# BIOLOGY AND MANAGEMENT OF GRIZZLY BEAR ON THE YUKON NORTH SLOPE

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**APRIL 1990**

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SUMMARY

This report reviews the biology and management of grizzly bears on the Yukon North Slope.

Densities of grizzly bears in a study area in the Barn Mountains varied from 25.6/1000 km² to 26.3/1000 km² in May and September 1973, respectively, and from 29.4 km/1000 km² to 30.3/1000km² in May and September 1974, respectively. Estimates of densities for coastal plains and low foothills areas in Alaska range from 1.3 to 11.1 bears/1000 km². Reported data suggest a low incidence of man-caused mortalities.

The median age of male grizzly bears in the Barn Mountains was significantly greater than for those in the Tuktoyaktuk Peninsula, N.W.T. and western Brooks Range, Alaska, which is attributed to the low hunting pressure of bears in the Barn Mountains. If man-caused mortalities have been light since then, the age structure of the grizzly bear population of the Barn Mountains would likely be similar nowadays.

Minimum breeding ages for female bears were most comparable to those in southwest Yukon, the Brooks Range in Alaska and the Tuktoyaktuk Peninsula in N.W.T. The mean litter size (2.07, n=16) was consistent with that of the north-central Alaska Range. The risk of overharvesting females during years of low cub productivity is pointed out.

Average annual home range size for adult males, adult females without young, adult females with cubs, adult females with yearlings, and adult females with two-year olds is 520 km², 123 km², 124 km², 101 km², and 701 km², respectively. In the Barn Mountains, females without cubs consistently used annual and seasonal ranges smaller than those in Tuktoyaktuk Peninsula, west-central Alberta, and Jasper National Park. Male spring /early summer ranges did not differ between those areas. The grizzly bear density of the barn Mountains was 2-6 times greater than for the Tuktoyaktuk Peninsula, west-central Alberta and Jasper National Park. Median spring body weights as well as maximum growth rates of bears of these four regions were smallest in Northern Yukon. It is suggested that the smaller home ranges, smaller body weights, and lower maximum growth rates of Northern Yukon bears is most likely a result of bears competing for available space and food resources within a population at or near carrying capacity.

It is also suggested that although individual grizzly bears may prey or scavenge on carcasses of caribou that migrate through the bears´home ranges, they do not actually migrate with the herds.

Average daily rates of movement ranged from 0.5 to 3.9 km/day and 0.4 to 1.6 km/day for males and females, respectively. Males were observed more frequently than females at elevations ≤ 1500

ft, and females more frequently than males at elevations > 1500 ft.

When compared at a monthly basis, males were observed more frequently than females at elevations ≤, and females more frequently than males at elevations > 1500 during all months except August. Females used areas > 1500 more frequently annually and during all months except June. The elevational distribution of male grizzlies did not differ significantly from the theoretical distribution. Females generally occurred at higher elevations than males during both hunting seasons. It follows that recreationist and hunters would have a greater probability of encountering male bears when using areas along valley floors and over slopes, and females when using sites on mid and upper slopes. Harvest mortalities among females could be reduced by expending harvest efforts along main river corridors.

Bear feed primarily on crowberries and roots of Eskimo potato. In June/July grasses were eaten almost exclusively. Berries and grasses made up the greatest proportion of foods eaten in August and September, although legume roots and arctic ground squirrels were also important.

Known den emergence times ranged from 2-12 May. Dens were primarily (33 or 92%)k situated in the montane regions of the Arctic Plateau or British Mountains. Only three dens (8%) were situated on the Yukon Coastal Plain. Dens were situated at mean elevations of 618 m ASL in the edge of the coastal lowlands. Most dens were excavated in stabilized or partially stabilized talus slopes. A southeasterly aspect was preferred for den sites. Grizzly bears were not considered to be limited by the availability of sites suitable for denning in Northern Yukon.

The Barn Mountains study was not considered extensive enough to derive reproductive information in a representative sample of females. This type of data is required to calculate acceptable man-caused mortality rates. In view of current fiscal constraints, this is not considered feasible. Instead this type of data should be extrapolated from the study in north-central Alaska Range.

It is proposed to determine current bear density for the Barn Mountains by further fieldwork. However, first priority should be given to determining densities for the Richardson Mountains and British Mountains. Two types of approaches are suggested: 1) short-term intensive capture-mark-release studies, 2) early spring den site surveys. A standardized data collection system to monitor harvest and non-harvest related mortalities is also proposed.

Grizzly bear habitat in the Northern Yukon is considered to be relatively stable due to severe climatic conditions. Unless major developments are proposed that would alter the nature of habitats on a broad scale in Northern Yukon, there may be little requirement for a detailed habitat classification. Evaluation of habitat use or importance for minor localized developments could most likely be dealt with on a site-specific basis.

No satisfactory, cost-effective method has been developed to census bears in most areas. Many workers rely on extrapolations from areas of intensive study to estimate population numbers. For the Barn Mountains a bear density of 26 bears/1000 $km^2$ is reported.

It is suggested that the quality of the bear habitat may be relatively low in the Malcolm River and British Mountains ecodistrict as the upper mountain slopes are predominantly unvegeted. However the Porcupine Caribou Herd calves, in and then migrates through this area several times during spring, summer and fall. This may off-set some limitation on bears resulting from annual variations in the relative availability of such foods as berries. By extrapolation bear densities found in similar areas in Northern Alaska and those in the Barn Range to the whole IFA settlement area the following density estimates were derived:

1) Coastal plains and low foothills - 6.5/1000 $km^2$
2) Barn and Buckland Mountains - 26/1000 $km^2$
3) British and Richardson Mountains - 15/1000 $km^2$

The total grizzly population in the IFA settlement area is estimated at 316 bears, including 151 bears in Northern Yukon National Park and 165 on territorial lands by extrapolation these densities.

A review of harvest strategies for grizzly bears in several North American jurisdictions is given. Strategies range from 2-6% total allowable harvest mortality depending on the assumed sex-specific vulnerabilities of bears and other variables like survival rates, age distribution, longevity, growth rates, reproductive rates, age of maturity. The LESMOD model was used to calculate sustainable harvest levels of bears for Northern Yukon. A population model was generated with the same age structure, longevity, birth, sex, and mortality rates as those observes for the Northern Yukon population. Different absolute and proportional harvest rates were applied to the model to estimate acceptable man-caused mortality rates. Subadult and adult males were considered twice, respectively three times, as vulnerable to harvest as adult annual removals were ≤ 5 bears. The modeled population stabilized when annual removals were ≤ 7%. However, in the latter case the residual population declined progressively from a starting number of 106 bears to 101 and 74 bears as annual harvest rates increased from 1% to 7%. It is concluded that bear populations can be managed more effectively through the application of models based on absolute rather then proportional harvest rates. Actual allowable harvest rates may be much lower because LESMOD assumes that the productivity of females is constant from year to year. The model does not compensate for stochastic annual variations in cub production resulting from, for example, failures in berry crops or other food supplies.

A conservative maximum harvest mortality rate of 4 percent is proposed as it may be difficult to monitor non-harvest mortalities. The sex ratio should be 3 males to 1 female in the annual kill. Based on a wounding loss of 25%, a kill comprised of 75% males and 25% females and a maximum annual allowable kill of 4% of the estimated standing population, the maximum quota should be 5 bears (4 males and 1 female) on territorial lands and 4 bears (3 males and 1 female) in the National Park.

The total known man-caused mortality on territorial and park lands of 2 and 6 bears, respectively, during the period 1980-1987 was less than the annual allowable kill of 5 and 4 bears, respectively, for those areas. Assuming that all mortalities have been recorded, these data suggest that the grizzly bear populations in the IFA settlement area, and in general the Northern Yukon, are largely unexploited. Harvest quotas should be established on a rotation basis within existing game management subzones to ensure a long-term uniform distribution in the harvest of bears.

The following recommendation are provided:

1) a census program should be conducted to verify that the data presented by Nagy et al. (1983a) for the Barn and Buckland mountains are still valid, and verify estimates used in this paper for the Richardson and British Mountains;

2) a standardized data collection system should be maintained to monitor harvest and non-harvest related man-caused mortalities (illegal, problem wildlife, self-defence) on Territorial and Parks lands to ensure that the annual number of man-caused mortalities do not exceed the allowable annual kill;

3) research directed at determining the relative availability and productivity of existing grizzly bear habitats should be conducted to provide a valid basis for comparing the productivity of habitats and grizzly bear populations in Northern Yukon with that of other regions;

4) all translocations of problem bears should be recorded and the data included in any evaluation of annual mortalities within each management area, i.e. a translocated bear should be considered as a mortality;

5) the types and geographic distribution of personal or property damage complaints should be recorded and reviewed annually to identify potential areas where bear-man conflicts could lead to non-harvest bear mortalities;

6) annual total known man-caused mortalities should be evaluated in the context of annual mortalities in adjacent areas in Yukon, Northwest Territories and Alaska, to identify potential population sinks that could detrimentally affect the population and allowable harvest in IFA;

7) the distribution of kill locations should be evaluated on an annual basis to ensure that bears (particularly adult females) are not depleted within localized area and to identify potential population sinks;

8) the age-sex structure of the kill should be monitored to ensure that the proportion of females in the annual and cumulative running total kill does not exceed 25 percent;

9) a sex-specific harvest strategy, such as that outlined by Smith (1989), should be developed and implemented in consultation with local outfitters or communities to ensure an equitable allocation of the grizzly bear resource and to minimize the risk of overharvest, particularly that of female grizzly bears; and,

10) educational programs directed at all land users (hunters, recreationists, etc.) should be developed and implemented to reduce the potential for bear-man conflicts that result in bear mortalities.

# INTRODUCTION

During the mid 1970's a population study on grizzly bears in the Northern Yukon was completed by the Canadian Wildlife Service. Similar studies were done on the Tuktoyaktuk Peninsula, N.W.T., and in northeastern Alaska. In the latter area studies are continuing. The information base from which to manage grizzly bears in the Inuvialuit settlement area can be enhanced by using relevant information from other studies in the region.

This report presents for the first time an attempt to review information on the biology and management of grizzly bears pertinent to the Yukon North Slope. The purpose of this review is to provide a summary of information to direct management and further research.

The report starts with a review of population characteristics of Northern Yukon grizzly bears, followed by a section on data deficiencies. The final sections provide estimates of harvestable surpluses for grizzly bears in the IFA settlement area using a computer population simulation model as well as recommendations for monitoring and regulating annual harvest.

# BIOLOGY AND MANAGEMENT OF GRIZZLY BEARS ON THE YUKON NORTH SLOPE

## 1.0 Population Characteristics, Home Range Size and Movements, Food Habits and Habitat Use

## 1.1 Population Characteristics

### 1.1.1 Densities

Intensive capture programs in Northern Yukon were conducted during the post-emergence period in May, when a nearly complete snow cover facilitated observations of bears and recently opened dens, and in September (Nagy et al. 1983a) (Figure 1). Approximately 210 hours were flown with Bell 47G3-B2 (piston) or 206B (turbine) helicopters during 1973 and 1974. The entire study area was flown on a 2-3 day interval, with all unmarked bears captured and marked with color coded ear streamers. The distribution of captured bears was plotted on topographic maps on a regular basis to identify areas that may have been occupied by unmarked bears. Those areas were then searched. We felt that we had marked the greatest proportion (estimated at 95% of population) because:

1. intensive searches and capture operations were conducted during periods when bears and their dens were most visible;
2. few unmarked bears were observed during radio telemetry surveys; and,
3. intensive searches with helicopters during September 1974 failed to yield bears that were not already known to reside on the study area.

Grizzly bear densities based on the enumerated population, including cubs and yearlings, varied from season to season and from year to year in Northern Yukon (Nagy et al. 1983a). In 1973 the enumerated population was 88 and 86 bears during May and September, respectively, giving densities of 25.6 to 26.3 bears/1000 $km^2$. Similarly, in 1974 the enumerated population was 103 and 98 bears during May and September, giving densities of 29.4 to 30.3 bears/1000 $km^2$. Fluctuations in the yearly densities were a result of variation in reproductive success and observed mortality (Nagy et al. 1983a). The estimates of total population were based on the assumption that no mortalities, other than those which were documented, occurred in the study area (Nagy et al. 1983a).

Nagy et al. (1983a) conducted capture work primarily in an area encompassing the Barn Mountains and eastern portions of the Buckland Mountains (Figure 1). As a result, the reported densities should not be considered representative of those occurring on the coastal plains or Richardson and British mountains. Estimates of bear densities for coastal plains and low foothills areas in Alaska range from 1.3 to 11.1 bears/1000 $km^2$ (Reynolds 1980).

### 1.1.2 Natural Mortality

Nagy *et al*. (1983a) recorded 3 natural grizzly bear deaths. In 1973, 2 bears died of natural causes; including a cub whose cause of death could not be ascertained and, a 6 year old 152 kg male who had been killed and partially consumed by a 9 year old 273 kg male. In 1974, a cub died of undetermined natural causes. Data were inadequate to estimate age specific natural mortality rates.

Natural mortality rates reported in the literature are highly variable. Craighead and Craighead (1967) reported cub mortality rates of 39 percent in Yellowstone National Park. Glenn *et al*. (1976) reported a 38 percent mortality rate among cubs at McNeil Falls, Alaska. Miller *et al*. (1982) estimated mortality rates using age structure data for an over-exploited grizzly bear population in the Mackenzie Mountains, N.W.T. They estimated cub and subadult mortality rates to be 27 and 24.5 percent, respectively. The average adult male and female mortality rates were 13.2 and 12.8 percent, respectively, and when pooled, the adult mortality rate was 13.1 percent. Miller *et al*. (1982) did not differentiate between natural and man-caused deaths in their estimates of age specific mortality rates. Reynolds and Hechtel (1988) reported mean natural mortality rates of 27 percent for cubs, 6 percent for yearlings, 8 percent for 2-year-olds, and 3 percent for adult females during the period 1982-87 for a grizzly bear population in Northcentral Alaska Range. Human-caused mortality in that population was 12.8-13.3 percent (range 3.9-17.2 percent) based on probable adjusted population estimates.

### 1.1.3 Harvest Mortality

Nagy *et al*. (1983a) reported a harvest mortality of 5 bears in Northern Yukon in 1974. A 15 year old female and her 3 yearlings were harvested after they destroyed a fishing camp near Shingle Point. In addition, an adult female originally captured approximately 4 miles north of Mount Davies Gilbert in 1972 was harvested near Coal Mine Lake in the Mackenzie Delta, N.W.T.

The Fish and Wildlife Branch, Government of the Yukon recorded 8 grizzly bear kills within the Inuvialuit settlement area during 1980-85. These included 1 male in 1980, 1 male and 2 of unknown sex in 1982, 2 males in 1983, and 1 male and 1 female in 1985. Ages were reported for 2 bears; both were subadults (1 female age 3 years and 1 male age 2 years). The location of known kill sites suggests that most bears were killed either on the coast or in the adjacent coastal lowlands (Figure 2).

If the mortality data presented here accurately reflects actual man-caused mortalities then hunting pressure on Northern Yukon grizzly bears is light. This is particularly true when compared to known rates of man-caused mortality for bears in other regions (e.g., Mackenzie Mountains, southwest Yukon and Tuktoyaktuk Peninsula, N.W.T.). The fact that one female from the Northern Yukon was harvested in the Mackenzie Delta suggests that bears move between the Yukon and N.W.T. This suggests that grizzly bear within the settlement area should be managed in the context of estimated mortality rates on populations in adjacent areas in Yukon, N.W.T., and Alaska.

1.1.4 Age Distribution

The age structure data for grizzly bears of Northern Yukon (Nagy et al. 1983a) were compared with those for hunted grizzly bear populations in the western Brooks Range (Reynolds 1980) and Tuktoyaktuk Peninsula and Richards Island, N.W.T. (Nagy et al. 1983b). Reynolds (1980) presented age distribution data for the eastern Brooks Range, Alaska, however, the data were presented in a form that did not allow for statistical comparisons. The number of individuals in each age class were averaged across years for each population using reported tabular data (Table 1). Bears of unknown sex were prorated for each age class using an expected ratio of 50:50 males to females (Eberhardt et al. 1986). The resulting average age distribution was used in subsequent comparisons. The median age of males and females in each population were compared using Kruskal-Wallis tests (Gibbons 1985).

The median ages of females in Northern Yukon (n = 55, median age 7.5), Tuktoyaktuk Peninsula (n = 50, median age 6.5), and Western Brooks Range (n = 62, median age 4.5) populations did not differ significantly (P = 0.33). In comparison, the median age of males in Northern Yukon (n = 51, median age 10.5) was significantly greater than for those in the Tuktoyaktuk Peninsula (n = 40, median age 3.5) and Western Brooks Range (n = 52, median age 3.5) (P = 0.0008). Male grizzly bears in Northern Yukon were most likely older because the population was unhunted.

Age structure is an indicator of hunting pressure (Beecham 1980). Unhunted and lightly hunted populations usually contain a higher proportion of older individuals than do hunted populations (LeCount 1982). Males are generally more vulnerable to harvest than females (Nagy et al. 1983a, Miller and Miller 1988), and as a result, the sex ratio of the standing population should favour females in heavily hunted populations. Nagy et al. (1983b) reported that a disproportionately large number of males appeared in the harvest on Tukoyaktuk Peninsula, N.W.T. They compared the sex and age classes of harvested and averaged spring populations using Chi-square analyses, and found that overall males were twice as vulnerable to harvest as females (vulnerability ratio of 1.9:1). Males 3 and 4 years old and males 5 years old and older had the highest vulnerability ratios, being 4 and 2 times as vulnerable to harvest, respectively, as females of the same age classes. On average males comprised 38 percent of the total population >3 years in the heavily hunted Tuktoyaktuk Peninsula population during the period 1974-77 compared to 50 percent of the standing population in unhunted Northern Yukon during 1974-75.

These comparisons further support the contention of Nagy et al. (1983a) that the Northern Yukon population was in a state of long-term equilibrium. Assuming that man-caused mortalities have been light, it is likely that the age-sex structure of the Northern Yukon grizzly bear has not changed significantly since 1973-74. This is probably particularly true for bears in the Barn and British Mountains.

### 1.1.5 Sexual Maturity

Minimum ages at which females successfully conceived and produced young the following year were 5.5, 6.5, and 7.5 years (n = 3). Successful breeding ages for 9 other females ranged between 9.5 and 13.5 years. In addition, three 7 and two 8-year old females were observed in estrus or with attendant males during the study but their reproductive status was not determined the following year. Three females successfully bred at 18.5 (n = 1) and 20.5 years (n = 2).

Minimum breeding ages for female grizzly bears in Northern Yukon were most comparable with those in southwestern Yukon (6.5 years) (Pearson 1975), Brooks Range in Alaska (6.5 to 9.5 years) (Reynolds 1976), and Tuktoyaktuk Peninsula, N.W.T. (4.5 to 7.5 years) (Nagy et al. 1983b).

### 1.1.6 Litter size

Nagy et al. (1983a) observed 14 different litters of young ranging in age from cubs to 2-year olds during 1973 and 1974. Average litter sizes were 2.0 for cubs (n = 6), 2.0 for yearlings (n = 4), and 2.17 for 2-year olds (n = 6). Two litters were observed as yearlings and subsequently as 2-year olds. The combined mean litter size including cubs, yearlings, and 2-year olds was 2.07 young.

