)	74	37.5	5.4	36.3-38.7
	(NCS)	*15*	*27.3*	*8.3*	*22.7-31.9*
March 7, 1988	(C)	39	33.2	3.3	32.2-34.2
	(NCS)	*16*	*23.1*	*8.8*	*18.4-27.8*
March 17,.1988	(C)	14	32.4	4.8	29.7-35.1
	(NCS)	*25*	*26.9*	*9.0*	*23.2-30.6*

Table 5. Average snow penetrability at crater sites (C) and non-crater sites (*NCS*) in all forested habitat types combined in the Tweedsmuir-Entiako and Itcha-Ilgachuz caribou winter ranges, December 1987 - March 1988.

		N	Mean	Standard Deviation	95% Confidence Interval
Tweedsmuir-Entiako					
January 13, 1988	(C)	67	.976	.037	.966-0.986
	(NCS)	*3*	*.970*	*.053*	*.878-1.062*
January 28, 1988	(C)	99	.973	.054	.963-0.983
	(NCS)	*2*	*1.000*		
February 23, 1988	(C)	74	.881	.119	.854-0.908
	(NCS)	*15*	*.903*	*.124*	*.835-0.971*
March 7, 1988	(C)	39	.948	.055	.930-0.966
	(NCS)	*16*	*.795*	*.145*	*.719-0.871*
March 17, 1988	(C)	14	.863	.092	.809-0.917
	(NCS)	*25*	*.696*	*.188*	*.618-0.774*
Itcha-Ilgachuz					
January 23, 1988	(C)	121	.991	.019	.987-0.995
	(NCS)	*9*	*1.000*		
February 2, 1988	(C)	143	.988	.027	.984-0.992
	(NCS)	*7*	*.964*	*.049*	*.921-1.000*
February 20, 1988	(C)	60	.984	.025	.978-0.990
	(NCS)	*31*	*.981*	*.056*	*.961-1.000*
March 2, 1988	(C)	99	.998	.012	.996-1.000
	(NCS)	*39*	*.985*	*.043*	*.971-0.999*
March 20,.1988	(C)	23	.981	.041	.962-1.000
	(NCS)	*8*	*.933*	*.190*	*.778-1.088*

Table 4. Average snow depth at crater sites (C) and non-crater sites (*NCS*) in all forested habitat types combined in the Itcha-Ilgachuz caribou winter range, December 1986 - March 1987, December 1987 - March 1988.

		N	Mean	Standard Deviation	95% Confidence Interval
1986/87					
December 16, 1986	(C)	17	38.4	8.1	36.3-40.5
	(NCS)	*6*	*40.2*	*3.6*	*36.4-44.0*
January 10, 1987	(C)	1			
	(NCS)	*1*			
January 25, 1987	(C)	27	52.6	6.3	50.1-55.1
	(NCS)	*29*	*51.9*	*5.7*	*49.7-54.1*
February 6, 1987	(C)	39	58.4	4.5	57.0-60.8
	(NCS)	*22*	*52.6*	*8.3*	*48.9-56.3*
March 3, 1987	(C)	53	56.7	8.7	54.3-59.1
	(NCS)	*15*	*53.7*	*7.1*	*49.8-57.6*
March 26, 1987	(C)	5	66.8	7.3	57.8-75.8
	(NCS)	*13*	*65.1*	*8.6*	*59.9-70.3*
1987/88					
December 14, 1987	(C)				
	(NCS)	*1*	*33.0*		
January 23, 1988	(C)	121	33.8	4.2	33.1-34.5
	(NCS)	*9*	*32.6*	*4.1*	*28.5-35.7*
February 2, 1988	(C)	143	37.4	3.9	36.7-38.1
	(NCS)	*7*	*37.6*	*3.3*	*34.6-40.6*
February 20, 1988	(C)	60	42.9	5.4	41.5-44.3
	(NCS)	*31*	*42.8*	*5.3*	*41.0-44.6*
March 2, 1988	(C)	99	37.7	5.5	36.6-38.8
	(NCS)	*39*	*35.5*	*6.1*	*33.6-37.4*
March 20,.1988	(C)	23	33.4	7.7	30.1-36.7
	(NCS)	*8*	*29.8*	*7.9*	*23.2-36.4*

Table 6. Average snow depth at snow stations in 3 habitat types (wetland, mature and immature pine stands in the Itcha-Ilgachuz winter range, January - March 1986, December 1986 - March 1987, December 1987 - March 1988. (Only winter 1986/87 and 1987/88 measurements were taken at established snow stations.

