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MOUNTAIN GOAT STATUS AND MANAGEMENT IN THE YUKON

Norman Barichello
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Mountain Goats, (*Oreamnos americanus*), are relatively rare in the Yukon and yet they are an important big-game resource. Traditionally they played a spiritual and ceremonial role to the indigenous people, and more recently they have become valued as a sport hunting resource, primarily due to the value of their horns and pelt.

Mountain Goats occur in the Yukon at the northern extent of their distribution, often in apparently isolated pockets. They are considered rare in the Yukon, although specific areas at times support relatively high densities.

Goats have had a history, over their entire range, of severe population exploitation. Some populations have been extirpated, others have been lost but replenished through transplants. Most have suffered some degree of depletion.

Excessive hunting has undoubtedly been the most debilitating factor on mountain goat population dynamics (Foster 1977). Goats are habitat specialists utilizing traditional areas. They are conspicuous during the summer due to their white pelage and they respond to predators by placing themselves in precipitous terrain, a strategy completely inappropriate to protect themselves from human hunters. In addition, the differentiation of sexes is difficult in the field and therefore females can not receive the regulatory protection they need.

The difficulties of counting and classifying goats influence the ability of managers to firstly, identify population decline, and secondly, to respond through reasonable controls or restrictions. More often than not population decline is recognized too late and the only feasible course of action is severe hunting restrictions. And so the history of mountain goat management has been one of widespread decline, followed by very restrictive management (Johnson 1977).

The history of goats and goat management in the Yukon has followed a pattern typical throughout North America. Yukon goat populations are perhaps more sensitive to human exploitation than their southern counterparts. They are at the northern extent of their range and occur often in isolated pockets. Goat habitat in the Yukon may be marginal, and isolated populations are likely less robust than populations distributed contiguously. Environmental factors limiting the northern extent of their range are no doubt more severe or more variable. It is therefore imperative that goats be managed very carefully in the Yukon.

It is the purpose of this paper to explore the historic and current population status, distribution and harvest, to determine population and productivity trends, and to provide the framework for a management plan.

STUDY AREA

The Yukon Territory is approximately 483,000 km^2 and has been divided into 22 ecological regions, based on physiography, drainage and geology, climate, glaciation, surface deposits, terrain and vegetation (Oswald and Senyk 1977). Mountain goats are primarily found in the Logan, Coast and St.Elias Mountains ecoregions. These areas are for the most part, above tree-line, characterized by rugged terrain and ice-covered peaks, and comprise about 9.4% of the Yukon's land mass.

For wildlife management purposes the Yukon has been divided into 11 zones, with major rivers and roads acting as boundaries (Fig. 1). Each of these zones has been further subdivided into subzones, primarily based on relatively discrete mountain blocks.

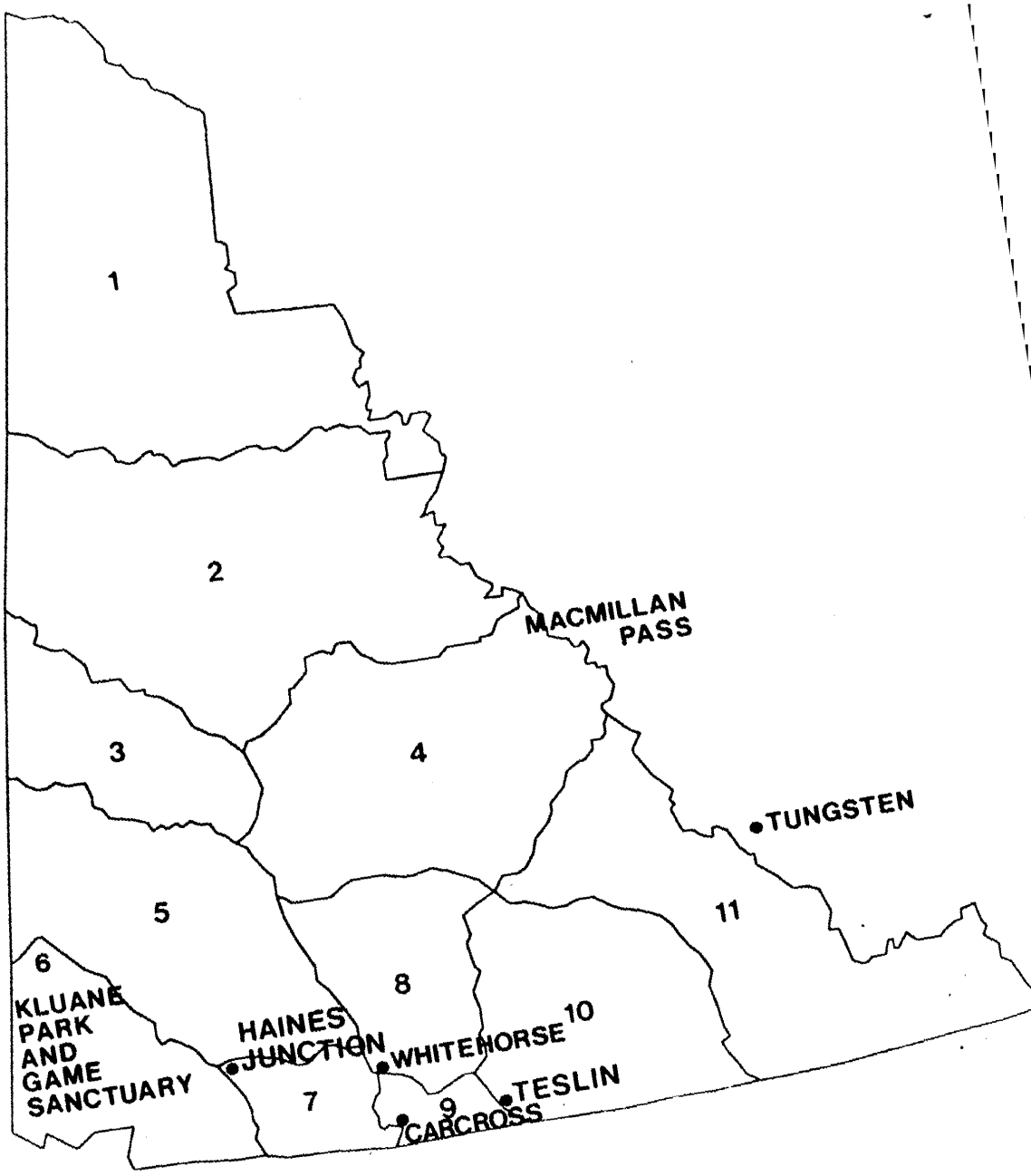

Figure 1. Map depicting Game Management Zones in the Yukon.

METHODS

Goats in the Yukon have, since 1973, been censused using any of a number of types of helicopters, and following a drainage-survey technique as adopted by Hoefs (1978). This involves generally a one-pass flight along a contour line, and includes an entire mountain block. Where the vertical relief is particularly dramatic more than one pass is taken at various elevations to achieve complete visual coverage. In the earlier years (1973-78), surveys were often multi-species surveys intended to determine abundance and distribution of a number of big-game species. More recently surveys have been designed to count and classify only mountain goats or mountain sheep. We expect that current surveys, where both the procedure and the search-image changed according to the terrain, are more accurate than historic surveys.

Goats were counted, mapped and classified as either adults, kids, and since 1984, yearlings. Productivity estimates were presented as the percentage of kids in the herd in mid-summer. For management purposes locations were recorded by management subzone and specific locations were ignored.

Topographic, vegetative and climatic characteristics of Yukon goat habitat were described according to Oswald and Senyk's (1977) ecological classification of regions in the Yukon.

Where surveys have been replicated over time, population growth was determined by the regression of the natural log of observed numbers against time (Caughley 1977). The slope of the regression line represents the mean annual, exponential observed rate of increase (r). Its antilog (a) was used to calculate the percentage rate of population increase according to the equation:

(1) $(a - 1) * 100 =$ percentage increase.

Three years of data, 1973, 1978 and 1986, were used in the analysis. In 1973 and 1978 complete census was achieved. Current census was achieved from 1984 through 1987, by surveying a few subzones annually. Annual population growth was compared against weather records at Carcross, Yukon, from Environment Canada. Average temperature and snow accummulation was estimated from monthly measurements from October to March, and compared between years.

Despite their rather conspicuous colouration in the summer, goats are difficult to locate from aerial survey. They do not readily run from aircraft as do sheep so there is no advantage of movement to enhance observability. Also goats have a tendency to hide from aircraft, particularly those accustomed to low elevation overflights. Therefore sightability tends to deteriorate with increased survey intensity. Ground surveys may contribute to higher sightability but, due to the roughness of the terrain, are limited by the area that can be covered . Assessments have been made comparing fixed-wing to helicopter modes of

search, and comparing both methods to ground survey, however, no specific census technique has been found to be precise (VanDrimmelin 1983). The changing behavioural response of goats to replicated surveys further biases the calculation of variance. Surveys in the Yukon represent one-pass helicopter searches, and census results are therefore considered minimum counts. No effort has been made to statistically determine the level of confidence.

Since 1974 the skulls of all goats shot by licenced hunters have been required to be submitted to the Yukon Government for inspection. Location, date of kill, sex and age of the kill, as well as horn length and circumference measures have been recorded. Age, total horn length, and horn base circumference, were compared between years, zones and sexes, using standard analysis of variance procedure, and Duncan's Multiple Range testing (Sokal and Rohlf 1981).

For comparison, data were grouped according to management prescriptions which changed generally in accordance to survey results. Therefore, average population and kill data from 1973-77, 1978-79, and 1980-1986, are compared. Where goat range in Zones 7 and 9 extended into British Columbia and was part of the inventory survey, the B.C. goat kill within 12 miles of the B.C.-Yukon border adjoining Zones 7 and 9 was included in the analysis of harvest rates.

RESULTS

Status and Distribution

Mountain goats in the Yukon are at the northern extent of their distribution (Fig. 2), and are generally confined to the southern portion of the Coastal mountains, the Cassiar Mountains along the B.C.-Yukon border, the Logan Mountains and the Itsi Mountains (Fig. 3). Scattered individual sitings have been reported in the vicinity of known goat population centres, according to Fig. 3.

Yukon goats appear to be generally associated with very rugged areas which receive substantial precipitation, and are often associated with active glaciers. At the B.C.-Yukon border near an area considered good goat habitat the annual average precipitation is 761 mm, in contrast to the Whitehorse area which receives 260 mm and where goats appear to be replaced by sheep as the common alpine ungulate. Further east, in the Logan Mountains where goats are again common, precipitation averaged about 605 mm (Oswald and Senyk 1977). As well, precipitation is notably greater at higher elevations, where the goats dwell, due to strong topographic influences (Oswald and Senyk 1977).

