A PRELIMINARY ESTIMATE OF GRIZZLY BEAR ABUNDANCE IN THE SOUTHWEST YUKON

Yukon
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by
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ABSTRACT

Grizzly bear (Ursus arctos) abundance was determined for a 6310 km^2 study area in the southwest Yukon in 1985. A one year time restriction was placed on the duration of this study. Twenty-seven bears were immobilized, aged and radio-collared. Adults ($\geq$6 years) made up 49% of the population, followed by yearlings, subadults, and cubs at 21%, 15% and 15%, respectively. Adult male home ranges (1169$\pm$ 460 km^2) were on average four times larger than adult female home ranges (279$\pm$ 73 km^2). Our preliminary estimate of grizzly bear abundance was between 82 and 139 animals (mean 100) or 13 to 22 bears/1000 km^2 (mean 16/1000 km^2). Capture biases were not evident with the 5 techniques used to locate bears. Sightability of bears was low (24%) despite the fact that the majority (88%) of relocations were made in open and semi-open habitats. Females with cubs had the highest sightability. The potential affects of food availability, hunting, female home range measurements, female population size, and composition on the total population estimate were assessed. We suggest that biases may have been present which would have potentially affected our population estimate. As a result, we suggest the bear population estimate in this paper is preliminary.

INTRODUCTION

Grizzly bear predation has been documented as the primary cause of moose calf mortality, and the main factor limiting the growth of moose populations in the southwest Yukon (Larsen et al. 1985, Gauthier and Larsen 1986, Larsen et al. 1989[a], and Larsen et al. 1989b). A management program to enhance low density moose population was proposed by Larsen and Gauthier (1985). Based on policy direction to enhance moose populations over the short term, Larsen and Gauthier (1985) recommended that grizzly bear densities be reduced to 50% of their prereduction levels within 2 years. The objective of the current study was to estimate the number of grizzly bears present in the moose enhancement area prior to the reduction of bears, in order to ensure that bear removal targets were neither exceeded or fell short of the desired level. A grizzly bear population estimate was required within a 1 year time frame.

Previous grizzly bear population estimates from the territory have been made in the Southwest Yukon (Pearson 1975) and the North Slope (Nagy et al. 1983). The former study was located 120 km west of the current study area, but in a region which was biogiographically distinct from our area. A third estimate was made in the current study area in 1985 using a mark-recapture technique (Department of Renewable Resources unpublished files). That study yielded unrealistic estimates of bear numbers, however, the home range and composition data from marked bears were used in the population estimate presented in this paper.

STUDY AREA

The study area (6310 km^2) was located in the Coast Mountiain Range of the Southwest Yukon, approximately 50 km southwest of Whitehorse and 120 km southeast of Kluane National Park (Fig. 1). The study area was separated into a core (2,549 km^2) and a peripheral (3,761 km^2) area based on the relative abundance of moose (Larsen 1982, Johston and McLeod 1983, Markel and Larsen 1984). Most of the grizzly bear field work was carried out in the core area. This was also the area of highest moose density.

The study area is characterized by high plateaus and rugged mountains to 2,600 meters above sea level (a.s.l.) which are dissected by deep river valleys. In the extreme south, extensive glaciers blanket the most rugged terrain occurring in the area. Elsewhere, small snowpatches, cirques, and talus slopes are common at higher elevation.

The area is generally cool and dry. Mean monthly temperatures range from -21^{o} C in January to 13^{o} C in July, with a mean annual temperature of -1^{o} C (Phillips 1982). The study area lies in he rainshadow of the St. Elias and Coast Mountains which creates one of the most arid regions in the Yukon, averaging 250 to 300 mm of annual precipitation. Both temperature and precipitation are locally affected by numerous large water bodies in the area. Snow is present from October through May. Snowdepths generally increase with elevation, reaching 30-60 cm in valley floors by early March. Normally, snow melt has occurred on south facing slopes by late April, and in high plateaus by late May. "Green-up" generally occurs in early June.

The study area is characterized by extensive alpine and subalpine habitats, with 76% of the area above treeline (1200 m). Subalpine communities are dominated by shrub birch (Betula glandulosa) and willow (Salix spp.) communities. Alpine and mountainous communities are largely dominated by lichens and graminoids. South facing slopes are generally very dry where aspen (Populus tremuloides) and grasses are common. Lodgepole pine (Pinus contorta) occur in flat, dry areas. On wetter slopes, white spruce (Picea glauca) is the predominant vegetation occurring from treeline to valley bottoms. Paperbirch (Betula papyrifera), aspen and cottonwood (Populus balsamifera) are scattered throughout valleyfloors. Floodplains are generally stable, with the exception of the Watson River and portions of the Wheaton river, owing to the buffering of spring meltwater by headwater lakes. The active floodplains are more like those Pearson (1975) described in the Alsek area of Kluane Park, with early seral communities rich in eskimo potatoe (Hedysarum alpinum) and soapberry (Shepherdia canadensis). The physiography, climate, and vegetation of the area are described in more detail by Oswald and Senyk (1977) and Davies et al. (1983).

Wolf (Canis lupus), grizzly bear and black bear (Ursus americanus) are the most common large carnivores which inhabit the area. In mid-winter 1983, wolf densities of 13 wolves/1000 km^2 were documented by Hayes et al. (1985). There are no estimates of black bear abundance. Dall's sheep (Ovis dalli) occur at 300/1000 km^2 (Barichello, pers. comm.), moose at 190/1000 km^2 (Johnston et al. 1984) and woodland caribou (Rangifer tarandus) at 20/1000 km^2 (Farnell, Yukon Fish and Wildlife Branch, Whitehorse, pers. comm.).

The area was important to Indians, other residents, and non-resident moose hunters. Three of 13 native bands in the Yukon extensively used the study area for moose hunting. In the early 1980s, 7% of the non-Indian resident moose harvest and hunting effort took place in the study area, which represents only 1% of the Yukon. By 1986 the non-Indian harvest had dropped by 71%, (Larsen et al. 1989).

Mineral exploration activity is common in the central and southern portions of the study area. Forestry harvest in the study area is limited to fuelwood cutting in an old burn at the northern extreme of the area. Livestock and agriculture are restricted to the northern boundary near Whitehorse.

METHODS

Grizzly bear location techniques

Five techniques were used to locate bears between April and July 1985:

1) Post-denning bear surveys, using a high speed fixed wing aircraft (eg. Cessna 185), were flown between April 9 and May 20. Surveys were conducted at low levels (30 - 150) above ground level (a.g.l.) following terrain contours. The entire study area was searched, however, the majority of the flying was concentrated in the core area (Fig. 2).

2) Intensive aerial surveys, using 2 supercub fixed wing aircraft, were conducted daily in the core area between May 22 and July 3. Four survey blocks were established to ensure systematic coverage of the core area (Fig. 2). Aircraft flew between 30 - 150 meters a.g.l. at speeds of 80 - 160 km/hr. Search patterns varied from contours along mountain slopes, parallel lines along valley bottoms and tight circles over forested areas. The 4 survey blocks were each searched 5 times over the summer, at a search intensity of approximately 0.94 min/km^2 survey time. A helicopter was dispatched for collaring when a bear was located.

3) Bears were also located during a moose calf mortality study (Larsen et al. 1989a). Fifty-nine newborn moose calves were radio-collared between May 22 and June 6. The majority (92%) of calves were within the core area (Fig.2). This area was also the major calving grounds, as determined by radio-collared females (Department of Renewable Resources files). Subalpine and alpine habitats (> 1,067 m) were searched most intensively for newborn calves as these areas were preferred for calving.

Calves were monitored 3 times a day until June 24, daily from June 25-30 and then once every second day between July 1-18. When a mortality signal was detected, a helicopter crew immediately investigated the site and searched for predators in the vicinity of the dead calf. If a grizzly bear was spotted, it was immobilized and collared.

4) Bears were captured between May 9 and July 18 using Aldrich foot snares (Troyer et al. 1961). Twenty-one cubby sets were established throughout the core area (Fig. 2). Snares were set in major valleys where bears had been previously observed, and were equipped with radio-beacons which were de-activated once the snare was sprung. Snares were checked twice daily during the first 6 weeks, and once every 2 days for the remaining 4 weeks. Commercial mink food (horse meat) was used as bait. Fresh bait was added twice over the summer.

5) Solitary, radio-instrumented adult bears were monitored every 3 days during the breeding season (June 10 - July 19) in an attempt to locate other uncollared breeding bears.

Immobilization and handling

Bears were immobilized with either a 1:1 combination of Ketamine hydrochloride (Parke-Davis) and Xylazine hydrochloride (Rompun, Cutter Laboratories) or with M99 (Etophine hydrochloride). The Ketamine/Rompun mixture was administered at a dosage rate of 5mg/kg body weight, and M99 from 3 to 5mg (1mg/cc) per bear. The antagonist M50-50 (Diprenorphine) was injected intramuscularly in bears immobilized with M99. Drugs were administered by a Cap-chur dart gun (Palmer Chemical and Equipment C., Douglasville, Georgia), fired from either a helicopter or, in the case of snared bears, from the ground. Induction time (I.T.) was calculated from the time of darting to complete immobilization. Bears which recieved multiple darts were excluded from analysis of I.T.