Habitat type	N	Mean	Standard Deviation	95% Confidence Interval
1985/86				
Mature Pine				
January 22,1986	19	43.5	5.3	41.0-46.0
February 6, 1986	29	51.1	5.6	49.0-53.2
February 24, 1986	29	61.8	11.5	56.4-66.2
March 15, 1986	22	52.0	9.4	47.8-56.2
Wetland				
January 22, 1986	13	62.8	4.4	60.2-65.4
February 6, 1986	29	56.5	7.4	53.7-59.3
March 15, 1986	9	34.6	4.2	31.4-36.8
1986/87				
Mature Pine				
December 19, 1986	30	41.8	3.8	40.4-43.2
January 8, 1987	30	45.6	5.4	43.6-47.6
January 26, 1987	30	50.8	5.3	48.8-52.8
February 6, 1987	30	54.9	6.9	52.3-57.5
February 24, 1987	30	55.1	7.6	52.3-57.9
March 3, 1987	30	61.8	5.9	59.6-64.0
March 26, 1987	30	60.0	7.3	57.3-62.7
Immature Pine				
December 19, 1986	30	40.8	4.1	39.3-42.3
January 8, 1987	30	42.8	4.7	41.0-44.6
January 26, 1987	30	48.0	5.8	43.1-54.7
February 6, 1987	30	55.4	6.6	52.9-57.9
February 24, 1987	30	55.7	8.0	52.7-58.7
March 3, 1987	30	55.0	13.8	49.8-60.2
March 26, 1987	30	56.6	8.1	53.6-59.6
Wetland				
December 19, 1986	30	50.5	6.2	48.2-52.8
January 8, 1987	30	57.3	4.9	55.5-59.1
January 26, 1987	30	66.7	5.8	64.5-68.9
February 6, 1987	30	71.3	7.0	68.7-73.9
February 24, 1987	30	74.3	6.5	71.9-76.7
March 3, 1987	30	77.7	14.1	72.4-83.0
March 26, 1987	30	72.5	13.5	67.4-77.6

1987/88

Mature Pine				
December 18, 1987	30	23.3	2.0	22.6-24.0
January 3, 1988	30	27.2	3.1	26.1-28.3
January 23, 1988	30	32.8	2.4	32.0-33.7
February 2, 1988	30	38.2	2.6	37.3-39.1
February 20, 1988	30	40.1	2.4	39.2-41.0
March 2, 1988	30	38.5	3.4	37.3-39.7
March 20, 1988	30	36.7	2.9	35.7-37.8
Immature Pine				
December 18, 1987	30	21.6	2.9	20.5-22.6
January 3, 1988	30	27.0	2.9	26.0-28.1
January 23, 1988	30	29.9	6.6	27.6-32.2
February 2, 1988	30	36.5	6.3	34.3-38.8
February 20, 1988	30	37.0	3.9	35.6-38.4
March 2, 1988	30	32.5	5.3	30.6-34.5
March 20, 1988	30	33.3	4.6	31.7-35.0
Wetland				
December 18, 1987	30	29.4	2.5	28.6-30.3
January 3, 1988	30	33.7	3.1	32.6-34.8
January 23, 1988	30	39.7	3.7	38.4-41.1
February 2, 1988	30	49.5	3.1	48.4-50.6
February 20, 1988	30	50.0	3.2	48.9-51.2
March 2, 1988	30	48.6	4.1	47.2-50.1
March 20, 1988	30	47.8	4.5	46.2-49.4

APPENDIX IV

SUMMARY OF FECAL ANALYSIS DATA

Table 1. Percent composition of vegetation types in fecal pellet groups determined by fecal fragment analysis from samples collected in the Itcha-Ilgachuz and Tweedsmuir-Entiako study areas.