Litter sizes of North American grizzly bears vary from 1.7 in Glacier Park, Montana (Martinka 1974) and in southwestern Yukon (Pearson 1975), to 2.3 in Tuktoyaktuk Peninsula, N.W.T. (Nagy et al. 1983b) and Nelchina Basin, Alaska (Miller and McAllister 1982). The mean litter sizes for grizzly bears in Northern Yukon were consistent with those reported for Northcentral Alaska Range of 2.04 cubs and 2.0 yearlings per litter (Reynolds and Hechtel 1988).

### 1.1.7 Reproductive Interval

The normal reproductive interval or birth interval for most grizzly bear populations in North America is 3-4 years (Hensel et al. 1969, Craighead et al. 1969, Mundy and Flook 1973, Pearson 1975, Glenn et al 1976, Nagy et al. 1983b, Reynolds and Hechtel 1988, Nagy et al. 1989). As a result, 6 to 8 years may be required to track females in a population through 2 complete reproductive cycles to obtain reliable data on reproductive intervals and success. Nagy et al. (1983a) conducted intensive grizzly bear research in the Northern Yukon for only 2 years. As a result, their estimates of reproductive intervals were based on known ages of young at weaning and the assumption that females bred successfully after weaning young. They estimated that the reproductive interval ranged from 3 to 5 years (n = 4), with the majority of females producing litters at estimated intervals of 3 to 4 year (Nagy et al. 1983a). The reproductive histories of all females observed on the study area are provided in Table 2.

Grizzly bears may not always produce young subsequent to breeding efforts following weaning (Craighead et al. 1969, 1976; Reynolds 1988). Females may fail to breed, may breed but fail to produce cubs, or may lose their litters. Scarcity of fall foods such as berries may cause failures in cub production the following year (Rogers 1976). Reynolds (1988) reported complete losses of the cub cohort during 1983. Although the actual cause of that loss was not ascertained it was attributed to either a berry crop failure or to a combination of unseasonably alternating warm and cold conditions with little snow cover. These failures affect future recruitment and may synchronize productivity among females within a population (Rogers 1976). For example, if females in a population consistently produced young on a 3 year interval then approximately 33 percent of the adult females should produce cubs annually. However, if there was a failure in cub production in one year approximately 66 percent of the females could produce cubs the following year. Alternately 66 percent of females may not be accompanied by young during summer and fall due to reproductive failures. In a hunted population this situation could affect the vulnerability of females to harvest mortality. If only females with young (cubs, yearlings, and two-year olds) are protected from hunting, a significant proportion of females could be potentially vulnerable to harvest during years of reproductive failures. This suggests the need for monitoring reproductive success among female grizzly bears or the production of fall foods and for developing an adaptive harvest strategy to reduce the risk of over-harvesting females.

### 1.1.8 Breeding Season

Nagy et al. (1983a) observed females with attendant males between 5 May and 15 July, with the highest frequency of paired adults observed between late May and the end of June.

## 1.2 Home Range Size and Movements

### 1.2.1 Home Range Size

Minimum convex polygon (MCP) estimates of annual home range size (Mohr 1947) for Northern Yukon grizzly bears were obtained from Nagy et al. (1983a). Mean home range size estimates, weighted by the number of locations, were calculated by bear class by 1) multiplying the area in each individual's MCP estimate by the number of locations used in the calculation of that polygon, 2) summing these values across individuals, 3) summing the number of locations used in the calculation of individual MCP's, and 4) dividing 2) by 3) (Matchett 1985). Age and sex classes described by Nagy et al. (1983a) were adult males, subadult males, subadult females, adult females without young, adult females with cubs, adult females with yearlings, and adult females with 2-year old young. MCP size estimates for individual bears for which more than one year of data were obtained were treated as independent estimates of home range size.

The average annual home range size for adult males and adult females without young were 520 (n = 20) and 123 (n = 18) $km^2$, respectively. The average annual home range size for adult females with cubs (n = 4) was 124 $km^2$ (average of 5 location/bear), while those for females with yearlings (n = 2) and females with 2-year olds (n = 1) were 101 (average of 8 location/bear) and 701 $km^2$ (16 locations), respectively. In general males had the largest home ranges, followed by adult females with 2-year olds, females without young, females with cubs, females with yearlings, and subadults.

Home ranges of grizzly bears overlap among sex and age classes allowing animals to freely exploit seasonally or annually available food sources (Craighead and Mitchell 1982, Ballard et al. 1982, Nagy et al. 1983b). Although significant overlap may occur among home ranges, core seasonal or annual activity areas may be used exclusively by an individual (Martinka 1970, Russell et al. 1979, McLellan 1981, Aune et al. 1984). Pearson (1975) suggested that home ranges of female grizzly bears were often associated with mountain massifs.

### 1.2.2 Factors Affecting Home Range Size

Grizzly bear home ranges vary in size among regions in North America (Pearson 1975; Craighead 1976; Reynolds 1976; Nagy and Russell 1978; Russell et al. 1979; Reynolds and Hechtel 1980; Nagy et al. 1983a,b; IGBC 1987; Nagy et al. 1988); among sex, age, and reproductive classes within regions (Pearson 1975, Nagy et al. 1983b); among classes of bears within and among regions as changes occurred in habitat quality (Pearson 1977, Reynolds and Hechtel 1980, Knight et al. 1984), topographic structure (Pearson 1977, Hamer and Herrero 1983), and density caused by population growth or exploitation (Young and Ruff 1982). However, it is difficult to compare home range size estimates reported in the literature to determine if actual differences occur among populations, and if they occur, to identify the factors that may cause those differences. This is because the methods used to collect data (tracking, duration, location sample sizes, sampling intensity) and calculate areas vary among studies (IGBC 1987).

Nagy and Haroldson (in press) compared home range sizes of grizzly bears in Northern Yukon Territory (Nagy et al. 1983a); Tuktoyaktuk Peninsula and Richards Island, Northwest Territories (Nagy et al. 1983b); west-central Alberta (Nagy et al. 1988, 1989); and Jasper National Park (Russell et al. 1979). They used a categorical approach (Slade and Swihart 1983) to derive indices of annual and seasonal range size from location data obtained for equivalent classes of adult grizzly bears. Classed indices of range size were compared to determine if differences occurred among populations. Grizzly bear age, weight, density, standing biomass, maximum growth rate, known man-caused mortality, and reproductive data (Russell et al. 1979; Nagy et al. 1983a,b; Nagy et al. 1989; Kingsley et al. 1988; Kingsley pers. commun. 1989) were compared among populations to help interpret the results of home range comparisons. Standing biomass combines information on density estimates and body size of individuals in a population and thus provides more meaningful comparisons of relative habitat capacities (Miller and Ballard 1982). Maximum standing biomass of large mammals occurs near K (Fowler et al. 1980).

The 4 populations compared occupied interior type ecosystems where salmon were not available (Nagy and Haroldson in press). Although they did not have quantitative data to compare habitat quality among the ecosystems, they felt that any differences would be small when considered on a continental scale. As a result, their underlying assumption was that if differences occurred in range size among the populations, they were primarily caused by factors that influenced population sociality, structure, and/or density rather than by differences in habitat quality.

Estimates of annual and seasonal ranges differed significantly among the 4 populations studied (Nagy and Haroldson in press). Seasons were defined as spring-early summer (15 May to 21 September) and mid-summer-early fall (22 July to 21 September). Females without cubs in Northern Yukon consistently used annual and seasonal ranges that were significantly smaller than those used by the same class of adult females in the other 3 study areas. Spring-early summer ranges of males did not differ suggesting that males in all areas used similar sized ranges during the breeding season. The decrease in range size from spring-early summer to mid-summer early-fall that was evident for males and females without cubs likely reflected a cessation of breeding activity and increased foraging efforts during the late summer hyperphagic period.

The differences observed in annual home range size among the study areas were considered to be largely due to differences in population density (Nagy and Haroldson in press). Population densities in Northern Yukon were 2 to 6 times greater than those reported for Tuktoyaktuk Peninsula, west-central Alberta, and Jasper National Park. The Northern Yukon population occupied a relatively stable undisturbed environment, was in a state of long term equilibrium (Nagy et al. 1983a), and was probably at carrying capacity. Populations in Tuktoyaktuk Peninsula, west-central Alberta, and Jasper National Park had been subjected to substantial rates of man-caused mortality for at least a decade (Nagy et al. 1983a,b, 1989). The estimated minimum standing grizzly bear biomass in Northern Yukon was approximately 7 times greater than in Tuktoyaktuk Peninsula and 4 times greater than in west-central Alberta.

The median spring weights of physically mature males and females were largest in west-central Alberta, followed by Jasper National Park, Tuktoyaktuk Peninsula, and Northern Yukon. In predicted asymptotic spring weights and lengths of both sexes, the west-central Alberta bears were largest at most ages, the Tuktoyaktuk Peninsula bears second largest, and Northern Yukon bears the smallest (Kingsley et al. 1988, M. Kingsley pers. comm.). In addition, maximum growth rates for male grizzly bears were 20 kg/year in Northern Yukon, 24 kg/year in Tuktoyaktuk Peninsula, and 30 kg/year in west-central Alberta (Kingsley et al. 1988, M. Kingsley pers. comm.). Similarly, those for females were 15 kg/year in Northern Yukon, 19 kg/year in Tuktoyaktuk Peninsula, and 25 kg/year in west-central Alberta.

In general, the Northern Yukon supported more small, slow growing bears but had a higher standing biomass of bears than the other areas (Nagy and Haroldson in press). The smaller home ranges, smaller body weights, and lower maximum growth rates of Northern Yukon bears were most likely a result of bears competing for available space and food resources within a population at or near carrying capacity. In Tuktoyaktuk Peninsula, west-central Alberta, and Jasper National Park, where man-caused mortalities have reduced grizzly bear densities below carrying capacity, competition for space would have been reduced allowing bears to use resources over larger annual ranges. The energetic costs to individuals of movements within larger home ranges may have been offset by greater exclusive use of foods, resulting in larger body size and higher maximum growth rates. This conclusion appears to have been supported by the fact that Tuktoyaktuk Peninsula, west-central Alberta, and Jasper National Park had fewer but larger faster growing bears with larger home ranges.

Habitat quality undoubtedly determines the minimum size of an annual home range that will support a bear within a given habitat type (Nagy and Haroldson in press). However, it seems clear that population density plays an important role in determining the actual range size used. Based on comparisons of home range indices and population parameter Nagy and Haroldson (in press) concluded that:

1) Grizzly bear home range size is a function of both habitat quality and population density.
2) Physical fitness as measured in body weights is a function of habitat quality and population density.
3) If body weights of grizzly bears increase as population density decreases, and reproductive success is related to body weight, then the overall physical fitness and reproductive success of a population may increase when numbers are maintained below maximum carrying capacity.
4) As density increases, population growth may be progressively limited by the proportion of females that can adequately meet nutritional requirements for successful reproduction. In a high density population, the home ranges of all breeding females may be adequate in size to allow them to produce cubs in years of abundant or average food production. However, only those breeding females that occupy home ranges in the best habitats may produce cubs during years of poor food production.
5) Body weights cannot be used as reliable indices of habitat quality in the absence of information on population density.
6) Estimates of food biomass available per unit area are required before comparisons of habitat quality can be made among regions occupied by grizzly bears in North America.

### 1.2.3 Movements

Watson et al. (1973) suggested that grizzly bears in the Arctic mountains made substantial movements in relation to migrating barren ground caribou. Data presented by Pearson (1976) and Nagy et al. (1983a) did not substantiate that contention. In fact, during June when caribou were moving generally to the north and west, some adult grizzly bears were moving east and south away from the areas occupied by the Porcupine caribou herd. These movements may have been more closely related to the breeding activities of the bears rather than to activities associated with predation or scavenging on caribou. Nagy et al. (1983a) suggested that while individual grizzly bears - especially adult males - may prey or scavenge on carcasses of caribou that migrate through the bear´s home ranges, they do not actually "migrate" with the herds. Although it was generally assumed that bears may move long distances to reach the core caribou calving area of the Western Arctic Herd, Reynolds (1980) data did not support this. Reynolds (1980) suggested that it was more probable that bears whose home ranges overlap calving areas or migratory corridors concentrate their feeding in these areas during the calving and post-calving migratory periods.

1.2.4 Daily Rates of Travel

Weighted average daily rates of travel were calculated for male and female grizzly bears of Northern Yukon (Nagy unpublished data). The linear distances travelled and elapsed time (days) between successive radio locations were determined. The data were pooled semi-monthly using the middle date for each survey period for each sex. The average distance travelled daily was calculated as the sum of the distances travelled divided by the total number of days between successive surveys for bears pooled in each semi-monthly period.

In general males had greater daily rates of travel than did females. Average daily rates of movement ranged from 0.5 to 3.9 km/day and 0.4 to 1.6 km/day for males and females, respectively. Knight et al. (1984) and Reynolds (1980) reported average daily rates of travel of 1.34 km/day and 4 km/day for adult males in Yellowstone National Park and Alaska, respectively. Long range movements of 26 km in 10 hours (Linderman 1974) and 54 km in 62 hours (Craighead 1976) have been reported. In Banff National Park mean daily movements of 1.5-3.0 km/day were recorded for radio collared adult female grizzly bears (Hamer and Herrero 1983).

Average daily travel rates for male and female grizzly bears were 1.43 (0.03-10.44) and 1.34 (0.11-3.36) km/day, respectively, during the breeding season (Nagy unpublished data). The maximum rate of travel for males was 10.44 km/day over 4 days, while that for females was 3.4 km/day over 2 days. The maximum distance observed between 2 consecutive locations for males and females was 42.2 and 19.6 km, respectively. Similarly, Nagy et al. (1988) found that the average distance between sequential subsets of locations for males ranged from 15 to 30 km during the breeding season. Long range movements of bears may be common during the breeding season as males search for estrous females.

Russell et al. (1979) suggested that seasonal movements of 50 to 150 km may be common and would allow adult males to learn when and where preferred foods are most available in Jasper National Park, and in spring it would increase the chances that a male would come in contact with sexually receptive females. Similarly, Reynolds (1980) reported that movement of individual bears outside of their activity centers did not usually occur, however, such movements during the breeding season or in search of food or denning sites was recorded. Pearson (1975) reported maximum linear seasonal movements of 45, 61, and 145 km for males in northern interior Yukon. Movements may be abrupt and direct or random and indirect as bears search for available food resources (Knight et al. 1984, Hechtel 1978, Archibald 1983). Similarly, in Northern Yukon individual bears may make long range movements in order to exploit seasonally available rich food sources (caribou calves, carrion, hedysarum roots, berries, etc.) but stay within their normal home range.

These data have significant implications when dealing with problem bears and identifying individuals within populations. Bears may move long distances from problem sites within a short period of time subsequent to an incident. Further, sites were non-harvest related mortalities chronically occur such as garbage dumps associated with DEW line sites or traditional hunting or fishing camps along the arctic coast may act as population sinks (Knight et al. 1988). Because bears occupy large annual or seasonal home ranges, those population sinks may impact bear populations over a large area.

### 1.2.5 Influence of the Availability of Seasonal Foods on Movement Patterns

The influence of the relative availability of or spatial distribution of seasonally important food items on the size of seasonal ranges and movements of grizzly bears was investigated in west-central Alberta (Nagy et al. 1988). Radio locations were obtained on a weekly basis with fixed wing aircraft. Estimates of the average distances (AVD) between subsets of 4 radio telemetry locations were calculated. In this analysis an AVD value is calculated for the first 4 locations, then the first chronological location is dropped and the next added till values are obtained sequentially for the entire data set. Seasonal changes in AVD values were similar during 3 years when berries were available in late summer. AVD values for males during those 3 years ranged between 15 and 30 km from the time of emergence to end of June or early July. This was followed by about 50% lower AVD values in July and August and an increase in early September to values comparable to those in spring. Bears actively prepare for hibernation (hyperphagic period) during late summer (Nelson et al. 1983). The high fall values for males usually continued until denning. AVD values for females gradually declined throughout the active period during those 3 years (Nagy et al. 1988). During the fourth year there was a general failure in the berry crop on the study area. AVD values for males and females remained relatively high throughout the year. In particular contrast to other years, AVD values of both sexes increased dramatically during the hyperphagic period and remained at a level 2 to 3 times greater than that observed at an equivalent time in other years.

Grizzly bears in west-central Alberta presumably expand their late summer ranges to search for existing areas of berry production or alternate high energy foods (hedysarum roots, carrion, etc.) during years when there is a general failure in the berry crop (Nagy et al. 1988). Similarly, the year to year movements and distribution of grizzly bears in Northern Yukon may be significantly influenced by the availability of berries, carrion, or ground squirrels.

### 1.2.6 Elevational Distribution

The elevational distribution of grizzly bears in the Northern Yukon was re-analyzed (Nagy unpublished data) using 319 radio telemetry locations obtained by Nagy et al. (1983a). Locations were assigned to one of 2 elevation classes including: 1) sea level to 1500 feet and 2) areas above 1501 feet. The amount of land area available to bears in each elevation class was determined by plotting and recording the elevational class for 1285 random locations (Marcum and Loftgaarden 1980). The coordinates for the random locations were generated using a table of random numbers (Marcum and Loftsgaarden 1980, Gibbons 1985). Data were pooled by sex in order to meet the sample size requirements of statistical tests used.

Two general hypotheses were tested including:
1) Ho1: male and female grizzly bears are distributed independently among the 2 elevational classes in Northern Yukon; and,
2) Ho2: the elevational distribution of male and female grizzly bears conformed to the availability of elevational classes in Northern Yukon.
Each hypothesis was tested for each month during May to September, annually, and during the spring and fall hunting seasons. A chi-square test for independence was used to compare the annual and monthly elevational distribution of males and females (test Ho1) (Gibbons 1985). A chi-square goodness-of-fit-test was used to compare the annual and monthly elevational distributions of males and females with a theoretical distribution based on availability of elevational categories (test Ho2) (Gibbons 1985).

The annual elevational distribution of male and female grizzly bears differed significantly (test Ho1) ($P<0.05$) (Table 3). Although both elevational classes were used annually by both sexes, males were observed more frequently than females at elevations $\leq$1500 feet and less frequently than females at elevations >1500 feet. When the data were compared on a monthly basis, males were observed more frequently than females at elevations $\leq$1500 feet and less frequently than females at elevations >1500 feet during all months ($P<0.05$) except August (Table 3).

The annual and monthly elevational distribution of female grizzly bears differed significantly from the theoretical distribution based on availability (test Ho2) ($P<0.05$) (Table 4). Females were observed at elevations ranging from sea level to 3,250 feet, but used areas at elevations >1500 feet more frequently than expected annually and during all months except

June (Table 4). In comparison, the elevational distribution of male grizzly bears did not differ significantly from the theoretical distribution based on availability (test Ho2) ($P<0.05$) (Table 5). Males were observed at elevations ranging from sea level to 3,000 feet, but did not use either elevation class more frequently than expected on an annually or monthly basis (Table 5).

No significant differences were found between the elevation ranges used by females during the periods when the spring (15 April to 21 June) and fall (1 August 31 October) grizzly bear hunts would occur (Table 6). This was the case for males as well (Table 6). However, females generally occurred at higher elevations than males during both hunting season ($P < 0.05$) (Table 7).

In general these data indicate that male and female grizzly bears distribute themselves differently in the Barn Mountains. Males generally used elevation ranges ≤1500 and >1500 feet equally. However, females selected areas of higher elevation throughout the year, possibly to reduce the potential for interaction with males. Further, the probability of encountering males and females would differ with elevation. Recreationists and hunters would have a greater probability of encountering male grizzly bears when using areas along valley floors and lower slopes (≤ 1500 feet) and females when using sites on mid and upper slopes (>1500 feet). Harvest mortalities among females could be reduced by expending harvest efforts along the main river corridors and providing hunter education programs directed at sexing bears in the field.