After immobilization, a premolar (pm1) was extracted for age determination (Klevezal and Kleinenberg 1976, Thomas 1977, Fogl and Mosby 1978), an upper lip was tattooed for permanent marking, ear tags and collar flags (7 cm by 30 cm) were attached for temporary marking, and radio-collars (Telonics, Mesa, Arizona) were attached for tracking.

Population composition and home range delineation

Composition of the population was based on the 1985 capture sample from spring and early summer. Bears were classified as adult males or adult females (≥6 yrs), subadult male or females (2-5 yrs), yearling male or female (1 yr) and cubs of the year (.5 yrs).

Home ranges were calculated from radio-collared bears monitored between April 1985 and June 1986. All locations were made with a fixed wing aircraft and plotted on a 1:250,000 scale topographic map. A SAS computer program was used to calculate minimum polygon home range areas (Mohr 1947).

Grizzly bear population estimate

A grizzly bear population estimate for the study area was developed in 3 stages. First, as many adult female bears as possible were radio-collared and monitored within the core area. The average home range size ($\pm$ 90% CI) was calculated. This value was then divided into the total study area to determine the total female population, uncorrected for home range overlap. Second, the percent overlap was determined from the female home ranges in the core area. An overlap correction factor was calculated by dividing the sum of the individual home range areas by the total area occupied by the same bears. The uncorrected mean number of female bears ($\pm$ 90% CI) for the study area was then multiplied by the overlap correction factor to obtain a corrected female bear population. Third, the proportion of adult females in the population was estimated by applying the mean adult male : adult female ratio from the radio-collared bears. Once the total adult population was determined, the remainder of the population (subadults, yearlings, and cubs) was estimated by applying the adult : non-adult ratio from the 1985 capture sample. The non-adult and adult estimates were totalled to determine the bear population at den emergence in 1985.

Potential confounding factors

A major assumption in our study was that the bear population information collected from the core area was representative of the entire study area. Two types of potentially confounding factors could invalidate that assumption: 1) factors which would result in an unequal density of bears between the core and peripheral areas (food availability, hunting pressure); and, 2) factors which would result in an inflated or deflated bear density in the core area, (adult female home range size, adult female population size, composition).

Food availability - Vegetation communities which were described by Oswald et al. (1981) and Davies et al. (1983) were ranked according to their food preference for grizzly bears. Three preference classes (nil-low, low-moderated, moderate-good) were used to describe relative food quality based on species composition. Communities rich in shrub fruits and Hedysarum ranked highest, followed by graminoid communities. Areas with little or no known bear foods received the lowest rating. The proportions of these classes were compared between the core and peripherial areas to determine if there was a difference in habitat quality that could have influenced bear distribution and, therefore, density.

The effects of animal protein availability on bear distribution was examined by comparing the number of relocations of individual adult bears within the moose calving area (core area) to the non-calving area (peripheral area). This comparison was made before and after the period when calves were most vulnerable to bear predation, i.e. mid-May to late July (Larsen et al. 1989a). Only bears with home ranges which overlapped both the core and peripheral areas were used in this analysis. If bears were attracted to newborn calves, movements should shift from the peripheral to the core area during the spring and summer and away from the core area following calving.

Hunting - The harvest of grizzly bears in the study area, between 1973 and 1985, was determined by compulsory submissions from non-Indian resident and non-resident hunters. Bears killed in defense of life and property or during research programs were required by law to be reported. We have no estimate of the harvest by Indians and poachers. Harvest patterns within the core and peripheral areas were compared to determine if the harvest of bears had influenced bear density.

Female home range size - Adult female home range size was determined from 165 relocations of 8 radio-collared bears within the core area between May 1985 and June 1986. Individuals with <9 relocations were not used to analyze home range size. As a result of the limited number of relocations and the short duration of this study, we questioned whether our data represented the true home ranges. To test this, we determined individual home ranges with increasing numbers of relocations. We would expect the home range size to increase as the number of relocations increased, until a plateau was reached indicating the maximum or true home range size.

Female population size - We attempted to capture all adult females within the core area, however, because of the limited duration of the study we were concerned that a total capture would not be achieved. We used sightability as an indirect means of assessing the likelihood of a total capture. Sightability was measured as the number of radio-collared bears which were observed without telemetry, compared to the number of radio-collared bears present. Sightability was determined during the intensive fixed winged surveys in the core area from late May to early July. Concurrent with, or immediately following each non-telemetry survey, radio-collared bears were located by a second aircraft. We recorded cover types utilized by radio-collared bears on sightability surveys. This was done by visually classifying the vegetation within a 30 m radius of the bear. Four broad vegetation types were used: shrub-alpine (open), shrub-confier (semi-open), and shrub-confier-deciduous and conifer forest (closed).

Composition - Age and sex composition of the captured bears was used to extrapolate from the estimated adult female population to the total population. One of the critical steps in this process was defining the minimum age of adults. Minimum ages of 5 to 7 years have been reported in the literature. For our population estimate, we used bears $\geq$ 6 years, however, to demonstrate the sensitivity of this parameter on the overall population estimate, we recalculated the population using animals $\geq$ 7 years.

RESULTS AND DISCUSSION

Immobilization

Twenty-seven bears were immobilized, 20 with M99 and 7 with Ketamine/Rompun. Two of the bears immobilized with the latter drugs died within 5 days of capture, while none of the bears immobilized with M99 died from the drug. One bear was killed when a dart punctured its lung.

The mean induction time did not vary by drug type. Bears receiving M99 (n=18) were immobilized in 7.6 min., compared to 8.0 min. for bears (n=3) receiving Ketamine/Rompun. Bears immobilized with Ketamine/Rompun were occasionally aroused when approached or during handling. The use of this drug was therefore discontinued early in the program.

Population composition

Composition of the study animals depends on the age criteria used to define an adult bear. If the mean age of first parturition is used to define an adult, northern grizzly bears become adults between the ages of 5 years (Spraker et al. 1981) and 10 years (Reynolds and Hetchel 1980). The mean age of first litter was reported to be between 7 and 8 years by Bunnell and Tait (1981). In our radio-collared sample, 2 of the 3, 6-year old females were accompanied by offspring (1 with yearlings and the other with newborn cubs, Appendix 1). We do not know the mean age of first litter in our study, population, however, at least some bears had their first litter at 5 or 6 years of age. Based on this data and similar results from at least some northern grizzly bear populations (Table 1), we defined adults as $\geq$ 6 years (there were no 5 year old bears in our sample). For the purpose of comparing our results with the other northern studies using a minimum adult age of 7 years, we have presented our composition data based on that minimum age as well (Table 1).

Adult females ($\geq$ 6 years) in our captured sample represent 26% (n=10), adult males 23% (n=9), subadults 15% (p=6), yearlings 21% (n=8), and cubs 15% (n=6). Our data are similar, to those studies using a minimum adult age of $\geq$ 5 years, except for a lower proportion of subadults (Table 1). If adults were defined as $\geq$ 7 years, the proportion of subadults in our study was similar and the proportion of adults is lower then the mean composition from the other studies. This disparity in percentage of adults and subadults is likely the result of the overall small sample (n=39) relative to the large number of 6 year old animals in our study (n=6, Appendix 1). As shown here, the minimum age used is critical to the determination of the composition of our study animals.

Of the 19 adult bears for which a sex was determined in our study, 10 were females and 9 were males (Appendix 1), for a 90 male to 100 female sex ratio. This value is similar to the average sex ratio of 83 males to 100 females calculated for all northern studies in Table 1. Fewer males would be expected in naturally regulated populations based on mortality patterns and promiscuous breeding strategies (Bunnell and Tait 1981, 1985).

Our data suggest that the capture method did not likely bias the composition results (Table 2). Most age/sex groups were captured using a combination of capture techniques. The relatively high proportion of single adult males in the post-denning surveys was likely a function of their availability, as males are usually the first to emerge from winter dens (Pearson 1975). Females with cubs did not appear to be underrepresented in the overall sample as they were caught as frequently as other age/sex groups. This contradicts Miller and Ballard (1982) who reported that females with cubs were observed and caught less frequently than other age/sex groups when using aerial searching techniques. Our conclusion is based on a small sample of bears.

Home ranges

Four hundred and twenty telemetry relocations were made of 20 individual bears (Appendix 2). Most of these relocations (76%) were made over 4 (May - Aug.) of the 9 months (April 1985 - June 1986) in which collars were monitored (Table 3).

