HISTORICAL PATTERNS OF MOUNTAIN GOAT HARVEST

IN BRITISH COLUMBIA[1]

Bryan Richard Foster

Department of Animal Science
Faculty of Agriculture
The University of British Columbia
Vancouver, B. C. V6T 1W5

Abstract: About 80 percent of the mountain goats in North America reside in British Columbia. Management of the species in this Province has developed as a result of the need for herd protection form over-hunting. A decline in quality of mountain goat sport hunting is discussed in reference to the sale of licences, hunter-dynamics and catch-per-unit-effort trends. Mountain goat tag sales declined over the period 1965 - 1975, although big game tag sales have increased. Opposing characteristics of resident and non-resident mountain goat hunters are discussed. The non-resident hunter exerts constant and greater time in the field to bag a mountain goat, resulting in higher success rates than resident hunters. The non-resident hunter is less affected by increases in licence fees or changes in the bag limit. Non-resident hunters utilize longer and guided hunting trips, enabling harvest of trophy males from relatively unexploited populations. The age composition of the northern British Columbia goat harvest from 1969 to 1975 shows proportionately more younger cohorts each year. Analyses of mountain goat catch-per-unit-effort ($r = 0.94$) suggest resident hunter harvest has been closely related to access. During the 11 year period 1964 - 1974 the percent of the total goat kill taken in the southern half of the Province has declined from 75 percent to 35 percent. Analyses document temporal and spatial patterns of hunting pressure and harvest of mountain goats in British Columbia over this period. Many Game Management Areas have experienced peaks in mountain goat hunter effort and harvest and are now declining. Access appears to have been the primary cause for over-exploitation of numerous mountain goat herds within this Province. Contrary to past regulatory methods, mountain goat management should be based on smaller land units, such as watersheds.

Mountain goats are an important resource in British Columbia, contributing in excess of $200,000 to the Province's annual revenue from direct economic game regulations (British Columbia Fish and Wildlife Branch 1976), and from miscellaneous hunter transportation and equipment fees. In terms of the amount of recreation (the number of hunting days) provided to resident big game hunters, the species ranks fifth among thirteen big game species in British Columbia (Pearse and Bowden 1972). Additionally, British Columbia is rated best in North America for mountain goat trophy hunting (at least up to and including the early 1960's), holding approximately 70 percent of the total recorded trophies (Baker 1964). This has most likely resulted because approximately 80 percent of all continental mountain goat population exist within the Province (Perse and Bowden 1972).

Currently, industrial and wildlife interests are forcing biologists to make critical decisions at an increasing rate and often on non-scientific bases. To date, regulation of harvest has been the predominant means of game management in British Columbia. Detrimental consequences of this type of management have been documented for mountain goats in the Kootenay region of southeastern British Columbia (Phelps et al. 1975) and in western Alberta (Quaedvlieg et al. 1973).

---

[1] A supplement consisting of historical mountain goat hunter effort, harvest and success patterns within each Game Management Area is available from the British Columbia Fish and Wildlife Branch, Parliament Buildings, Victoria, B. C.

A decline in quality of mountain goat hunting is believed to have resulted from past harvest regulatory methods (Pearse and Bowden 1972; Foster 1976a). Both the quality of recreational experience and the quantity of harvested animals are affected by the status of individual populations. The ecological characteristics of this species have retarded proper management by limiting application of known sampling methods for estimating population parameters. Greater efficiency in mountain goat management will require the availability of baseline information on historic and present distributions, and population trends.

This paper examines the implications of alternative patterns of regulatory management on the harvest and status of British Columbia's mountain goat resource. It is believed that industrial development and variability in mountain goat ecology necessitates a localized approach to management of the species within the Province. Both resident and non-resident hunters may have to be managed on separate bases.

I thank the British Columbia Fish and Wildlife Branch for their contribution of available mountain goat data for this Province. Acknowledgments also go to the University of British Columbia Biological Data Centre for their advice and use of the equipment for data processing. Finally, I extend thanks to Dr. F. L. Bunnell, for advice and assistance during the preparation and initial stages of this project. Dr. Bunnell and Dr. D. M. Shackleton reviewed this manuscript.

BACKGROUND AND METHODS

Development of Mountain Goat Management in British Columbia

A department for protecting game was instituted in 1905, known as the Provincial Game Commission of British Columbia. From annually published Game Commission Reports, access was noted to be a major factor in the decimation of local goat populations as early as 1909. During this period, big game hunters were rarely encountered past the immediate vicinity of transportation links (Millar 1916). Both Coastal and Stooey Indians were blamed for significant reductions of many big game stocks; in particular, the Coastal Indians killed goats in large numbers for their hair (British Columbia Game Commission 1910). Stelfox (1971) and Millar (1916) discuss the decline in numbers of other big game species in the Canadian Rockies, as a result of indiscriminate hunting with firearms by resident Indians, explorers, miners, railway builders and settlers.

Although by 1912 the number of licenced hunters had increased fivefold since 1909 (British Columbia Game Commission 1912), regulated hunting appeared to have had little effect upon overall stocks of mountain goats even though bag limits were generous during this period:

> "In this Province, a man (non-resident) pays one hundred dollars for a
> general licence ... So for this sum he may kill two moose, one wapiti,
> three caribou, three goat, three sheep (only two of one species and
> not more than one in the Kootenay), five deer, and grizzly and black
> bear without limit ..." (British Columbia Game Commission Report 1909)

Table 1 presents a summary of mountain goat economic regulations. Remoteness of the ranges, worthlessness of the hide, small esteem as a trophy or meat source, and abundance of more desirable and accessible big game were believed by Millar (1916) to have retarded depletion of goats, as compared to the fate of most other big game species in the Canadian Rockies. Beyond a bag limit of two, there appeared to be no necessity to restrict shooting of mountain goat in any part of the Province (British Columbia Game Commission Report 1918).