Pearson (1975) and Russell *et al*. (1979) reported seasonal and annual variations in the elevational distribution of grizzly bears by sex and age classes. Adult males in southwestern Yukon moved to lower ground following emergence from their winter dens, while adult females and immature animals remained higher on mountain sides near their dens until late May (Pearson 1975). In Jasper National Park, Alberta, Russell *et al*. (1979) observed that lone females, females with subadults and independent subadults spent disproportionately greater amounts of their time in areas above valley floors than did adult males. Although overlap in the elevational ranges used occurred, significant differences were obtained when the elevational distribution of adult males were compared with that of other sex and age classes. The results obtained for the Northern Yukon appear consistent with the findings of other researchers.

## 1.3 Food Habits

Grizzly bears in Northern Yukon primarily fed on crowberries (*Empetrum nigrum*) and roots of Eskimo potato (*Hedysarum alpinum*) during late May (Nagy et al. 1983a). In June and July grasses were consumed almost exclusively. Berries and grasses again constituted the greatest proportion of foods eaten in August and September, although legume roots (Hedysarum spp) and arctic ground squirrels (Spermophilus undulatus) were also important. Crowberry was the most commonly eaten berry, while soapberry was also occasionally consumed. Most of the animal matter was identified as remains of arctic ground squirrels, while remains of barren ground caribou (Rangifer tarandus groenlandicus) were infrequent. One scat contained traces of an unidentified bird species (Nagy et al. 1983a).

The nearly complete lack of caribou remains in grizzly bear scats collected in Northern Yukon was unexpected because the Porcupine caribou herd migrates through the area (Nagy et al. 1983a). However, a small number of grizzlies were captured near carcasses, and a number of bears were observed on caribou carcasses during telemetry flights. Whether these bears actually killed the caribou, were feeding on carrion, or had claimed carcasses from wolves could not be ascertained. J. Russell (pers. comm.) also observed several instances of grizzly bears feeding on caribou in Northern Yukon in the late 1970´s.

Vaccinium spp berries may be of variable importance in Northern Yukon, depending on availability. Evidence was not found of grizzly bears fishing for Arctic char (Salvelinus alpinus) in any of the coastal rivers of Yukon Territory, however on 2 occasions bears were seen feeding on beluga (Delphinapterus leucus) which had died and washed up on the beach. Ground squirrels were utilized to some degree during August and September, but not to the degree observed on the Tuktoyaktuk Peninsula, N.W.T. (Nagy et al. 1983b). The low incidence of arctic ground squirrels in the diet of bears in Northern Yukon may be a result of more difficult digging conditions due to the rocky nature of soils in the area (Nagy et al. 1983a).

Although the species of plants and animals consumed vary from region to region, the general seasonal feeding regime of Northern Yukon bears were similar to those of other northern populations (Pearson 1975, Reynolds 1976, Nagy et al. 1983b, Johnston et al. 1985). Known food species include: bearberry (Arctostaphylos uva-ursi), alpine bearberry (Arctostaphylos alpina), common crowberry (Empetrum nigrum), soapberries (Shepherdia canadensis), blueberries (Vaccinium spp), bog cranberry (Vaccinium vitis-idaea), alpine blueberry (Vaccinium uliginosum), willow catkins (Salix spp), grasses (Graminae spp), sedges (Carex spp), milk vetch (Astragulus spp), alpine hedysarum (Hedysarum alpinum), oxytrope (Oxytrope borealis), horsetails (Equisetum arvense), coltsfoot (Petasites spp), emergent aquatics, moose (Alces alces), beluga carrion (Delphinapterus leucus), caribou/reindeer (Rangifer tarrandus), arctic ground squirrels (Spermophilus undulatus), small mammals (microtines), birds, and carrion.

## 1.4 Habitat Use

Nagy et al. (1983a) observed grizzly bears throughout their Northern Yukon study area (Figures 3 and 4) but did not collect habitat use data during their study. Habitat maps were not available for the Northern Yukon, therefore it was not possible to determine the availability or relative importance of existing habitats to grizzly bears. The plant foods available on some of the major topographic features in the Northern Yukon include (summarize from Wiken et al. 1981):

1. inactive deltas: sedges, cottongrass
2. moraine: cottongrass, bog cranberry, alpine blueberry, crowberry
3. polygonal grounds: bog cranberry, sedges, cottongrass
4. poorly drained meadows: cottongrass, sedges
5. tussock/dwarf heath tundra: bog cranberry, cottongrass
6. river and stream channels: alpine hedysarum, oxytrope, bistort, fescue, grasses, variety of herbs, horsetails, sedges, spike trisetum, soapberry
7. lower slopes: alpine blueberry, oxytrope, fescue, spike trisetum
8. toe slopes: alpine blueberry, crowberry, cottongrass, horsetails, sedges
9. tussock/dwarf to low heath tundra: alpine blueberry, bog cranberry, cottongrass, sedges
10. tussock tundra on terraces: cottongrass, sedges
11. alpine tundra: alpine bearberry, sedges
12. well drained low elevation alluvial terraces: alpine bearberry, dune grass, sedges
13. poorly drained low elevation terraces: alpine bearberry, bog cranberry, cottongrass, sedges
14. elevated terraces: alpine blueberry, crowberry, bistort, grasses, horsetails, sedges
15. south facing slopes: alpine bearberry, alpine blueberry, soapberry,
16. tussock/dwarf to low heath tundra: alpine blueberry, bog cranberry, cottongrass, sedges
17. tussock heath tundra on north facing slopes: alpine bearberry, alpine blueberry, bog cranberry, crowberry, cottongrass

Research is required to 1) map and describe available habitats and 2) to determine the importance of those habitats to bears based on the seasonal availability of foods and use by grizzly bears.

### 1.4.1 Denning and Emergence

Nagy et al. (1983a) recorded approximate emergence dates for 16 radio-collared bears. Active males were observed on the study area during late April (n = 4) and early May (n = 2) when capture and telemetry surveys commenced. Known emergence times ranged from 2-12 May. Emergence times for adult males did not appear to be different from those for adult females without young. Dates of departure from winter dens in Northern Yukon appeared to be 2 weeks to one month later than those reported for more southerly latitudes (Craighead and Craighead 1972, Hamer et al. 1979). Denning times were not determined.

### 1.4.2 Characteristics of Den Sites

Nagy et al. (1983a) located 36 dens during their study. Dens were primarily situated in the montane regions of the Arctic Plateau or British Mountains (33 dens or 92%). Only 3 dens (8%) were situated on the Yukon Coastal Plain. Dens were situated at mean elevations of 618 m asl (range 419-914 m) in the mountains (n = 17), 147 m asl (range 137-152 m) along river banks (n = 3), and 120 m asl (range 117-121) on the edge of the coastal lowlands (n = 3). Most dens were excavated in stabilized or partially stabilized talus slopes (n = 31). A natural rock cave was used as a den, while another was excavated in peat bank. The average degree of slope for sites on which dens were dug was 30.3 degrees (n = 23, range 22-43). A southeasterly aspect was preferred for den sites, with 15 (62.5%) oriented to the south, 6 (25%) to the east, and 3 (12.5%) to the west. Steep slopes undoubtedly provide greater ease in construction of dens, while slopes with a southerly aspect receive an early, deep insulative cover of snow from prevailing north and northwest winds. Grizzly bears were not considered to be limited in Northern Yukon by the availability of sites suitable for denning.

## 2.0 Deficiencies in Available Data

### 2.1 Population Characteristics

Nagy et al. (1983a) studied grizzly bears in the Barn and British Mountains in Northern Yukon during 1972-74. The data obtained should not be considered representative of those for grizzly bears throughout the Northern Yukon. The physiography of the British and Richardson mountains along the western and eastern boundaries of the Northern Yukon, respectively, differs from that in the Barn Mountains study area. As a result, some grizzly bear population parameters such as densities, productivity, etc. may differ across the Northern Yukon. In addition, the 3 year study was primarily designed to census bears; to obtain baseline data on population characteristics, home range size, and denning sites; and, to obtain information on the distribution of grizzly bears relative to a spur line of the proposed MacKenzie Valley Pipeline. Because the study was of short duration limited data were obtained on reproductive rates (litter sizes, reproductive interval, ages of first production) and natural and man-caused mortality rates. Because female grizzly bears do not first successfully conceive until ages 5.5 to 9.5 years and produce cubs every 2 to 5 years (Craighead et al. 1969, Pearson 1975, Glenn et al. 1976, Russell et al. 1979, Reynolds 1980, Miller et al. 1982, Nagy et al. 1983a,b, Nagy et al. 1989, Mundy and Flook 1973, Martinka 1974, Reynolds 1976, Craighead and Mitchell 1982, McLellan 1984) a period of 5-10 years of study may be required to obtain reproductive histories on a representative sample of females in an area. These types of data are required to derive acceptable man-caused mortality rates for a population through modeling efforts (Talyor et al. 1987). My guess is that this would not be feasible considering current government fiscal constraints. These types of data may be best derived from the data currently being obtained in a study of the population dynamics of hunted grizzly bear populations in Northcentral Alaska Range (Reynolds and Hechtel 1986,1988, Reynolds et al. 1987).

A census program should be considered to verify that the data presented by Nagy et al. (1983a) are still valid for Northern Yukon. However first priority should be given to a census of bears in the Richardson and British mountains. This would provide population and density estimates for grizzly bears across the Northern Yukon that could be used to derive more precise estimates of allowable harvest. Some possibilities include: 1) short term (2-3 year) intensive capture-mark-release studies directed at obtaining baseline density data (Miller et al. 1987), or 2) early spring den site surveys.

Miller et al. (1987) derived density estimates for black and brown bears using a modified capture-recapture technique on a 1,317 $km^2$ study area in Alaska. Miller et al. (1987) divided their study area into quadrats in which search efforts were allocated and documented. An attempt was made to search for marked vs unmarked bears in each quadrat each day. Unmarked bears were captured and marked. The total operating cost of that study was about $60,000 over a 10 day period. The density estimates obtained, when extrapolated to a larger area, provided an objective and replicable estimate of the size of the bear population (Miller et al. 1987). In addition, these density estimates provide the baseline data required to evaluate the impacts of developments or man-caused mortality on population.

Den site surveys would be directed at locating active spring dens when there is a nearly complete cover of snow in late April-early May. The number of bears occupying dens could be derived through direct counts of bears and examining tracks at the sites. For example, during spring 1974 in Northern Yukon we located 10 dens by locating radio collared bears prior to or during the period of emergence. We also located 17 dens of uncollared bears or 63% of the total number of active dens found that spring during helicopter or fixed wing surveys. Dens generally occurred on mountain slopes and could be identified by the tailings of bedding material or earth and tracks on the snow. In addition, bears were often observed at or near the den sites. These counts could be confounded by the variation in emergence times among reproductive classes of bears. However, if surveys were conducted on a 2-3 day interval on relatively small representative sites during late April to mid-May most dens could likely be found.

A standardized data collection system should be maintained to monitor harvest and non-harvest related mortalities. The collection of age (collection of premolar teeth for aging of bears through cementum annuli), sex (provide evidence of sex of kill), and kill location data through a system of compulsory registration should be continued. The resulting data should be evaluated on an annual basis. Data on actual mortality rates (combined legal, wounding loss, illegal, poaching, self-defence kills) are difficult to obtain. A significant effort is often required to verify man-caused mortalities. For example, I often obtained second and third hand information on kills when working on Tuktoyaktuk Peninsula, N.W.T. It often took several days to weeks to track down people who supposedly killed bears. People were often suspicious and did not always volunteer information. Because much of the Northern Yukon is remote, it will be extremely difficult to monitor non-harvest related kills. However, in order to manage grizzly bears effectively in the Northern Yukon a concerted long-term effort (dollars and man power) will be required to obtain this type of information. Primary emphasis should be placed on obtaining this type of data.

2.2 Habitat use

Data on the relative availability and productivity of grizzly bear habitats, and seasonal patterns of habitat use by different sex and age classes of grizzly bears are lacking. Habitats in the Northern Yukon may be considered to be relatively stable because of severe climatic conditions. Unless major developments are proposed that would alter the nature of habitats on a broad scale in the Northern Yukon, there may be little requirement for this type of data. Evaluation of habitat use or importance for minor localized developments could most likely be dealt with on a site specific basis. A major effort will be required to obtain this type of information. Two generalized procedures could be followed to obtain this type of data including:

1) Representative age-sex classes of grizzly bears would be captured, radio collared, tracked, and observed through ground or aerial radio telemetry in representative areas (Hamilton and Archibald 1986). Adult females are preferred because they have smaller home ranges and generally show a greater degree of fidelity to home range sites. The characteristics of use sites would be evaluated to identify seasonally important areas.

Alternately, data obtained by Nagy et al. (1983a) could be evaluated to describe the characteristics of habitat used and to identify seasonally important areas. This may not provide high quality data because it would be difficult to locate the actual sites used. However, the existing radio location data could be used cost effectively to identify general patterns of grizzly bear habitat use if habitat maps were generated for the Northern Yukon. These radio locations could be superimposed on the habitat maps.

2) Actual and potential use could be rated for existing habitats based on known grizzly bear use (bears or their sign observed opportunistically within habitats) or on the availability of seasonally important food items within existing habitats (qualitative ratings) (Hamer and Herrero 1988, Hadden et al. 1986). In this approach, bears would not be captured and radio collared.

In either case a habitat classification system or habitat map of the area would be required before the availability, distribution, and importance of existing habitat could be ascertained.

## 3.0 Estimates of Harvestable Surplus

### 3.1 Estimates of Population Numbers

Grizzly bears are highly mobile, often secretive, and occupy extremely large home ranges. Although Miller et al. (1987) developed a method of deriving reliable population density estimates for grizzly bears in relatively open habitats, no satisfactory cost effective method has been developed to census bears in most areas (Eberhardt et al. 1986). Zunnino and Herrero (1972), Martinka (1974), Pearson (1975), Lortie (1978), Miller and Ballard (1982), Tompa (1984), Nagy and Gunson (1989) estimated population numbers using density data extrapolated from areas of intensive study. Reynolds and Hechtel (1980) reported that extrapolation of bear densities from areas and habitats of intensive study gave the best population estimates.

Nagy et al. (1983a) reported densities of 26 bears/1000 $km^2$ for an unhunted grizzly bear population in the Barn Mountains and the eastern portions of the Buckland Mountains in Northern Yukon (Nagy et al. 1983a). Nagy (1988), in a review of the general vegetative characteristics of Northern Yukon National Park, suggested that the quality of bear habitats may be relatively low in the Malcolm River and British Mountain ecodistricts as the upper slopes of mountains are predominantly unvegetated. However, approximately 135,000 caribou calve and then migrate through this area several times during the spring, summer, and fall (Urquhart 1983). The influence of the availability of caribou as a potential food source on grizzly bear densities in that area is unknown, but may off-set some limitation on bears resulting from annual variations in the availability of such foods as berries. A similar situation may exist in the Richardson Mountains.

Reynolds (1980) provided density estimates of 1.3 bears/1000 $km^2$ for coastal plains, 7.7 to 20 bears/1000 $km^2$ for low foothills, and 3.8 bears/1000 $km^2$ for mountainous areas in the southwestern National Petroleum Reserve and central and eastern Brooks Range, Alaska (Crook 1971, Curatolo and Moore 1975, Reynolds 1976). Curatolo and Moore (1975) and Reynolds (1976) reported a density of 6.7 bears/1000 $km^2$ for the mountains and foothills of the eastern Brooks Range, Alaska adjacent to the Northern Yukon. The eastern Brooks Range grizzly bear population was hunted, and as a result densities could be expected to be lower than those reported by Nagy et al. (1983a) for Barn and Buckland mountains.

The following density estimates were extrapolated to Game Management Subzones:

1) coastal plains and low foothills - 6.5 bears/1000 $km^2$
2) Barn and Buckland mountains - 26 bears/1000 $km^2$ (Nagy et al. 1983a)
3) British and Richardson mountains - 15 bears/1000 $km^2$

A density of 6.5 bears/1000 $km^2$ or one quarter of those reported for the Barn and Buckland mountains was used to estimate population numbers for management units that encompassed the coastal plains and low foothills. That density is within the range reported for similar areas in Alaska (1.3 and 7.7 to 20 bears/1000 $km^2$). In addition, similar areas on Tuktoyaktuk Peninsula supported a density of 4.2-4.7 bears/1000 $km^2$; the population was hunted. As a result, the densities used to estimate numbers of bears on the coastal plains and low foothills in Northern Yukon are probably realistic.

A density of 15 bear/1000 $km^2$ was used to estimate population numbers in management units that encompassed the British and Richardson mountains. The British and Richardson mountains were assumed to be physiographically most similar to the eastern Brooks Range. Densities of bears were assumed to be less than those reported for the Barn and Buckland mountains but greater than those reported for the hunted population in eastern Brooks Range.

The IFA settlement area includes approximately 8,331 $km^2$ of Territorial lands and 9,748 $km^2$ of national and Territorial parks (Table 8). Approximately 70 percent of the Territorial lands are comprised of mountainous ecoregions, with the balance including coastal plain and low foothills ecoregions. In comparison 76 percent of the Park lands are comprised of mountainous ecoregions, with the balance including coastal plains and low foothills.

The grizzly bear population was estimated at 316 bears, including 151 bears in parks (subzones 1, 2, 3, 6, 7, 8, 9, 10, 11) and 165 on territorial lands (subzones 4, 5, 12, 13, 14, 25) by extrapolating the densities describe above over the management subzones (Table 8).

### 3.2 Estimates of Acceptable Man-caused Mortality Rates

A number of authors have estimated acceptable man-caused mortality rates for grizzly bear populations.

#### 3.2.1 THE QUOTA - A New Management System for Yukon Grizzly Bear (Lortie 1978)

"Grizzly bear managers have generally accepted a level of harvest of 4 percent as a rule of thumb. Losses of 10 percent from southern parks have resulted in short-term population declines whereas removals of 5 percent have not yet jeopardized the long-term numerical stability of these populations. Reynolds (1975) and (1976) recommends a low harvest policy not to exceed 3 percent on Brooks Range grizzly populations. On the intensive study area with a fifteen year record of harvest, harvest levels of 7 percent over 2 years (1973 and 1974) coupled with other mortalities has strongly altered the reproductive potential of this population. For Alaska G.M.U.'s 24, 25, and 26, and area of 150,000 $mi.^2$, Reynolds (1975) recommends the harvest of 30 bears per year or a level of 2 percent to allow recovery" (Lortie 1978).

"Indeed, it may be that a 4 percent level of harvest on hunted Yukon populations is optimistic. As a consequence, with all previous discussions in mind and at present no accountability for man-induced non-hunting losses, a maximum level of sport harvest of 3 percent will apply to all Yukon grizzly populations. In areas of specific management concern, a level of 2 percent has been applied" (Lortie 1978).

#### 3.2.2 The Management of Grizzly Bears In The Yukon, Canada (Sidorowicz and Gilbert 1981)

A computer-assisted model of grizzly bear (*Ursus arctos* L.) population growth in the Yukon Territory was developed and used to project changes in a hypothetical population based on biological data for the species (Sidorowicz and Gilbert 1981). The basic conservative assumptions of the model were (Sidorowicz and Gilbert 1981):

1) population size was 5,000 bears;
2) minimal reproductive rate was 2 cubs per litter, 1 litter every 4 years (0.5 cubs per female per year on average);

3) initial age structure was 60 percent under age 7 (immature), 32 percent aged 7 to 14 (breeding), 8 percent age 14 (but non breeding);
4) initial age structure was 1:1;
5) all bears died at age 18 years;
6) no sex-specific mortality in some modeling scenarios; and,
7) fertility of females commences in the 7th year and ceases in the 15th.