Our best estimates of the average adult female (n=8) and adult male (n=5) home ranges were 279 $\pm$73 km^2, and 1169 $\pm$ 460km^2 (90% CI), respectively. The average home range of adult males was 4 times larger (T= -3.70, $p<0.05$) than adult female ranges (Table 4, Figure 3). The mean subadult female range was 189 $\pm$ 213 km^2 (90% CI) and for subadult males 357 $\pm$ 133 km^2 (90% CI). Generally, home range values from this study were higher than the mean values from other northern studies, except for adult female home ranges which were similar (Table 4).

Male residency and thus home range size, is often difficult to evaluate due to their extensive movements (Pearson 1975, Miller et al. 1982). In these situations, an underestimate of adult male home range would likely occur. In our study, all relocations of adult male bears, within the 9 month monitoring period, were within the study area boundaries (Fig. 3). This may explain the large average male home range size recorded in this study.

Sightability

Grizzly bears are extremely difficult animals to spot from the air, even when they are found in open cover. The sightability of grizzly bears was low with only 24% of the radio-collared bears observed during intensive aerial surveys between May 22 and July 3 (Table 5). During this same period, the majority (88%) of radio-collared bear relocations were made in open and semi-open habitats (Table 6).

Females with cubs had the highest sightability, and single adults the lowest (Table 5). The relatively high sightability of females with cubs may be due in part to the fact that groups of animals are more conspicuous compared to single animals. As well, females with offspring were found more often in open habitats compared to other age/sex groups (Table 6). These results differ from Ballard et al. (1982) in which a radio-collared female grizzly bear with 3 cubs was observed less frequently than other radio-collared bears, and from Miller and Ballard (1982) who suggested that females with cubs have a lower probability of being captured than other bears.

Our results suggest that only one quarter of the bears were observed during intensive (0.94 min/km^2) supercub flights. Bears often avoided detection by hiding under willows or logs, or laying beside large rocks or tree stumps. This hiding behavior was best demonstrated by an adult radio-collared male who did not move from a clump of willows despite a helicopter hovering over the site at 15 meters for approximately 5 minutes.

We believe that sightability was highest immediately after den emergence (April to early May). We were unable to confirm this, however, as we did not have an adequate number of bears radio-collared at that time. The presence of snow, the location of dens in the subalpine (Pearson 1975), and the close affiliation of females with cubs to their den sites for a short time after den emergence, (Ballard _et al_. 1982, Glenn and Miller 1980), all suggest that sightability would be best at this time. Further work is needed to determine sightability of grizzly bears during the post denning period compared to the summer period. The post-denning period may be the best time to survey grizzly bears in the southwest Yukon.

Grizzly bear population estimate

Our best estimate of the number of grizzly bears in the study area was between 82 and 139 animals (mean = 100). This estimate was derived as follows:

a) A mean adult female home range of 279 $\pm$ 73 km^2 was determined from 8 radio-collared bears (Fig 3). By extrapolating to the entire study area (6310 km^2), we obtain an adult female population (mean $\pm$ confidence limits), uncorrected for overlap, of 23 (18 to 31) animals.

b) The adult female population, corrected for internal overlap, was 26 (21 to 36). This was calculated by multiplying the uncorrected mean estimate by the overlap correction factor (1.15), based on the 8 radio-collared bears [2234 km^2 (sum of the 8 individual home ranges) - 1942 (total area occupied by the same bear) x 23 (uncorrected mean number of females)].

c) A population of between 82 and 139 bears (mean = 100) was then calculated based on the proportion of adult females to adult males, and the proportion of adults to non-adults. If 26 adult females occurred in the population and the adult male to female sex ratio was 90 : 100, then 23 adult males occupied the study area. If the adult population was 49 and adults comprised 49% of the population, then the mean number of bears would be 100. The upper and lower levels were calculated, following the same procedure. The estimated density of bears ranged from 13 to 22 bears/1000 km^2 (mean = 16/1000 km^2).

Adult females were used as the foundation for this population estimate, rather then another age/sex classes, as their home ranges are relatively small and discrete. This characteristic increased the possibility of capturing most of the adult females within the core area, in the 1 year time limit of this study (Miller et al. 1982). This in turn increased the possibility of estimating the total bear population. As well, sex related capture biases such as Pearson (1975) encountered were avoided by restricting our home range analysis to only female bears. Home range extensions of radio-collared bears outside of artificial study borders (Miller et al. 1982) were avoided by using actual home range borders of the female bears.

Potential confounding factors

Food availability

Food (vegetation and meat) availability is thought to be the ultimate limiting factor in northern grizzly bear populations (Curatolo and Moore 1975; Reynolds 1979, 1980; Quimby 1974; Quimby and Snarski 1974). Numerous studies have reported on the effects of food availability (eg. salmon spawning streams, garbage dumps, berry crops, ungulate calving and wintering range) on grizzly bear movement patterns and home ranges (cited in LeFranc et al. 1987). Availability and distribution of preferred bear foods might have affected the distribution of grizzly bears in our study area.

This was first evaluated by comparing the distribution of preferred vegetation (Table 7, Appendix 3) in the core area to the remainder of the study area (Fig. 4). Overall, the proportion of low, moderate, and good bear habitat, was significantly different (G=342, $P<0.05$) between the core area and the remainder of the study area, however, this difference was attributable to the proportion of the low classes of habitat in the 2 areas. The proportions of moderate and good habitat were similar between the 2 areas, therefore, we conclude that vegetation did not likely cause bears to concentrate in either the core or peripheral areas.

We then examined the potential effects of the seasonal availability of moose calves on bear distribution between the core and peripheral areas. The mean annual (1983 and 1985) mortality rate of moose calves in our study area was 75%, with grizzly bears accounting of 58% of those deaths (Larsen et al. 1989a).

To test whether the availability of newborn moose calves influenced bear distribution, we compared relocation frequency of collared bears in the calving area, during and outside of the calving period. Calving was concentrated in the core area (Fig. 2), and calves were available, and most vulnerable, to bear predation between May 15 and July 30 (Larsen et al. 1989a). If bears were attracted to newborn calves then we would expect more relocations within the core area between mid-May and the end of July compared to the non-calving period. In the non-calving area, we would expect fewer relocations during the calving period compared to the non-calving period.

The number of relocations was significantly dependent ($P<.05$) upon the calving area and period (Table 8). The majority of relocations in the core area occured in the calving period. This suggests that bears may have been attracted to the calving area during the calving period. However, the relationship does not hold when comparing the number of relocations in the non-calving area during the calving period. Our results are inconclusive.

Hunting

Hunting has been reported to be a major source of mortality on bear populations throughout North America (Cowan 1972, Bunnell and Tait 1985). The latter authors suggest that hunting accounts for at least 50% of the mortality in most populations. Therefore, it is possible that recent hunting affected the distribution of adult female and male bears in the study area, to the extent that the sample densities were not representative of the total area.

The major sources of reported, human-caused mortality were resident, non-resident and control kills (Appendix 4). Mortality from all sources were combined for the period 1973 to 1984, as we assumed that bears removed as late as 1973 may have affected the present density.

Twelve adult females were removed from 8 of the 23 Game Management Subzones (GMS) (Fig. 5). In some cases the sample area boundary bissected a GMS, therefore, we were uncertain if the animal was removed from the sampled area. To the best of our knowledge, 6 adult females were removed from within the sampled area, and 6 from the peripheral area. Because the sampled and peripheral areas were not the same size, the harvest density was higher inside the sampled area (1 female bear/324 km^2) compared to the peripheral area (1 female bear/728 km^2). The relative proportion of adult males removed in the core and peripherial area was similar to that of females (Fig. 5), with 1 adult/647 km^2 in the sampled area and 1 adult/1456 km^2 in the peripherial area. The removal of adult bears over the past 12 years was therefore not evenly distributed throughout the study area. As a result, the density reported for the core area, and used in our extrapolations, may have been less than the density in the peripherial area. By applying the lower sample area female density to the study area, we may have underestimated the total population.

Home range and adult female estimates

Both adult female and male home ranges may have been underestimated, based on the cumulative relocation analysis (Fig. 6). Bears with the least number of relocations had the smallest home ranges and those with the most relocations had the largest home ranges. However, based on a comparison with other northern grizzly bear studies of longer duration, our home range estimates were likely not grossly underestimated as they were not substantially different from the norm (Table 4). We conclude that we did not measure the true home range size of bears in our study area, but that our estimates were likely close to the true home range size.

We probably missed some adult females in the core area, based on the low sightability of adult females (31%) on aerial surveys (Table 5). The result of this bias would be to underestimate the adult female density and thus the total population.

Adult age criteria

The technique which we have used to estimate the total population size was very sensitive to changes to the minimal adult age. This was mainly due to the relatively high number of 6 year old animals in our capture sample, compared to the total capture sample. We previously estimated that between 82 and 139 grizzly bears inhabited the study area, based on adults $\geq$6 years. If we recalculate the population size using adults $\geq$7 years, the population increases to between 136-227 bears (mean = 170), or 70% higher than the previous estimate. This illustrates one of the potential dangers of extrapolating from small sample sizes.