Goats in the Yukon appear to be more common on intrusive and metamorphic bedrock groups (Fig. 4), than on sedimentary bedrock. In a few locales, south and east of Carcross, on Mt.White near Jakes Corner, and in the Itsi

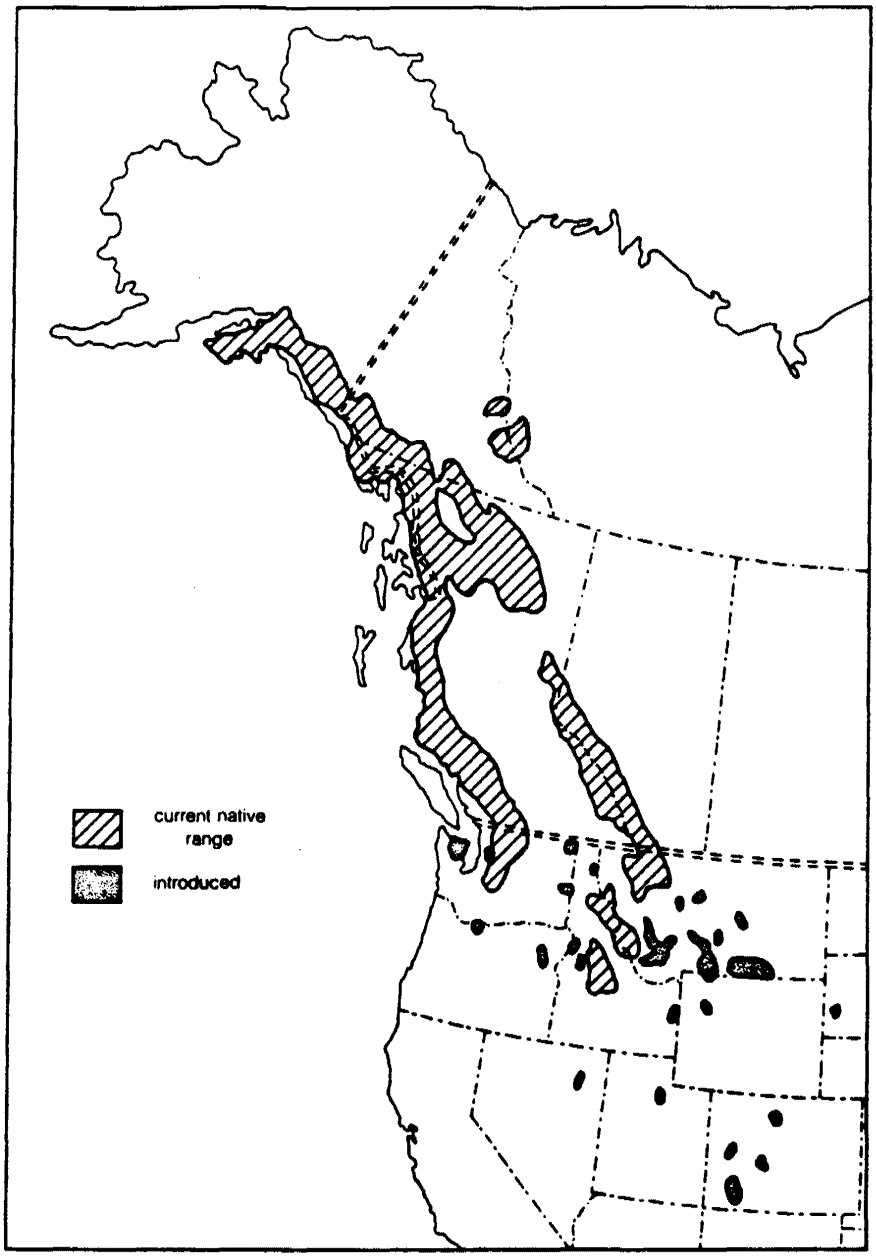

Figure 2. Distribution of mountain goats in North America (from Chadwick 1983).

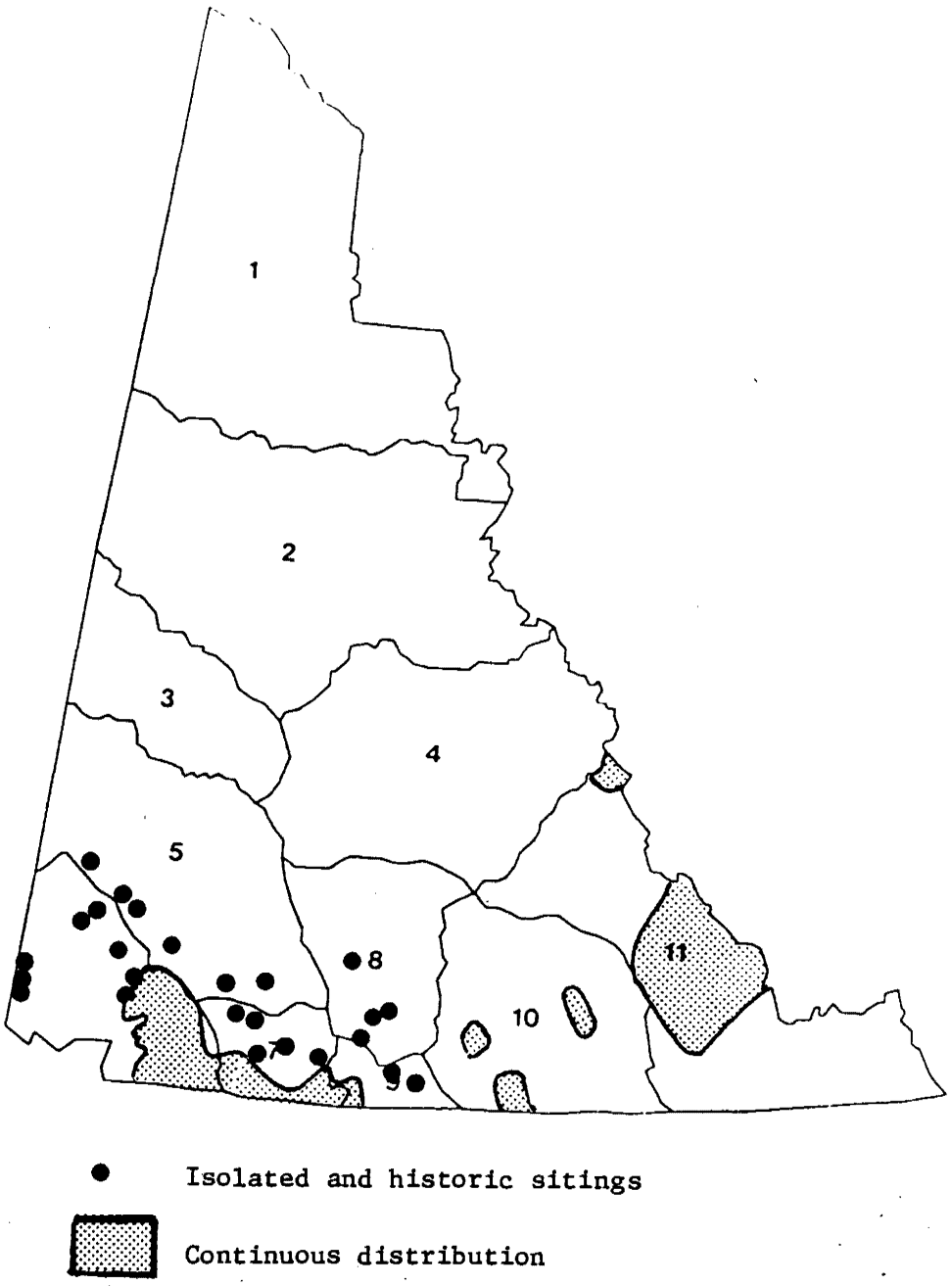

Figure 3. Distribution of mountain goats in the Yukon.

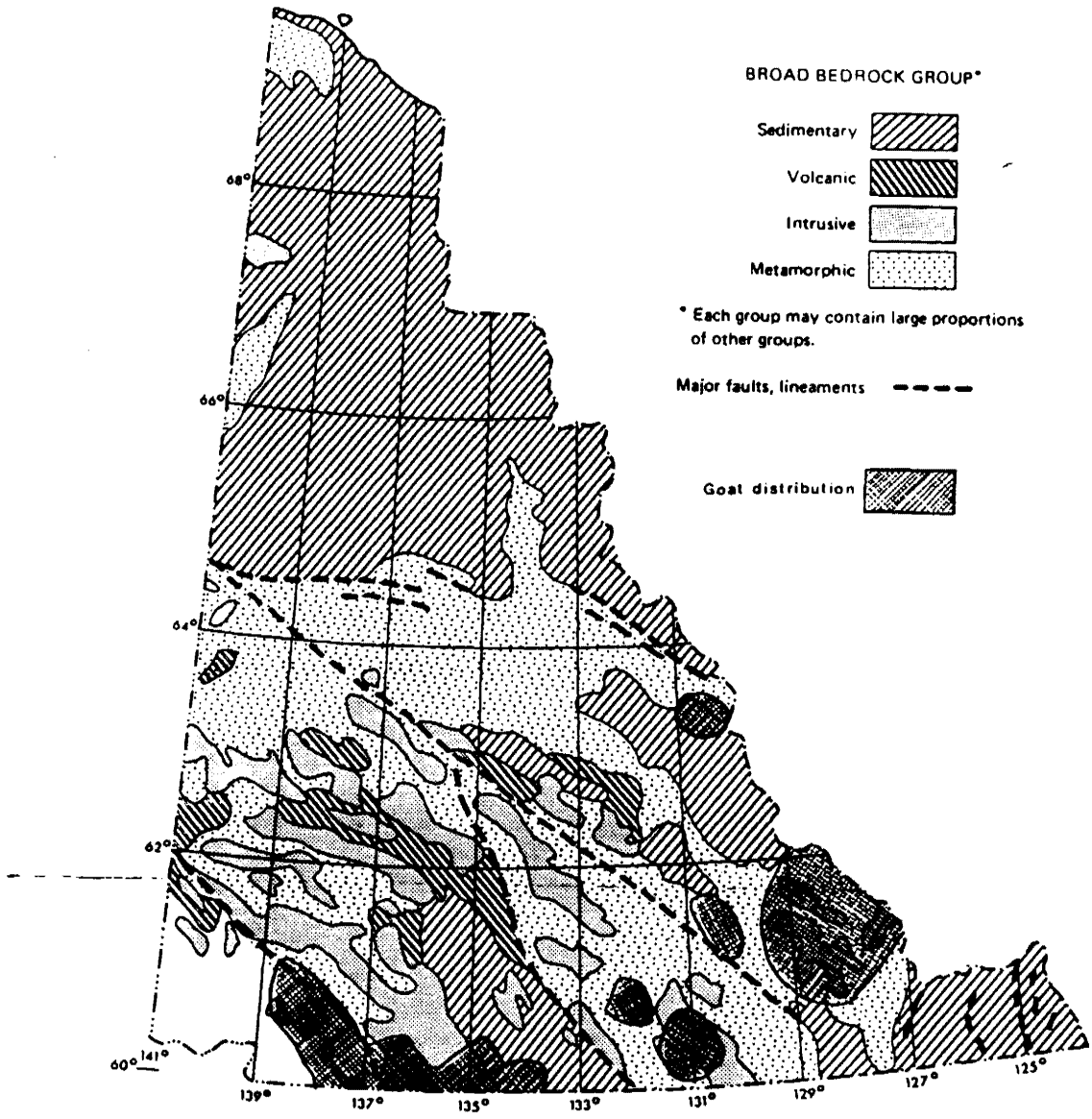

Figure 4. Distribution of mountain goats in the Yukon in relation to bedrock groups (from Oswald and Senyk 1977).