"When no sex-specific mortality is assumed, the population is stable when adult mortality (ages 3-14) is slightly less than 5 percent, and deaths in the whole population do not exceed 10.5 percent. Consistent growth results when adult mortality is reduced to 4.5 percent, because of increased numbers of breeding age animals. Total mortality of the adult segment, such as the 4.5 just mentioned, is a composite figure; some 2-3 percent is attributed to natural deaths and a further 2 percent to hunting and trapping" (Sidorowicz and Gilbert 1981).

"When mortality of adult females is reduced relative to adult males (as provided by existing regulations), higher total mortality is allowable because the population productivity is not decreased with decreased population size" (Sidorowicz and Gilbert 1981).

"Clearly, the results obtained are quite sensitive to initial assumptions. Not only mortality rates, but also sex ratio, age distribution, and longevity can affect the model population size, growth rate, and composition. Even more important may be assumptions about reproductive rate and age of sexual maturity.... The assumptions made in the present study are, therefore, both general and conservative. Consequently, the theoretical results presented must be considered only gross estimates" (Sidorowicz and Gilbert 1981).

"..., we estimate that adult mortality (natural and hunted) should be limited to 4.5 percent... If hunting pressure is directed away from adult females (e.g., by licensing restrictions), proportionally more males could be taken without affecting population productivity" (Sidorowicz and Gilbert 1981).

### 3.2.3 Modeling The Sustainable Harvest of Female Polar Bears (Taylor et al. 1987)

Taylor et al. (1987) "explored the boundaries of sustainable harvest of polar bears (Ursus maritimus) by considering a range of values for population parameters in a discrete, age specific model structured to mimic polar bear life history. Survival rate of adult females is the predominant factor affecting population growth rate and sustainable harvest of polar bears although other factors may also be significant; e.g., cub survival, litter size, and age of 1st reproduction. The parameter of least importance is litter production rate. Deferred reproduction has a small effect on population growth rate. These findings are consistent with theoretical predictions for populations experiencing density independent mortality mainly restricted to juveniles. The critical issue, when considering the long-term effect of any harvest, is the effect on numbers of breeding females. Under optimal conditions the sustainable yield of adult female polar bears is typically <1.6 percent of the total population" (Taylor et al. 1987).

"The structure of polar bear life history biology reduces the question of sustainable harvest to essentially 3 factors: (1) population numbers; (2) adult female survival rates; and (3) number of harvested bears that are adult females" (Taylor et al. 1987).

3.2.4 Impacts of Increased Hunting Pressure on the Density, Structure, and Dynamics of Brown Bear Populations in Alaska´s Management unit 13 (Miller 1988)

Miller (1988) developed a simple deterministic model based on Lotus 1-2-3 (Lotus Development Corporation) to estimate numbers of bears that could be theoretically taken from a population of 823 individuals (age >2.0 years). Miller (1988) used an iterative process to obtain a number approximating the population estimate for GMU 13 (i.e., 823 bears), including a stable age distribution and the reproductive parameters. A two fold differential between male and female vulnerability to hunting was maintained. That is males were twice as vulnerable to harvest as females. "The total sustainable mortality included no natural mortality, except for very old bears. Natural mortality exists, although it is difficult to quantify. Addition of conservative estimates of natural mortality to the model provides a more realistic maximum estimate of sustainable levels of mortality. When this is done, current harvests markedly exceed estimated sustainable levels in all categories (age classes). The sustainable harvest of 21 adult (>5 years old) females is 2.5 percent of the total population (age >2 years). The sustainable mortality rate was 2.2 percent for a stabilized harvest of females age >3 years when he computed values using methods comparable to those presented by Taylor et al. (1987).

3.2.5 Current Harvest Strategy and Allocation Of Harvestable Grizzly Bears Using A Point System Weighted By Bear Sex

Smith (pers. comm. 1989) manages for a total man-caused mortality of 2 percent of females and 6 percent of males in the annual kill. Smith (1989) has implemented a sex weighted point system to regulate grizzly bear harvest in outfitting areas in the Yukon Territory. The system was designed to achieve an optimal balance between high hunting flexibility for outfitters; a highly dispersed, sustainable harvest of bears; and, prevent the localized overharvest of females. The system is enforced through a system of compulsory submission of all male pelts for inspection and removal of bacula. Point values of 1 for males and 3 for females were used because this value difference related to the desired 6 percent male and 2 percent female harvest rates; 2) there was minimal risk of excessive harvests at each end of the harvest sex composition spectrum; 3) this value difference provided reasonable incentives to develop hunting strategies selective for males; and, outfitters could easily calculate their remaining points (Smith 1989).

"Three-year point totals were allocated to individual outfitting areas based on the amount of the estimated sustainable yield, by sex, remaining after allowing for anticipated resident sport kills and kills in defense of life and property. To disperse hunting, the 4 largest outfitting areas were each subdivided into 2 or 3 blocks with individual points allocated to each block. Outfitters could use points at any time during the 3-year period, points being deleted from their totals as bears were harvested, but faced a $5,000 penalty if they harvested grizzly bears when no points remained. They could exceed allotted point values by 2 if the last bear was a female. All grizzly bears taken by non-residents associated with an outfitting operation were included." (Smith 1989)

The system was implemented in consultation with individual outfitters. Additionally, hunting guides were provided with a brochure describing differences in morphology and behaviour of male and female grizzly bears (Smith 1989).

The point system is seen by big game outfitters as a major improvement from an earlier system of annual quotas, and, while short-term benefits to the harvest composition have not been observed, we believe that the long-term benefits are likely (Smith 1989). The point system will continue in the Yukon, but with greater emphasis on guide training. Outfitters receive a 3-year allocation where there are harvest concerns; a 5-year allocation will be used where there are no concerns (Smith 1989).

### 3.2.6 Harvest Strategy in Northern Continental Divide Ecosystem, Montana

Dood et al. (1986) recommended a maximum total man-caused mortality rate (known and unreported) of 6 percent for grizzly bears in the Northern Continental Divide Ecosystem in Montana, and suggested that a 4 percent level of harvest would allow for population growth.

### 3.2.7 Harvest Strategies in British Columbia

Tompa (1984) recommended that the annual man-caused mortality (legal plus wounding loss and illegal kills) should not exceed 5 percent under the most optimal conditions in British Columbia. R. Demarchi (1988 pers. comm.) indicated that an annual removal rate of 5 percent and harvest rate of 3 percent has lead to an increase in grizzly bear numbers in southeastern British Columbia. Further, R. Demarchi (1988 pers. comm.) and F. Harper (1987 pers. comm.) indicated that managers in British Columbia strive for a sex ratio of approximately 35 percent females to 65 percent males in their annual harvest.

### 3.2.8 Estimates of Allowable Man-caused Mortality for Northern Yukon Using LESMOD

The deterministic population projection computer program LESMOD (School of Forestry, University of Montana) was used: 1) to generate a population model with the same age structure, longevity, birth rates, sex ratios, and natural mortality rates as those observed for the Northern Yukon population (Nagy et al. 1983a); and 2) to apply different absolute and proportional harvest rates to the resulting model to estimate acceptable man-caused mortality rates harvest rates. Age-sex distributions, first ages of cub production, litter sizes, reproductive or birth intervals, sex ratios, and fecundity rates obtained for Northern Yukon grizzly bears during 1973-74 (Nagy et al. 1983a) were used as base line data to generate the model. Mean age specific instantaneous and finite mortality rates were derived from data presented by Nagy et al. (1983a). Because the population was unhunted, the data presented by Nagy et al. (1983a) should be considered representative of stable population at or near carrying capacity.

"LESMOD is a user-interactive system for projecting growth of a population using a modified "Leslie matrix" technique. The population is represented in subgroups by age and sex. Starting populations are specified for each subgroup. The population of an age/sex group for the next year is calculated from the population of the "one-year-younger" age group of the same sex from the previous year, adjusted for deaths and hunting. Deaths are specified by a death rate, which is calculated from a user-defined function of the previous years total population (population-dependent death rates). Hunting is specified by a number or proportion of additional deaths (or reduction of deaths). The populations of the age-zero groups (male and female newborns) are calculated from the previous years population of females in each age group, by applying a birth rate and a birth sex ratio parameter. The birth rate is calculated from a user-defined function of the previous years total population (population-dependent birth rates). A birth-sex ratio parameter is optionally different from 0.50, and is the same for all ages of mothers." (Metzgar user manual) All rate functions are calculated using a Modified Michaelis-Menton equation of the form: $Min + (Max-Min) * 1 - [V^x / (0.05P_{95}^x + V^x)]$ where, Min = the minimum value of the function is permitted, Max = maximum value the function is permitted, V = an independent variable (eg. death rate), x = an exponent controlling the shape of the function, and P = the value of V at which the function takes a value 95 percent of the distance between Min and Max (Harris *et al*. 1986).

Age-sex distributions, first ages of cub production, litter sizes, reproductive or birth intervals, sex ratios, and fecundity rates obtained for Northern Yukon grizzly bears during 1973-74 (Nagy *et al*. 1983a) were used as base line data to generate the model. Mean instantaneous mortality rates ($k_x$) weighted by $N_{x,t}$ were calculated by age class for males and females, where

$$k_x = \ln N_{(x+1,t+1)} - \ln N_{(x,t)} \text{ and}$$

$$\text{mean } k_x = (k_x * N_{x,t}) / N_{x,t}.$$

Mean finite age specific mortality rates ($q_x$) were then calculated for males and females, where

$$q_x = 1 - e_{kx}.$$

Age classes included cubs (<1 year), yearlings ($\geq$ 1 and <2 years), subadults ($\geq$2 and $\leq$4 years), and adults ($\geq$5 years). Mean age specific fecundity rates ($M_x$) were estimated based on known ages of first cub production, litter sizes, reproductive intervals, and sex ratios.

The youngest age of cub production was established at 5 years with maximum cub production occurring at 8 years when females reach physical maturity (Kingsley *et al*. 1983, Kingsley *et al*. 1988). Females were assumed to produce young till maximum age was attained (Pearson 1975, Nagy *et al*. 1983a, Nagy *et al*. 1983b), but their level of production was assumed to decline as they approached maximum longevity. Birth rates were not considered to be density dependent, however, survivorship of young till age $\leq$4 years was considered to be strongly density dependent. Litter size was not considered to be density dependent. The sex ratio of litters at birth in the model was assumed to be 50 males to 50 females. The sex ratio for grizzly bears captured bears in the Northern Yukon did not differ significantly from the theoretical 50:50 ratio of females to males (Nagy *et al*. 1983a).

The average observed age structures for males and females of the Northern Yukon population were used as the starting age structures during the modeling procedure. In the model bears were distributed over 24 age groups (ages 0 to 23). This was consistent with the maximum ages of male (25 years) and female (22 years) grizzly bears captured in Northern Yukon (Nagy *et al*. 1983a). A Qx schedule was estimated using values derived for Northern Yukon and supplemented with data from Tuktoyaktuk

Peninsula and Richards Island, Northwest Territories bears (Nagy et al. 1983b). Death rates were assumed to be density dependent for bears ≤4 years, to be constant till age 15 years, and to increase after that age till maximum age was attained. An iterative procedure was then used to develope the final population model. The initial estimated Qx schedule was modified until the model stabilized at carrying capacity (106 bears) and the resulting age structures and median ages of males and females did not deviate significantly ($P < 0.05$) from the average observed population. The age structures were compared using a Kolmogorov-Smirnov two sample test and the median ages using a Kruskal-Wallis test (Gibbons 1985). The population was projected over 100 years. The resulting model was used to estimate acceptable harvest rates.

Mean instantaneous and finite mortality rates by age class for males and females are given in Table 9. The mortality and fecundity rate schedules used to generate the stable population model are given in Tables 10, 11, 12, and 13. Approximate mortality rates with changing population size for male and female grizzly bear cubs, 1 and 3-year olds, 2-year olds, and 4-year olds are illustrated in Figures 5 and 6, respectively. Population size is scaled to carrying capacity (N/K).

A comparison of natural mortality rates presented by Reynolds and Hechtel (1986), Reynolds et al. (1987), and Reynolds and Hechtel (1988) suggests that natural mortality rates, particularly those for cubs, varied among years (Table 14). The large variation in cub mortality was considered to be a result of annual variations in food production. Ballard et al. (1988) reported natural mortality rates of 21 percent for cubs and 14 percent for yearlings in a harvested population in the Noatak River area, Alaska. Smith and Taylor (1987) assumed mortality rates of 15 percent for subadult males, 4 percent for subadult females, 3 percent for adult males, and 3 percent for adult females in population projection models for hunted populations in central Yukon (Table 14). The natural mortality rates of 2-3 and 4 percent used for prime age adult males (ages 8-18 years) and females (ages 5-15 years), respectively, in the final Northern Yukon grizzly bear model were nearly identical to those reported by Reynolds and Hechtel (1988) and assumed by Smith and Taylor (1987) for those classes of bears.

The age distribution by sex for the average known and generated stable population are given in Table 15. The CDF ($DN = 0.1978$; $P = 0.2471$) and median ages of males of the averaged observed (median age 10.5, $N = 51$) and modeled (median age 7.5, $N = 56$) populations did not differ significantly ($P>0.05$). However, males in the modeled population were generally younger than those in the average observed population. The CDF ($DN = 0.1982$; $P = 0.255$) and median ages for females of the average observed (median age 7.5, $N = 55$) and modeled (median age 6.5, N

= 50) populations did not differ significantly ($P>0.05$). The resulting population model simulated the age structure of females of the average observed population more closely than that of males.

The final population model was harvested. In the simulated hunts females with cubs, yearlings, and two year olds were protected from harvest. As a result, males were generally more vulnerable to harvest than females. Adult males were considered to be more vulnerable to harvest than subadult males because of size--hunters presumably select for large trophy bears. Age-sex specific harvest vulnerability ratios were estimated using data presented by Nagy et al. (1983b) (Table 16). The model was harvested using proportional and absolute grouped sex hunts. In proportional hunts a constant proportion of the standing population was removed annually, while in absolute hunts a constant number of bears were removed annually during 100 year simulation runs. Proportional hunts were run separately using annual harvest rates of 1 to 11 percent, while absolute hunts were run separately using annual removals of 1 to 11 bears.

The modeled population stabilized under absolute hunts when annual removals were $\leq$5 bears (Table 17). The population progressively declined from a starting population of 106 bears to 101 and 85 bears as annual removals increased from 1 to 5 bears, respectively, but stabilized within 40 years (Table 17). The population became extinct within 50 years when 6 bears were removed annually, with annual removals of >6 bears resulting in a shorter extinction time (Table 17).

The modeled population stabilized under proportional hunts when annual removal rates were $\leq$7 percent (Table 18). However, the residual population declined progressively from a starting number of 106 bears to 101 and 74 bears as annual harvest rates increased from 1 percent to the maximum allowable of 7 percent, respectively (Table 18). Harvest rates of >7 percent caused a continued decline in the population during the 100 year simulation period (Table 18).

A comparison of proportional and absolute hunts suggests that more conservative removal rates are required to maintain long term stability in bear populations if harvest quotas are established using percentage harvest rates. Bear managers generally establish harvest quotas by first deriving population estimates and then apply standard acceptable harvest rates (3 to 6 percent) to establish annual quotas. Once a harvest quota is established it could be maintained for an extended period of time. If an annual harvest quota was established for the modeled population using the same procedure the annual harvest quota would be 6 percent of 100 bears or 6 bears. At a 6 percent annual harvest the modeled population declined but stabilized at 84 within 30 years. However, when 6 bears were removed annually from the modelled population it became extinct in 37 years. This is because in the model the 6 percent annual harvest rate is applied to a declining standing population, not to the initial starting population. As a result the actual number of bears that can be taken annually declines with time because the allowable 6 percent harvest is applied to a declining standing population. This comparison further suggests that bear populations can be managed more effectively through the application of models based on absolute rather than proportional harvest rates.

The model simulated a spring harvest where females with cubs, yearlings, and subadult young ($\leq 2$ years) were protected from harvest. The analyses indicated that a maximum absolute annual removal of 5 bears from an initial starting population of 106 bears or an annual removal rate of 5 percent of the initial standing population (5 bears/106 bears = 4.7 percent) would result in long term population stability. Bears aged $\geq 3$ years were harvested in the model using an average vulnerability ratio of 2.9 to 1.0 for males and females, respectively. As a result, the ratio of males to females should be approximately 3 to 1, respectively, in an annual sustainable harvest.

Actual allowable harvest rates may be lower because LESMOD is a deterministic model. The program assumes that the productivity of females is constant from year to year. That is a mature female is assumed to produce 0.3 cubs every year. As a result, the model does not compensate for stochastic annual variations in cub production resulting from, for example, failures in berry crops or other food supplies. Stochastic models generally produce more conservative acceptable mortality rates (Metzgar pers. commun. 1990).

## 4.0 Estimates of Allowable Man-caused Mortality for Northern Yukon

Comparisons of acceptable harvest rates recommended by other authors and those derived using LESMOD suggest that the maximum allowable man-caused mortality rate should not exceed 7 percent of the standing population, although the most generally acceptable rate is approximately 4 percent. This rate should include harvest (known harvest and wounding losses) and non-harvest (problem wildlife, self-defence, and illegal kills) related mortalities. Tompa (1984) estimated that the actual kill was between <u>25-50</u> percent higher than the known kill because of wounding losses and illegal kills. Brannon <u>et</u> <u>al</u>. (1988) estimated unreported losses of around 2.9 percent based on rates of illegal deaths of radio collared bears in the Northern Continental Divide Ecosystem, Montana. In Alberta, non-harvest related mortalities averaged between 27 and 47 percent of the total known annual kill in most bear management areas during 1972-87 (Nagy and Gunson 1989). Although it is impossible to derive accurate estimates of wounding losses, the data provided by Nagy and Gunson (1989) suggests that significant levels of non-harvest mortality can occur and these should be compensated for when deriving harvest quotas. Non-harvest mortalities are probably low in Northern Yukon because much of the area is remote and unsettled. However, because it may be difficult to monitor non-harvest mortalities, a conservative maximum known man-caused mortality rate of 4 percent is recommended. The sex ratio should be 3 males to 1 female in the annual kill.

The annual allowable kill was estimated at 7 bears on Territorial lands (5.25 males and 1.75 females) and 6 bears in the Parks (4.5 males and 1.5 females) (Table 19). Assuming a conservative estimate of a 25 percent wounding loss, the maximum quota should be 5 bears (4 males and 1 female) on Territorial lands and 4 bears (3 males and 1 female) in the Parks. Those values are based on a maximum annual allowable kill of 4 percent of the estimated standing population, a wounding loss of 25 percent, and a kill comprised of 75 percent males and 25 percent females.

## 5.0 Current Status of the Northern Yukon Grizzly Bear Population

The total known man-caused mortality on Territorial and Park lands of 2 and 6 bears, respectively, during the period 1980-87 was less than the annual allowable kill of 5 and 4 bears, respectively, for those areas. The average annual kill during the period 1980-87 in adjacent areas in Alaska (east of Hula Hula River) was 1.75 bears (range 0-5) (summarized from data provided by H. Reynolds). The kill in Alaska was predominantly male (14 of 19 known sex kills, or 74 percent). Assuming that all mortalities have been recorded these data suggest that the grizzly bear populations in the IFA settlement area and, in general the Northern Yukon, are largely unexploited.