In summary, one of the potential biases which we considered (underestimation of adult female home ranges) may have resulted in an inflated population estimate. Two others (disproportional harvest of adult females between the core and peripheral areas, and a less then total count of adult females in the core area) may have resulted in an under estimate. We have no means of quantifying these potential biases and, therefore, suggest that further studies are required.

Management Implications

An instantaneous assessment of the population was possible due to the intensive, short-term approach of this study. The reliability of the estimate may however, be questioned as a result of several biases which could not be quantified. We suggest that a more reliable popuation estimate, or at least one with potentially fewer biases, would likely be obtained if the study was conducted over a longer time frame, i.e. 2-3 years.

The accuracy of the current population estimate would improve with additional information on female home range size and a complete count of females in the sampled area. The ability to address the other biases with additional work is not clear. Therefore, prior to embarking on a long-term program to obtain a more precise population estimate, the additional cost should be weighed against the potential increase in reliability.

We feel that although our population estimate is preliminary, our results serve as a rough estimate of population size. If grizzly bear reductions occur in the future, these results could serve as a reasonable population basis.

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Table 1 Composition information from Northern grizzly bear studies.

Area (reference)	% adults	% subadults	% yearlings	% cubs	adult males per 100 adult females
A) Minimum adult age of 7 years					
Mackenzie Mtns NWT (Miller et al. 1982)	51	24	10	14	70
SW Yukon (Pearson 1975)	44	32	17	7	--
Northern Yukon (Nagy et al. 1983 a)	56	24	9	11	106
Tuk Peninsula NWT (Nagy et al. 1983 b)	37	35	13	16	45
Eastern Brook Range, AK (Reynolds, 1976)	51	21	18	9	93
Nelchina, South Central AK* (Ballard et al. 1982)	44	29	18	9	77
Mean	47	28	14	11	78
This study	33	31	21	15	90
B) Minimum adult age of 5-6 years.					
Swan Hills, Alberta (Nagy and Russell 1978)	21	58	8	13	--
Western Brook Range, AK (Reynolds, 1984)	47	24	12	17	77
Alaska Range (Reynolds and Hechtel 1984)	45	25	15	16	72
Upper Susitna, Alaska (Miller and Ballard, 1980)	45	28	23	4	140
Susitna Hydro Project, AK (Miller, 1985)	43	34	6	17	67
Mean	40	34	13	13	89
This study	49	15	21	15	90

* Our calculation from reported raw data.

Table 2. Observation frequency of bear age/sex groups by location method

Location method	single adult female ≥6 yrs	female with. c.o.y. (.5 yr)	female with yrls	single adult male ≥6 yrs	subadult* male and female (2-5 yrs)	Total
Post-denning fixed-wing surveys (Apr 9-May 20)		1	2	4	2	9
Snaring (May 9-July 18)	1	1		2	1	5
Intensive mid-summer surveys (May 22-July 3)	1	3	1	1	3	9
Moose collaring and monitoring (May 22-July 18)		1	1	1	1	4
Total	2	6	4	8	7	27

*Including 2 yearlings not accompanied by a female.

Table 3. Frequency of radio telemetry locations by age, sex and month.

Age/Sex	N	1985							1986		
		April	May	June	July	Aug.	Sept.	Oct.	May	June	Total
Adult females (≥6 yrs)	8	0	9	52	32	26	25	13	5	3	165
Adult males (≥6 yrs)	5	2	8	43	19	6	9	4	1	2	94
Subadult/yearling females	3	0	8	31	14	5	7	3	1	1	70
Subadult/yearling males	4	0	12	33	26	5	13	8	2	2	91
Total	20	2	37	159	81	42	54	28	9	8	420
Percent total relocations		0.5	8.8	37.8	19.3	10.0	12.9	6.7	2.1	1.9	

Table 4 Home range information from Northern grizzly bear studies.

Area (reference)	Mean minimum home range size (sq. km)			
	Adult*		Subadult	
	Male	Female	Male	Female
Mackenzie Mtns. (Miller et al. 1982)	-	265	-	-
S.W. Yukon (Pearson 1975)	287	86	70	88
Northern Yukon (Nagy et al. 1983a)	286	121	841	36
Tuk Peninsula NWT (Nagy et al. 1983b)	875	514	1516	20
Eastern Brook Range (Reynolds 1976)	702	382	-	-
Western Brook Range (Reynolds and Hechtel 1980)	776	220	142	113
Alaska Range (Reynolds and Hechtel 1983)	710	132	23	65
Nelchina Alaska (Miller and Ballard 1980)	850	415	848	118
Susitna Hydro Project, Alaska (Miller and McAllister 1982, Miller 1984)	1014	294	1218	320
Means	688	270	665	109
This study	1169	279	357	189

* Adults varied from 5 to 8 years. Results from the current study were based on adults $\geq$ 6 years.

Table 5 Sightability of radio-collared grizzly bears between May 22 and July 3, 1985, Rose Lake area.

Bear Classes	Number of collared bears available	Number of collared bears observed	% of marked bears observed
single adult females	2	0	0
single adult males	13	1	8
females/cubs	7	4	57
females/yearlings	7	1	14
subadults	21	6	29
TOTAL	50*	12	24

* Includes duplicates as the same bears occurred in the study area during repeated searches.

Table 6. Habitat cover use by radio-collared grizzly bears.

	% utilization (n)			
Bear Class	Open	Semi-open	Closed	Total
Single adult females	43 (23)	26 (14)	30 (16)	53
Adult females/ cubs	65 (37)	30 (17)	5 (3)	57
Adult females/ yearlings	75 (18)	21 (5)	4 (1)	24
Single males	40 (36)	43 (39)	17 (15)	90
Subadults	58 (72)	39 (48)	3 (4)	124
Total	53 (186)	35 (123)	11 (39)	348

Table 7. Distribution of bear vegetation classes (km^2) within the study area.

Area	Bear Vegetation Classes (%)			
	nil-low	low-moderate	moderate-good	Total
Core	1600 (82%)	259 (13%)	83 (4%)	1942 (100%)
Peripherial	2593 (59%)	1353 (31%)	422 (10%)	4368 (100%)
Total	505	1612	4193	6310

Table 8. Relocation frequency of adult grizzly bears with home ranges both inside and outside of the moose calving areas (core area).

Bear Frequency	Age/Sex	Calving Area (core)		Non-Calving Area (peripheral)	
		calving[1] period	non-calving[2] period	calving period	non-calving period
0990	adult male	6	0	0	8
0195	adult male	7	4	5	5
0145	adult male	8	0	7	3
1730	adult male	3	0	4	5
0214	adult female	2	0	0	10
0035	adult female	1	0	8	9
0155	adult female	12	4	1	2
0204	adult female	3	3	12	7
Total (%)		42 (30)	11 (8)	37 (27)	49 (35)

[1]Calving period represents the time when calves were available and most vulnerable to bear predation, i.e. May 15 to July 30 (Larsen et al. 1987).

[2]Non-calving period represents the time when calves were either not available (April to May 15) or not vulnerable (August to October).