Range near MacMillan Pass, goats occur in scattered populations which are at relatively low densities on limestone rock (Oswald and Senyk 1977).

The vegetation common to Yukon goat range is typically coastal. Treeline is generally above 1350 m in contrast to much of the adjacent areas where treeline is about 1200 m. Alpine fir is the dominant overstory cover in the subalpine.

The total current estimate of goats in the Yukon is about 1700 goats, with densities ranging from about 1 to 40 goats per 100 km^2 where goats occur. A summary of minimum population counts (1+-year old goats), by zone and year are presented in Table 1, and the current minimum density estimates of 1+-year old goats by zone, are presented in Table 2.

Population levels, densities and individual sitings by Game Management Zone are as follows:

Zone 1. No sitings have been reported.

Zone 2. At least one unconfirmed siting, by a hunting guide, has been reported in the Wernecke Mountains, on the Yukon/N.W.T. border.

Zone 3. A goat was allegedly shot on the gold creeks south of Dawson City in the 1950's. No other sitings have been reported.

Table 1. Minimum population counts of non-kid goats.

ZONE	YEAR	MINIMUM COUNT
5		<10 (estimated)
6		900 (estimated)
7 - West	1973	8
	1978	35
	1984-87	25
7 - East	1973	27
	1978	68
	1984-87	170
7 - Total	1973	35
	1978	103
	1984-87	195
9	1973	8
	1979	12
	1987	25
10	1977	19
11	1975	181
	1983	218 (3 1/2 Subzones)

Table 2. Current minimum density estimates of 1+ year old goats, by subzone.

SUBZONE	1+ YEAR OLD GOATS	AREA (KM^2)		DENSITY (No./100 km^2)
		Yukon	B.C.	
7-07	2	400		0.5
7-08	4	450		0.9
7-10	18	290		6.2
7-11	24	60		40.0
7-12	6	510		1.2
7-28	39	240	190	9.0
7-33	9	210	170	2.4
7-34	28	60	60	23.3
7-35	31	60	60	25.6
7-36	25	280	280	4.5
9-05	23	250		9.2
9-06	26	320	225	4.8
9-08	12	180		6.7
10-28	17	1220		1.4
11-01	15	1150		1.3
11-19	3	1620		0.2
11-20	7	1050		0.7
11-23	22 (34)	1340		2.5
11-24	134	450		29.4
11-31	13	1280		1.0
11-32	14	960		1.5
11-33	51	500		10.0

Zone 4. A female goat was shot on Keele Peak in September 1987.

Zone 5. Five isolated pockets of goats were known to occur in the Kluane Range near Tincup Lake, Rockslide Creek, Mineral Creek, and a mountain east of Pickhandle Lake, and by Harrison Lake in the Sifton Range (Fig. 5). All had disappeared by the 1960's. In the 1970's a single goat was observed above Harrison Lake, and was joined by another goat a year or so later. In 1983, 3 goats were observed in the vicinity of Harrison Lake in the Sifton Range, and in 1988 one goat was observed by the Aishihik Road.

Zone 6. This area comprises Kluane Park and the surrounding Kluane Game Sanctuary. Licensed hunting has been restricted since the early 1970's. Hoefs (1974) and Christiansen (1973) estimated the goat population to be approximately 900. North and west of the Slims River, 8 isolated populations were recognized, while south and east, populations were found to be continuous and stretching south into B.C. (Fig. 6). These contiguous populations are at average densities of 40/100 km^2 which is considered to be the highest goat density in the Yukon.

Zone 7. Goats in Zone 7 are confined to an area largely straddling the Yukon/B.C. border where densities appear to be highest in the eastern half (Fig. 7). Most of the goat range is apparently shared between B.C. and the Yukon, and

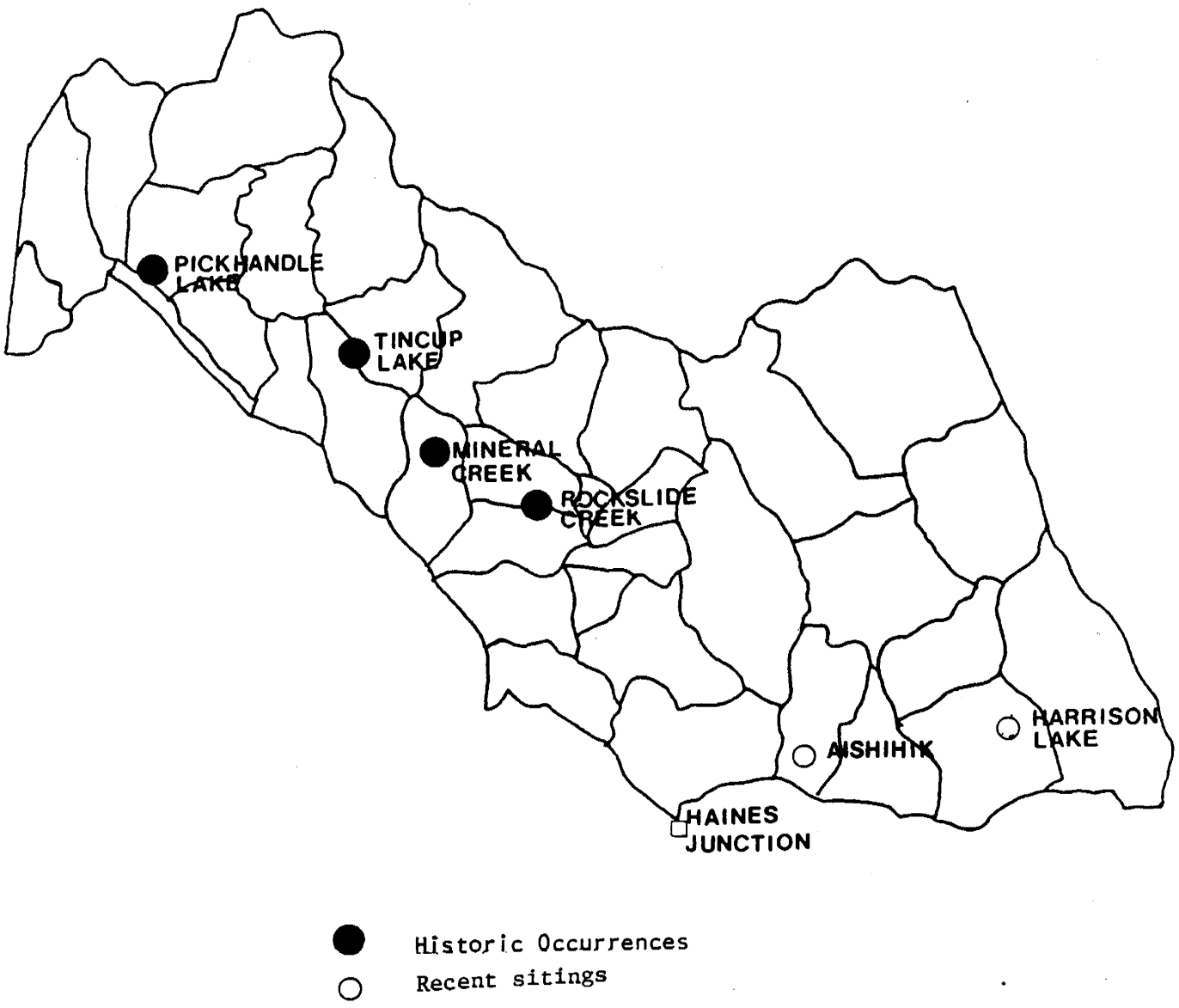

Figure 5. Known historic distribution of goats in Game Management Zone 5.

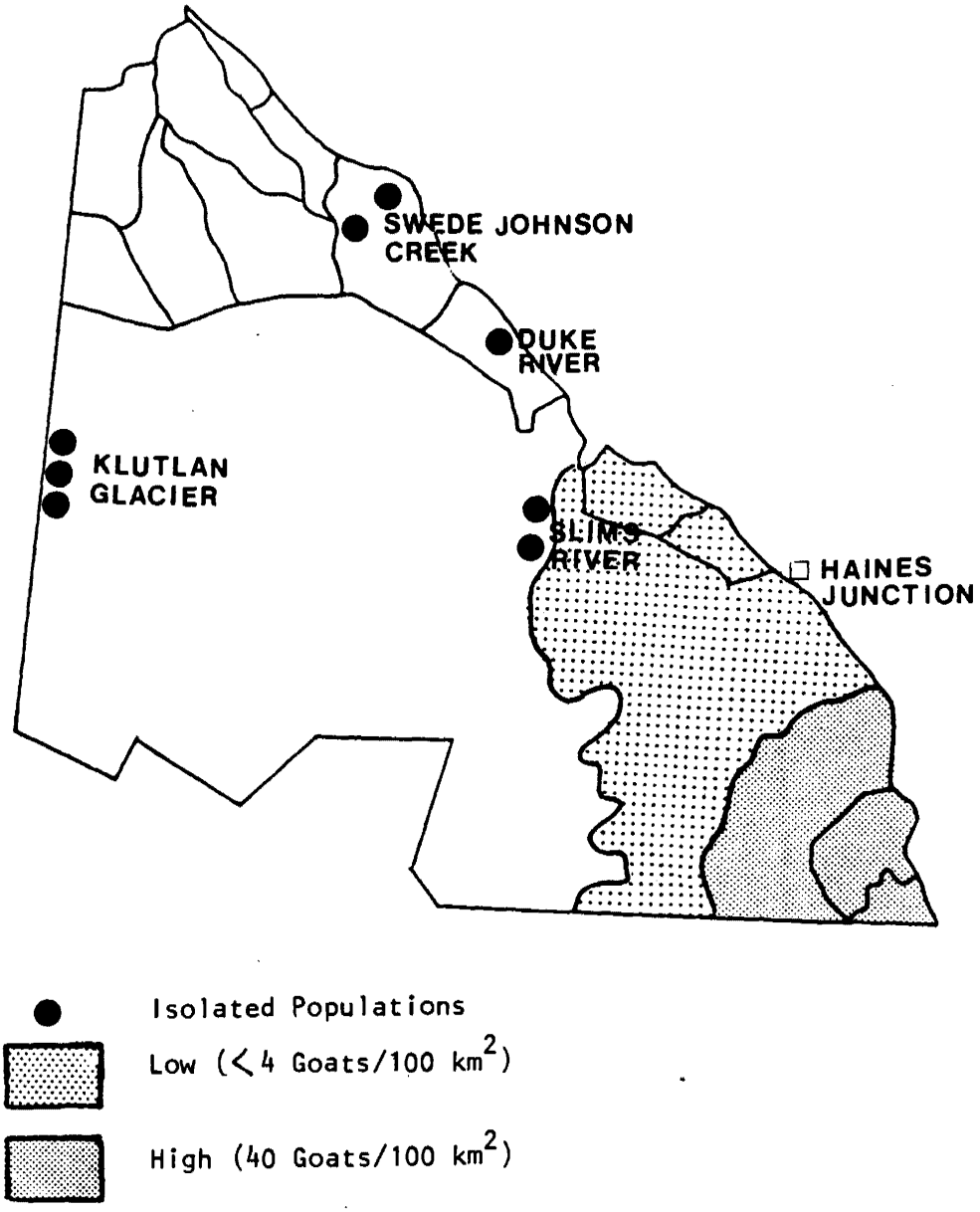

Figure 6. Distribution of goats in Game Management Zone 6, by density (from Hoefs 1977).