## 6.0 Management Areas

The grizzly bear populations could be managed within two general management zones, including the Parks and Territorial portions of the settlement area because of the relatively low estimated numbers of bears. However, harvest quotas should be established on a rotating basis within existing game management subzones to ensure a long term uniform distribution in the harvest of bears. This would prevent the depletion of bears within the most accessible areas of the settlement area, particularly in coastal regions and along the major river systems.

## 7.0 Recommendations for Monitoring and Regulating Annual Harvest

Known annual man-caused mortality, translocation, and personal or property damage complaint data should be reviewed annually, including:

1) a census program should be conducted to verify that the data presented by Nagy et al. (1983a) for the Barn and Buckland mountains are still valid, and verify estimates used in this paper for the Richardson and British mountains;

2) a standardized data collection system should be maintained to monitor harvest and non-harvest related man-caused mortalities (illegal, problem wildlife, self-defence) on Territorial and Parks lands to ensure that the annual number of man-caused mortalities do not exceed the allowable annual kill;

3) research directed at determining the relative availability and productivity of existing grizzly bear habitats should be conducted to provide a valid basis for comparing the productivity of habitats and grizzly bear populations in Northern Yukon with that of other regions;

4) all translocations of problem bears should be recorded and the data included in any evaluation of annual mortalities within each management area, i.e., a translocated bear should be considered as a mortality;

5) the types and geographic distribution of personal or property damage complaints should be recorded and reviewed annually to identify potential areas where bear-man conflicts could lead to non-harvest bear mortalities;

6) annual total known man-caused mortalities should be evaluated in the context of annual mortalities in adjacent areas in Yukon, Northwest Territories and Alaska, to identify potential population sinks that could detrimentally affect the population and allowable harvest in IFA;

7) the distribution of kill locations should be evaluated on an annual basis to ensure that bears (particularly adult females) are not depleted within localized area and to identify potential population sinks;

8) the age-sex structure of the kill should be monitored to ensure that the proportion of females in the annual and cumulative running total kill does not exceed 25 percent;

9) a sex-specific harvest strategy, such as that outlined by Smith (1989), should be developed and implemented in consultation with local outfitters or communities to ensure an equitable allocation of the grizzly bear resource and to minimize the risk of over harvest--particularly that of female grizzly bears; and,

10) educational programs directed at all land users (hunters, recreationists, etc.) should be developed and

implemented to reduce the potential for bear-man conflicts that result in bear mortalities.

LITERATURE CITED

Archibald, W.R. 1983. Problem analysis: grizzly bears and coastal development with particular reference to intensive forestry. B.C. Fish and Wildl. Branch, Victoria. Bull. No. B-26. 24pp.

Aune, K., T. Stivers, and M. Madel. 1984. Rocky Mountain Front grizzly bear monitoring and investigations. Mont. Dep. Fish, Wildl. and Parks, Helena. 239pp.

Ballard, W.B., S.D. Miller, and T.H. Spraker. 1982. Home range, daily movements, and reproductive biology of brown bear in southcentral Alaska. Can. Field-Nat. 96(1):1-5.

Ballard, W.B., K.E. Roney, D.N. Larsen, and L.A. Ayres. 1988. Demography of Noatak grizzly bears in relation to human exploitation and mining development. Alaska Dep. Fish and Game. Fed. Aid Wildl. Restoration. Proj. W-22-5 and W-22-6. Job 4.20. 100pp.

Beecham, J. 1980. Some population characteristics of two black bear populations in Idaho. Inter. Conf. Bear Res. and Manage. 4:201-204.

Craighead, F.C., Jr. 1976. Grizzly bear ranges and movement as determined by radio tracking. Int. Conf. Bear Res. and Manage. 3:97-109.

Craighead, J.J. and F.C. Craighead, Jr. 1967. Management of grizzly bears in Yellowstone National Park. 118 pp.

Craighead, F.C. and J.J. Craighead. 1972. Data on grizzly bear denning activities and behavior obtained by using wildlife telemetry. Int. Conf. Bear Res. and Manage. 2:84-106.

Craighead, J.J., F.C. Craighead, Jr., and J. Sumner. 1976. Reproductive cycles and rates in the grizzly bear, Ursus arctos horribilis, of the Yellowstone ecosystem. Inter. Conf. Bear Res. and Manage. 3:337-356.

Craighead, J.J., M.G. Hornocker, and F.C. Craighead, Jr. 1969. Reproductive biology of young female grizzly bears. J. of Reprod. Fert. 6:447-475.

Craighead, J.J. and J.A. Mitchell. 1982. Grizzly bears (Ursus arctos). PP. 515-556 In: J.A. Chapman and G.A. Feldhamer, eds. Wild Mammals of North America: Biology Management, Economics. Hopkins, Baltimore, MD.

Crook, J.L. 1971. Determination of abundance and distribution of brown bear (Ursus arctos) north of the Brooks Range, Alaska.

M.S. Thesis, Univ. Alaska, Fairbanks. 78pp.

Curatolo, J.A. and G.D. Moore. 1975. Home range and population dynamics of grizzly bear in the eastern Brooks Range, Alaska. Chapter 1, 79pp. IN: R.D. Jakimchuk, Ed. Studies of large mammals along the proposed Mackenzie Valley gas pipeline route from Alaska to British Columbia. Arctic Gas Biol. Rep. Ser. Vol. 32.

Dood, A.R., R.D. Brannon, and R.D. Mace. 1986. Final programmatic environmental impact statement: the grizzly bear in northwestern Montana. Mont. Dep. Fish. Wildl. and Parks, Helena. 287pp.

Eberhardt, L.L., R.R. Knight, and B.M. Blanchard. 1986. Monitoring grizzly bear population trends. J. Wildl. Manage. 50(4):613-618.

Fowler, C.W., W.T. Bunderson, M.B. Cherry, R.J. Ryer, and B.B. Steele. 1980. Comparative population dynamics of large mammals: a search for management criteria. Final rep. to U.S. Marine Mammal Commission, Washington, D.C. PB80-178627. 230pp.

Gibbons, J.D. 1985. Nonparametric methods for quantitative analysis. (second ed.). Am. Sci. Press, Inc. Columbus, Ohio. 491pp.

Glenn, L.P., J.W. Lentfer, J.B. Faro, and L.H. Miller. 1976. Reproductive biology of female brown bears, Ursus arctos, McNeil River, Alaska. Inter. Conf. Bear Res. and Manage. 3:381-390.

Hadden, D.A., W.J. Hann, and C.J. Jonkel. 1986. An ecological taxonomy for evaluating grizzly bear habitat in the Whitefish Range of Montana. PP 67-77 IN: G.P. Contreras and K.E. Evans, eds. Proceedings--Grizzly bear habitat symposium. U.S.D.A., Forest Serv. Intermountain Res. Stat., Ogden, Utah. Gen. Tech. Rep. Int-207.

Hamer, D., and S. Herrero, eds 1983. Ecological studies of the grizzly bear in Banff National Park. Final Rep. Prep. for Parks Canada. Contract WR 4-80. Univ. of Calgary, Alta. 303pp.

Hamer, D. and S. Herrero. 1988. Grizzly bear food and habitat in the front ranges of Banff National Park. Final Rep. Prep. for Parks Canada. Contract WR 149-83. By Univ. Calgary, Alberta. 163pp.

Hamer, D., S. Herrero, R.T. Ogilvie, and T. Toth. 1979. Ecological studies of the Banff National Park grizzly bear, Cascade/Panther region 1978. Year 3. Preliminary Rep. Prep. for Parks Canada. Contract WR 96-78. Prep. by Univ. Calgary, Alberta. 86pp.

Hamilton, A.N. and W.R. Archibald. 1986. Grizzly bear habitat in the Kimsquit River valley, coastal British Columbia: evaluation. Pp 50-57 IN: G.P Contreras and K.E. Evans, eds. Proceedings--Grizzly bears habitat symposium. U.S.D.A., Forest Serv. Intermountain Res. Stat., Ogden, Utah. Gen Tech. Rep. Int-207.

Harris, R.B., L.H. Metzar, and C.D. Bevins. 1986. GAPPS users manual. Montana Cooperative Wildlife Research Unit, University of Montana. 123 pp.

Hechtel, J. 1978. Behavioral ecology of a barren-ground grizzly bear female and her young in the National Petroleum Reserve - Alaska. Preliminary Rep. Mont. Coop. Wildl. Res. Unit, Univ. Mont., Missoula. 11pp.

Hensel, R.J., W.a. Troyer, and A.W. Erickson. 1969. Reproduction in the female brown bear. J. Wildl. Manage. 33(2):357-365.

Interagency Grizzly Bear Committee (IGBC). 1987. Grizzly bear compendium. Natl. Wildl. Fed., Washington D.C. 540pp.

Johnston, W.G., J.A. Staniforth, and C.A. McEwen. 1985. A review of northern grizzly bear ecology and habitat mapping techniques. Northern Biomes Ltd. 82pp + App.

Kingsley, M.C.S., J.A. Nagy, and H.V. Reynolds. 1988. Growth in length and weight of northern brown bears: differences between sexes and population. Can. J. Zool. 66: 981-986.

Kingsley, M.C.S., J.A. Nagy, and R.H. Russell. 1983. Patterns of weight gain and loss for grizzly bears in northern Canada. Inter. Conf. Bear Res. and Manage. 5:174-178.

Knight, R.R., D. Mattson, and B. Blanchard. 1984. Movements and habitat use of the Yellowstone grizzly bear. U.S.Dep. Inter. Interagency Study Team, Bozeman, Mont. 177pp.

LeCount, J.S. 1982. An analysis of the black bear harvest in Arizona (1968-78). Arizona Game and Fish Dep., Fed. Aid in Wildl. Restor. Proj. W-78-R. 42pp.

Linderman, S. 1974. Ground tracking of arctic grizzly bears. Fed. Aid Wildl. Rest. Proj. W-17-6, Job 4.12R. Final Rep., July 1, 1973-June 30, 1974. Alaska Dep. Fish and Game, Juneau. 23pp.

Lortie, G.M. 1978. The quota - a new management system for Yukon grizzly bear. Pres. to Yukon Outfitters Assoc., 22 April 1978. Prep. by Yukon Territorial Gov. Wildl. Branch, Whitehorse. 14pp.

Marcum, C.L. and D.O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44:963:968.

Martinka, C.J. 1970. Grizzly bear ecology studies, Glacier National Park. Prog. Rep. 1969, U.S.D.I., Natl. Park Serv., Glacier Natl. Park, Mont. 43pp.

Martinka, C.J. 1974. Population characteristics of grizzly bears in Glacier National Park, Montana. J. Mammal. 55(1):21-29.

Matchett, M.R. 1985. Moose-habitat relationships in the Yaak River drainage, Northwestern Montana. M.Sc. Thesis, Univ. Mont., Missoula. 229pp.

McLellan, B.N. 1981. Akamina-Kshinena grizzly project, progress report, 1980 (year two ). B.C. Fish and Wildl. Branch, Victoria. 88pp.

McLellan, B.N. 1984. Population parameters of the Flathead grizzlies. B.C. Fish and Wildl. Branch, Victoria. 28pp.

Miller, S.D. 1988. Impacts of increased hunting pressure on the density, structure, and dynamics of brown bear populations in Alaska's Management Unit 13. Fed. Aid. Wildl. Restoration. Project W-22-6. Job 4.21. Alaska Dep. Fish and Game, Juneau, 151pp.

Miller, S.D. and W.B. Ballard. 1982. Density and biomass estimates for an interior Alaskan brown bear, Ursus arctos, population. Can. Field-Nat. 96(4): 448-454.

Miller, S, E.F. Becker, and W.B. Ballard. 1987. Density estimates using modified capture-recapture techniques for black and brown bear populations in Alaska. Int. Conf. Bear Res. and Manage. 7:23-36.

Miller, S. and D.C. McAllister. 1982. Big game studies. Vol VI. Black Bear and Brown Bear. Final Phase I Report. Susitna Hydroelectric Project. Alaska Dep. Fish and Game, Anchorage. 233pp.

Miller, S.J., N. Barichello, and D. Tait. 1982. The grizzly bears of the Mackenzie Mountains Northwest Territories. N.W.T. Wildl. Serv. Completion Rept. No. 3. 118pp.

Mohr, C.D. 1947. Table of equivalent populations of North American small mammals. Am Midl. Nat. 37: 223-249.

Mundy, S.J. and D.R. Flook. 1973. Background for managing grizzly bears in the national parks of Canada. Can. Wildl. Serv. Rept. series No. 22. 35pp.

Nagy, J.A. 1988. Proposed methods of mapping habitats and determining grizzly bear habitat use in the Firth River Corridor, Northern Yukon National Park. Prep. for Environ. Canada, Parks. Prairie and Northern Region. 58pp.

Nagy, J.A. and J.R. Gunson. 1989. Management plan for grizzly bears in Alberta. Discussion Draft. Alta. Forestry, Lands and Wildl. Fish and Wildl. Div. 167pp.

Nagy, J.A. and M.A. Haroldson. In press. Comparisons of some home range and population parameters among four grizzly populations in Canada. Int. Conf. Bear Res. and Manage. 8:000-000.

Nagy, J.A., and R.H. Russell. 1978. Ecological studies of the boreal forest grizzly bear (Ursus arctos L.) - annual report for 1977. Can. Wildl. Serv., Edmonton. 72pp.

Nagy, J.A., A.W.L. Hawley, and M.W. Barrett. 1988. Characteristics of grizzly bear home ranges in west-central Alberta. Draft Report. Alta. Environment Centre, Vegreville, Alberta. 20pp.

Nagy, J.A., A.W.L. Hawley, M.W. Barrett, and J.W. Nolan. 1989. Population characteristics of grizzly and black bears in west-central Alberta. Alta. Environment Centre, Vegreville, AB. AECV88-R1. 33pp.

Nagy, J.A., R.H. Russell, A.M. Pearson, M.C. Kingsley, and B.C. Goski. 1983a. Ecological studies of the grizzly bear in the arctic mountains, Northern Yukon Territory, 1972 to 1975. Can. Wildl. Serv. Rep. 104pp.

Nagy, J.A., R.H. Russell, A.M. Pearson, M.C. Kingsley, and C.B. Larsen. 1983b. A study of grizzly bears on the barren grounds of Tuktoyaktuk Peninsula and Richards Island, Northwest Territories, 1974 to 1978. Can. Wildl. Serv. Rep. 136pp.

Nelson, R.A., E.G. Folk jr., E.W. Pfeiffer, J.J. Craighead, C.J. Jonkel, and D.L. Steiger. 1983. Behavior, biochemistry, and hibernation in black, grizzly, and polar bears. Int. Conf. Bear Res. and Manage. 5:284-290.

Pearson, A.M. 1975. The northern interior grizzly bear (Ursus arctos L.) Can. Wildl. Serv. Rep. Ser. No. 34, Ottawa. 86pp.

Pearson, A.M. 1976. Population characteristics of the Arctic mountain grizzly bear. Inter. Conf. Bear Res. and Manage. 3:247-260.

Pearson, A.M. 1977. Habitat, management and the future of Canada´s grizzly bears. Pages. 33-40 in T. Mosquin and C Suchal, ed. Proc. Symp. Canada´s threatened species and habitats. Canadian Nature Federation and World Wildlife Fund.

Reynolds, H.V. 1975. Big game investigations. Movements and population discreetness of north slope grizzly bears. Comparison of censusing techniques of north slope grizzly bears. Food habits of north slope grizzly bears. Fed. Aid Wildl. Restoration Proj. W-17-6, Job Nos. 4.8R, 4.10R, and 4.11R. Job Prog. Rep., July 1, 1973-June 30, 1974. Alaska Dep Fish and Game, Juneau. 26pp.

Reynolds, H.V. 1976. North slope grizzly bear studies. Alas. Dep. of Fish and Game, Juneau. 20pp.

Reynolds, H.V. 1980. North slope grizzly bear studies. Alaska Dept. of Fish and Game, Juneau, Alaska. 20pp.

Reynolds, H.V. and J.L. Hechtel. 1980. Big game investigations. Structure, status, reproductive biology, movements, distribution, and habitat utilization of a grizzly bear population. Fed. Aid Wildl. Restoration. Proj. W-17-11, Job 4.14r. Job Prog. Rep., 1 July, 1978-20 June 1979. Alas. Dep. Fish and Game, Juneau. 66pp.

Reynolds, H.V. and J.L. Hechtel. 1986. Population structure, reproductive biology, and movement patterns of grizzly bears in the Northcentral Alaska Range. Final Rep. Fed. Aid Wildl. Restoration. Proj. W-21-2, W-22-2, W-22-3, and W-22-4. Job 4.16R. Alaska Dep. Fish and Game, Juneau. 53pp.

Reynolds, H.V. and J.L. Hechtel. 1988. Population Dynamics of a hunted grizzly bear population in the Northcentral Alaska Range. Fed. Aid. Wildl. Restoration. Proj. W-22-6, Job 4.19. Job Prog. Rep. June 1988. Alas. Dept. of Fish and Game Div. of Game. 52pp.

Reynolds, H.V, J.L. Hechtel, and D.J. Reed. 1987. Population dynamics of a hunted grizzly bear population in the Northcentral Alaska Range. Fed. Aid Wildl. Restoration. Proj. W-22-5. Job 4.19R. Alas. Dept. of Fish and Game Div. of Game. 59pp.

Rogers, L.L. 1976. Effects of mast and berry crop failures on survival, growth and reproductive success for black bears. Proc. North Am. Wildl. and Nat. Resour. Conf. 41:431-438.

Russell, R.H., J.W. Nolan, N.G. Woody, and G. Anderson. 1979. A study of the grizzly bear (Ursus arctos L.) in Jasper National Park, 1975-78 final report. Can. Wildl. Serv. Edmonton. 136pp.

Sidorowicz, G.A. and F.F. Gilbert. 1981. The management of grizzly bears in the Yukon, Canada. Wildl. Soc. Bull. 9(2):125-135.

Slade, N.A., and R.K. Swihart. 1983. Home range indices for the hispid cotton rat (Sigmondon hispidus) in northeastern Kansas. J. Mammal. 64:580-590.

Smith, B.L. 1989. Sex weighted point system regulates grizzly bear harvest, 1985 to 1988. Yukon Renewable Resources. Final Report. 26pp.

Smith, B.L. and M.K. Taylor. 1987. Notes regarding population projections for central Yukon grizzly bears using ANURSUS. Unpubl. Rep.

Taylor, M.K., D.P. DeMaster, F.L. Bunnell, and R.E. Schweinsburg. 1987. Modeling the sustainable harvest of female polar bears. J. Wildl. Manage. 51(4):811-820.

Tompa, F.S. 1984. Grizzly bears in British Columbia--harvest must be reduced. Pres. at Annu. Conf. West. Assoc. Fish and Wildl. Agencies. July 1984, Victoria, B.C. 9pp.

Urquhart, D.R. 1983. The status and life history of the Porcupine caribou herd. Dep. Renewable Resour., Yukon Territ. 78pp.

Watson, G.H., W.H. Prescott, E.A. DeBock, J.W. Nolan, M.C. Dennington, H,J, Poston, and I.G. Stirling. 1973. An inventory of wildlife habitat of the Mackenzie Valley and the Northern Yukon. Rep. prepared by Can. Wildl. Serv., Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development Rep. No. 73-27:157pp.

Wiken, E.B., D.M. Welch, G.R. Ironside, and D.G. Taylor. 1981. The Northern Yukon: an ecological land survey. Lands Directorate, Ecological Land Classification Series, No. 6. 197pp + Map.