Institution of four administrative regions for wildlife management enabled more detailed population observation and control, as noted by pre- and post-1922 Game Commission Reports (British Columbia Game Commission 1909 - 1956 Foster 1976a). However, inadequacies of this system were evident with increased human settlement in British Columbia. In 1925, five administrative regions were formed, and by 1967, there were 28 Game Management Areas (G.M.A's) Then in 1975, the GMA's were further subdivided into over 200 Management Units (MU's) for the purpose of game management. Table 2 presents the temporal increase of protective controls created and enforced for mountain goat in British Columbia.

It was apparent by the 1940's that greater consideration had to be taken in game management affairs due to the increased drain upon the wildlife resources of the Province. The need for a carefully planned scientific management program was becoming more evident (British Columbia Game Commission 1948), especially in light of the publication of Aldo Leopold's book in 1933.

Table 1. Summary of economic regulations on mountain goat in British Columbia (1905 - 1976).

	NON-RESIDENT				RESIDENT		
	General Firearms & Anglers Licence ($)		Trophy Fee ($)	Mountain Goat Tags ($)	Ordinary Firearms Licence ($)	Limited Entry Hunting Licence ($)	Bag Limit (Maximum Aggregate)
	Alien	Canadian					
1905-08	100	100	-	-	-	-	5
1909-12	100.00	100.00	-	-	-	-	3
1913-17	100.00	100.00	-	-	2.50	-	3
1918-30	25.00	25.00	15.00	-	2.50	-	2
1931-32	50.00	50.00	15.00	-	2.50?	-	2
1933-34	50.00	50.00	15.00	-	3.50	-	2
1935-49	25.00	25.00	15.00	-	3.00	-	2
1950	25.00	25.00	15.00	1.00	3.00	-	2
1951	25.00	25.00?	23.00	1.00	3.00	-	2
1952	25.00	25.00?	25.00	2.00	3.00/4.00	-	2
1953-63	25.00	25.00?	25.00	2.00	4.00	-	2
1964-73	25.00	15.00	40.00	2.00	4.00	-	2
1974-77	75.00	7.00	100.00	15.00	7.00	5.00	1

By the early 1950's, game managers were gaining more insight into how economic restraints could limit legal hunting pressure. In addition to increased costs of licences and trophy fees, residents experienced something entirely new - mountain goat tags (Table 1). The introduction of goat tags in 1950 was believed to allow a flow of data from hunter to biologist such that hunting pressure and harvest could be accurately estimated. Initially only records of tag sales were kept, but in 1952 the first British Columbia Game Questionnaire Analysis was produced. Unfortunately, data returns from postcard questionnaires regarding mountain goat were negligible for the first few years and did not merit statistical evaluation.

In 1964 a change in sampling procedures involved the issuance of tag-licences with an attached stub, upon which the hunter's name and address were recorded. This procedure was believed to permit more efficient sampling of the species (sheep, goat, grizzly bear, caribou and elk), and has continued until 1975 for mountain goat. For the first time, the 1976/77 mountain goat hunting season is under control of a Compulsory Reporting System, mandatory for all successful hunters.

Justification for the Statistical Presentation

Analysis of most mountain goat data from prior to 1967 has not been attempted for two reasons; (1) Historic accounts of distribution, abundance and harvest before the 1960's are relatively inaccurate and therefore potentially misleading, and (2) Administrative changes within the Province of British Columbia during the 1960's and earlier have periodically necessitated changes in boundaries of Resident Areas (RA) and Game Management Areas (GMA).

The period 1967 to 1974 has seen relatively consistent boundaries to GMA's (Fig. 1)[1], enabling statistical analysis and comparison of stratified data over eight years. Although boundaries changed in 1975 from the older GMA's to smaller MU's on a Provincial basis, data pertaining to MU's currently being obtained, can still be combined to enable continuation of the comparisons presented in this paper.

---

[1] See British Columbia Fish and Wildlife Branch Hunting Regulations for physical description of GMA boundaries.

Table 2. Protective controls on mountain goat in British Columbia (1958 - 1976).

Year	Closed GMA's[a]	GMA Special Area Closures[d]	Harvest Restrictions		Season Length (Maximum days/ Minimum days)	GMA's with Bag Limit of One[a,fg]
			Sex	Age		
1958	1,5	?	None	1 yr (7.6cm horn)	123/4	7,8,11
1959	1,5	?	"	"	123/3	7,8
1960		?		"	122/3	7,8
1961	1,5,7a	?		"	123/3	7,8
1962	1,5,7a	7		None	123/9	7,8
1963	1,5	7,10		"	123/10	7,8
1964	1,5	2,7,10		"	135/9	7,8
1965	1,5	2,7,10		"	134/9	7,7a,8,9
1966	1,5	2,7,10		"	134/3	7,7a,8,9,10,11
1967	1,24	2,7,10		"	148/3	5,6,7,8,10,11
1968	1,24	2,3,7,10,11	GMA 11: d only	"	134/2	5,6,7,8,10,11
1969	1,24	2,3,7,10,11,25[b]	GMA 11: d only	"	134/2	1,2,5,6,7,8,9,10,11,20-28
1970	1,24	2,3,7,10,11,25	GMA 10: d only	>1 yr (7.6cm born)	134/2	1-11,20-28
1971	1,7,10,24	2,3,8,11,25	GMA 11: d only (portion)	>1 yr for GMA's 2,3 4,5,6,8,9,16-23,27,28	140/2	Province (1-28)
1972	1,7,10,11,24	2,3,8,25,28	None		121/8	"
1973	1,6,7,10,11,15, 18,24	2,3,4,5,8,9,13,20,25, 27,28	None		139/9	"
1974	1,6,7,10,11,15 18,24	2,3,4,5,8,9,13,20,22, 25,27,28	"		88/9	"
1975	129 M.U.'s[c]	13 closed portions of M.U.'s[e]	"		84/22	"
1976	113 M.U.'s	15 closed portions of M.U.'s	None[d]		113/23[e]	"

[a] See Fig. 1 for Game Management Area (GMA) descriptions.
[b] GMA 25 was closed for research purposes from 1969-1973. From 1974 to the present, a smaller study area has been closed.
[c] M.U.'s are smaller "Management Units".
[d] Adults only are eligible for harvest in Special Limited Entry areas.
[e] Portions of the Mann Special Limited Entry area (M.U. 6-15) allow 19½ days of mountain goat hunting.
[f] From 1958-1966, there were 21 GMA's. From 1967-1974, there were 28 GMA's.
[g] All other GMA's have a bag limit of two goats.

