Proceedings of The First International Mountain Goat Symposium

KALISPELL, MONTANA
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FOREWORD

The initial idea of having a Symposium dealing with mountain goat ecology and management was conceived by several members of the Alaska Department of Fish and Game when it became clear that goat populations had declined statewide. At that time a questionnaire was sent to a variety of institutions and agencies where goats occur to determine if there was sufficient interest to conduct such a meeting. The response to that questionnaire was overwhelming and the stage was set.

During the summer of 1975 the Northwest Section of The Wildlife Society agreed to sponsor the Symposium and the then current President E. Reade Brown, Washington Dept. of Game, appointed the Symposium Committee. Dr. Richard Mackie, President of the N. W. Section during the Symposium, took the challenge from Brown and both provided considerable support in the planning stages.

The Symposium Committee's intention was to put together a program with a resulting publication which would bring together all existing work being conducted on goats and thus represent the state of the art. To that end I believe the Committee was successful.

The mountain goat is the last of the North American ungulates to have its own Symposium. The information contained in this publication reflects that fact. Considerably more research is needed before knowledge of the goat will reach the level of that attained for other big game species.

A few individuals deserve special recognition for their efforts in organizing and following through with the Symposium. Mr. D. R. Halladay and his agency, British Columbia Fish and Wildlife Branch, provided considerable leadership and financial aid in helping to assure the Symposium's success. Mr. Rolf Johnson, Washington Dept. of Game, did an excellent job of canvassing all of the North American management agencies responsible for mountain goat management. Mr. William Hall, Alberta Recreation, Parks and Wildlife, was responsible for and did an excellent job of recruiting our senior editor, Dr. William Samuel, University of Alberta. Dr. Samuel and Mr. Wally Macgregor (B. C. Fish and Wildlife) had the most difficult task of preparing and assuring that all papers were prepared in a professional manner suitable for publication. I believe their efforts are well represented. Whatever benefits and successes occurred as a result of the Symposium should be attributed to the aforementioned individuals, the Symposium Committee members, and the N. W. Section of The Wildlife Society. Whatever shortcomings occurred are my responsibility.

Warren Ballard, Chairman
Mountain Goat Symposium Committee

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DISTRIBUTION, ABUNDANCE AND MANAGEMENT STATUS OF MOUNTAIN GOATS IN NORTH AMERICA[1]

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Abstract: The current status of the mountain goat (Oreamnos americanus) in North America is reviewed using results of questionnaires sent to management agencies. Of the nine United States and four Canadian provinces or territories with goats, British Columbia has the largest native population. Mountain goat range including current, historic, and introduced populations is summarized by maps provided by wildlife biologists. Census techniques are described. Mountain goat management approaches are reviewed and hunting regulations summarized. Only six states and four provinces have huntable goat populations. Goat hunting regulations have become much more restrictive in recent years and nearly all management agencies have initiated some type of "permit only" hunting.

The mountain goat (Oreamnos americanus) is found only in northwestern North America. Although four subspecies (Oreamnos americanus americanus, O. a. columbiae, O. a. kennedy, and O. a. missoulae) were recognized at one time, Cowan and McCrory (1970) found no valid reasons for recognizing subspecies within Oreamnos americanus. Although subspecies designations occasionally occur in the literature[2], most authorities (Cowan, Pers. comm.) do not split the species.

This paper is a compendium of reports solicited from all states, provinces, and territories throughout mountain goat range. The goat biologist from each of the management agencies was sent a "status-management outline" and cover letter requesting specific information on mountain goat distribution (both historic and current), census techniques, and management. I would like to express my appreciation to the following individuals who contributed much information to this paper: W. Ballard, Alaska; W. Hall, Alberta; W. Macgregor, British Columbia; R. Denney, Colorado; L. Kuck, Idaho; R. Weckweth, Montana; G. Tsukamoto, Nevada; N. Simmons, Northwest Territories; F. Ebert, Oregon; A. Richardson, South Dakota; R. John, Utah; R. Corsi, Wayoming; M. Hoefs, Yukon Territory; and K. Baker, Parks Canada.[1]

DISTRIBUTION

The historical occurrence of mountain goats of North America does not differ appreciably from current distribution. Mountain goats were found in many of the mountainous areas of western North America from southeastern Alaska to southcentral Washington in the coastal range and as far south as central Idaho in the Rocky Mountains. The present distribution of mountain goats is presented in Figure 1. More specific distributions are shown in the accompnaying status reports for each province or state.