Young, B.F., and R.L. Ruff. 1982. Population dynamics and movements of black bears in east central Alberta. J. Wildl. Manage. 46(4):845-860.

Zunnino, F. and S. Herrero. 1972. The status of the brown bear (Ursus arctos) in Abruzzo National Park, Italy, 1971. Bio. Conserv. 4(4):263-272.

Table 1. Age and sex structure of grizzly bears in Northern Yukon during 1973 and 1974 and averaged over the period 1973-74.

| | 1973 | | | | 1974 | | | | AVERAGE 1973-74 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE CLASS | M | F | U | TOTAL | M | F | U | TOTAL | M | F | TOTAL |
| 0.5 | 0 | 1 | 3 | 4 | 0 | 0 | 17 | 17 | 5 | 6 | 11 |
| 1.5 | 3 | 7 | 4 | 14 | 0 | 0 | 3 | 3 | 3 | 5 | 9 |
| 2.5 | 2 | 1 | 0 | 3 | 3 | 7 | 4 | 14 | 4 | 5 | 9 |
| 3.5 | 0 | 2 | 0 | 2 | 2 | 1 | 0 | 3 | 1 | 2 | 3 |
| 4.5 | 3 | 3 | 0 | 6 | 0 | 2 | 0 | 2 | 2 | 3 | 4 |
| 5.5 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 6 | 2 | 2 | 3 |
| 6.5 | 4 | 4 | 0 | 8 | 0 | 0 | 0 | 0 | 2 | 2 | 4 |
| 7.5 | 3 | 3 | 0 | 6 | 3 | 4 | 0 | 7 | 3 | 4 | 7 |
| 8.5 | 0 | 1 | 0 | 1 | 3 | 3 | 0 | 6 | 2 | 2 | 4 |
| 9.5 | 2 | 3 | 0 | 5 | 0 | 1 | 0 | 1 | 1 | 2 | 3 |
| 10.5 | 1 | 1 | 0 | 2 | 2 | 3 | 0 | 5 | 2 | 2 | 4 |
| 11.5 | 3 | 3 | 0 | 6 | 1 | 1 | 0 | 2 | 2 | 2 | 4 |
| 12.5 | 2 | 2 | 0 | 4 | 3 | 3 | 0 | 6 | 3 | 3 | 5 |
| 13.5 | 3 | 3 | 0 | 6 | 2 | 2 | 0 | 4 | 3 | 3 | 5 |
| 14.5 | 1 | 2 | 0 | 3 | 3 | 3 | 0 | 6 | 2 | 3 | 5 |
| 15.5 | 2 | 1 | 0 | 3 | 1 | 2 | 0 | 3 | 2 | 2 | 3 |
| 16.5 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 3 | 2 | 1 | 2 |
| 17.5 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 1 | 2 |
| 18.5 | 3 | 1 | 0 | 4 | 1 | 1 | 0 | 2 | 2 | 1 | 3 |
| 19.5 | 1 | 0 | 0 | 1 | 3 | 1 | 0 | 4 | 2 | 1 | 3 |
| 20.5 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 21.5 | 1 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 1 | 2 |
| 22.5 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 1 | 1 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 25.5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| TOTAL | 37 | 41 | 7 | 85 | 36 | 40 | 24 | 100 | 44 | 48 | 93 |

M = males; F = female; U = unknown sex

Table 2. Reproductive history of female grizzly bears handled in Northern Yukon, 1972-74.

| Age In Years | Bear Identification by Year of Capture | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | W-R 1973 | W-W 1973 | G-R 1973 | O-LB 1973 | G-P 1973 | R-G 1973 | R-LB 1973 | R-P 1973 | L-P 1973 |
| 0.5 | - | - | - | - | - | - | - | - | - |
| 1.5 | - | - | - | - | - | - | - | - | - |
| 2.5 | - | - | - | - | - | - | - | - | - |
| 3.5 | - | - | - | - | - | - | - | - | - |
| 4.5 | C-WF | - | - | - | - | - | - | - | - |
| 5.5 | C-N | MS | - | - | - | - | - | - | - |
| 6.5 | - | WC | - | - | - | - | C-N | - | - |
| 7.5 | - | W1Y | C-IE | MS | - | C-IE | C-IE | - | - |
| 8.5 | - | W2Y | C-IE | WC | - | C-IE | - | - | - |
| 9.5 | - | W3Y | - | C-WY-1 | MS | - | - | - | - |
| 10.5 | - | C-S4Y-1 | - | NO | WC | - | - | - | - |
| 11.5 | - | O-WC-2 | - | - | WY | - | - | - | - |
| 12.5 | - | - | - | - | W2Y | - | - | C-IE | - |
| 13.5 | - | - | - | - | C-S3Y-1 | - | - | NO | - |
| 14.5 | - | - | - | - | NO | - | - | - | C-IE |
| 15.5 | - | - | - | - | - | - | - | - | O-IE |
| 16.5 | - | - | - | - | - | - | - | - | - |

| | | | |
|---|---|---|---|
| C | Captured | O | Observed |
| WC | With cubs of year | NO | Not observed |
| WY | With yearling young | MS | Mated successfully |
| W2Y | With two year old young | IE | In estrus |
| W3Y | With three year old young | N | Not in estrus |
| W4Y | With four year old young | WF | With maternal female |
| S2Y | Weaned 2 year old young | | |
| S3Y | Weaned 3 year old young | | |
| S4Y | Weaned 4 year old young | | |

The number of young known to accompany each female is given at the end of the notation. Litter sizes were given only for years when a female was observed. If a female was first observed with 2 yearling young, I did not assume that she had 2 cubs the previous year. As we did not observe mortalities among litter mates, the data reported here can be used as the litter sizes for all females on 1 July.

Table 2. Reproductive history of female grizzly bears handled in Northern Yukon, 1972-74. Continued.

| | Bear Identification by Year of Capture | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age in Years | G-B 1973 | LB-G 1973 | Y-R 1973 | W-Y 1973 | L-G 1973 | Y-P 1973 | R-O 1973 | P-O 1973 | G-G 1973 |
| 0.5 | - | - | - | - | - | - | - | - | - |
| 1.5 | - | - | - | - | - | - | - | - | - |
| 2.5 | - | - | - | - | - | - | - | - | - |
| 3.5 | C-N | - | - | - | - | - | - | - | - |
| 4.5 | NO | - | - | - | C-N | - | - | - | - |
| 5.5 | - | - | - | - | NO | - | - | - | - |
| 6.5 | - | - | - | - | - | - | - | - | - |
| 7.5 | - | - | - | - | - | - | - | - | - |
| 8.5 | - | - | - | - | - | - | - | - | - |
| 9.5 | - | - | - | - | - | C-N | - | - | - |
| 10.5 | - | - | - | - | - | NO | - | - | - |
| 11.5 | - | - | - | MS | - | - | - | - | - |
| 12.5 | - | - | - | WC | - | - | C-MS | - | - |
| 13.5 | - | C-IE | MS | C-WY-2 | - | - | O-WC-3 | - | - |
| 14.5 | - | NO | WC | C-S2Y-2 | - | - | - | - | - |
| 15.5 | - | - | C-WY-2 | - | - | - | - | - | - |
| 16.5 | - | - | C-S2Y-2 | - | - | - | - | - | - |
| 17.5 | - | - | - | - | - | - | - | - | C-N |
| 18.5 | - | - | - | - | - | - | - | - | O-N |
| 19.5 | - | - | - | - | - | - | - | - | - |
| 20.5 | - | - | - | - | - | - | - | MS | - |
| 21.5 | - | - | - | - | - | - | - | C-WC-1 | - |
| 22.5 | - | - | - | - | - | - | - | NO | - |

| | | | |
|---|---|---|---|
| C | Captured | O | Observed |
| WC | With cubs of year | NO | Not observed |
| WY | With yearling young | MS | Mated successfully |
| W2Y | With two year old young | IE | In estrus |
| W3Y | With three year old young | N | Not in estrus |
| W4Y | With four year old young | | |
| S2Y | Weaned 2 year old young | | |
| S3Y | Weaned 3 year old young | | |
| S4Y | Weaned 4 year old young | | |

The number of young known to accompany each female is given at the end of the notation. Litter sizes were given only for years when a female was observed. If a female was first observed with 2 yearling young, I did not assume that she had 2 cubs the previous year. As we did not observe mortalities among litter mates, the data reported here can be used as the litter sizes for all females on 1 July.

Table 2. Reproductive history of female grizzly bears handled in Northern Yukon, 1972-74. Continued.

| Bear Identification by Year of Capture | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age In Years | G-W 1973 | G-O 1973 | R-L 1973 | R-R 1973 | B-R 1973 | W-O 1973 | L-L 1973 | L-Y 1973 | B-B 1973 |
| 0.5 | - | - | - | - | - | - | - | - | - |
| 1.5 | - | - | - | - | - | - | - | - | - |
| 2.5 | - | - | - | - | - | - | - | - | - |
| 3.5 | - | - | - | - | - | - | - | - | - |
| 4.5 | - | - | - | - | - | - | - | - | - |
| 5.5 | - | - | - | - | - | - | - | - | - |
| 6.5 | - | - | - | - | - | - | MS | - | - |
| 7.5 | - | - | - | - | C-N | C-IE | WC | - | C-IE |
| 8.5 | - | - | - | - | C-IE | - | C-W2Y-2 | - | - |
| 9.5 | - | C-N | - | - | - | - | - | MS | - |
| 10.5 | - | C-IE | - | - | - | - | - | WC | - |
| 11.5 | C-MS | - | - | - | - | - | - | WY | - |
| 12.5 | C-WC-2 | - | - | - | - | - | - | C-S2Y-2 | - |
| 13.5 | - | - | - | - | - | - | - | - | - |
| 14.5 | - | - | - | - | - | - | - | - | - |
| 15.5 | - | - | - | - | - | - | - | - | - |
| 16.5 | - | - | - | - | - | - | - | - | - |
| 17.5 | - | - | - | - | - | - | - | - | - |
| 18.5 | - | - | C-MS | - | - | - | - | - | - |
| 19.5 | - | - | O-WC-2 | - | - | - | - | - | - |
| 20.5 | - | - | - | C-MS | - | - | - | - | - |
| 21.5 | - | - | - | O-WC-2 | - | - | - | - | - |
| 22.5 | - | - | - | - | - | - | - | - | - |

| | | | |
|---|---|---|---|
| C | Captured | O | Observed |
| WC | With cubs of year | NO | Not observed |
| WY | With yearling young | MS | Mated successfully |
| W2Y | With two year old young | IE | In estrus |
| W3Y | With three year old young | N | Not in estrus |
| W4Y | With four year old young | | |
| S2Y | Weaned 2 year old young | | |
| S3Y | Weaned 3 year old young | | |
| S4Y | Weaned 4 year old young | | |

The number of young known to accompany each female is given at the end of the notation. Litter sizes were given only for years when a female was observed. If a female was first observed with 2 yearling young, I did not assume that she had 2 cubs the previous year. As we did not observe mortalities among litter mates, the data reported here can be used as the litter sizes for all females on 1 July.

Table 2. Reproductive history of female grizzly bears handled in Northern Yukon, 1972-74. Continued.

| Bear Identification by Year of Capture | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age in Years | P-P 1973 | P-L 1973 | Y-L 1973 | LB-W 1973 | G-LB 1973 | O-W 1973 | Y335 1973 | L-W 1973 |
| 0.5 | - | - | - | - | - | - | - | - |
| 1.5 | - | - | - | - | - | - | - | - |
| 2.5 | - | - | C-N | - | - | C-N | - | - |
| 3.5 | - | C-N | - | - | - | - | - | C-N |
| 4.5 | - | - | - | - | C-N | - | - | C-N |
| 5.5 | - | - | - | - | - | - | - | - |
| 6.5 | - | - | - | - | - | - | - | - |
| 7.5 | - | - | - | - | - | - | C-N | - |
| 8.5 | - | - | - | - | - | - | - | - |
| 9.5 | - | - | - | MS | - | - | - | - |
| 10.5 | - | - | - | WC | - | - | - | - |
| 11.5 | - | - | - | WY | - | - | - | - |
| 12.5 | - | - | - | C-W2Y-3 | - | - | - | - |
| 13.5 | MS | - | - | - | - | - | - | - |
| 14.5 | WC | - | - | - | - | - | - | - |
| 15.5 | C-WY-3 | - | - | - | - | - | - | - |

C Captured
WC With cubs of year
WY With yearling young
W2Y With two year old young
W3Y With three year old young
W4Y With four year old young
S2Y Weaned 2 year old young
S3Y Weaned 3 year old young
S4Y Weaned 4 year old young

O Observed
NO Not observed
MS Mated successfully
IE In estrus
N Not in estrus

The number of young known to accompany each female is given at the end of the notation. Litter sizes were given only for years when a female was observed. If a female was first observed with 2 yearling young, I did not assume that she had 2 cubs the previous year. As we did not observe mortalities among litter mates, the data reported here can be used as the litter sizes for all females on 1 July.

Table 3. Comparison of the distribution by elevation class and month of male and female grizzly bears in Northern Yukon 1973-74.

| PERIOD OF COMPARISON | ELEVATION CLASS (FEET) | DISTRIBUTION MALES | OBSERVED DISTRIBUTION FEMALES | EXPECTED DISTRIBUTION FEMALES | OBSERVED MINUS EXPECTED | P VALUE |
|---|---|---|---|---|---|---|
| ANNUAL | | | | | | |
| | 0-1500 | 96 | 74 | 123 | -49 | |
| | >1500 | 44 | 105 | 56.3 | 48.7 | $P < 0.05$ |
| MAY | | | | | | |
| | 0-1500 | 20 | 17 | 27.7 | -11 | |
| | >1500 | 11 | 26 | 15.3 | 10.7 | $P < 0.05$ |
| JUNE | | | | | | |
| | 0-1500 | 19 | 9 | 14 | -5 | |
| | >1500 | 4 | 8 | 2.96 | 5.04 | $P < 0.05$ |
| JULY | | | | | | |
| | 0-1500 | 22 | 16 | 26.3 | -10 | |
| | >1500 | 9 | 21 | 10.7 | 10.3 | $P < 0.05$ |
| AUGUST | | | | | | |
| | 0-1500 | 10 | 10 | 14.7 | -4.7 | |
| | >1500 | 7 | 15 | 10.3 | 4.71 | N.S.D |
| SEPTEMBER | | | | | | |
| | 0-1500 | 20 | 20 | 30.9 | -11 | |
| | >1500 | 13 | 31 | 20.1 | 10.9 | $P < 0.05$ |

Table 4. Comparison of use and availability of elevational classes by month for female grizzly bears in Northern Yukon 1973-74.

| PERIOD OF COMPARISON | ELEVATION CLASS (FEET) | RANDOM DISTRIBUTION | OBSERVED DISTRIBUTION FEMALES | EXPECTED DISTRIBUTION FEMALES | OBSERVED MINUS EXPECTED | P VALUE |
|---|---|---|---|---|---|---|
| ANNUAL | | | | | | |
| | 0-1500 | 877 | 74 | 122 | -48 | |
| | >1500 | 408 | 105 | 56.8 | 48.2 | $P < 0.05$ |
| MAY | | | | | | |
| | 0-1500 | 877 | 17 | 29.3 | -12 | |
| | >1500 | 408 | 26 | 13.7 | 12.3 | $P < 0.05$ |
| JUNE | | | | | | |
| | 0-1500 | 877 | 9 | 11.6 | -2.6 | |
| | >1500 | 408 | 8 | 5.4 | 2.6 | N.S.D |
| JULY | | | | | | |
| | 0-1500 | 877 | 16 | 25.3 | -9.3 | |
| | >1500 | 408 | 21 | 11.7 | 9.25 | $P < 0.05$ |
| AUGUST | | | | | | |
| | 0-1500 | 877 | 10 | 17.1 | -7.1 | |
| | >1500 | 408 | 15 | 7.94 | 7.06 | $P < 0.05$ |
| SEPTEMBER | | | | | | |
| | 0-1500 | 877 | 20 | 34.8 | -15 | |
| | >1500 | 408 | 31 | 16.2 | 14.8 | $P < 0.05$ |

Table 5. Comparison of use and availability of elevational classes by month for male grizzly bears in Northern Yukon 1973-74.

| PERIOD OF COMPARISON | ELEVATION CLASS (FEET) | RANDOM DISTRIBUTION | OBSERVED DISTRIBUTION MALES | EXPECTED DISTRIBUTION MALES | OBSERVED MINUS EXPECTED | P VALUE |
|---|---|---|---|---|---|---|
| ANNUAL | | | | | | |
| | 0-1500 | 877 | 96 | 95.5 | 0.45 | |
| | >1500 | 408 | 44 | 44.5 | -0.05 | N.S.D |
| MAY | | | | | | |
| | 0-1500 | 877 | 20 | 21.2 | -1.2 | |
| | >1500 | 408 | 11 | 9.84 | 1.16 | N.S.D |
| JUNE | | | | | | |
| | 0-1500 | 877 | 19 | 15.7 | 3.3 | |
| | >1500 | 408 | 4 | 7.3 | -3.3 | N.S.D |
| JULY | | | | | | |
| | 0-1500 | 877 | 22 | 21.2 | 0.84 | |
| | >1500 | 408 | 9 | 9.84 | -0.8 | N.S.D |
| AUGUST | | | | | | |
| | 0-1500 | 877 | 10 | 11.6 | -1.6 | |
| | >1500 | 408 | 7 | 5.4 | 1.6 | N.S.D |
| SEPTEMBER | | | | | | |
| | 0-1500 | 877 | 20 | 22.5 | -2.5 | |
| | >1500 | 408 | 13 | 10.5 | 2.52 | N.S.D |

Table 6. Comparison of elevational classes used during the spring and fall hunting season by female and male grizzly bears in Northern Yukon 1973-74.

| COMPARISON | ELEVATION CLASS (FEET) | DISTRIBUTION SPRING HUNT | OBSERVED DISTRIBUTION FALL HUNT | EXPECTED DISTRIBUTION FALL HUNT | OBSERVED MINUS EXPECTED | P VALUE |
|---|---|---|---|---|---|---|
| FEMALES: | | | | | | |
| | 0-1500 | 23 | 32 | 34.3 | -2.3 | |
| | >1500 | 32 | 50 | 47.7 | 2.29 | N.S.D. |
| MALES: | | | | | | |
| | 0-1500 | 35 | 35 | 39.3 | -4.3 | |
| | >1500 | 14 | 20 | 15.7 | 4.29 | N.S.D. |

Table 7. Comparison of elevational classes used by female and male grizzly bears in Northern Yukon 1973-74 during the spring and fall hunting seasons.

| PERIOD OF COMPARISON | ELEVATION CLASS (FEET) | DISTRIBUTION MALES | OBSERVED DISTRIBUTION FEMALES | EXPECTED DISTRIBUTION FEMALES | OBSERVED MINUS EXPECTED | P VALUE |
|---|---|---|---|---|---|---|
| SPRING HUNT | | | | | | |
| | 0-1500 | 35 | 23 | 39.3 | -16 | |
| | >1500 | 14 | 32 | 15.7 | 16.3 | $P < 0.05$ |
| FALL HUNT | | | | | | |
| | 0-1500 | 35 | 32 | 52.2 | -20 | |
| | >1500 | 20 | 50 | 29.8 | 20.2 | $P < 0.05$ |

Table 8. Estimates of the number of grizzly bears by game management subzone in the Northern Yukon IFA.