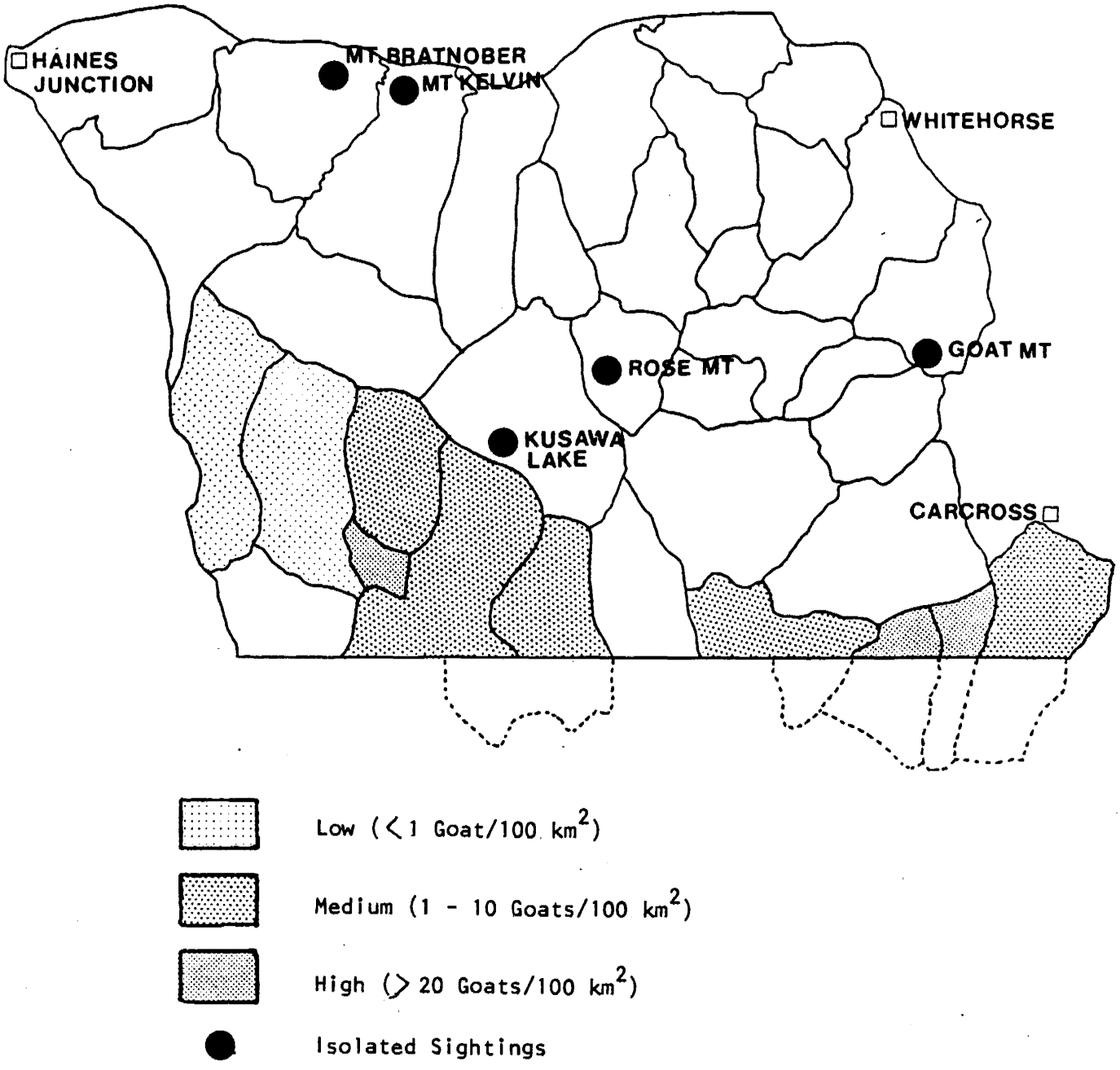

Figure 7. Distribution of goats in Game Management Zone 7, by density.

north-south goat movements appear to be common. Individual goat sitings have also been made on Rose Mountain, on a mountain bordering the north-east end of Kusawa Lake, on Mount Kelvin and on Goat Mountain off the Alligator Lake Road.

Recent goat surveys in Zone 7 have found a total of 142 1+-year-old goats, 80% of which were east of Kusawa Lake/River. This total includes goats sighted in B.C. but on mountain blocks straddling the B.C.-Yukon border. Surveys in 1973 and 1978 located 42 and 123 1+-year-old goats, respectively, over a similar distribution. Based on the 1973 surveys Hoefs (1974) estimated there to be no more than 100 goats in Zone 7, which he described as having been decimated by human hunting. Hoefs (1978) was of the opinion that goat ranges were good in the southern half of Zone 7, and should therefore support much higher densities than those observed in 1973 and 1978.

Goat densities (1+-year-olds) currently average about 1.5/100 km^2 in Zone 7-west and about 5.6/100 km^2 in Zone 7-east. Within subzones where goats were sighted, densities range from 0.5 to 25 goats per 100 km^2 (see Table 2).

One particular subzone, 7-35, was thought to provide a barometer of goat population status. It is a relatively isolated ridge, relatively cheap to survey due to its size and proximity to Whitehorse, and it has what we consider to be good siteability for goats. The block has been surveyed

on a fairly regular basis since 1973. A population of 7 1+-year-old goats in 1973 grew steadily until 1982 when it peaked at about 30 1+-year-old goats, and a density of 25/100 km^2.

Zone 8. Individual sitings have been reported at Twin Lakes (1984), off the Big Salmon River (1984 and 1985), east of Lake Laberge (1987), off the Teslin River, on McClintock Mountain and on Grey Mountain near Whitehorse (Fig. 8). No resident populations have been known to flourish in Zone 8.

Zone 9. Goats are common in the south-west corner of Zone 9, south of Tagish Lake in the mountains straddling the B.C.-Yukon border. An isolated population occurs in the vicinity of Mt. White, near Jakes Corner, the core of which were re-introduced into the area in 1983 and 1984, after an indiginous population was extirpated in the 1960's (Fig. 9). A lone goat was observed on Mount Bryde in 1979.

In August of 1983 and 1984 a total of 11 adults and one kid were captured in the Kluane Game Sanctuary and relocated to Mt.White (northern half of subzone 9-08). Within the year one billy and the kid died, but in the following two years there was 100% survivorship of marked goats. Kids were produced in the two years following the transplant some of which survived at least until late winter. Monitoring was discontinued in 1987. At least 11 and likely more 1+-

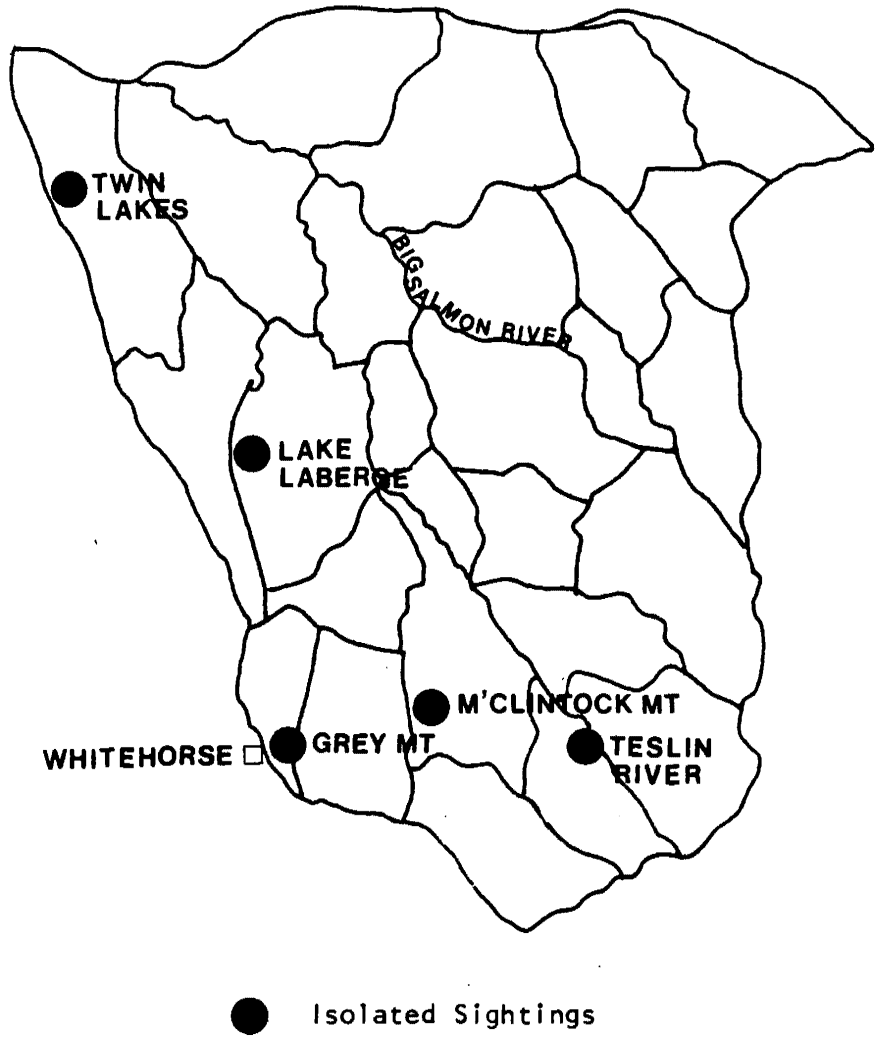

Figure 8. Location of goat sightings in Game Management Zone 8.