British Columbia has more native goat range than any other state, province, or territory and the largest population of mountain goats in the world. An estimated 100,000 mountain goats inhabited British Columbia in 1964 (Table 1) prior to recent declines. A program of transplanting goats has not yet been initiated in British Columbia. Currently consideration is being given to the possibilities of transplanting goats to areas where they have been extirpated or barriers prevented their establishment.

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[1] Editor's note. Selected specific reports for some states, provinces or territories, although not presented at the Symposium, were submitted for publication. They are included in the "Status" section of these proceedings.

[2] And in these proceedings (Editor).

Figure 1. Distribution of Mountain Goats in North America.

Table 1. A summary of mountain goat abundance in North America by state or province.

State or Province	Estimate of numbers based on past records	Current estimate of numbers
British Columbia	100,000 (1964)	20,000 - 60,000
Alaska	no estimate	15,000 - 25,000
Washington	10,000 (1961)	no estimate
Montana	no estimate	no estimate
Idaho	2,785 (1955)	2,200 - 2,500
Yukon Territory	no estimate	1,400
Alberta	no estimate	1,200
Colorado	(introduced 1948)	575
Northwest Territories	no estimate	400 +
South Dakota	(introduced 1924)	300 - 400
Wyoming	no estimate	70
Nevada	(introduced 1964)	30
Oregon	(introduced 1950)	28 - 30
Utah	(introduced 1967)	no estimate
Parks Canada		1,670 - 1,770

In Alaska, range of mountain goats has increased northward and inland to the Chugach, Kenai, Wrangell, and Talkeetna Mountains. The goat may also be extending its range into the Alaska Range. Recent transplants to Kodiak and Baronof Islands have further extended goat range in Alaska. Native populations began declining on the Kenai Peninsula about 1970. Since that time, it has become evident that a statewide decline has occurred. The estimated current population is between 15,000 and 25,000 animals (Table 1).

The current distribution of mountain goat in Washington extends throughout most of the native range in the Cascades and also occurs in the Olympic Peninsula and Selkirk Mountains as a result of transplants. Re-introductions to Mount St. Helens and Mt. Pilchuck restored goats where native populations were extirpated. Mountain goat transplants from Alberta and Alaska to the Olympic Peninsula during the 1920's have substantially increased goat range in Washington. Current distribution in the Olympic Peninsula extends throughout the eastern, mountainous half of Olympic National Park and adjacent National Forest. Transplants of goats to the Selkirk Mountains in northeastern Washington have also increased goat range in Washington State. Mountain goat populations in Washington have declined somewhat in recent years in the Cascades, but have been increasing on the Olympic Peninsula.

The distribution of mountain goat in Montana has changed dramatically since initiation of a transplanting program in 1941. Between 1941 and 1972, a total of 294 goats was transplanted to 14 new areas within the state. Most of the release areas were in isolated mountain ranges east of the Continental Divide. The present distribution of native goat populations has changed very little from historic distribution. Only a few, small isolated areas once occupied by goats are now believed to be extirpated or supporting remnant populations. These small herds are currently not being hunted. All other native herds appear either stable or are showing signs of increasing. Montana does not estimate population numbers, but rather conducts surveys to gather information on production and distribution.

Despite population declines in Idaho, the present distribution of mountain goats remains essentially the same as when white men first settled in the state, with the exception of relatively recent introductions that have expanded goat range in Idaho. Mountain goats have been successfully transplanted to the southern shores of Lake Pend Oreille, the Seven Devils mountain range in west

central Idaho, and near Palisades Reservoir near the Idaho-Wyoming border. Idaho is managerially dominated by deer and elk and most information on mountain goats is obtained secondarily while conducting aerial surveys for deer or elk. Current population trends in Idaho are down, especially in the Selkirk and Cabinet Ranges. The total statewide population is estimated at 2200 to 2500 mountain goats.