| SUB-ZONE | MANAGE AREA | ECO REG | AREA ($km^2$) | ESTIMATED DENSITY (BEARS/ 1000 $km^2$) | ESTIMATED NUMBER OF BEARS |
|---|---|---|---|---|---|
| 4 | IFA | CP | 1681 | 6.5 | 11 |
| 5 | IFA | CP | 842 | 6.5 | 5 |
| 12 | IFA | MT | 2161 | 26 | 57 |
| 13 | IFA | MT | 1932 | 26 | 51 |
| 14 | IFA | MT | 1356 | 26 | 36 |
| 25 | IFA | MT | 360 | 15 | 5 |
| | SUBTOTAL | | 8331 | | 165 |
| 1 | TP | HI | 101 | 6.5 | 1 |
| 2 | NP | CP | 805 | 6.5 | 5 |
| 3 | NP | CP | 1410 | 6.5 | 9 |
| 6 | NP | MT | 1302 | 15 | 20 |
| 7 | NP | MT | 1086 | 15 | 16 |
| 8 | NP | MT | 508 | 15 | 8 |
| 9 | NP | MT | 1818 | 15 | 27 |
| 10 | NP | MT | 583 | 15 | 9 |
| 11 | NP | MT | 2136 | 26 | 56 |
| | SUBTOTAL | | 9748 | | 151 |
| | TOTAL | | 18079 | | 316 |

SUBZONE: Game management subzone
ECO REG: CP- Coastal Plains
MT- Mountains
HI- Herschel Island
MANAGE AREA:
IFA- Innuit Settlement Area (excluding national park)
TP- Herschel Island Territorial Park
NP- Northern Yukon National Park
AREA: Area of game management subzone
EST DENSITY: Estimated number of bears/1000 $km^2$
EST NUMBER OF BEARS: Estimated number of bears in game management subzone derived by extrapolating estimated density over area of subzone

Table 9. Mean instantaneous ($k_x$) and finite ($q_x$) mortality rates ($k_x$) by age class for grizzly bear populations in Northern Yukon derived from age structure data.

| Age Class | $K_x$ Values | | $Q_x$ Values | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| Cubs | 0.00 | -0.34 | 0.00 | 0.29 |
| Yearlings | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-4 years | 0.00 | 0.00 | 0.00 | 0.00 |
| ≥5 years | -0.03 | 0.00 | 0.03 | 0.00 |

Table 10. Summary of data used to establish mean age specific fecundity rates ($M_x$) for grizzly bears in Northern Yukon.

| Parameter | |
|---|---|
| First age of cub production (years) | 5.5-7.5 |
| Mean litter size (cubs) | 2.1 |
| Reproductive interval (years) | 3.5 (3-5 years) |
| Sex ratio (male:females) | 37M:41F |
| $M_x$ | 0.30 |

Table 11. Estimated minimum, maximum, P50P, and P95P age specific birth rates for female grizzly bears in Northern Yukon.

| Age | Min | Max | P50P | P95P |
|---|---|---|---|---|
| 0 | 0.0 | 0.0 | 0.50 | 1.00 |
| 1 | 0.0 | 0.0 | 0.50 | 1.00 |
| 2 | 0.0 | 0.0 | 0.50 | 1.00 |
| 3 | 0.0 | 0.0 | 0.50 | 1.00 |
| 4 | 0.0 | 0.0 | 0.50 | 1.00 |
| 5 | 0.10 | 0.10 | 0.50 | 1.00 |
| 6 | 0.15 | 0.15 | 0.50 | 1.00 |
| 7 | 0.20 | 0.20 | 0.50 | 1.00 |
| 8 | 0.30 | 0.30 | 0.50 | 1.00 |
| 9 | 0.30 | 0.30 | 0.50 | 1.00 |
| 10 | 0.30 | 0.30 | 0.50 | 1.00 |
| 11 | 0.30 | 0.30 | 0.50 | 1.00 |
| 12 | 0.30 | 0.30 | 0.50 | 1.00 |
| 13 | 0.30 | 0.30 | 0.50 | 1.00 |
| 14 | 0.30 | 0.30 | 0.50 | 1.00 |
| 15 | 0.30 | 0.30 | 0.50 | 1.00 |
| 16 | 0.30 | 0.30 | 0.50 | 1.00 |
| 17 | 0.30 | 0.30 | 0.50 | 1.00 |
| 18 | 0.30 | 0.30 | 0.50 | 1.00 |
| 19 | 0.25 | 0.25 | 0.50 | 1.00 |
| 20 | 0.25 | 0.25 | 0.50 | 1.00 |
| 21 | 0.25 | 0.25 | 0.50 | 1.00 |
| 22 | 0.10 | 0.10 | 0.50 | 1.00 |
| 23 | 0.01 | 0.01 | 0.50 | 1.00 |

MIN: The minimum birth rate calculated by a rate function.

MAX: The maximum birth rate from a rate function.

P50P: The proportion of the carrying capacity at which birth rate function achieved 50% of its change.

P95P: The proportion of the carrying capacity at which birth rate function has achieved 95% of its change. (The four parameters above specify the shape of a rate function. (Restrictions of $0 \leq$ MIN $\leq$ MAX; $0 \leq$ P50P $\leq$ P95P.)

Table 12. Estimated minimum, maximum, P50P, and P95P age specific death rates for female grizzly bears in Northern Yukon.

| Age | Min | Max | P50P | P95P |
|---|---|---|---|---|
| 0 | 0.10 | 0.40 | 0.95 | 1.25 |
| 1 | 0.08 | 0.25 | 0.95 | 1.25 |
| 2 | 0.08 | 0.35 | 0.95 | 1.25 |
| 3 | 0.08 | 0.25 | 0.95 | 1.25 |
| 4 | 0.08 | 0.20 | 0.95 | 1.25 |
| 5 | 0.04 | 0.04 | 0.50 | 0.95 |
| 6 | 0.04 | 0.04 | 0.50 | 0.95 |
| 7 | 0.04 | 0.04 | 0.50 | 0.95 |
| 8 | 0.04 | 0.04 | 0.50 | 0.95 |
| 9 | 0.04 | 0.04 | 0.50 | 0.95 |
| 10 | 0.04 | 0.04 | 0.50 | 0.95 |
| 11 | 0.04 | 0.04 | 0.50 | 0.95 |
| 12 | 0.04 | 0.04 | 0.50 | 0.95 |
| 13 | 0.04 | 0.04 | 0.50 | 0.95 |
| 14 | 0.04 | 0.04 | 0.50 | 0.95 |
| 15 | 0.04 | 0.04 | 0.50 | 0.95 |
| 16 | 0.12 | 0.12 | 0.50 | 0.95 |
| 17 | 0.12 | 0.12 | 0.50 | 0.95 |
| 18 | 0.12 | 0.12 | 0.50 | 0.95 |
| 19 | 0.25 | 0.25 | 0.50 | 0.95 |
| 20 | 0.25 | 0.25 | 0.50 | 0.95 |
| 21 | 0.25 | 0.25 | 0.50 | 0.95 |
| 22 | 0.25 | 0.25 | 0.50 | 0.95 |
| 23 | 1.00 | 1.00 | 0.50 | 0.95 |

MIN: The minimum death rate calculated by a rate function.

MAX: The maximum death rate from a rate function.

P50P: The proportion of the carrying capacity at which death rate function achieved 50% of its change.

P95P: The proportion of the carrying capacity at which the death rate function has achieved 95% of its change. (The four parameters above specify the shape of a rate function. (Restrictions of $0 \leq MIN \leq MAX$; $0 \leq P50P \leq P95P$.)

Table 13. Estimated minimum, maximum, P50P, and P95P age specific death rates for male grizzly bears in Northern Yukon.

| Age | Min | Max | P50P | P95P |
|---|---|---|---|---|
| 0 | 0.10 | 0.40 | 0.95 | 1.25 |
| 1 | 0.08 | 0.25 | 0.95 | 1.25 |
| 2 | 0.08 | 0.40 | 0.95 | 1.25 |
| 3 | 0.08 | 0.25 | 0.95 | 1.25 |
| 4 | 0.08 | 0.20 | 0.95 | 1.25 |
| 5 | 0.03 | 0.03 | 0.50 | 0.95 |
| 6 | 0.03 | 0.03 | 0.50 | 0.95 |
| 7 | 0.03 | 0.03 | 0.50 | 0.95 |
| 8 | 0.02 | 0.02 | 0.50 | 0.95 |
| 9 | 0.02 | 0.02 | 0.50 | 0.95 |
| 10 | 0.02 | 0.02 | 0.50 | 0.95 |
| 11 | 0.02 | 0.02 | 0.50 | 0.95 |
| 12 | 0.02 | 0.02 | 0.50 | 0.95 |
| 13 | 0.02 | 0.02 | 0.50 | 0.95 |
| 14 | 0.02 | 0.02 | 0.50 | 0.95 |
| 15 | 0.02 | 0.02 | 0.50 | 0.95 |
| 16 | 0.03 | 0.03 | 0.50 | 0.95 |
| 17 | 0.03 | 0.03 | 0.50 | 0.95 |
| 18 | 0.03 | 0.03 | 0.50 | 0.95 |
| 19 | 0.08 | 0.08 | 0.50 | 0.95 |
| 20 | 0.16 | 0.16 | 0.50 | 0.95 |
| 21 | 0.20 | 0.20 | 0.50 | 0.95 |
| 22 | 0.40 | 0.40 | 0.50 | 0.95 |
| 23 | 1.00 | 1.00 | 0.50 | 0.95 |

MIN: The minimum death rate calculated by a rate function.

MAX: The maximum death rate from a rate function.

P50P: The proportion of the carrying capacity at which the death rate function achieved 50% of its change.

P95P: The proportion of the carrying capacity at which death rate function has achieved 95% of its change. (The four parameters above specify the shape of a rate function. (Restrictions of $0 \leq$ MIN $\leq$ MAX; $0 \leq$ P50P $\leq$ P95P.)

Table 14. Age specific natural mortality rates (percent) estimated for male and female grizzly bears in Northern Yukon, observed in Northcentral Alaska Range, and estimated for central Yukon.

| | North Yukon Model | | Observed In Northcentral Alaska Range (a) | | | | | | Estimated Rates for Central Yukon (b) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1986 | | 1987 | | 1988 | | | |
| Age | M | F | M | F | M | F | M | F | M | F |
| 0 | 25 | 25 | 44 | 44 | 36 | 36 | 27 | 27 | 0 | 0 |
| 1 | 16 | 16 | 12 | 12 | 12 | 12 | 6 | 6 | 0 | 0 |
| 2 | 24 | 21 | 8 | 4-8 | 7 | 3-7 | 8 | 3-8 | | |
| 3 | 16 | 16 | | - | | - | | - | | |
| 4 | 14 | 16 | | \| | | \| | | \| | 15 | 4 |
| 5 | 3 | 4 | | \| | | \| | | \| | | |
| 6 | 3 | 4 | | \| | | \| | | \| | | |
| 7 | 3 | 4 | | \| | | \| | | \| | | |
| 8 | 2 | 4 | | \| | | \| | | \| | | |
| 9 | 2 | 4 | | \| | | \| | | \| | | |
| 10 | 2 | 4 | | \| | | \| | | \| | | |
| 11 | 2 | 4 | | \| | | \| | | \| | | |
| 12 | 2 | 4 | | \| | | \| | | \| | | |
| 13 | 2 | 4 | | \| | | \| | | \| | | |
| 14 | 2 | 4 | | \| | | \| | | \| | | |
| 15 | 2 | 4 | | 4 | | 3 | | 3 | 3 | 3 |
| 16 | 3 | 12 | | \| | | \| | | \| | | |
| 17 | 3 | 12 | | \| | | \| | | \| | | |
| 18 | 3 | 12 | | \| | | \| | | \| | | |
| 19 | 8 | 25 | | \| | | \| | | \| | | |
| 20 | 16 | 25 | | \| | | \| | | \| | | |
| 21 | 20 | 25 | | \| | | \| | | \| | | |
| 22 | 40 | 25 | | \| | | \| | | \| | | |
| 23 | 100 | 100 | | \| | | \| | | \| | | |
| 24 | | | | \| | | \| | | \| | | |
| 25 | | | | - | | - | | - | | |

a-Northcentral Alaska Range 1986 (Reynolds and Hechtel 1986); Northcentral Alaska Range 1987 (Reynolds et al. 1987); and Northcentral Alaska Range 1988 (Reynolds and Hechtel 1988). Reynolds and Hechtel (1986), Reynolds et al. (1987), and Reynolds and Hechtel (1988) did not present natural mortality rates for males age ≥3 years.

b-Central Yukon (Smith and Taylor 1987).

Table 15. Comparison of the average age structure of Northern Yukon grizzly bears (1973 and 1974), and the final stable age structure generated using LESMOD.

| Age (Years) | Average Known | | Model | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| 0.5 | 5 | 6 | 7 | 7 |
| 1.5 | 3 | 5 | 5 | 5 |
| 2.5 | 4 | 5 | 4 | 4 |
| 3.5 | 1 | 2 | 3 | 3 |
| 4.5 | 2 | 3 | 3 | 3 |
| 5.5 | 2 | 2 | 2 | 2 |
| 6.5 | 2 | 2 | 2 | 2 |
| 7.5 | 3 | 4 | 2 | 2 |
| 8.5 | 2 | 2 | 2 | 2 |
| 9.5 | 1 | 2 | 2 | 2 |
| 10.5 | 2 | 2 | 2 | 2 |
| 11.5 | 2 | 2 | 2 | 2 |
| 12.5 | 3 | 3 | 2 | 2 |
| 13.5 | 3 | 3 | 2 | 2 |
| 14.5 | 2 | 3 | 2 | 2 |
| 15.5 | 2 | 2 | 2 | 2 |
| 16.5 | 2 | 1 | 2 | 1 |
| 17.5 | 1 | 1 | 2 | 1 |
| 18.5 | 2 | 1 | 2 | 1 |
| 19.5 | 2 | 1 | 2 | 1 |
| 20.5 | 1 | 1 | 1 | 1 |
| 21.5 | 1 | 1 | 1 | 1 |
| 22.5 | 1 | 1 | 1 | 0 |
| 23.5 | 0 | 0 | 1 | 0 |
| 24.5 | 1 | 0 | | |
| 25.5 | 1 | 0 | | |
| Total | 51 | 55 | 56 | 50 |
| Median Age | 10.5 | 7.5 | 7.5 | 6.5 |
| Mean Age | 10.3 | 8.5 | 9.0 | 7.8 |

Table 16. Estimated age specific rates of vulnerability used to harvest male and female grizzly bears in the Northern Yukon LESMOD model.

| | Vulnerabilities | |
|---|---|---|
| Age | Males | Females |
| 0 | 0.0 | 0.0 |
| 1 | 0.0 | 0.0 |
| 2 | 0.0 | 0.0 |
| 3 | 2.0 | 1.0 |
| 4 | 2.0 | 1.0 |
| ≥5 | 3.0 | 1.0 |

Females with cubs, yearlings, and 2-year olds protected from harvest.

The relative vulnerability of age groups to an increase or decrease in hunting. If hunt is zero, vulnerability is not used by the computer program.

Table 17. Population projections for absolute grouped sex hunts of the Northern Yukon grizzly bear model.

| Number of Bears Removed Annually | New Stable Population | Years Till Population Stable | Maximum Population | Minimum Population |
|---|---|---|---|---|
| 1 | 101 | 27 | 106 | 98 |
| 2 | 98 | 28 | 106 | 94 |
| 3 | 96 | 17 | 106 | 91 |
| 4 | 92 | 23 | 106 | 86 |
| 5 | 85 | 37 | 106 | 79 |
| 6 | NS: pop 0 at 37 yrs | | | |
| 7 | NS: pop 0 at 25 yrs | | | |
| 8 | NS: pop 0 at 20 yrs | | | |

Females with cubs, yearlings, and 2-year olds protected from harvest.

Maximum Population: Maximum number of bears in population during period when population is stabilizing under current harvest regime.

Minimum Population: Minimum number of bears in population during period when population is stabilizing under current harvest regime.

NS: Population does not stabilize; population declines to X number of bears after 100 years or less.

Table 18. Population projections for proportional grouped sex hunts of the Northern Yukon grizzly bear model.

| Proportion (%) of Population Removed Annually | New Stable Population | Years Till Population Stable | Maximum Population | Minimum Population |
|---|---|---|---|---|
| 1 | 101 | 27 | 106 | 98 |
| 2 | 99 | 28 | 106 | 95 |
| 3 | 96 | 27 | 106 | 91 |
| 4 | 93 | 17 | 106 | 88 |
| 5 | 89 | 23 | 106 | 84 |
| 6 | 84 | 30 | 106 | 79 |
| 7 | 74 | 19 | 106 | 73 |
| 8 | NS: pop 38 at 100 yrs | | | |
| 9 | NS: pop 13 at 100 yrs | | | |
| 10 | NS: pop 4 at 100 yrs | | | |
| 11 | NS: pop 1 at 100 yrs | | | |
| 12 | NS: pop 0 at 80 yrs | | | |
| 13 | NS: pop 0 at 65 yrs | | | |

Females with cubs, yearlings, and 2-year olds protected from harvest.

Maximum Population: Maximum number of bears in population during period when population is stabilizing under current harvest regime.

Minimum Population: Minimum number of bears in population during period when population is stabilizing under current harvest regime.

NS: Population does not stabilize; population declines to X number of bears after 100 years or less.