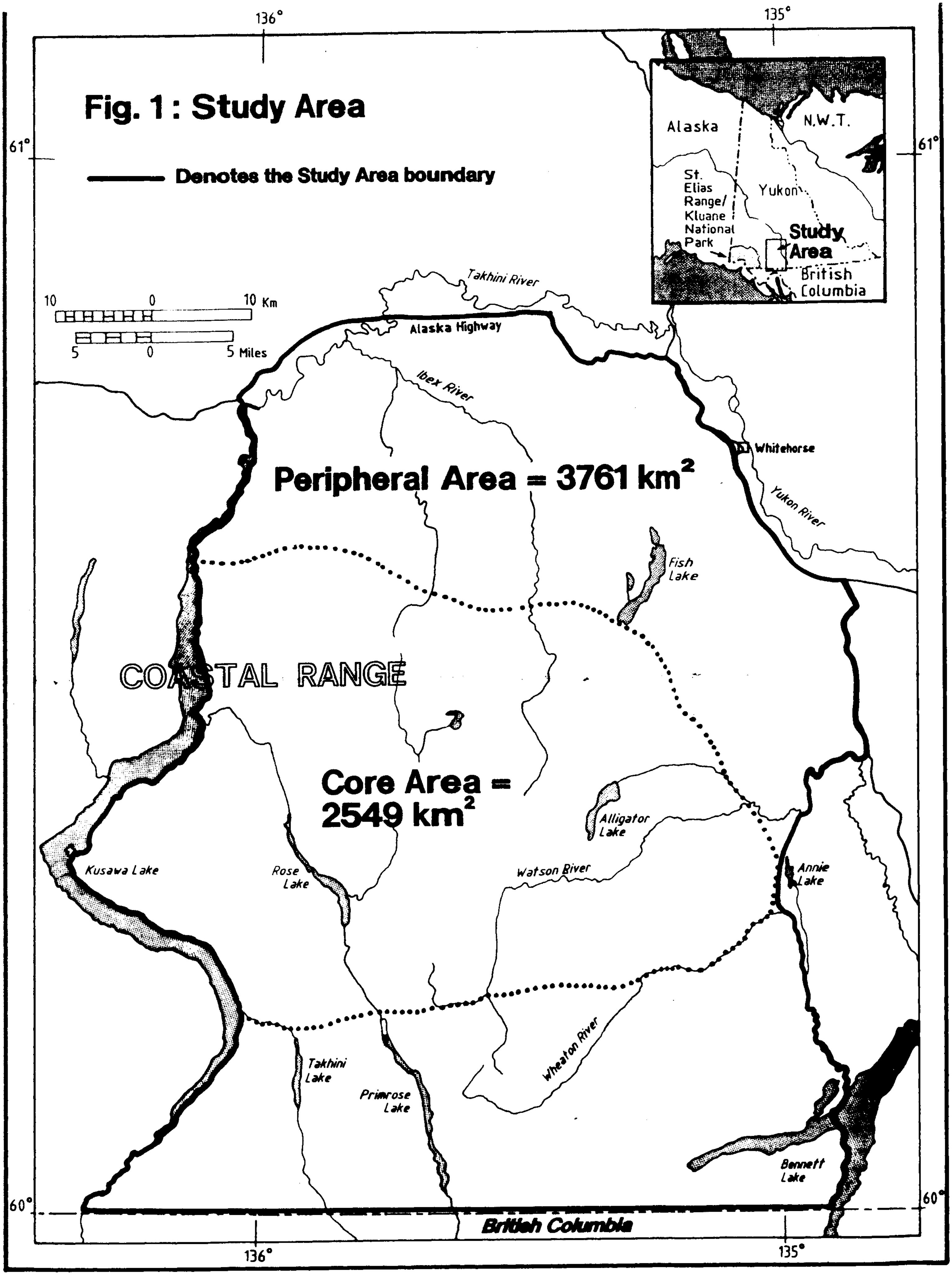


Fig. 1 : Study Area
Denotes the Study Area boundary
136°
135°
61°
60°
Alaska
N.W.T.
Yukon
St. Elias Range/ Kluane National Park
Study Area
British Columbia
10 0 10 Km
5 0 5 Miles
Takhini River
Alaska Highway
Ibex River
Whitehorse
Yukon River
Peripheral Area = 3761 km²
Fish Lake
COASTAL RANGE
Core Area = 2549 km²
Alligator Lake
Annie Lake
Kusawa Lake
Rose Lake
Watson River
Wheaton River
Takhini Lake
Primrose Lake
Bennett Lake
British Columbia

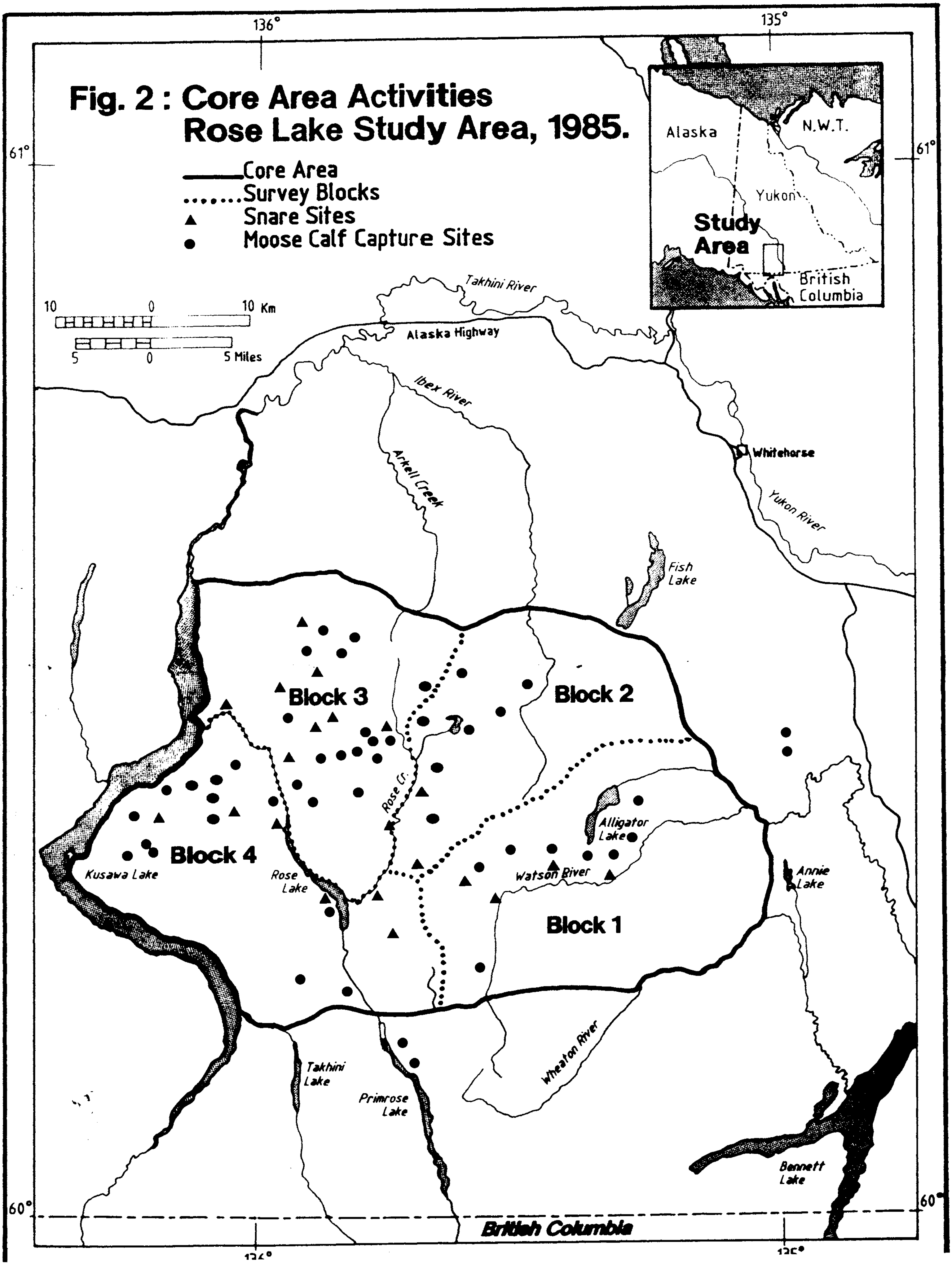


Fig. 2 : Core Area Activities
Rose Lake Study Area, 1985.
Core Area
Survey Blocks
Snare Sites
Moose Calf Capture Sites
136°
135°
61°
60°
10 0 10 Km
5 0 5 Miles
Alaska
N.W.T.
Yukon
Study Area
British Columbia
Takhini River
Alaska Highway
Ibex River
Arkell Creek
Whitehorse
Yukon River
Fish Lake
Block 3
Block 2
Block 4
Block 1
Rose Cr.
Alligator Lake
Watson River
Kusawa Lake
Rose Lake
Annie Lake
Wheaton River
Takhini Lake
Primrose Lake
Bennett Lake
British Columbia

Fig. 3 : Minimum Home Ranges of Adult Female and Male Grizzly Bears in the Rose Lake Study Area, 1985 – 1986.