Goat ranges are limited to the southern one-third of the Yukon Territory and these ranges are marginal compared to goat ranges in British Columbia and the Alaska panhandle. The largest goat population in the Yukon Territory is found in the recently established Kluane National Park. The estimated population in this area is 900 and, naturally, they are protected. There are about 500 other goats scattered throughout the lower one-third of the Yukon is small bands. The goat population in the Yukon, including Kluane National Park, is estimated at 1400 animals (Table 1).

Historic distribution of mountain goats in Alberta extended throughout all mountain areas along the east slope of the Rocky Mountains from the United States boundary north to the Kakwa River. Their numbers were thought to be in the thousands at one time. Presently goats inhabit about 70 percent of the historic range and number around 1200 (Table 1). In 1972, a total of seven goats were transplanted to Shunda Mountains east of Nordegg. In 1975, two kids were observed, so apparently the transplant has been successful, at least initially. About half of the goat population in Alberta is hunted and the other half totally protected. The present status of the harvested population appears to be static with little or no growth taking place. The goat populations in closed areas are increasing.

Mountain goats have never occurred naturally in Colorado; however, some mis-identified sightings have been reported. Colorado has had a very successful transplant program beginning in 1948. A total of 13 translocations involving 64 goats has been responsible for Colorado's current goat population of 575 animals (Table 1). The source of these goats was Montana, Idaho, South Dakota, British Columbia, and elsewhere in Colorado.

Mountain goats were introduced into the Black Hills of South Dakota in 1924 from Alberta, Canada (Richardson, 1971). The estimated population of 300 to 400 animals has remained stable for the last 20 years (Richardson op. cit.).

Mountain goats are not native to Oregon, but have been transplanted to the Eagle Cap Wilderness in the Wallowa Mountains and Tanner Butte area in the Columbia Gorge. In the mid 1960's, goat numbers peaked in the Eagle Cap Wilderness about fifteen years after introduction. Low production or survival from 1967 through 1969 resulted in a decline, and numbers since 1971 have remained stable at between 25 and 30 goats. The status of the Tanner Butte population remains uncertain.

Goat populations within National Parks in western Canada are as follows:

1.	Jasper National Park	500 - 600
2.	Banff National Park	500
3.	Yoho National Park	300
4.	Kootenay National Park	200
5.	Waterton Lakes National Park	100
6.	Mt. Revelstoke/Glacier National Parks	70
		1,670 - 1,770

These populations are native, relatively stable, and non-hunted except at Park borders.

Mountain goats were transplanted to Utah in 1967. The release area was in the Wasatch Mountains immediately east of Salt Lake City, and the total population in the state is still confined to this area. Goats were found for the first time last year and their current population is unknown.

In Wyoming, a winter population of 70 mountain goats inhabit the northwestern part of the state. Recent trends have been towards a slight increase in goat numbers.

Mountain goats are not native to Nevada, but were introduced to the Ruby Mountains in 1964. Based on random sightings and occasional aerial census, the mountain goat appears to have become established at low levels. The current mountain goat population is estimated at 30 animals.

The Northwest Territories has only sparsely populated goat habitat. The best goat habitat is in the southwest corner of the province on both sides of the Upper Flat River. There probably are

no more than 400 goats in this rather large area, but a few extend farther north.

CENSUS TECHNIQUES

Most of the states and provinces survey their goat populations with fixed-wing aircraft, helicopter, or both. The Yukon Territory conducts aerial surveys in both winter and summer, relying on summer surveys for classification and winter surveys for determining winter range. The states and provinces with annual summer surveys are: Alaska, Montana, the Yukon Territory, Alberta, Colorado, and Oregon. Only Idaho, Parks Canada, and British Columbia conduct an aerial population survey in the winter.

In recent years, Idaho, Alberta, Colorado, the Yukon Territory, and British Columbia have conducted aerial surveys by helicopter. Alaska and Montana have used helicopter surveys to a limited extent. Classification counts from helicopter are considered reliable in the Yukon Territory, but unsatisfactory in Montana. Classification by most agencies is limited to the ratio of kids:100 older goats. Other provinces and states (such as Washington) conduct annual ground surveys, but rely on aerial surveys on an irregular schedule. Ground surveys have been used to a limited extent in Alaska, but have provided more accurate age composition data that that acquired from fixed-wing aircraft.