Table 19. Estimates of the number of grizzly bears available for harvest and known man-caused mortalities by game management subzone in the Northern Yukon IFA.

| SUB-ZONE | MANAGE AREA | ECO REG | ESTIMATED NUMBER OF BEARS | ESTIMATED ALLOWABLE KILL | TKMM (80-87) | SPORT KILL (80-87) | NON-SPORT KILL (80-87) |
|---|---|---|---|---|---|---|---|
| 4 | IFA | CP | 11 | 0 | 1 | 0 | 1 |
| 5 | IFA | CP | 5 | 0 | 1 | 1 | 0 |
| 12 | IFA | MT | 57 | 2 | 0 | 0 | 0 |
| 13 | IFA | MT | 51 | 2 | 0 | 0 | 0 |
| 14 | IFA | MT | 36 | 1 | 0 | 0 | 0 |
| 25 | IFA | MT | 5 | 0 | 0 | 0 | 0 |
| | SUBTOTAL | | 165 | 7 | 2 | 1 | 1 |
| 1 | TP | HI | 1 | 0 | 1 | 0 | 1 |
| 2 | NP | CP | 5 | 0 | 4 | 0 | 4 |
| 3 | NP | CP | 9 | 0 | 0 | 0 | 0 |
| 6 | NP | MT | 20 | 1 | 0 | 0 | 1 |
| 7 | NP | MT | 16 | 1 | 1 | 0 | 0 |
| 8 | NP | MT | 8 | 0 | 0 | 0 | 0 |
| 9 | NP | MT | 27 | 1 | 0 | 0 | 0 |
| 10 | NP | MT | 9 | 0 | 0 | 0 | 0 |
| 11 | NP | MT | 56 | 2 | 0 | 0 | 0 |
| | SUBTOTAL | | 151 | 6 | 6 | 0 | 6 |
| | TOTAL | | 316 | 13 | 8 | 1 | 7 |

SUBZONE: Game management subzone
ECO REG: ECO REG: CP- Coastal Plains
MT- Mountains
HI- Herschel Island
MANAGE AREA:
IFA- Innuit Settlement Area (excluding national park)
TP- Herschel Island Territorial Park
NP- Northern Yukon National Park
EST ALLOW KILL: Estimated allowable kill = estimated number of bears * .04
TKMM: Total known man-caused mortality
SPORT KILL: Total known kill of bears through sport harvest
NON-SPORT KILL: Total known kill of bears through causes other than sport harvest

**Figure 1.** **Location of study area in which Nagy _et_ _al_. (1983a) conducted grizzly bear research in Northern Yukon during 1973-74. Game management subzones are indicated.**

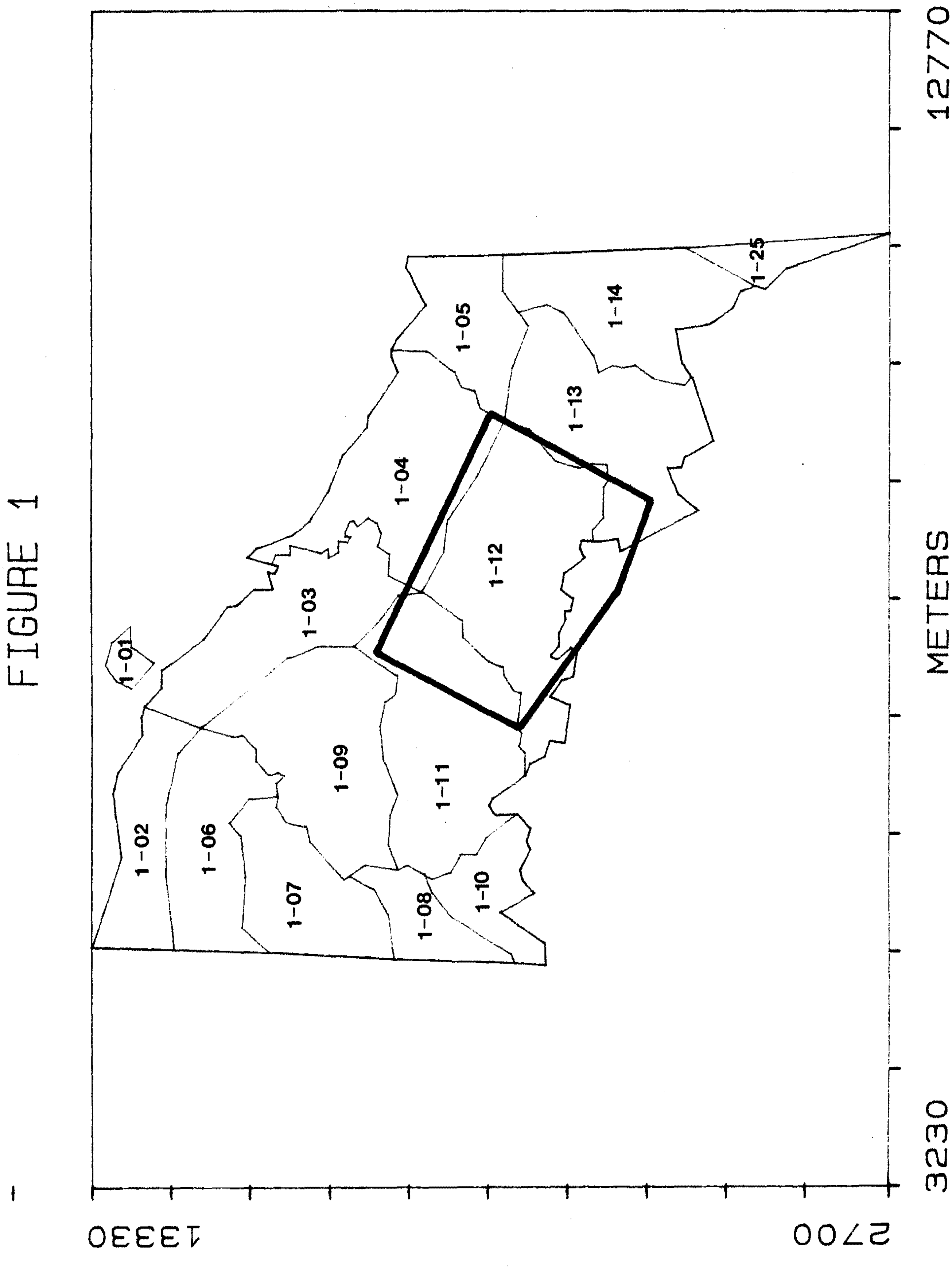


**Figure 2. Known sites where man-caused grizzly bear mortalities occurred during 1973-74 and 1980-85. The number of bears killed each site is provided beside each location.**

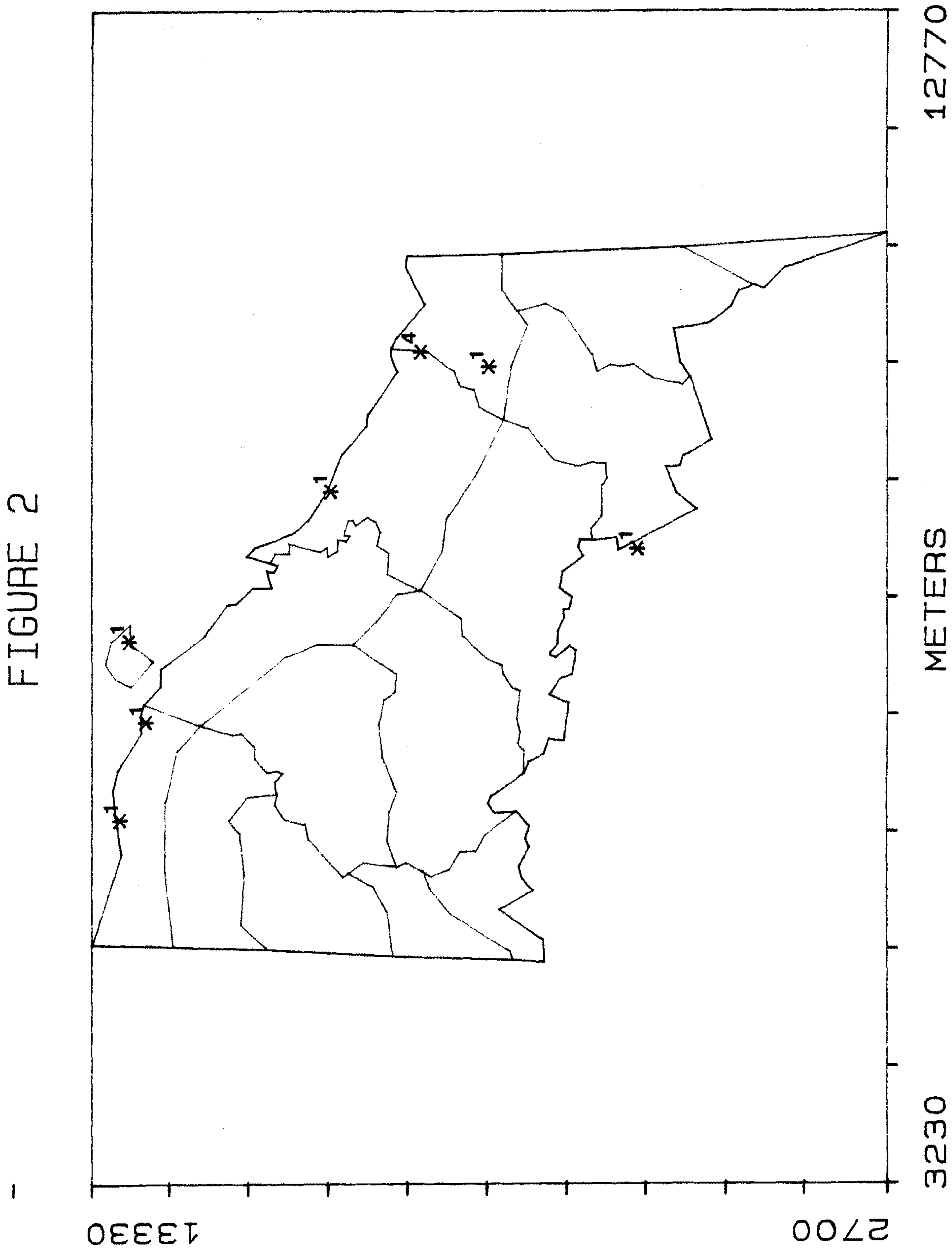


**Figure 3. Known distribution of female grizzly bears in Northern Yukon based radio telemetry location data obtained by Nagy <u>et</u> <u>al</u>. (1983a).**

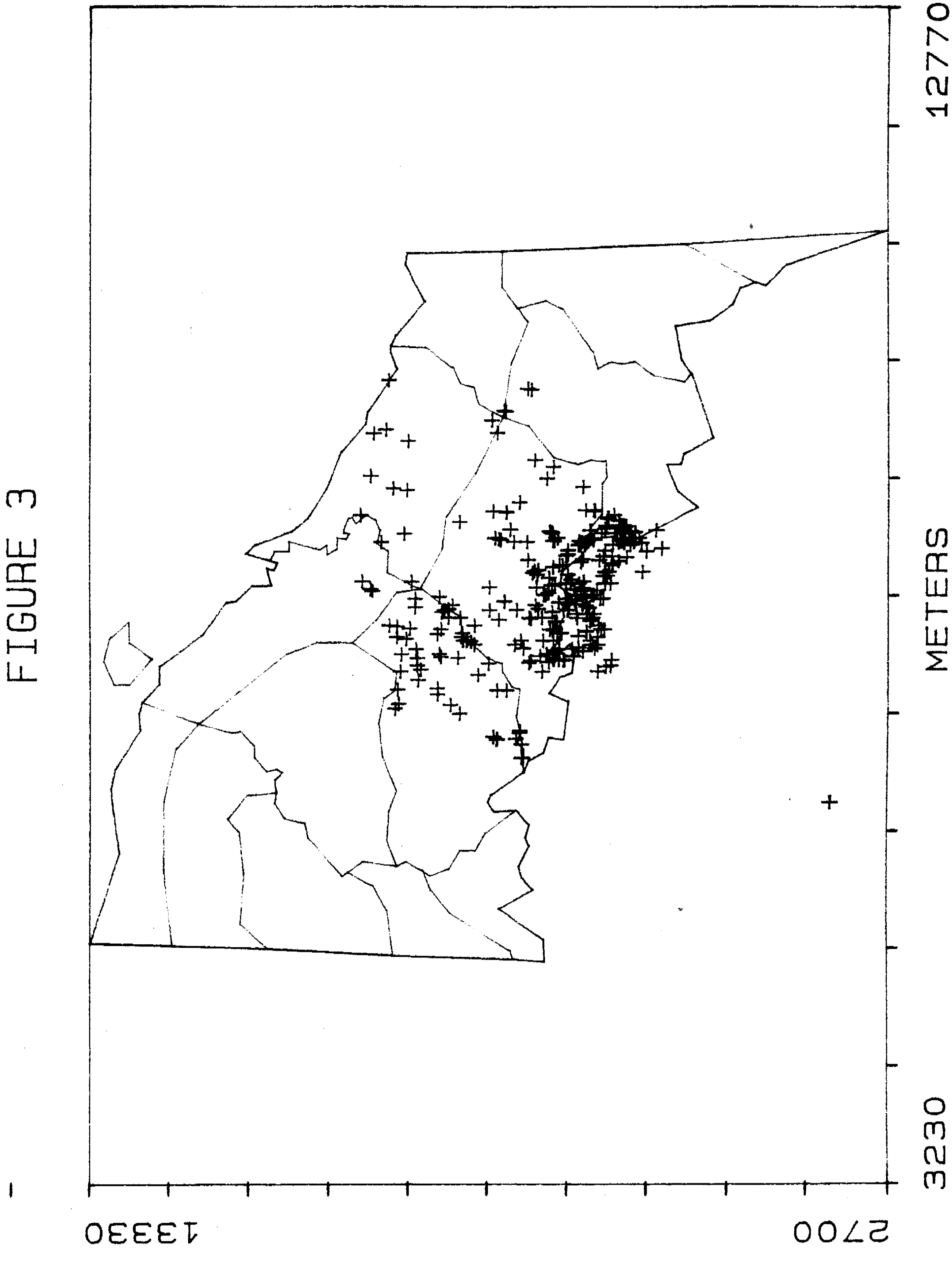
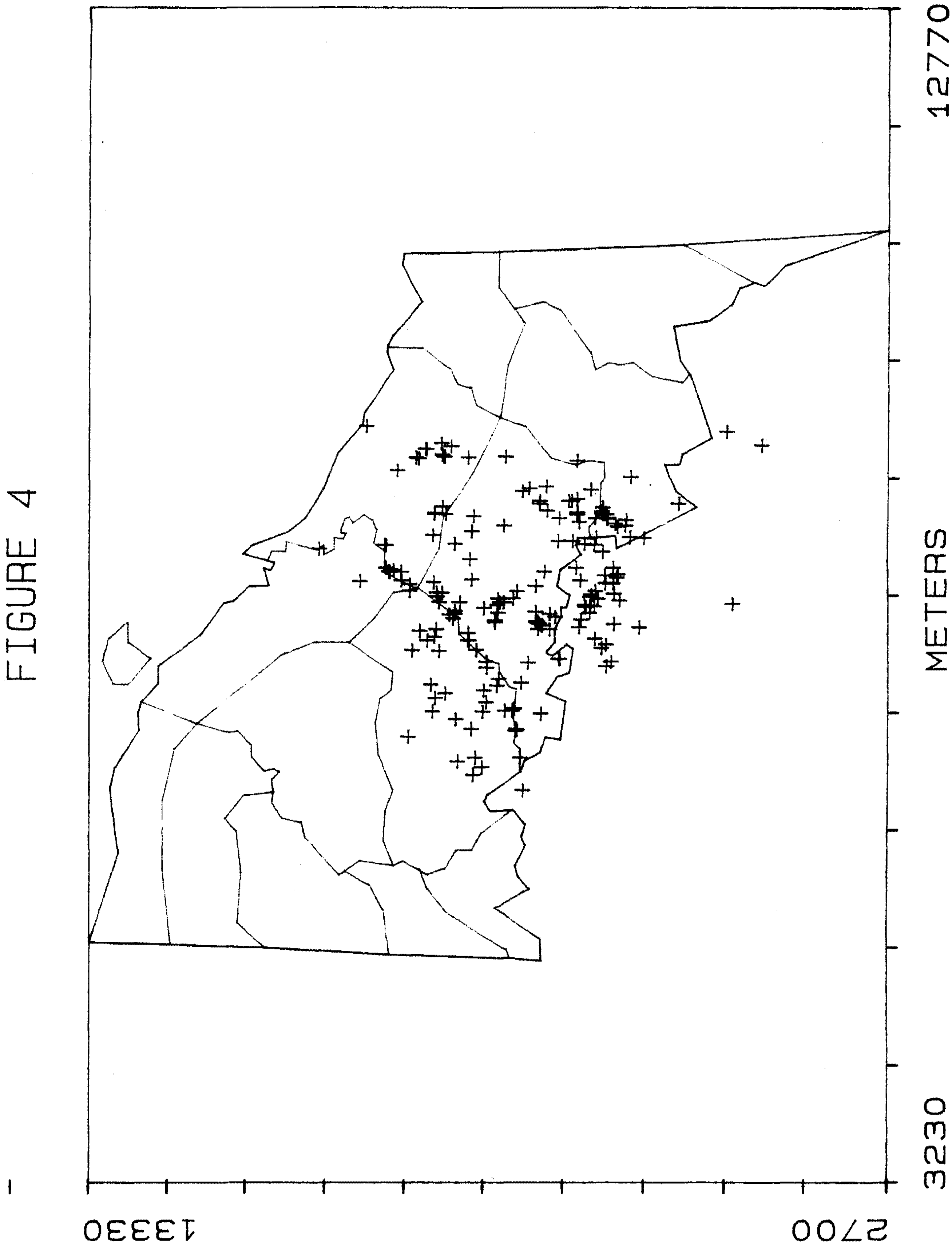


**Figure 4. Known distribution of male grizzly bears in Northern Yukon based radio telemetry location data obtained by Nagy et al. (1983a).**



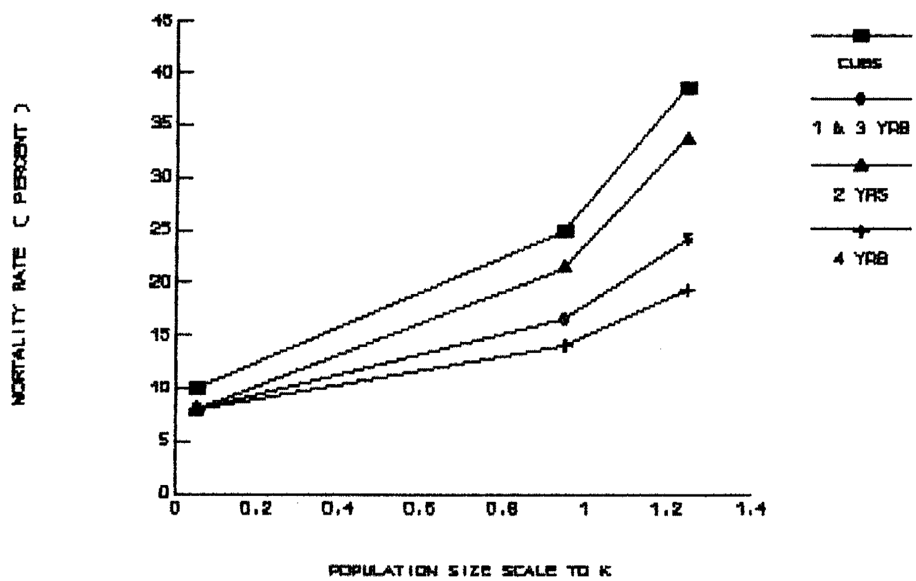



Figure 5. Approximate mortality rates with changing population size for female grizzly bear cubs, 1 and 3-year olds, 2-year olds, and 4-year olds. Population size is scaled to carrying capacity (N/K).

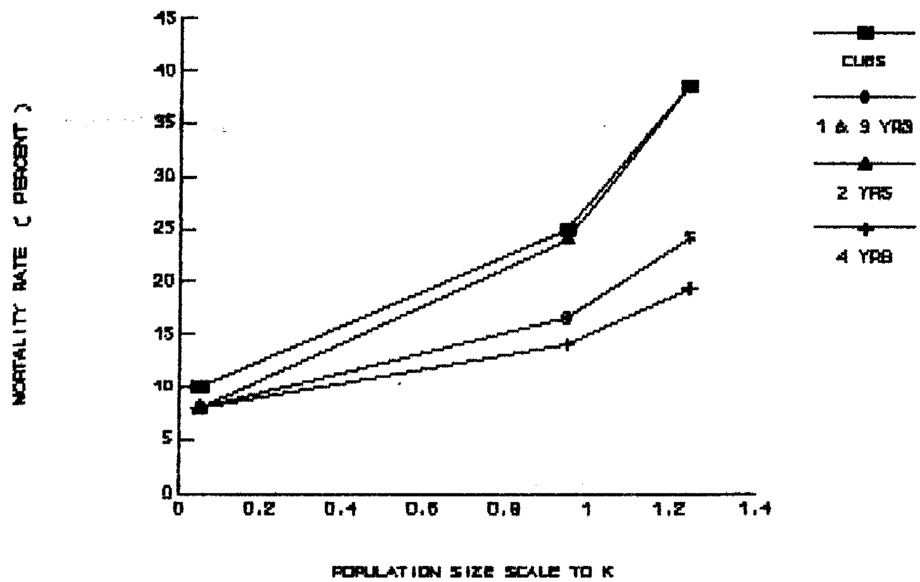



Figure 6. Approximate mortality rates with changing population size for male grizzly bear cubs, 1 and 3-year olds, 2-year olds, and 4-year olds. Population size is scaled to carrying capacity (N/K).