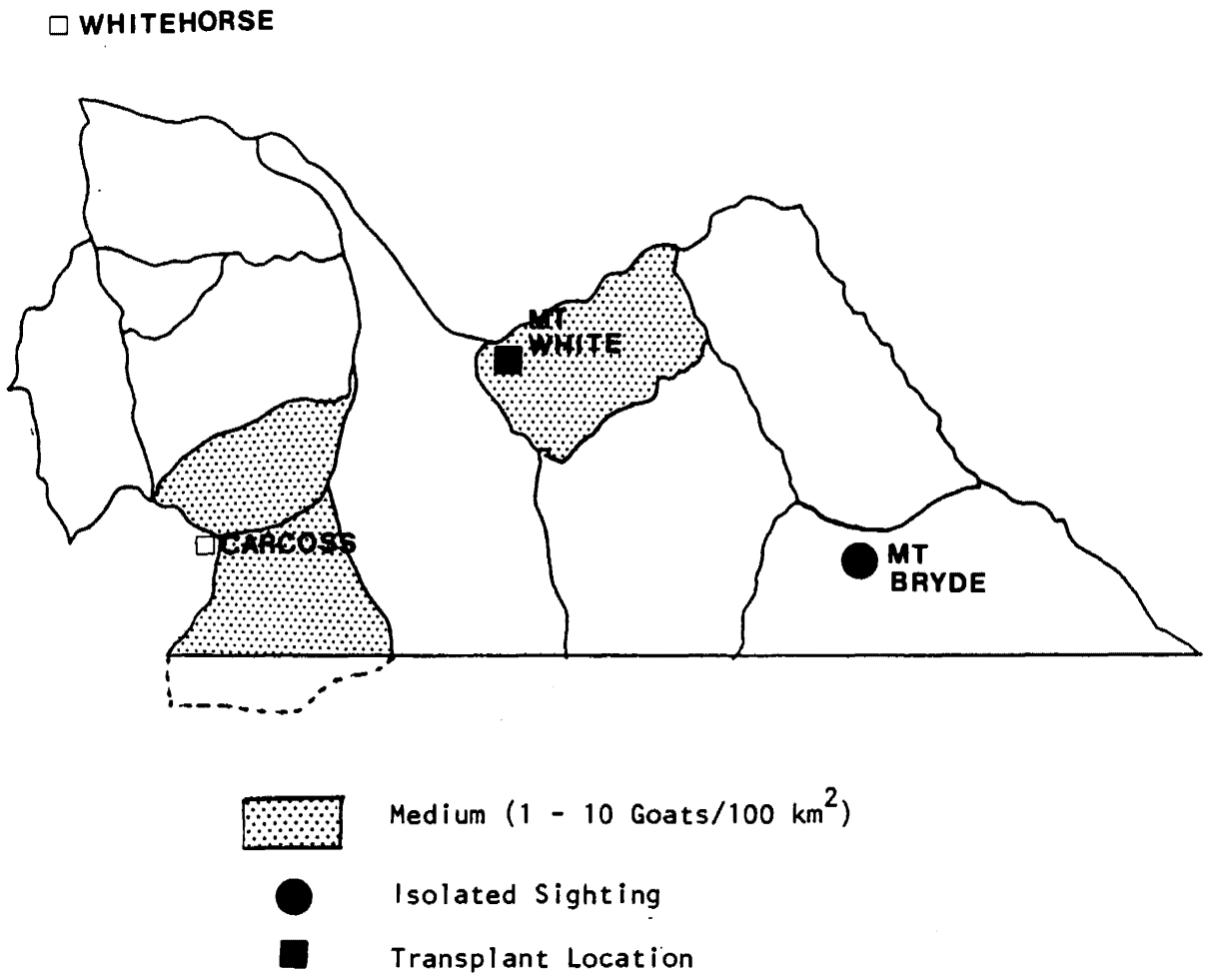

Figure 9. Distribution of goats in Game Management Zone 9.

year-old goats currently exist on Mt.White, at a density of about 9.1/100 km^2.

In the southern part of Zone 9, 8 1+-year-old goats were counted in 1973, 12 in 1978 and 30 in 1987. Most of the observations were made in an area between Windy Arm and Striker Lake, in the vicinity of Mt. Conrad, Mt. Patterson and Charlie Peak. Most of the goat sitings in 1978 were in B.C. while in 1987 only half were in B.C. The density of 1+-year-old goats in subzone 9-06 is currently about 5.6/100 km^2.

Zone 10. Three core populations occur in Zone 10, in the Cassiar Mountains near the B.C.-Yukon border, in the Thirty Mile Range of the Pelly Mountains, and along the Black River in the southeast corner of the Pelly Mountains (Fig. 10). On an all-species survey over much of the Cassiar Mountains in 1977, 27 1+-year-old goats were sighted, most of which were in the vicinity of Goat and Ice Lakes. No recent systematic census has been completed. Based on outfitter knowledge of the area, Lortie et al. (1978) estimated there to be about 80 to 100 goats for the entire Zone 10. Within the subzones where goats have been observed in Zone 10, densities are about 1.7/100 km^2.

Zone 11. Goats appear to be scattered throughout the Logan Mountain at various densities (Fig. 11). In 1976, Hoefs and Lortie (1976) estimated there were 300 goats in the Logan Mountains in rather marginal habitat and

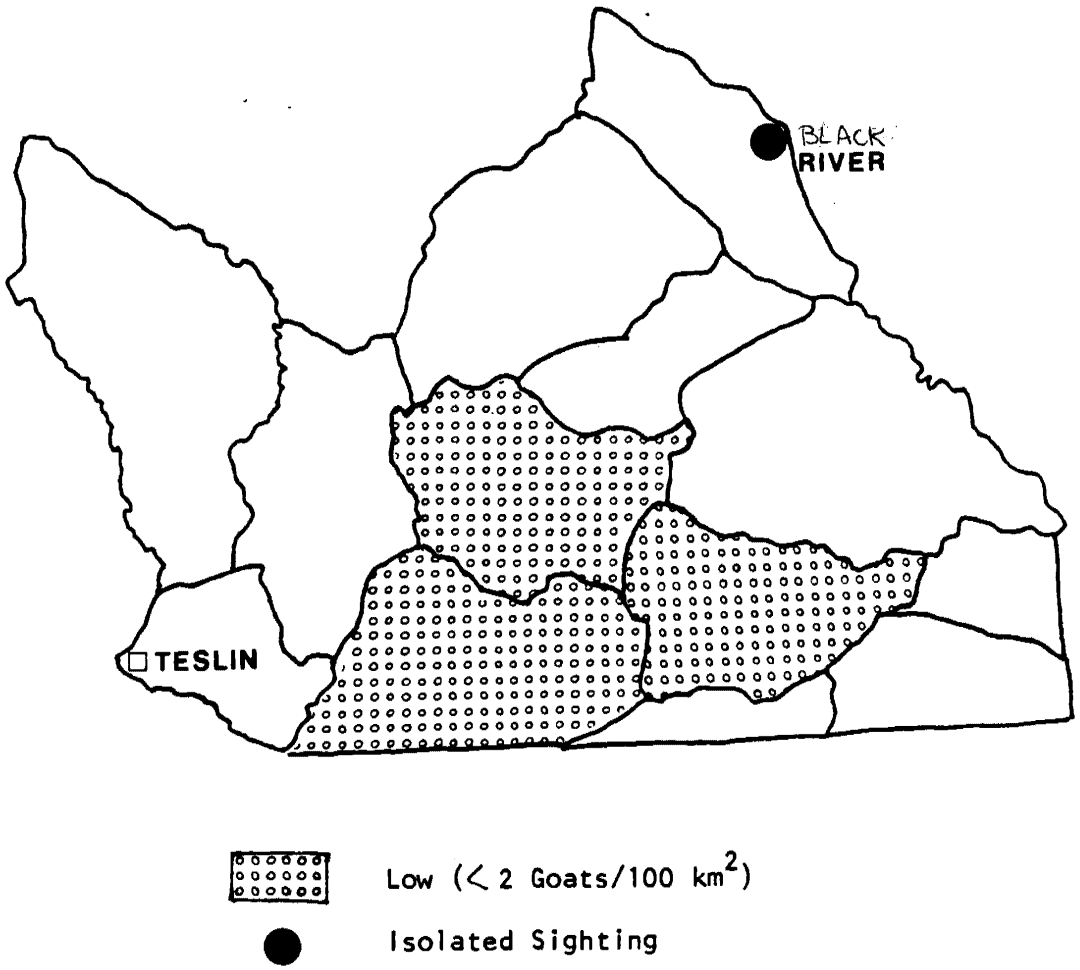

Figure 10. Distribution of goats in Game Management Zone 10.

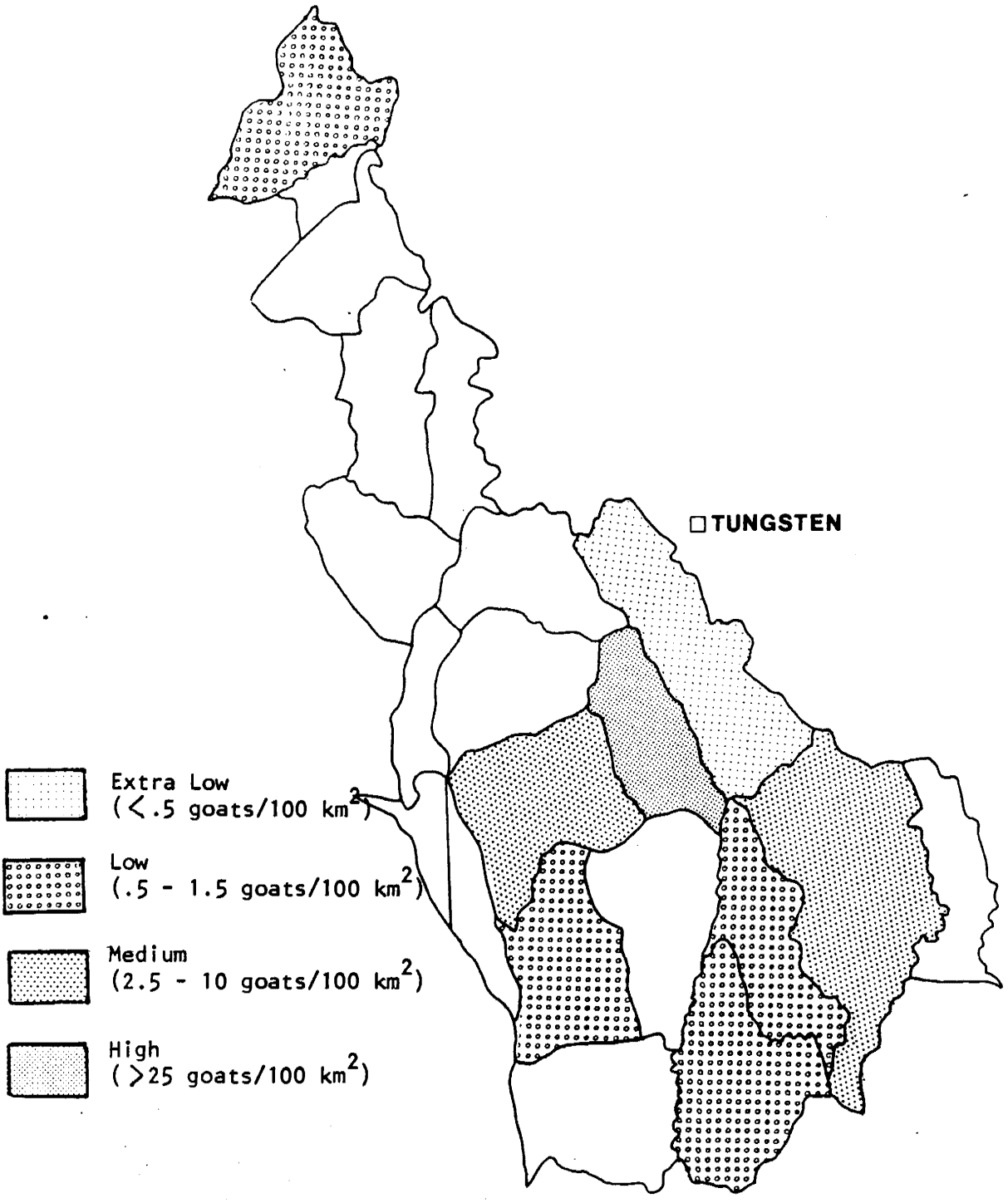

Figure 11. Distribution of goats in Game Management Zone 11, by density.

experiencing low productivity. Surveys in 1983 in two specific subzones in the Logan Mountains, however, found relatively high densities of goats; 134 1+-year-old goats were found in one area of about 450 km^2 (29.8/100 km^2), and 51 in another area of about 500 km^2 (10.2/100 km^2). We suspect goat densities in the Logan Mountains to vary considerably. Detailed topographic mapping may shed some light on habitat quality to explain the distribution of goats in the Logans.