Date	Terrestrial Lichen	Arboreal Lichen	Conifer	Shrub	Forb	Grass	Sedge/ Rush	Moss/ Clubmoss
Itcha/Ilgachuz								
Feb. 1984	38.8	35.1	3.1	1.4	1.7	13.3	3.3	3.3
1985								
June 3-12	26.7	24.1	2.5	4.7	9.5	12.8	6.8	12.9
July 5	11.8	13.8	0.0	10.0	11.4	28.2	12.6	12.2
July 24	16.8	17.9	.2	14.8	10.9	22.6	10.6	6.2
Oct 20	38.5	42.3	4.4	2.1	7.2	2.1	1.5	1.9
Nov 10	45.0	30.7	1.9	2.0	.7	5.2	5.9	8.6
1986								
Jan 20	41.7	28.9	11.0	4.4	1.4	3.9	3.7	5.0
Feb 21	31.9	23.3	0.0	7.9	0.0	11.4	.4	25.1
(Alpine)								
Feb 23	35.1	33.2	8.3	3.8	1.7	4.0	3.8	10.1
March 21	33.0	14.9	0.0	4.5	2.1	7.5	0.0	38.0
(Alpine)								
March 23	26.6	34.3	13.9	5.0	1.8	5.1	.6	12.7
June 6	32.1	14.7	1.5	5.4	9.3	14.3	2.8	19.9
July 6	17.3	16.4	.8	13.8	13.9	18.3	5.4	14.1
Dec 17	32.4	40.9	11.7	1.9	3.0	2.5	2.6	5.0
1987								
Jan 9	41.2	7.2	13.3	4.1	4.2	3.3	4.7	22.0
Feb 5	34.6	36.4	15.8	3.3	1.9	1.3	2.0	4.7
March 3	35.0	31.2	19.8	3.5	3.5	2.0	2.0	3.0
April 13	33.8	28.7	7.6	2.7	19.1	3.1	2.3	2.7
May 9	42.1	28.0	7.2	1.8	1.4	6.4	6.0	7.1
Dec 16	38.1	43.2	.2	3.9	1.8	6.0	2.7	4.1
Tweedsmuir-Entiako								
1986								
Jan 11	33.3	33.7	14.0	6.2	4.1	1.6	1.0	6.1
Feb 10	32.4	32.0	17.8	4.2	3.5	4.6	2.3	3.2
March 3	25.5	24.6	17.7	5.0	7.4	1.4	3.1	15.3
Dec 13	32.4	29.7	14.4	4.8	2.6	2.1	1.1	12.9
1987								
Jan 17	30.7	27.9	9.9	4.7	2.1	2.9	2.4	19.4
Feb 16	33.7	32.2	9.8	6.3	2.1	1.6	.8	13.5
Feb 25	39.5	19.9	4.3	7.6	3.2	2.6	1.7	21.2
(Alpine)								
March 21	29.5	15.8	8.5	9.0	8.9	12.4	6.0	9.9

Table 2. Mean percent nitrogen values of caribou fecal pellet groups collected in the Itcha-Ilgachuz and Tweedsmuir-Entiako study areas.

	N	Mean	Standard Deviation	95% Confidence Interval
Itcha/Ilgachuz				
February 1984	8	1.53	.09	1.46-1.60
1985				
Feb	10	1.55	.48	1.22-1.88
March	10	1.41	.05	1.38-1.44
June 3-12	10	1.72	.28	1.52-1.92
July 5	10	2.41	.47	2.08-2.74
July 24	10	2.51	.26	2.33-2.69
October 20	9	1.67	.13	1.58-1.76
November 10	10	1.58	.12	1.49-1.67
1986				
January 20	10	1.65	.10	1.58-1.72
February 21 (Alpine)	10	1.46	.07	1.41-1.51
February 23	10	1.64	.06	1.59-1.69
March 19 (Alpine)	8	1.49	.13	1.38-1.60
March 23	10	1.61	.06	1.57-1.65
December 17	10	1.64	.11	1.56-1.72
1987				
January 8-11	6	1.67	.07	1.59-1.75
February 5-8	10	1.55	.05	1.52-1.58
March 3-5	10	1.53	.06	1.49-1.57
April 13	9	1.63	.11	1.54-1.72
May 9	9	1.82	.14	1.71-1.93
June 3-7	10	1.61	.32	1.38-1.84
December 16	10	1.61	.06	1.57-1.65
Tweedsmuir-Entiako				
1986				
January 11	10	1.71	.15	1.60-1.82
February 10	10	1.58	.09	1.51-1.64
March 3	10	1.68	.04	1.65-1.71
1987				
January 17-20	10	1.77	.11	1.69-1.85
February 16-19	10	1.71	.16	1.60-1.82
February 25-28 (Alpine)	10	1.63	.11	1.52-1.74
March 21-23	10	1.71	.13	1.62-1.80