Figure 1.

Administrative boundaries of Game Management Areas in
British Columbia (1967 - 1974). The dark line separates
'North' and 'South' British Columbia.

Data Source and Method of Analysis

The British Columbia Fish and Wildlife Branch contributed three sources of data for analysis.
Most information came from the annual British Columbia Game Harvest Questionnaire Analysis (1964-
1970) and the British Columbia Hunter Sample (1971 - 1975). These two series, obtained by returns
from hunter harvest questionnaires, contain the most complete data on British Columbia's mountain
goat harvest and hunter dynamics. No interpretation of the results has been included in these
publications. Pinegan (1968) has revised the outline of processing instructions for these data.
The Cache Creek Check (1969 - 1975) contributed similar harvest data from the annual hunter check-
ing station. These data represent mostly the northern portions of the Province. Hunting regu-
lations and historic Game Commission Reports are the third source of information, supplying data
on protective controls (such as season restrictions, bag limits, gear restrictions, rules of
conduct and habitat protection), economic regulations (including prices of hunting licences,
species tags, trophy fees, guide fees and limited entry permits), and hunting zones (GMA's, and
more recently, smaller MU's). All these data sources are currently employed by the British
Columbia Fish and Wildlife Branch in an attempt to efficiently manage Provincial big game
resources.

Analyses of data supplied by the British Columbia Fish and Wildlife Branch were conducted at
the University of British Columbia's Biological Data Centre on the PDP 11/45 Digital Computer.
Graphs were plotted with the Cal Com 565 Plotter.

Terms and General Considerations Regarding the Data

Several terms are defined: A 'hunter-unit' is one hunter hunting in one GMA. A hunter may
generate several hunting-units if he hunts in more than one GMA, and thus an estimate of hunting
pressure may be obtained. 'Hunter-success (CPUE) is the proportion of the hunting-units within a
region successfully harvesting more than one goat. Employing hunter-units in any calculations
involving the Province as a whole will introduce an artifact which will always be in the direction
of inflating the number of hunters and depressing hunter success.[1] Therefore, the true number of
hunters are used when examining data on a Provincial basis.

Symbols in the following text include:

b = slope of the regression (i.e. regression coefficient)
$S_{y.x}$ = standard error of estimate of the regression
R = correlation coefficient
r = coefficient of determination
N = sample size
P = probability of the significance of the statistic

---

[1] CPUE data from 1964 to 1975 indicate a mean inflation of 4.6 percent in hunting
pressure and a mean reduction of 1.9 percent in hunter success when using hunter-
units in Province-wide statistical comparisons.

(F,t,r,etc.) being treated, where:

  F tests the HO: parameter (B) of b = 0
  t tests the HO: B1 = B2
  r tests the HO: parameter (p) of r = 0

All data in percentages were statistically tested using the transformation $Y = arcsine \sqrt{Y}$.

Estimates are used for hunter effort and hunter harvest analyses (Finegan 1964). These data are based upon the frequency of occurence in the sample of the particular attribute (e.g. effort) being considered. However, the confidence placed upon these estimates contradicts the assumption of data normality in most cases, hence many of the limits may not be very realistic (British Columbia Game Questionnaire Analysis 1964). I have chosen not to apply potentially misleading confidence intervals and present the data in their untreated form.

RESULTS

Big Game Tag Sales in British Columbia

Present data analysis by the British Columbia Fish and Wildlife Branch does not enable input of data from all big game hunters, except for several species under the Compulsory Report System. Most data on legal hunter harvest are based upon sample returns, therefore it is required to compare some attribute of the sample to an absolute parameter in order to determine the significance of sample trends. Approximately 79 percent (r = 0.89) of the variation in licence sales for mountain goat, from the British Columbia Hunter sample (1970 - 1975), were found to be significantly accounted for by Government Agency summaries of sales of mountain goat tags throughout British Columbia (British Columbia Fish and Wildlife Branch 1971 - 1976).

Data on human population growth within the Province are comparable to trends in resident big game licence sales, for the period 1951 to 1973 (p<0.001) (Fig. 2). Sales of resident big game licences in British Columbia increased annually)p<0.001) until 1973; their decline in 1974 to the lower levels experienced over the following two years is believed to have been due to price increases for tags and licences during that period (Table 1).

Among more than 100,000 resident big game tags sold annually, only 3.5 percent of species tags sold to residents in 1964 were for mountain goat; in 1972, this proportion of tag sales had declined significantly (p=0.094) to a low of 2.5 percent. By 1975, resident mountain goat tag sales had declined by 30 percent over the previous decade (p = 0.110) and non-resident sales had decreased similarly (p = 0.447) but at a slower rate (p<0.001) (Fig. 3).[1] Factors resulting in differences in tag sales of resident and non-resident hunters appear to be constant for the two hunter classes.

Hunter Dynamics

Data from the Cache Creek game check station show that the number of 'days' required for resident hunter success has increased significantly (p = 0.037) since 1969. Non-residents appear to expend a constant (p = 1.000) and greater effort in bagging mountain goats than do residents. Annual differences between the two hunter types regarding time expenditure appear to be independent, as six of the seven years of data display opposing directional change about their regression (Fig. 4). Non-resident hunter success is higher than that of the non-guided resident hunter.

Because non-residents tend to exert greater time in the field per harvested goat, the desired result of obtaining a trophy animal is usually achieved (Fig. 5). Resident hunters who generally spend less time hunting and usually select statutory holidays for hunting trips (Foster 1976a), harvest greater proportions of adult females than do non-resident hunters. This preference by residents for females probably represents greater selection for meat rather than for a trophy (see also Baker 1964).

Data for seven years during 1964 - 1974 suggest that combined efforts of resident and non-resident hunters have succeeded in progressively harvesting younger cohorts, thereby decreasing the proportion of 5+ year-old animals in the harvest (Table 3). McIlroy (1972) shows a higher proportion of older aged bears being harvested from areas with the shortest history of hunting pressure. The 3.5 year-old cohort apparently made up the largest proportion of mountain goat age classes harvested in 1974 (24 percent). The 5+ year cohorts dropped from 54 percent in 1964 to 40 percent in 1974.