A small isolated population of goats occurs in the Itsi Mountains just south of the north Canol road. This is the northernmost population of goats in the Yukon (63 N), and perhaps North America. Systematic surveys in 1982 reported 15 1+-year-old goats in the Itsi Mountains, at a density of about 1.3/100 km^2.

Population Trend

Complete census has been repeated in only Zones 7 and 9. Over most of the area, replicated surveys occurred in 1973, 1978 and 1986. In two subzones, however, a complete search for goats was made over 9 and 11 years.

In Zone 7, the overall average annual rate of growth of 1+-year old goats from 1973 to 1986 was 11.3%, and of the total population of goats, 12.2% (Table 3). A breakdown by Zone 7-east and Zone 7-west found annual growth rates of 1+-year old goats of 12.0 and 10.3%, respectively, with the

Table 3. Population growth rates.

Zone	Population	Surveyed	No. of Years	Percentage Annual Rate or increase	r^2
Zone 7	Total	1973, 78, 85	3	12.16	0.8171
	1+ Year-olds	1973, 78, 85	3	11.30	0.8235
Zone 7 West (GMS 7-01 to 7-12)	Total	1973, 78, 85	3	11.91	0.5267
	1+ Year-olds	1973, 78, 85	3	10.33	0.4900
Zone 7 east (GMS 7-13 to 7-36)	Total	1973, 78, 85	3	12.69	0.9136
	1+ Year-olds	1973, 78, 85	3	11.98	0.9232
Subzone 7-35	Total	1973-84	11	13.44	0.8257
	1+ Year-olds	1973-84	11	15.21	0.8977
Subzone 9-06	Total	1973-87	9	8.29	0.9510
	1+ Year-olds	1973-87	9	8.28	0.9092

total population growing at 12.7 and 11.9%, from east to west. In subzone 7-35, separated on three sides by a major body of water and therefore relatively isolated, and which was surveyed each year from 1973 to 1984, the goat population grew at an annual average rate of 13.4% (Fig. 12). A consistent pattern, then, was observed of goat populations across Zone 7, growing at an annual rate of at least 10%

Subzone 9-06 which supports a small population of goats ranging across the B.C.- Yukon border similarly grew from 1973 to 1987, at an annual rate of 8.3% (see Fig. 12).

Average winter temperature or snow accummulation (October to March) did not vary between years, from 1973-1987 ($F=1.19$, $p=0.33$, and $F=0.85$, $p=0.58$, respectively). No patterns, then, were evident between goat population size and either average winter temperature or snow accummulation.

Productivity

Productivity, expressed as the percentage of kids in the herd in mid-summer, ranged from 9.2 (n=65) to 32.8 (n=58), from 1973 through 1987 over all subzones surveyed in Zones 7 and 9. No trend in mid-summer productivity was apparent in two subzones surveyed regularily since 1973 (Table 4).

Over the entire survey period, from 1973 to 1987, kids have represented on average, 19.0% of the goat population.

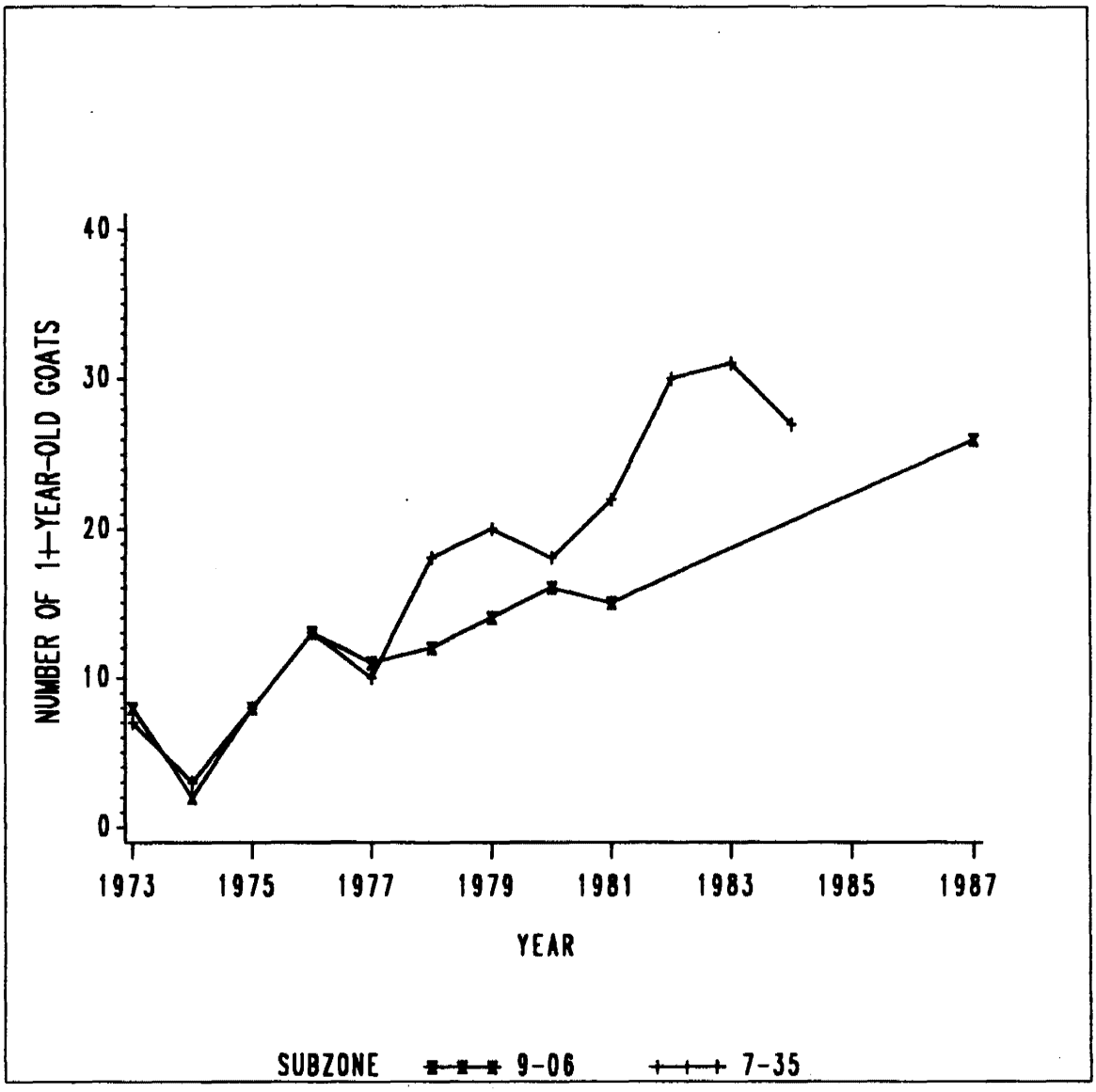

Figure 12. Population trend of non-kid goats in two subzones in the southwest Yukon, based on minimum counts.

Table 4. Productivity, expressed as the percentage of kids in the herd in mid-summer.

Year	Subzone 7-35	Subzone 9-06
1973	22.2	33.3
1974	0	33.3
1975	33.3	27.3
1976	18.8	7.1
1977	16.7	31.2
1978	28.0	29.4
1979	8.3	22.2
1980	14.3	20.0
1981	12.0	16.7
1982	26.8	--
1983	11.4	--
1984	30.0	--
1985	--	--
1986	--	--
1987	--	26.5

During the periods 1973-77, 1978-79 and 1980-87, kids as a percent of the population averaged 15.6% (n=238), 21.5% (n=200), and 19.8% (n=415), respectively.

Hunting Regulations

The history of goat hunting regulations in the Yukon since 1973 is presented in Table 5. Restrictions legislated in 1974 were a result of the 1973 surveys, and the opinion of the goat biologist, that goats were being excessively harvested in Management Zones 7 and 9. More restrictions were applied in 1978, again as a response to surveys. Goat hunting was permitted only in Zone 11 from 1980 to 1986, from 1 August to 31 October, to open hunting for residents, and a quota of 13 goats to non-residents. In 1986, resident only permit hunting was established in subzones 7-34 and 7-35 with one permit allocated per subzone, based on minimum population counts in 1985.

The Goat Harvest

The goat harvest by licenced hunters has ranged from 3 to 32 since 1973 (Table 6). Over three management periods the average annual harvest dropped from 23.6 to 15.5 to 9.1 from 1973-77 to 1978-79 to 1980-86, respectively (Table 7). In the Yukon, in Zone 7-west the harvest fell from an average of 5.4 per year from 1973-77 to 2.0 per year in 1978-79, and in Zone 7-east from 5.8 to 3.0 over the same periods. Meanwhile, the goat kill on the B.C. extensions of

Table 5. History of goat hunting regulations in the Yukon since 1973.

	Prior to 1974		1974		1978	
	Season	Restrictions	Season	Restrictions	Season	Restrictions
Resident						
Zone 7 West	1 Aug.-30 Sept.	Horns at least 10 cm.	1 Sept-30 Sept	Horns at least 20 cm.	No change	No change
7 East	"	"	1 Sept-30 Sept	Compulsory submission	Closed	
9	"	"	Closed		Closed	
10	"	"	1 Aug.-31 Oct.	Females with young and young protected	No change	No change
11	"	"	1 Aug.-31 Oct.	"	No change	No change
Non-Resident						
Zone 7-0A16	"	"	"	"	No change	No change
10-0A20	"	"	"	"	No change	No change
11-0A22	"	"	"	"	No change	No change
11-0A9	"	"	"	"	No change	No change

Table 5. (cont'd...)

	Prior to 1979		1980		1986	
	Season	Restrictions	Season	Restrictions	Season	Restrictions
Resident						
Zone 7 West	No change	No change	Closed		Closed	
7 East	Closed		Closed		1 Aug.-31 Oct.	2 permits only
9	Closed		Closed		Closed	
10	No change	No change	Closed		Closed	
11	No change	No change	No change	No change	No change	No change
Non-Resident						
Zone 7-0A16	No change	Quota: 2	Closed		Closed	
10-0A20	No change	Quota: 3	Closed		Closed	
11-0A22	No change	Quota: 12	No change	No change	No change	No change
11-0A9	No change	Quota: 1	No change	No change	No change	No change

Table 6. Total annual reported goat sport harvest.