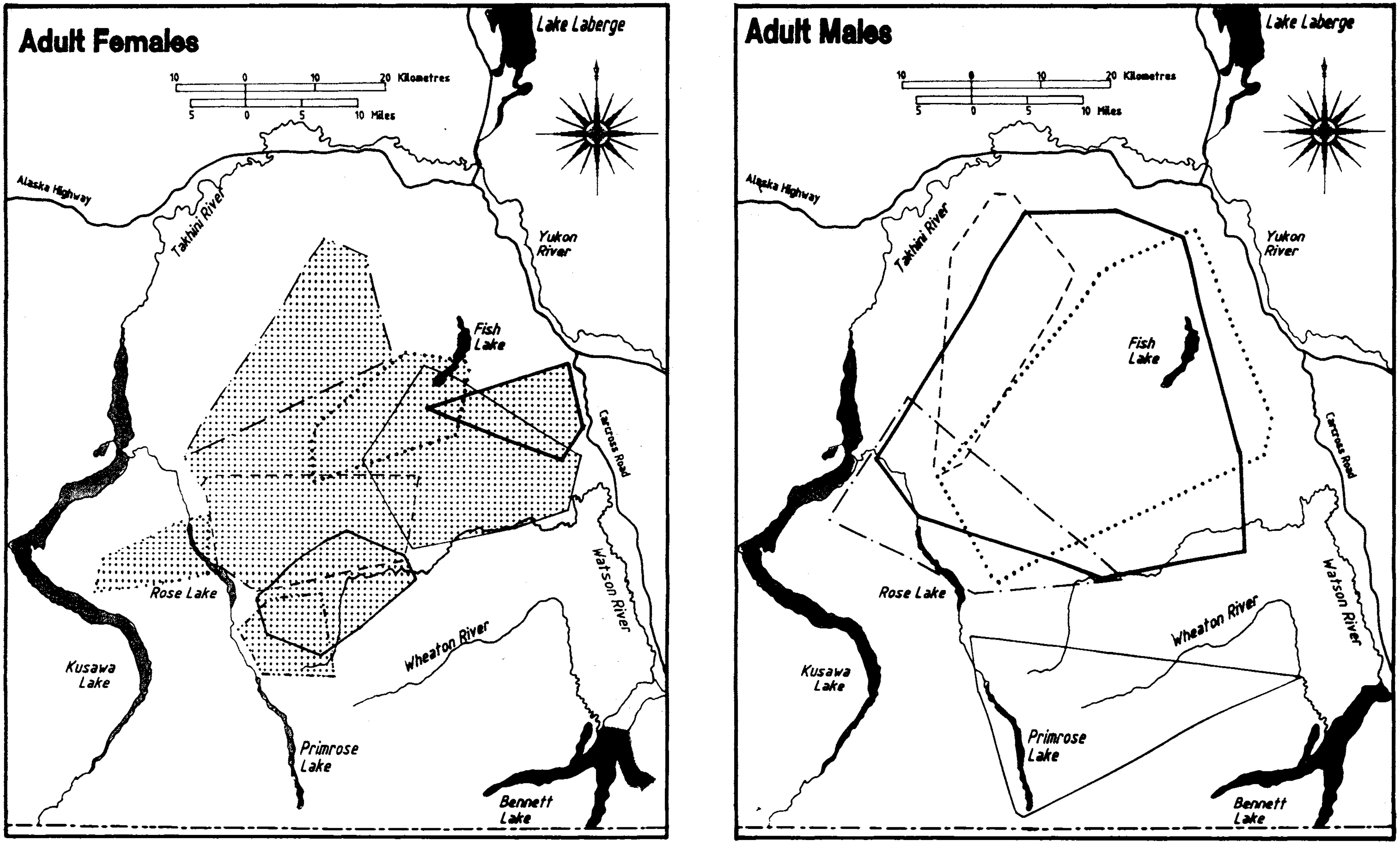


Fig. 4 : Grizzly Bear Vegetation Quality and Distribution

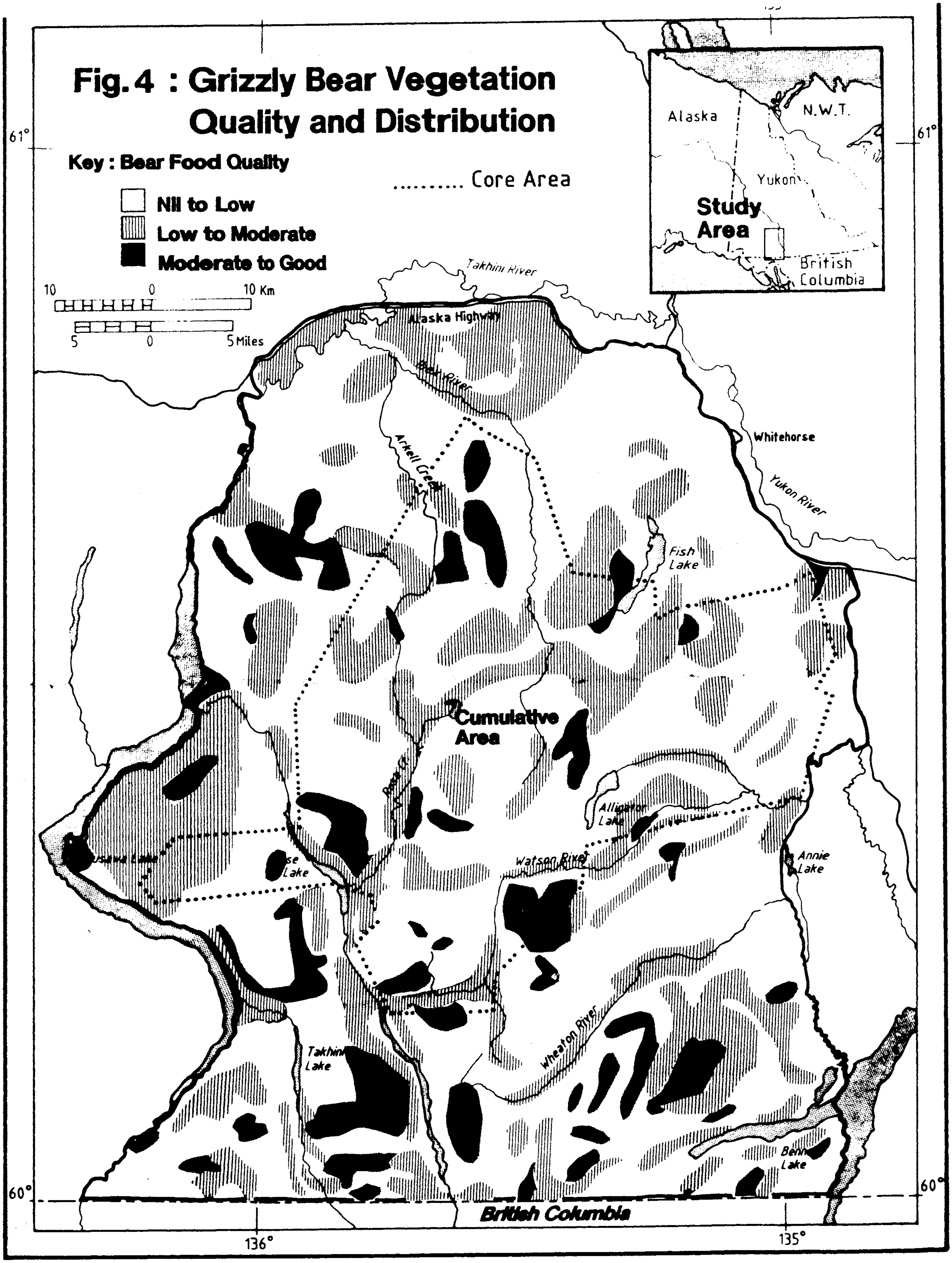


Fig. 5 : Distribution of removed adult Grizzly Bears by Game Management Subzone (1973–1984).