---

[1] A non-resident big game hunter is required to be accompanied by a certified big game guide. Non-resident hunters constitute approximately 97.5 percent of big game guide clientele in British Columbia. The resident segment (2.5 percent) approximates 0.1 percent of the total number of resident big game licence holders.
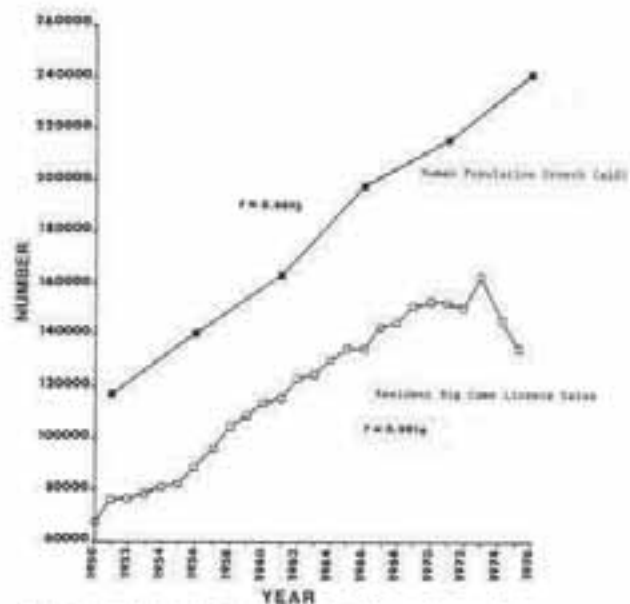
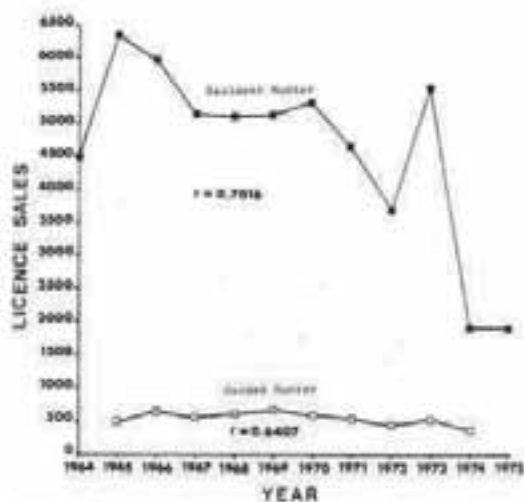Figure 2. Human population growth and resident big game licence sales.

Figure 3. Resident and non-resident licence sales for mountain goat in British Columbia (1964-1975).
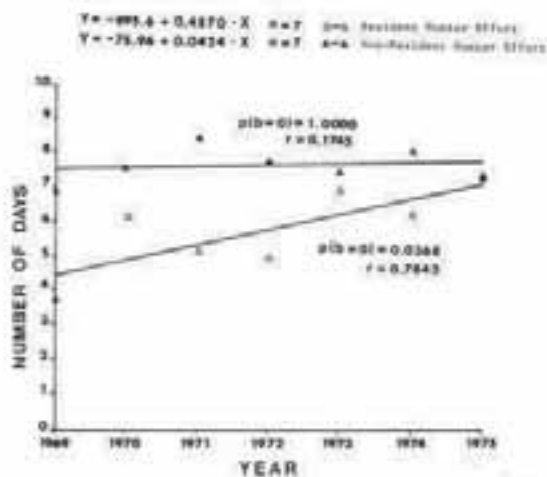

Figure 4. Effort of resident and non-resident hunters required to take a mountain goat in British Columbia (1969-1975).
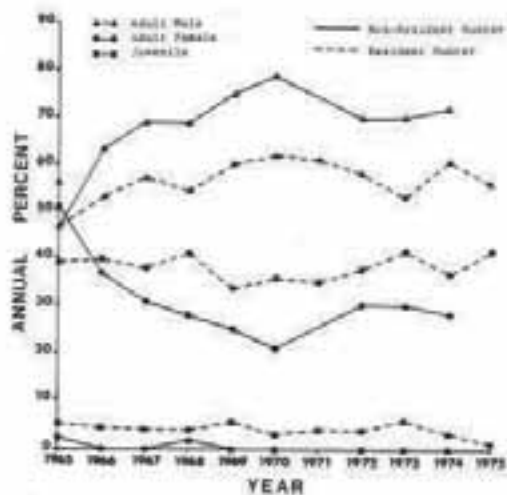

Figure 5. Hunter selectivity of mountain goat harvest in northern British Columbia (1965-1975).

Table 3. Significance values of temporal changes in the proportion of a specified age class harvested. Seven years' mountain goat data are taken from the Cache Creek Game Check (1966 - 1974).

	AGE OF GOAT HARVESTED (Yrs.)					
	0.5	1.5	2.5	3.5	4.5	5+
n	8	42	54	107	95	268
r	-0.8928	-0.0168	+0.9547	+0.2702	+0.1946	-0.6523
p(b=0)	0.0068	1.0000	0.0008	1.0000	1.0000	0.1603

Mountain Goat Harvest and Hunting Pressure

Mountain goat harvest ('catch') and hunting pressure ('effort') are significantly correlated (r = 0.936, p<0.001) within data collected in British Columbia from 1967 to 1974. Approximately 88 percent of the variation in mountain goat harvest is accounted for by the amount of hunter effort. The significance of this regression could have resulted or been influenced by the effect of unmeasured variables such as weather, access, population status of big game species, and their season length and bag limit.

Eleven years' data (1964 - 1974) show decreasing CPUE for mountain goat (p<0.001), with values in the mid-1970's appearing similar to those of the early 1900's (Fig. 6). Comparison of annual CPUE regression coefficients compiled on both a GMA and an RA basis (Foster 1976a) support the contention that mountain goat CPUE has been decreasing since at least 1964. Unfortunately, analyses indicate that hunter success at time t cannot be used to predict effort at time t+1 (r =.0285, 0.5<p<0.2) (Table 4) as less than three percent of the variation in hunter effort can be accounted for by hunter success of the previous year.