Year	Number	Percent Males
1973	23	73.9
1974	25	60.0
1975	23	65.2
1976	17	64.7
1977	32	59.4
1978	15	60.0
1979	17	70.6
1980	13	61.5
1981	17	70.6
1982	11	36.4
1983	7	71.4
1984	5	80.0
1985	8	75.0
1986	3	66.7
TOTAL	216	64.4

Table 7. Mean annual harvest and harvest as a percent of minimum population levels.

Zone		Annual Harvest	Minimum 1+ year-old pop. Estimate	Harvest as a Percent of 1+ year-old pop. Estimate
7-West	1973-77	5.4	15	36.0
	1978-79	2.0	35	5.7
7-East	1973-77	5.8	24	24.2
	1978-79	(3.0)	76	
9	1973-77	0.4	8	5.0
	1978-79	(0.5)	12	
10	1973-77	1.4	60-80	1.8-2.3
	1978-79	7.0		8.8-11.7
11	1973-77	10.6		4.4
	1978-79	6.5	(240)	2.7
	1980-86	9.1		3.8
Total	1973-77	23.6	347	10.6
	1978-79	15.5	335	4.6

Adjacent B.C. havest (within 12 miles of B.C./Yukon border)

7-West	1976-83	1.1
7-East	1976-83	2.9
9	1976-83	0.8

Zone 7, averaged 4.0 per year from 1976-83 (B.C. Wildlife Branch, unpublished data). In Zone 10 the annual goat kill increased from 1.4 to 7.0 from 1973-77 to 1978-79. The increased kill, in conjuction with the survey results of 1977, led to the eventual closure of goat hunting in 1980.

Expressing the goat kill as a percent of the minimum number of 1+-year old goats, according to census results during the period, the annual harvest from 1973 to 1977 was 36.0 and 24.2% of the goats observed in Zone 7-west and 7-east, respectively (see Table 7). This fell to 5.7 and 4.0% in the next two years. Accounting for the B.C. goat kill adjacent to Zone 7, and applying the average annual kill for the years 1976 to 1983 in the B.C. portion of the range, against the 1978 population estimate, 8.1% of the 1+-year-old observed goats were killed in 1978-79 in the vicinity of Zone 7. In Zone 9 the combined B.C.-Yukon goat kill was estimated to be about 10.8% of the minimum count of 1+-year old goats through 1978-79. In comparison, the annual goat harvest in Zone 11 since 1973 has been less than 4.5% of the estimated 1+-year old goats. In Zone 10 the goat kill jumped from around 2 to 10% of the estimated 1+-year old population from 1973-77 to 1978-79, prompting the government to close the goat hunting season for the entire area.

The number of billy goats killed by licensed hunters in the Yukon since 1973, as a percent of the entire licensed harvest is 64.4% (n=216). This is very similar to the

northern B.C. harvest which has yielded 62.5% billies (n=408). A comparison by area and year (Table 8) reveals similar sex ratios across zones and years. Zone 11 had the highest percentage of males in the harvest, of 67.7 (n=130), while Zones 9 and 10 yielded the lowest percent male harvest of 50.0 (n=2) and 59.1 (n=22), respectively. The bias toward males despite population sex ratios that are probably skewed toward females by as much as 1.4 females for every male, indicates that harvest is selective toward males, particularly in Zone 11.

Age and Horn Characteristics of the licenced kill.

A summary of the age and horn characteristics of the licensed Yukon goat harvest, by sex and year, and by zone and sex, is presented in Tables 9 and 10.

The average age of the 1980 goat kill was significantly greater than in all other years (1973-1986); 9.4 years (n=13), as compared to averages ranging from 4.5 to 7.0 years (n=3 to 32; $F=2.29$, $p<0.01$). No significant differences were observed of average ages of the goat kill between zones ($F=1.35$, $p=0.26$), or between sexes ($F=1.09$, $p=0.30$). The average ages of males and females killed by licensed goat hunters from 1973 to 1986 was 6.27 (n=127), and 6.66 (n=73), respectively.

Total horn length did not vary across years ($F=0.49$, $p=0.93$), zones ($F=1.43$, $p=0.24$), or sexes ($F=0.72$, $p=0.40$).

Table 8. Percent males in the licenced goat harvest.

	YEAR				
	1973-77	1978-79	1980-86	1976-83	1973-86
TOTAL YUKON	64.2 (120)[1]	65.6 (32)	64.1 (64)	- -	64.4 (216)
ZONE 7	60.7 (56)	75.0 (4)	- (0)	- -	61.7 (60)
ZONE 9	50.0 (2)	- (0)	- (0)	- -	50.0 (2)
ZONE 10	57.1 (7)	60.0 (15)	- (0)	- -	59.1 (22)
ZONE 11	71.7 (53)	69.2 (13)	64.1 (64)	- -	67.7 (130)
B.C.[2]	- -	- -	- -	62.5 (408)	- -

[1] Number shot in parenthesis.

[2] Within 12 miles of Yukon-B.C. border, south of zones 7 and 9.

Table 9. Licenced goat harvest, by sex and year.

SEX	YEAR	NUMBER SHOT	MEAN AGE	MEAN HORN LENGTH (INCHES)	MEAN BASE CIRC. (INCHES)
MALE	1973	17	6.07	8.26	4.82
	1974	15	6.00	8.69	5.10
	1975	15	6.57	9.05	5.38
	1976	11	5.09	8.66	5.12
	1977	19	6.79	8.84	5.27
	1978	9	7.11	8.72	5.60
	1979	12	5.33	9.06	4.94
	1980	8	10.38	9.06	5.41
	1981	12	5.42	8.57	5.03
	1982	4	6.00	9.15	5.40
	1983	5	4.25	8.58	5.10
	1984	4	5.25	9.24	5.20
	1985	6	6.17	8.39	5.12
	1986	2	6.50	8.88	4.96
	TOTAL	139	6.27	8.76	5.16
FEMALE					
	1973	4	8.75	10.01	4.34
	1974	10	6.89	8.52	4.13
	1975	8	6.25	8.75	4.19
	1976	6	5.83	8.48	4.16
	1977	13	7.38	9.23	4.38
	1978	5	5.80	8.86	4.20
	1979	5	6.00	8.79	4.19
	1980	5	7.80	8.76	4.09
	1981	5	6.40	8.87	4.09
	1982	7	6.71	8.98	3.94
	1983	2	5.00	8.70	4.09
	1984	1	7.00	8.19	4.02
	1985	2	4.50	8.84	4.21
	1986	1	5.00	8.50	4.02
	TOTAL	74	6.66	8.88	4.18

Table 10. Licenced goat harvest, by zone and sex.

ZONE	SEX	NUMBER SHOT	MEAN AGE	MEAN HORN LENGTH (INCHES)	MEAN BASE CIRC. (INCHES)
7	MALE	37	5.76	8.62	5.11
	FEMALE	23	6.27	8.96	4.30
9	MALE	1	5.00	7.52	5.12
	FEMALE	1	10.00	8.27	3.74
10	MALE	13	5.92	9.01	5.37
	FEMALE	8	6.00	9.35	4.30
11	MALE	88	6.53	8.79	5.15
	FEMALE	42	6.90	8.76	4.10

Average total horn length of male and female goats killed in the Yukon was 8.76 and 8.88 inches, respectively. The horn base circumference of males was significantly different than females, 5.16 inches, compared to 4.18 inches, respectively ($F=228.33$, $p<0.01$). No differences in horn circumference were extracted between year of kill, or zones.

DISCUSSION

The accuracy of goat surveys is hindered by observability problems associated with goat behaviour, the daily and seasonal timing of the survey, and weather conditions during the survey (Fox 1978). In addition, goats are apparently more difficult to observe with survey replications, probably due to a learned response to hide from approaching aircraft (Smith 1984). In the Yukon, these difficulties are compounded by the fact that there may be a seasonal shift in distribution from northern B.C. into the southern Yukon.

Where data exists it appears as though goats move north in the fall and perhaps winter on the north end of their range, in what falls largely in the Yukon. In subzone 7-11 no goats were observed in July, 1973 or July, 1986, and yet 24 mature goats were observed there in late August, 1978. In subzone 7-34 in 1984, 9 mature goats were located in August and 20 in September. Also in the B.C. portion of the goat range, much of the winter range was suspected to lie against the Yukon border (Steventon 1986). We would expect the northern part of the range to enjoy the benefits of a rain-shadow from weather systems generated in the Gulf of Alaska, and therefore to receive less snow-fall than range further south. Therefore a movement of goats north would be anticipated, as a compromise between food abundance and availability. Survey blocks consist of mountain blocks

straddling the Yukon-B.C. border and considered to be continuous goat range. However, goats at the southern extent of their range and well into B.C. are less likely to be counted than goats in the Yukon.

Uncertainty exists about the degree of error of July helicopter surveys. No doubt some goats are being missed but the magnitude of the sampling error from one pass helicopter flights is unknown. Replication would have allowed us to calculate the variation around an estimated population, however, if goat behaviour is modified with greater sampling intensity, greater precision would have been offset by greater sampling error. Also, we have not been able to test sightability as it relates to time of day, weather conditions or season. Fox (1978) found goat activity patterns and distribution, and therefore visibility, to vary with weather.

Despite these uncertainties of sampling bias and observability, the minimum counts of goats in 1973, 1978 and 1986 over the entire Zones 7 and 9, and the annual counts of goats on subzone 7-35 provide a general indication of goat status and trend.

In the Yukon goats are patchily distributed and at highly variable densities. The factors that control the distribution and abundance of goats are likely complex. In the Yukon goats occur at the highest densities in wetter areas, often in association with perpetual snow fields where

the topography is rugged and the bedrock usually intrusive or metamorphic. Although the distribution of goats may change in the fall-winter, to areas receiving less snowfall, they continue to use areas that receive much precipitation.

The needs of goats for topographic breaks as escape terrain are obvious. It is possible that a bedrock of intrusive or metamorphic rock provides more stable footing and a generally more stable landscape. Sedimentary rock in contrast is very unstable; it is subject to weathering and provides poor footing for goats.

The attraction to wetter landscapes may be related to higher annual yields of primary production or plant diversity, the availability of preferred forage such as subalpine fir, or may simply represent a niche not filled by thinhorn sheep. The latter point, however, is unlikely. In the Kluane Game Sanctuary goats and sheep appear to coexist at relatively high densities. Also, goats that have been transplanted in the southern United States have been found to outcompete sheep on shared ranges. The seasonal shift to drier clines within wet ecotypes may represent a compromise between abundant forage and access to forage.

Goats are cliff dwelling ungulates limited largely by the availability of adequate escape terrain. They appear not to run easily on level ground and hold fast on cliff terrain when harrassed by predators. Geist (1971) observed sheep and goats on shared range in northern B.C. and found

goats much more persistent on cliffs, in comparison to sheep which appeared to frequently utilize gentle slopes.

Goat physiology, morphology, and behaviour is also suggestive of a sedentary habitat specialist. Goats have relatively small hearts, and are extremely well insulated over most of their body including the upper half of their legs. These characteristics are compatible with sedentary winter habits on high elevation ranges, and their apparent reluctance to crater for forage as suggested by Geist (1971), all of which may imply a strategy to cut the costs of energy expense. High elevations in the winter often enjoy the temperature advantages of thermal inversion. By adopting sedentary habits, minimizing the flow of blood and utilizing optimum thermal habitats, goats may be able to persist on food scarce ranges (cliffs) in a "semi-dormant" state.