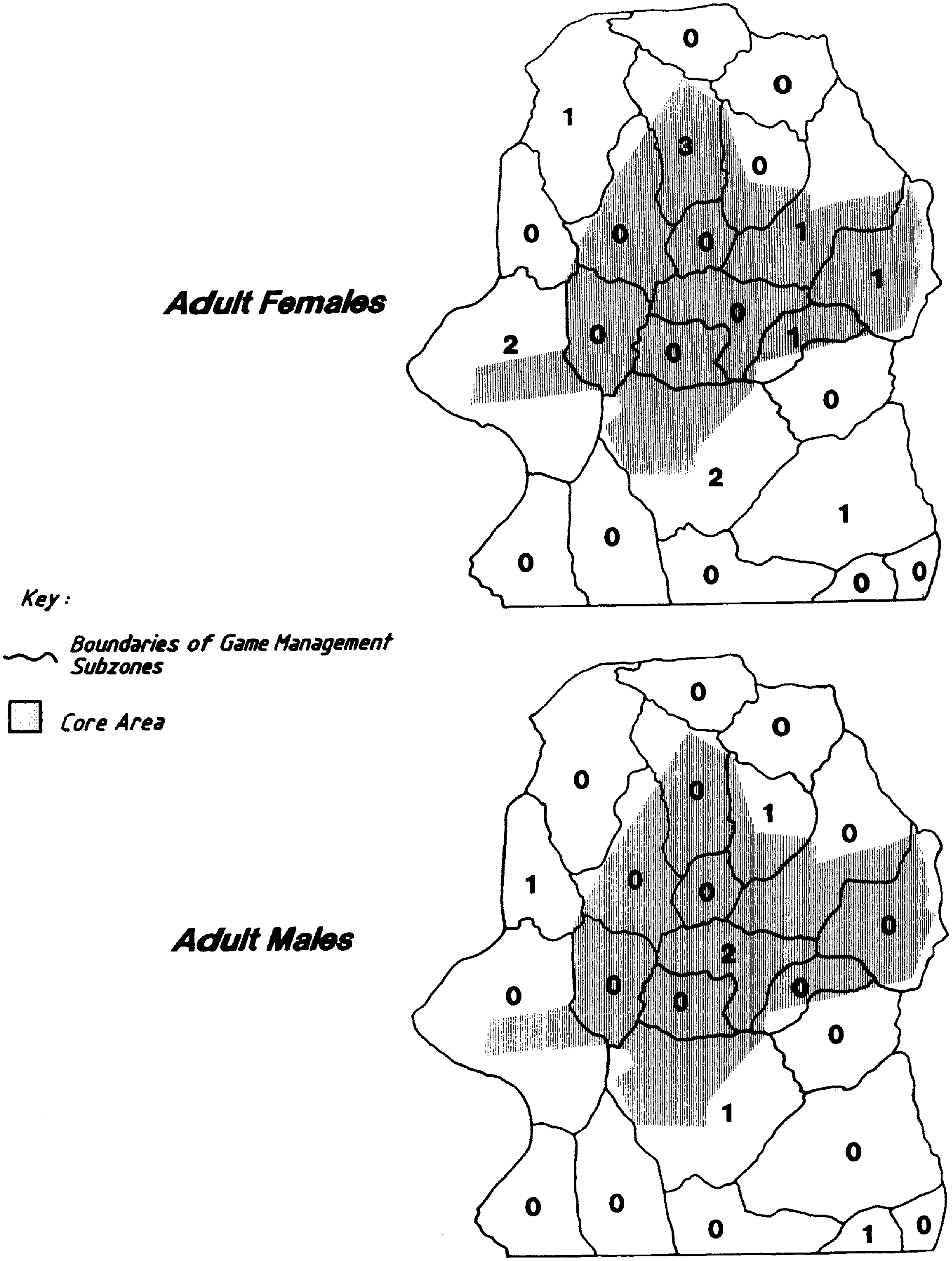
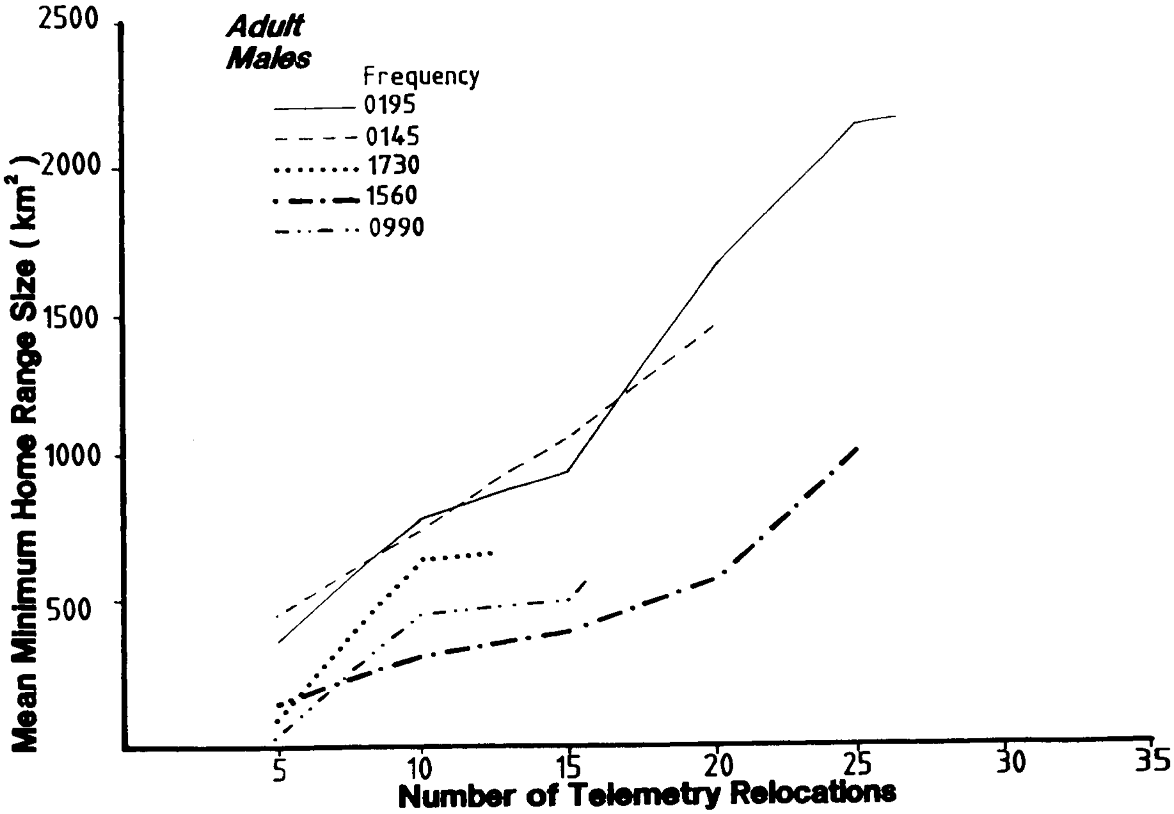
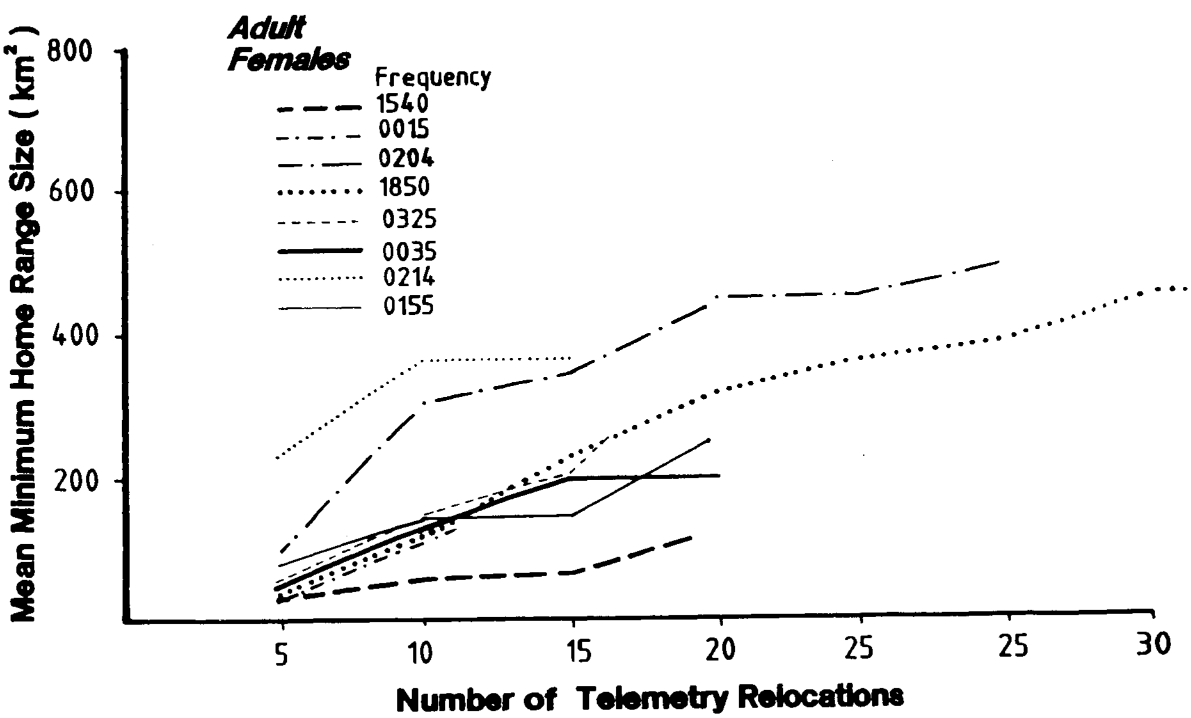


Fig. 6 : Grizzly Bear Home Range Size by Sex and Number of Relocations.





Appendix 1 Grizzly bears captured in the Rose Lake study area, 1985.

Bear Frequency	Class	Age yrs	Date immobilized	Status (denning 1985)
	Females			
1870	adult/2 yrls	6	May 3	dead May 8
1890	"/1 yrl	8	April 30	lost collar May 9
1850	"/2 coy*	6	May 9	alive
1870	subadult	3	May 22	alive
1540	adult/2 yrls	7	June 1	dead Aug. 23
0204	adult	9	June 5	alive
1940	subadult	2	June 4	dead July 19
0155	adult/1 yrl	10	June 10	alive
0035	adult	7	June 20	alive
0115	adult/2 coy	16	June 25	dead Aug. 14
0325	adult/2 coy	14	June 28	alive
0214	adult	6	July 17	alive
0066	subadult (sibling of of 1920)	1	Sept. 26	alive
Female Subtotal	13			
	Males			
9999	subadult	4	May 4	dead May 4
1940	adult	11	May 3	dead May 8
1900	adult	6	April 22	lost contact May 9
1679	adult	15	April 30	lost contact May 9
0145	adult	11	June 25	alive
0195	adult	21	April 23	alive
1630	subadult	2	May 8	alive
1730	adult	6	May 14	alive
1920	subadult (sibling of 0066)	1	May 23	alive
1479	subadult	2	May 25	alive
1560	adult	7	May 27	alive
0105	subadult	3	June 8	alive
0990	adult	6	June 27	alive
0125	adult	7	July 10	alive
Male Subtotal	14			
TOTAL	27			

* coy = cubs of the year

APPENDIX 2. Telemetry location data and home range size of individual grizzly bears in the Rose Lake study area, 1985.