Stratification of the data by arbitrarily dividing the Province into two portions on the basis of human settlement and development of wilderness (Fig. 1) indicates changes in patterns of hunting pressure and harvest (Fig. 7). CPUE has recently been lower in the 'South' but both regions show decreasing trends over the period 1964-1975. Proportions of mountain goat hunter pressure and harvest tripled in 'North' British Columbia and halved in the 'South' from 1964 to 1974 (Fig. 7 - inset).

Stratification of the data on a GMA basis shows greater regional variation in CPUE. Of 24 GMA's with sufficient sample returns, 63 percent (n = 15) show significant relationships between catch and effort (Table 4). A summary of the regional variation in peak effort and harvest between 'South' to 'North' British Columbia suggests a temporal gradient (Fig. 8).
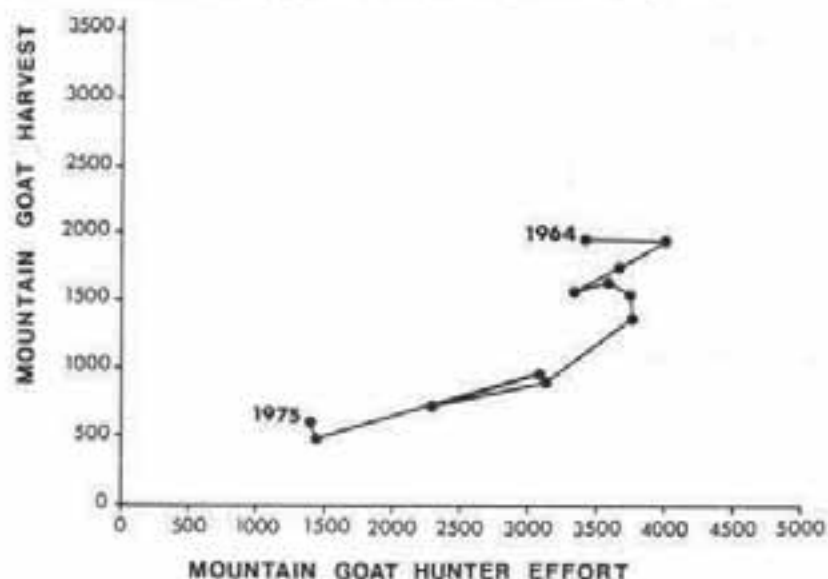

Figure 6. Mountain goat catch-per-unit-effort trends in British Columbia (1964 - 1975).
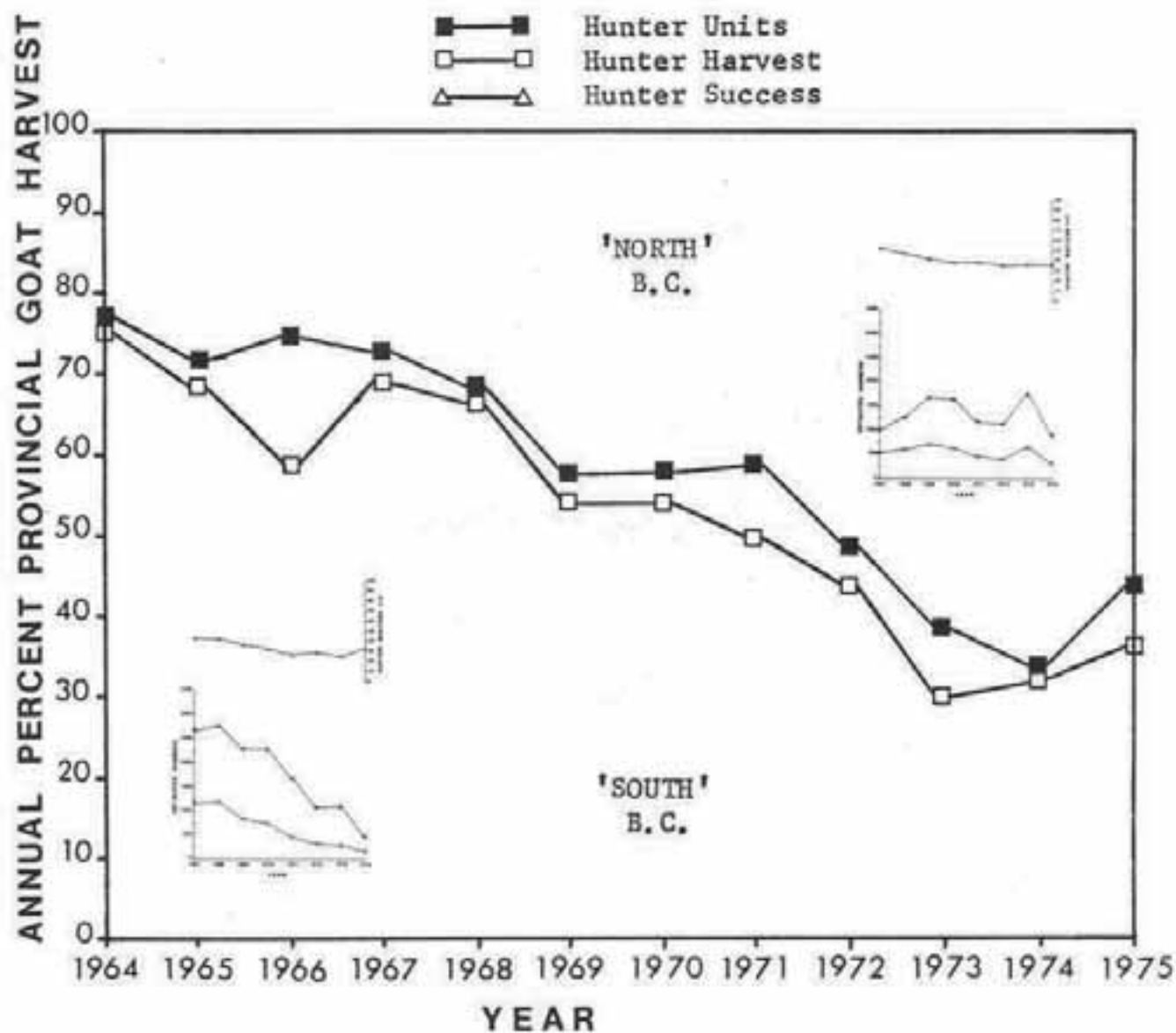
Figure 7. Temporal division of mountain goat hunting pressure, harvest, and success between 'North' and 'South' British Columbia (1964-1974). The areas above the main curves represent proportions of hunter effort and harvest in 'North' British Columbia and the areas below the main curves represent 'South' British Columbia. Insets show absolute changes in hunter effort, harvest and success within each subunit.