Goats find desirable terrain high in the mountains where the growing season is short, the precipitation exaggerated by the influence of topography and elevation, and where winter temperature inversions are common. In the Yukon where the growing season is even shorter than clines further south, the need for highly productive sites is likely important. Plants in high elevation, wet, coastal-type areas undoubtedly enjoy higher growth rates during the short northern growing season, than plants in similar, yet drier, situations. The advantage to living in a relatively

productive area may be particularly important in a biotype that is predominantly rock. Therefore, we suggest it is on these sites that goats persist. A combination of less rock and lower productivity prevents goats from extending their range north into the dry interior of the Yukon, where sheep are abundant. Only in areas where the topography is rugged and continuous, and associated with high plant productivity do we expect to find moderate to high densities of goats in the Yukon. Habitat mapping in the Yukon may elucidate the relationship between goat distribution and habitat needs.

Yukon's population of non-kid goats, accounting for those ranging across the Yukon-B.C. border, is currently estimated at about 1700. In areas where surveys have been repeated over a number of years there has been a consistent rate of increase of at least 0.10. We have no data to indicate that populations have attained stable densities. The concepts of population stability and range carrying capacity may not be useful, particularly for Yukon goats. In Alaska, Smith (1984) found goats experiencing an average annual rate of increase of -0.29 from 1968 to 1975, and of 0.12 from 1975 to 1983, reaching as high as 0.38 over a five year initial recovery period. Over the entire period he observed a radical change in population size. Smith (1984) went on to conclude that goat populations in the coastal ecotypes were governed largely by cyclic weather severity, and unexpectedly high potential rates of increase. Density dependent feed-back was only apparent during the initial

recovery period and data correlating population growth to density were inconclusive. We have insufficient data in the Yukon to describe population changes in detail or to suggest what factors may be controlling goat populations in the absence of hunting.

The Yukon data is also insufficient to allow an assessment of natality or mortality schedules regulating goat numbers. Similar to Smith (1984) we observed highly variable annual percentages of kids in the population. Smith (1984), in concurrence with Adams and Bailey (1982) and Stevens (1983) concluded that kid production was not a sensitive indicator of population performance. Mortality rates he believed were far more influential on population growth rates, a conclusion consistent with Caughley's (1977) general analysis of ungulate population dynamics and Adams and Bailey's (1982) assessment of goat demography.

Hoefs (1978a) was convinced that goats were severely depleted in the Yukon prior to 1973 by overhunting, which continued until 1978 at which time severe hunting restrictions were imposed. This analysis largely concurs with Hoefs, based on a fairly dramatic recovery of goat populations, across a number of areas, since hunting was restricted. The harvest of goats in Zones 7 and 9 was negatively correlated with population growth, substantiating the view that hunting losses were additive and detrimental to goat populations in the area.

Hunting, however, may have only contributed to goat population declines. Smith (1984) believed that weather was the most significant factor influencing goat populations. During favourable climatic periods Smith (1987) suggested that native goat populations could withstand additive hunting mortality, while at other times hunting was detrimental, as suggested by Hebert and Turnbull (1977), Kuck (1977), Chadwick (1983), Eastman (1977), and Fox (1978). The fact that mortality rates of adult goats during periods of increase was almost entirely due to hunting reinforces the views of most goat researchers, that losses of goats to hunting is largely additive (Smith 1987).

Density dependent responses on natality and mortality have not been clearly observed (Johnson 1986). It is possible that density effects are only obvious at the extremes in density or that density responses are delayed and therefore confounded by the effects of environment. Or, perhaps, environmental effects are so profound they mask any density dependent responses. At extremely low densities a density effect may be offset by declining reproductive fitness due to inbreeding as suggested by Johnson (1986).

Of interest is the fact that goats, over much of their North American distribution, declined during the early 1970's and recovered during the late 1970's and early 1980's (Hebert and Turnbull 1977, Chadwick 1983, Smith 1984, Dane 1977). Both Smith (1984) and Dane (1977) at least partially

attributed these declines to severe winters. Stevens (1983) found that severe winters were affecting goat reproductive success one and a half years later. One severe winter, then, may produce a trend over a number of years, of population decline. A series of bad winters may amplify the trend.

In the Yukon, the inverse correlation between goat harvest and population size infers that hunting was additive and had a detrimental effect on goats in the 1970's. Furthermore, no pattern was evident to indicate that temperature or snowfall reduced goat numbers in the 1970's. Hunting must be considered the most significant factor on goat population dynamics, and therefore prescribed gently.

The percentage of male goats in the harvest, 64.4, differed little from the entire B.C. licenced kill, of 65.5% (Hebert and Smith 1986), and of the northern B.C. harvest, of 62.5% (unpubl. data, B.C. Fish and Wildlife Branch). The average age of the Yukon kill for males and females was 6.3 and 6.7, respectively. In comparison, the average age of the B.C. goat kill from 1980 to 1984, varied between 5.1 and 5.6 years for males, and 5.6 and 6.0 years for females (Hebert and Smith 1986).

Smith (1986) compared the average age of harvested goats to that of adult animals dying naturally (as indicated by skulls found in the field), and found that hunter killed goats were on average younger than naturally dying goats.

He suggested that hunters were not discriminately selecting older animals, and that goats reaching their reproductive prime were as likely to be shot as those nearing their natural life expectancy. Therefore, the effect of additive losses due to hunting is likely aggravated by indiscriminate harvest on reproductively-prime individuals.

Management considerations for the Yukon

Goat management is compromised by a number of facets of goat biology. As mentioned previously, goats are difficult to identify by sex, they are difficult to inventory, they are habitat specialists and very traditional in their use of range, and in the Yukon they are often found in small isolated pockets. Females are found not only in larger groups but generally lower on the mountainside (Chadwick 1983). As such they tend to be easier than males to locate and approach by human hunters. The inability to identify females has facilitated their decline. The fact that goats are patchily distributed and confined to very traditionally-used areas has resulted in persistent hunting pressure on known goat cliffs.

Previous reports indicated that not only were they vulnerable to human hunting, but that wounding losses were also high due to the difficulty of killing goats, and orphans were unlikely to survive (Chadwick 1983). Furthermore productivity was considered generally low and

natural mortality rates high (Eastman 1977, Kuck 1977, Chadwick 1983). Chadwick (1983) went so far as to suggest that goats on marginal ranges, disturbed areas or isolated settings be entirely protected against hunting.

More recently studies have found that coastal goat populations can enjoy relatively high rates of increase, that productivity can be high and mortality rates exceptionally low. Therefore under good environmental conditions goat populations grow rapidly and can withstand additive hunting losses (Smith 1984, Smith 1987). However, Smith (1984) noted that goat populations suffer periodic and substantial losses during severe winters, and that hunting when accompanying these declining periods can contribute substantially to population decline. Stevens (1983) went further to suggest that reproductive failures would persist long after a severe winter, compounding the decline. Smith (1987) suggested that the appropriate strategy for managing goats over most of their range was to employ a tracking harvest system based on up-to-date assessments of population growth rates.

Clearly there are difficulties with a dynamic management program. Such a harvest strategy relies on up-to-date and accurate census data, and a sound understanding of biological processes. Because generally goats are poorly understood, erroneous assumptions of population processes are possible. Goat biologists are vague about natural rates

of natality and mortality, and density dependent mechanisms. Also data has historically been inadequate to even determine population levels. Sampling difficulties include poor sightability, biases due to changes in goat behaviour, and the inability to identify subpopulations, all of which contribute to imprecision.

A dynamic management approach also relies on hunter-kill information at the sub-population level, and the ability to respond quickly to alterations of sex-ratio. These conditions are difficult to administer.

We suggest that a goat management strategy be adopted that is both conservative and dynamic, that considers the value of goats, their sensitivity to hunting, the difficulties of inventory, and the importance of habitat. An underlying premise of the goat management strategy is that goat population ecology is very dynamic and at times highly unstable.

Some of the underlying assumptions that should be explicitly identified are:

1. Goats should be managed at the sub-population level. Generally, the subzone will define the management unit.
2. All goats killed by hunters should be submitted for compulsory inspection, to determine age, sex and horn growth characteristics. Voluntary cooperation should be requested of native (subsistence) goat hunters.
3. Part of our management obligation should be to achieve a

harvest biased heavily toward males.

4. Goat range, particularly winter range, should be protected entirely from industrial development.

5. Resident hunting restrictions will be lifted as goat populations reach acceptable densities, and if resources are made available for periodic monitoring of population status. Liberalization of hunting will occur only through a limited entry draw.

6. Non-resident hunting will be restricted according to quota allocation to specific outfitters.

7. The allocation of quotas and limited entry permits between residents and non-residents in areas where hunting restrictions will be lifted will be done according to government allocation policy.

8. Current regulations protecting adults accompanied by young, and their young, will continue.

Complete closures should be maintained in a number of areas, in particular, areas where goats are presently at low densities. Kuck (1986) suggested that goat hunting be allowed only on populations of at least 40 non-kids. In addition areas that are readily accessible or become so should be closed to hunting. Hunting should also be curtailed when populations are suspected to be declining or where the sex ratio of the kill is biased heavily towards females. Isolated populations should be watched carefully to ensure harvest does not become excessive.

Restrictive quota or permit hunts should be established in areas where goats are contiguously distributed and relatively accessible, where densities are sufficient (minimum population levels of 40+ non-kids) and where population growth or stability is suspected. If possible, sex-specific ranges should be identified and nursery areas protected. The number of permits should reflect a minimum current population count, and a rate of less than 5% of the non-kid minimum count be applied (Table 11), as recommended by Kuck (1986) for Idaho goats. To increase hunting opportunity, archery-only seasons could be introduced. Johnson (1986) found the goat hunting success of bow hunters to be aproximately 27%, in comparison to rifle hunters who enjoyed a success rate of at least 55%.

Subzone 7-35 should be surveyed annually to provide an estimate of population trend for Zones 7 and 9. Where the population has declined from previous estimates, harvest should be curtailed during the following year. Conversely if densities increase the number of hunting permits issued can be increased.

Open hunting can be maintained in areas that are relatively isolated, where goat densities are moderate to high and the range is continuous, and where the historic kill is biased to males.

Census should be done through intensive helicopter search.

Table 11. Recommended permit allocations based on minimum non-kid population counts, 1985-87.

Area	Minimum Number 1+-year-old goats	Suggested number of permits
Subzones 7-10, 11, 12	48	2
7-28	39	2
7-34, 35	59	3
9-05, 06, 08	61	3

Replication is desirable in conjunction with ground count validation. Surveys should be conducted toward sunrise or sunset under clear skies, in August if possible, according to the recommendations proposed by Fox (1978).

Goat habitat should be protected. Although land use alteration is unlikely, given the characteristics of goat habitat, roads and industrial activities in the vicinity of goat cliffs should be avoided where possible. Activities in goat habitat, in particular those associated with vehicular traffic (including ATV's), should be monitored closely.

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