Bear Frequency	Class	Age	Number of Locations	Location Period	Minimum Home Range (km^2)
1870	ad.female/2 yls	6	1	N/A	N/A
1890	ad.female/1 yrl	8	1	N/A	N/A
1850	ad.female/2 coy	6	39	May 9-Oct 15	432
1870	subad.female	3	33	May22-Oct 1	408
1540	ad.fem./2 yls	7	18	June 1-Aug. 23	112
0204	ad.female	9	29	June 5-Oct 9	511
1940	subad.female	2	12	June 4-July 19	33
0155	ad.female/1yrl	10	9	June 10-Oct 4	253
0035	ad.female	7	20	June 20-Oct 9	207
0115	ad.female/2 coy	16	19	June 25-Aug. 14	110
0325	ad.female/2 coy	14	17	June 28-Oct 9	247
0214	ad.female	6	14	July 17-May 15	362
0066	subad.female	1	25	May 23-Oct 15	126
9999	subad.male	4	1	N/A	N/A
1940	ad.male	11	1	N/A	N/A
1900	ad.male	6	1	N/A	N/A
1679	ad.male	15	2	N/A	N/A
0145	ad.male	11	18	June 25-Aug 12	1453
0195	ad.male	21	26	April 23-Oct 15	2188
1630	subad.male	2	23	May 8-Oct 15	207
1730	ad.male	6	12	May 14-Oct 1	639
1920	subad.male	1	25	May 23-Oct 15	126
1479	subad.male	2	25	May 25-Sept 24	934
1560	ad.male	7	22	May 27-Sept 15	1021
0105	subad.male	3	18	June 8-Oct 9	159
0990	ad.male	6	15	June 27-Oct 15	546
0125	ad.male	7	3	July 10-July 16	N/A

Appendix 3. Ranking of vegetation communities for bear food value (from Oswald 1981 and Davis et al. 1983).

Vegetation Community	Bear Food Value
Dryas/Grass Lichen	nil to low
Willow-shrub Birch-Dryas/Lichen	
Alpine Fir/Labrador Tea/Bog Moss	
White Spruce/Feathermoss	
White Spruce/Willow-Shrub Birch	
White Spruce/Lichen	
White Spruce/Nudum	
White Spruce/Dryas	
Black Spruce/Bog Moss	
Lodgepole Pine/Lichen	
Lodgepole Pine/Nudum	
Lodgepole Pine/Feathermoss	
Lodgepole Pine/Alder	
Aspen/Willow-Shrub Birch	
Willow-Shrub Birch/Lichen	
Sage/Grass	
Sedge/Wetland Moss	
Grass/Lichen	
White Spruce/Grass-Lichen	
White Spruce/Shrub Birch-Willow/Grass	
Willow-Dryas/Grass-Lichen	
White Spruce-Aspen/Willow-Lichen	
White Spruce/Willow-Feathermoss	
Lodgepole Pine-White Spruce/Feathermoss	
White Spruce-Alpine Fir/Willow-Shrub Birch	
Willow-Shrub Birch/Lichen-Grass	
White Spruce-Lodgepole Pine/Willow-Shrub Birch/Grass	
White Spruce/Twinflower/Feathermoss	
Lodgepole Pine/Grass	
Willow-Shrub Birch/Lichen	low to mod.
Willow-Shrub Birch/Dryas	
Willow-Shrub Birch/Grass-Sedge	
Willow-Shrub Birch/Grass-Sedge/Bog Moss	
Willow-Shrub Birch	
Alpine Fir/Feathermoss	
White Spruce/Equisetum	
White Spruce/Twinflower	
White Spruce/Bog Moss	
White Spruce/Grass	
Black Spruce/Labrador Tea	
Black Spruce/Sphagnum	
Lodgepole Pine/Willow-Shrub Birch	
Lodgepole Pine/Grass	
Lodgepole Pine/Kinnikinnick	

continued

Appendix 3 continued...

Vegetation Community	Bear Food Value
Lodgepole Pine-White Spruce/Wormwood-Grass	low to mod.
Aspen/Kinnikinnick	low to mod.
Aspen/Grass	low to mod.
Aspen/Highbush Cranberry	low to mod.
Willow/Sedge	low to mod.
Willow/Willow	low to mod.
Willow/Kinnikinnick	low to mod.
Willow-Shrub Birch/Bog Moss	low to mod.
Willow-Shrub Birch/Grass	low to mod.
Willow-Shrub Birch-Dryas/Grass	low to mod.
Aspen-White Spruce/Willow	low to mod.
Willow-Twinflower/Sedge-Bog Moss	low to mod.
White Spruce/Willow/Carex Concinna	low to mod.
White Spruce-Aspen/Kinnikinnik-Grass	low to mod.
White Spruce-Lodgepole Pine/Willow/Kinnikinnik	low to mod.
Aspen-White Spruce/Grass	low to mod.
Willow-Dryas-Shrub Birch/Lichen	low to mod.
Aspen-White Spruce/Willow/Kinnikinnik	low to mod.
White Spruce-Willow/Kinnikinnik	low to mod.
White Spruce/Willow-Twinflower-Sedge	low to mod.
White Spruce/Shrub Birch-Twinflower/Sedge	low to mod.
White Spruce/Lodgepole Pine/Kinnikinnik	low to mod.
White Spruce-Aspen/Willow/Grass	low to mod.
Aspen/Willow	low to mod.
Lodgepole Pine/Kinnikinnik-Lichen	low to mod.
White Spruce-Lodgepole Pine/Grass	low to mod.
White Spruce-Balsam Poplar/Willow/Kinnikinnik	low to mod.
Lodgepole Pine-Aspen/Kinnikinnik/Grass	low to mod.
Wormwood/Grass	low to mod.
Sedge-Grass/Lichen	mod. to high
Willow-Dryas/Sedge-Grass	mod. to high
Alpine Fir/Willow Shrub-Birch	mod. to high
White Spruce/Mossberry	mod. to high
White Spruce/Kinnikinnick	mod. to high
White Spruce/Soapberry	mod. to high
Aspen/Soapberry-Kinnikinnick	mod. to high
Willow/Horsetail	mod. to high
White Spruce-Aspen/Willow/Kinnikinnik	mod. to high
Willow/Labrador Tea-Sedge	mod. to high
Shrub Birch	mod. to high
White Spruce/Willow-Soapberry/Kinnikinnik	mod. to high
White Spruce-Aspen/Soapberry	mod. to high

Appendix 4. Reported grizzly bear harvest* by game management subzone from the Rose Lake study area 1973-1985.

Year	Sex	Age	Cause of Death	GMS
1973	female	5	hunting	7-22
1973	male	13	hunting	7-30
1974	male	4	hunting	7-16
1974	female	14	hunting	7-32
1976	female	13	hunting	7-30
1977	male	4	hunting	7-16
1977	male	6	hunting	7-19
1977	male	19	hunting	7-34
1979	male	1	hunting	7-13
1979	male	1	hunting	7-27
1979	female	8	hunting	7-30
1980	female	4	hunting	7-14
1980	female	13	hunting	7-16
1980	female	19	hunting	7-16
1980	male	1	hunting	7-26
1980	female	11	hunting	7-26
1981	unknown	unknown	unknown	7-15
1981	male	2	hunting	7-19
1981	female	4	hunting	7-22
1982	male	19	hunting	7-14
1982	female	7	hunting	7-16
1982	female	14	hunting	7-22
1983	male	14	hunting	7-24
1984	female	16	hunting	7-13
1984	female	ad.	control kill	7-21
1984	male	1	relocation	7-22
1984	female	1	relocation	7-22
1984	female	10	relocation	7-16
1984	male	8	hunting	7-24
1984	female	ad.	hunting	7-27
1984	female	2	hunting	7-31
1985	female	2	unknown	7-13
1985	female	10	hunting	7-15
1985	female	7	control kill	7-22
1985	male	7	hunting	7-24
1985	male	4	drugging	7-26
1985	male	11	drugging	7-29
1985	female	6	drugging	7-29
1985	male	.5	control kill	7-30
1985	female	.5	control kill	7-30
1985	female	16	control kill	7-30

*includes bears removed through hunting, control kills, drugging and relocations.

Appendix 5 Frequencies and approxinate cost of capturing grizzly bears in the Southwest Yukon, 1985.

Method of location	Total groups observed	Groups previously captured	Groups of unmarked bears captured	Numbers of fixed-wing aircraft hours	Total[1] cost (x1000)	Average bears captured (x1000)
Post-denning surveys (Apr 9-May 20)	9	0	9	123	22.4	2.5
Intensive summer surv. (May 22-July 3)	20	12	8	250	32.4	4.0
Breeding bear surveys (June 13-July 19)	7	6	1	55	6.5	6.5
Calf moose mortality (May 22-July 18)	5	3	2	53	40.0	20.0
Snaring (May 9-July 18)	6	4	2	79	32.0	16.0
Other[2]	5	0	5	N/A	5.0	1.0
Total	52	25	27	560	138.3	5.1

[1]Costs include: fixed-wing for locating; helicopter for immobilizing; bait and snares for snaring; calf moose mortality collars and helicopter time for collaring calves. This cost does not include manpower, drugs and bear collars.

[2]Bears located incidental to other field activities.