Figure 8. Years of regional peak mountain goat effort and harvest throughout British Columbia.

Table 4. Provincial and stratified catch-per-unit-effort data for mountain goat in British Columbia (1967 - 1974).

GMA	n^a	b^b	r^c	$p(r=0)$ $p(r=0)$	$S_{Y \cdot X}^e$	Y-Intercept	Confidence Limits (±)	n^a	r^c	$p(r=0)^d$
			CATCH-PER-UNIT-EFFORT					SUCCESS$_t$ - EFFORT$_{t+1}$		
1	-	-	-	-	-	-	-	-	-	-
2	8	0.4731	0.9166	0.0014	36.4417	-57.11	83.82	7	0.9625	0.0005
3	8	0.6944	0.8036	0.0163	24.1578	-19.96	58.89	7	0.4803	0.10
4	8	0.4762	0.8402	0.0090	32.9242	-62.26	108.01	7	0.7063	0.0761
5	6	0.1599	0.3768	0.10	3.5679	2.18	17.77	5	0.4407	0.10
6	4	-0.6667	0.5774	0.10	2.8867	15.00	14.32	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	5	0.4196	0.5041	0.10	4.7074	-2.03	33.23	4	0.9279	0.0721
9	8	0.2627	0.6843	0.0612	6.8140	0.67	16.18	7	0.3623	0.10
10	4	0.6363	0.9644	0.0356	8.5720	-34.54	49.86	3	0.0593	0.10
11	5	0.5458	0.9238	0.0250	23.0152	-139.20	194.85	4	0.4926	0.10
12	6	-0.0137	0.3445	0.10	0.5420	2.95	1.16	4	0.5814	0.10
13	7	0.1675	0.4428	0.10	5.2811	1.26	10.69	6	0.1322	0.10
14	7	0.2552	0.6640	0.10	5.2019	0.23	10.69	6	0.3990	0.10
15	3	0.5000	0.7313	0.10	4.9497	-3.50	54.26	-	-	-
16	8	0.6457	0.8083	0.0152	7.9272	-6.36	22.14	7	0.6927	0.0845
17	8	0.5691	0.8757	0.0044	10.7098	2.62	25.45	7	0.4875	0.10
18	-	-	-	-	-	-	-	-	-	-
19	8	0.2399	0.7994	0.0173	4.4204	2.81	6.48	7	0.3227	0.10
20	8	0.3733	0.9555	0.0002	14.1915	-3.58	27.34	7	0.4816	0.10
21	8	0.2308	0.5548	0.10	11.9791	9.11	24.60	7	0.0094	0.10
22	8	0.1727	0.8514	0.0073	4.2391	18.81	12.51	7	0.1863	0.10
23	8	0.6892	0.8284	0.0111	25.5088	-23.33	62.65	7	0.5591	0.10
24	-	-	-	-	-	-	-	-	-	-
25	8	0.5030	0.9735	0.0001	21.5430	-50.48	59.29	7	0.9391	0.0017
26	8	0.4328	0.9631	0.0001	16.0406	17.01	24.90	7	0.5188	0.10
27	8	0.3005	0.9778	0.0001	6.7446	25.42	13.24	7	0.5508	0.10
28	8	0.4140	0.8542	0.0069	6.0399	-0.77	14.64	7	0.6353	0.10
'NORTH'	56	0.4101	0.9700	0.0001	17.2800	-0.47	7.03	-	-	-
'SOUTH'	111	0.3224	0.9200	0.0001	22.0200	3.73	5.27	-	-	-
PROVINCE	167	0.9365	0.9365	0.0001	22.0681	2.44	4.52	139	0.0285	0.10

a n = sample size
b b = slope of the regression (regression coefficient)
c r = coefficient unit of determination
d probability of the significance of the statistic equalling zero
e standard error of estimate of the regression

DISCUSSION AND CONCLUSIONS

Big Game Tag Sales and Hunter Dynamics

Data from the British Columbia Hunter Sample simulates absolute mountain goat hunter - harvest dynamics. Resident big game tag sales are correlated with human population growth, maintaining an approximate seven percent of the total population. No data are available as to the trend in the proportional change of 'opportunistic' hunters, that is those who buy tags for more than one species. Any increase in the number of big game tags bought by individual hunters each year could show big game hunting as a decreasing function per capita.

The apparent decline and levelling off of both big game and mountain goat licence sales may be partially attributed to the change in Provincial bag limits from two mountain goat in 1970 to one in 1971. And, in this same period resident hunters experienced a 450 percent increase in licence and permit fees in order to hunt in a Limited Entry Area, while non-residents were faced with a 220 percent increase in mountain goat hunting fees. Foster (1976b) described a decrease and relocation of pheasant hunter activity as a consequence of economic guidelines extending beyond a cost threshold for middle-income residents. Non-residents have been accustomed to paying high hunting fees accumulating from transportation costs, guiding and trophy fees.

The increase in resident big game licence sales and the concomitant decrease in both resident and non-resident mountain goat tag sales during the late 1960's and the early 1970's (Figs. 2, 3) suggests decreasing quality in mountain goat sport hunting. Data from 1971 to 1975 show declining hunter interest in big game hunting as a whole within the Province, as contended by Pearse and Bowden (1972).

Support of the above statments are upheld by the fact that resident goat hunters have spent more time in the field since 1969 in order to bag a goat (Fig. 4). Ritcey (1974) commented that big game hunters apparently increase their efforts to maintain individual success when there are fewer animals. The non-resident goat hunter, on the other hand, exerts greater effort towards a hunt as a consequence of prepaid hunting trips (usually ranging from one to two weeks) in which the hunter does not wish to shoot an animal within the first few days of the hunt.

Access to relatively unexploited population contribute to higher success rates and allow a greater proportion of trophy (adult male) animals to be harvested, predominantly by the guided non-resident hunter. Once populations are opened to vehicle access, females and younger age classes are harvested by the resident hunter (Phelps et al. 1975). Eventually the ratio of accessible populations increasingly dominate newly exploited and inaccessible herds in an area and the proportion of females and younger cohorts confound the resident harvest data. Therefore, the increasing harvest of females and younger age classes is not a traditional population response to removal, but an artifact created from increased access to proportionately more herds.

Compensatory regulation among mountain goats appears to be negligible in the presence of 'heavy' harvest. Smith (1973) states that increased hunting pressure has resulted in decreasing horn size among sheep harvested in some areas of Alaska. Phelps et al. (1975) suggested that newly accessible goat populations (which are usually heavily exploited) decrease in reproductive output. A reduction in herd productivity is believed to be a function of removal itself and to social deprivation (i.e. the social effects of removed and/or orphaned animals on other herd members). Cumming (1974b) states that decreasing annual moose yields, in addition to a preponderance of the female cohort in the harvest is sufficient data for management action. Though this female selectivity does not show up well in Fig. 5, I have witnessed the harvest of proportionately less male goats in the population I am currently studying.

The Significance of Hunter Catch-Per-Unit-Effort (CPUE)

Quantitative evidence has been presented to support the contention that mountain goat sport hunting has become less attractive over the last decade. The declining involvement in the sport is believed to be a consequence to both hunter attitude (Pearse and Bowden 1972) and of a higher rate of access to a diminishing ratio of unexploited goat populations; hence, individual population status. The latter conjecture is expanded in terms of CPUE analysis.

The bases of CPUE analytical methods are centred around two assumptions. First, the amount of effort required to harvest a goat is proportional to the abundance of the stock in question. Second, stock abundance and CPUE is linearly related. Given that these two assumptions are met, the effect of reducing stock numbers becomes evident in a changing decrease in CPUE. However, the apparent decline in stock may not in itself be direct evidence of over-exploitation, but merely an indication that hunting is becoming one of the major factors in determining natural stock size (International Commission on Whaling 1964). Glover and Smith (1963), the International Commission on Whaling (1962, 1965 and 1966), McIlroy (1972), Lykke (1974), Mercer and Manuel (1974), and Cumming (1974a and 1974b) used harvest statistics as indices of relative population abundance in waterfowl, whales, black bear and moose.

The decline and high positive correlation between Provincial catch and effort statistics for mountain goat, in addition to a decreasing mountain goat hunter population, shows a decline in the hunted segment of Provincial populations. Glover and Smith (1963) conclude similarly for waterfowl populations despite increased numbers yielded in aerial survey data. The slight increase in the number of days per kill for non-resident hunters, in addition to the more noticeable increase in resident hunting days per kill, can additionally serve as abundance indices. However, effort signifies to totality of operations of travelling, searching, killing and recovering. Included are days of no success and inclement weather. The number of hours per hunter should be used as a more precise measure of effort.

The number of years that an area is hunted, in addition to trends in cumulative harvest, are inversely correlated to abundance indices for northern black bear populations (McIlroy 1972) and may be applicable to mountain goat populations. Each of these two factors affect hunter success values. Decreasing success rates suggest decreasing population status, however, Cumming (1974a) suggests that this factor may also be caused by the uneven distribution of hunters (e.g. as created by increased access.

Using the predictive least squares equation for the relationship between Provincial catch and effort data (r = 0.9364), one could presumably attempt to control goat population size by regulating effort and subsequent harvest. However, effort could not be predicted from success data of the previous year. Therefore, another method is required to anticipate effort, possibly in conjunction with increases in licence costs or with the introduction of a Provincial Limited Entry System. If hunting is indeed a factor controlling abundance of the Province's hunted goat populations, we would expect a trend line from left to right and bending over to a horizontal asymptote on the right side of Fig. 6, indicating dropping CPUE caused by competition between hunters for a limited resource at higher hunter densities. The former description of CPUE trends is expected to be apparent if data were available on rate of access, hunter effort, and goat harvest for exploited goat populations.

CPUE analysis may not reveal the decline of a goat population until the occurrence has taken place, unless the two assumptions discussed previously are met. If the assumptions regarding CPUE are not violated, the biologists may be able to use hunter sighting data as an easy and economical means of assessing locally exploited stocks (International Commission on Whaling 1963; Finegan 1973). Mercer and Manuel (1974) concluded that the number of animals seen per day per hunter and the percent success per day hunted (unit effort) as being the 'best' of five indicators of moose population change that they compared.

The difficulty of managing over a broad geographic region is that goats are extremely heterogenous in their dispersion. Even though hunter effort and harvest may be highly correlated and in decreasing trend on a stratified basis, as in certain GMA's (Table 4), the exploitation of recently accessible goat populations is masked by the overall GMA data (Phelps et al. 1975). Although annual yield for many GMA's is below that potentially sustainable, a few small areas have been known to have produced substantial portions of large regional harvests (Phelps et al. 1975). Therefore, it is the trend in ratio of inaccessible to accessible goat populations which one must consider when looking at CPUE data for a particular management area.

This phenomenon is apparent in the stratified comparison of 'North' and 'South' British Columbia; two sub-units which were arbitrarily defined on the basis of highway development and improvement (Figs. 7 and 8). The additional suggestion presented by these data is what many mountain goat hunters of the early 1960's have most likely shifted their interest to more abundant species, in the region of greatest access and development (i.e. 'south' British Columbia) rather than increasing their travels to 'North' British Columbia to hunt.

The greater percentage of undeveloped land helped to cover up the over-exploitation of goat populations recently documented in the Kootenay region of south-eastern British Columbia by Phelps et al. (1975). This phenomenon has most likely been applicable to the greater portion of this Province with the rates of exploitation merely lower in those GMA's of less access. Unfortunately, we are running out of 'undeveloped' areas and will not be able to continue the present area-wide scheme of management.

Until management of mountain goats develops further, I feel that hunting closures should coincide with new access until we have developed a Limited Entry System for this species on a population basis. The biologist will then be able to assign future levels of exploitation to be incurred by resident and non-resident hunters and predict the effects of this level of exploitation. This method would simulate wildlife management to a greater degree than past regulatory methods involving protection of game in hindsight.

In light of the present study, those biologists who are unable to manage species on a discrete population basis may wish to examine relationships between CPUE and absolute ungulate population size. The hypothesis to be tested is that varying levels of hunter effort will affect populations ranging through various distribution patterns. Density dependent and independent relationships could be explored in a simple simulation model.

LITERATURE CITED

Baker, M. 1964. Records of North American big game. Holt, Rinehart and Winston, New York. (cited in Pearse and Bowden 1972).

British Columbia Fish and Game Branch. 1958 - 1964. Game harvest questionnaire analysis (Ann. Reps.). Victoria, British Columbia. Mimeo.

_____. 1962 - 1964. British Columbia Fish and Game Branch (annual) hunting regulations. Queen's Printer, Victoria, British Columbia.

British Columbia Fish and Wildlife Branch. 1965 - 1970. Game harvest questionnaire analysis (Ann. Reps.) Victoria, British Columbia. Mimeo.

_____. 1965 - 1976. British Columbia Fish and Wildlife Branch (annual) game hunting regulations. Queen's Printer, Victoria, British Columbia.

_____. 1969 - 1975. Cache Creek Check (Ann. Reps.). Wildl. Manage. Harvest Statistics Nos. 1, 2, 3, 5, 6, 9 and 11. Victoria, British Columbia. Mimeo.

_____. 1971 - 1975. British Columbia hunter sample (Ann. Reps.). Victoria, British Columbia. Mimeo.

_____. 1971 - 1976. Summary of revenue derived from sale of various licences, collections, etc. (for the period April 1st to March 31st). Victoria, British Columbia. Mimeo.

British Columbia Game Commission. 1909 - 1913. Report of the Provincial Game Forest Warden of the Province of British Columbia. King's Printer, Attorney-General's Dept., Victoria, British Columbia.

_____. 1914 - 1919. Report of the Provincial Game Warden of the Province of British Columbia. King's Printer, Attorney-General's Dept., Victoria, British Columbia.

_____. 1920 - 1928(?). Annual Report of the Game Conservation Board of the Province of British Columbia. King's Printer, Attorney-General's Dept., Victoria, British Columbia.

_____. 1928(?) - 1951. Report of the Provincial Game Commission of the Province of British Columbia. King's Printer, Attorney-General's Dept., Victoria, British Columbia.

_____. 1952 - 1956. Report of the Provincial Game Commission of the Province of British Columbia. Queen's Printer, Victoria, British Columbia.

Cumming, H. G. 1974a. Moose management in Ontario from 1948 to 1973. Naturaliste Can. 101: 673 - 687.

_____. 1974b. Annual yield, sex and age of moose in Ontario as indices to the effects of hunting. Naturaliste Can. 101:539 - 558.

Finegan, R. F. 1968. Data processing instructions for the game harvest questionnaire analysis. Pages 186 - 198 in British Columbia Fish and Wildlife Branch (ed.) British Columbia Hunter Sample. 215pp. Mimeo.

_____. 1973. Some estimates of moose populations in British Columbia during the period 1950 - 1970. N. Am. Moose Conf. and Workshop 9:81 - 95.

Foster, B. R. 1976a. Exploitation and management of the mountain goat in British Columbia. Dept. of Zoology, The University of British Columbia, Vancouver, British Columbia. 273pp. Typescript.

_____. 1976b. The economic feasibility of pheasant enhancement on private lands in B. C. Dept. of Zoology, The University of British Columbia, Vancouver, British Columbia. 23pp. Typescript.

Glover, F. A. and J. D. Smith. 1963. Waterfowl status report. U. S. Fish and Wildl. Serv. Special Sci. Rep. Wildl. No. 75. (Cited in Watt, 1968).

International Commission on Whaling. 1962, 1964 - 1966. Thirteenth, fourteenth, fifteenth and sixteenth report of the Commission. London.

Lykke, J. 1974. Moose management in Norway and Sweden. Naturaliste Can. 101:723 - 735.

McIlroy, C. W. 1972. Effects of hunting on black bears in Prince William Sound. J. Wildl. Manage. 36:828 - 837.

Mercer, W. E. and F. Manuel. 1972. Some aspects of moose management in Newfoundland. Naturaliste Can. 101:657 - 671.

Millar, W. N. 1916. The big game of the Canadian Rockies - Conservation of fish, birds and game. Proc. Com. Meeting. The Methodist Book and Publishing House, Toronto.

Pearse, P. H. and G. Bowden. 1972. The value of resident hunting in British Columbia. Study Report No. 6. B. C. Fish and Wildlife Branch, Victoria, British Columbia. 58pp.

Phelps, D. E., B. Jamieson and R. A. Demarchi. 1975. Mountain goat management in the Kootenays. British Columbia Fish and Wildl. Brnach, Cranbrook, British Columbia. 39pp. Typescript.

Quaedvlieg, M., M. Boyd, G. G. Gunderson and A. Cook. 1973. Status of the rocky mountain goat in the Province of Alberta. Alberta Fish and Wildl. Div., Wildl. Inventory Special Rep., Edmonton, Alberta. 52pp. Mimeo.

Ritcey, R. W. 1974. Moose harvesting programs in Canada. Naturaliste Can. 101:631 - 642.

Smith, A. C. 1973. Annual report of survey inventory activities. Fed. Aid in Wildl. Proj. W-17-4, Part 1. Alaska Dept. of Fish and Game. Juneau, Alaska. Mimeo.

Stelfox, J. G. 1971. Bighorn sheep in the Canadian Rockies: a history 1800 to 1970. Can. Field Nat. 85:101 - 122.