MANAGEMENT

Non-consumptive Use - Many national and provincial parks attempt to preserve wilderness tracts and provide a place for outdoor enthusiasts to observe goats in a pristine setting. In some parks, interpretive hikes and evening programs by park rangers provide information on the life history and ecology of mountain goats to park visitors. Some state and provincial management agencies as well as national forests provide areas for roadside viewing and photography. As human populations continue to expand, more and more attention will be given to non-consumptive values of mountain goats.

General Hunting Regulations - In the last few years, goat hunting has become more restrictive in nearly all states and provinces. Most states and provinces regulate goat hunting by limiting the number of hunters through permits. These states and provinces are: Washington, Montana, Idaho, Colorado, Alberta, and South Dakota. Both Alaska and British Columbia initiated limited entry hunting in some areas and probably will regulate more areas by limited entry in the future. Only Yukon Territory and the Northwest Territories have not initiated a limited entry type of goat hunting.

Goats of either sex are legally taken in all states and provinces except in the Yukon Territory where nannies with kids are protected. British Columbia tried male-only-seasons, but found them unsatisfactory. The states and provinces which prohibit the taking of kids through horn length regulation are: Washington, Colorado, Alberta, and the Yukon Territory. Compulsory inspection of harvest goats by wildlife officials has been implemented in the Yukon Territory, British Columbia, and in some areas of Alaska.

The states and provinces where mountain goats are currently hunted are: British Columbia, Alaska, Washington, Montana, Idaho, Colorado, Alberta, the Yukon Territory, Northwest Territories, and South Dakota. Respective harvest are found in Table 2.

British Columbia has implemented more restrictive regulations in recent years including: shortening the length of the season; reduction in bag limits; area closures; limited entry hunting; male-only seasons, and; compulsory inspection of goats taken. The bag limit is currently one goat. Season length varies from 22 days in some areas to six months in one limited entry area. Most of the areas have a six week season. Because of the difficulty in distinguishing males from females under field conditions, male only seasons have not been satisfactory. In 1976, compulsory inspection was instituted on mountain goat; wildlife officials now measure horn lengths and pull an incisor from harvested goats. The total estimated harvest has declined from 2,517 goats in 1965 to 1,057 goats in 1975 (Table 2).

Alaska has also implemented more restrictive regulations in recent years. Seasons and bag limits have been reduced and other regulations implemented to better manage the resource. Hunters can no longer hunt goats the same day they fly into a hunting area. In 1975, the bag limit was reduced to one goat and the Kenai Peninsula and surrounding area were placed on permit hunting in 1976. Individual areas are closed to hunting when harvest exceeds 10 percent of the most recent goat survey. Since 1972, Alaska has had a "mandatory" harvest report ticket program. Each successful hunter is required to validate a harvest ticket upon killing a goat and return a goat harvest report to Alaska Fish and Game within 15 days after harvesting the bag limit. Unsuccessful hunters are required to complete the report within 15 days after the closing date of the season. In southcentral Alaska, all successful hunters are required to bring their permit and goat horns to a Fish and Game Department office within five days after killing a goat. At that time wildlife

personnel will estimate age and determine the sex of the animal and ask hunters questions relating to their hunting success.

Table 2. A summary of the mountain goat harvest in North America from 1972 - 1976.

State or Province	1972	1973	1974	1975	1976
British Columbia	1,184	1,412	859	1,057	884
Alaska	630	822	619	569	392*
Washington	253	266	272	238	291
Montana	234	280	306	237	*
Idaho	152	128	121	102	90*
Colorado	season closed	12	18	35	34
Alberta	14	13	28	29	29
Yukon Territory	54	42	30	25	17
Northwest Territories	(5 - 10 annually by residents, 46 mtn. goats from 1965 - 1975 by non-residents)				
South Dakota	season closed	12	---season closed---		14

*incomplete return

All mountain goat hunting in Washington occurs in goat management units on a controlled permit basis. The goat unit system of selected geographical areas and permit-only hunting was first developed in Washington and in recent years many other states and provinces have adopted a similar system. Anyone with a current Washington hunting license may apply for a goat permit in any one of the 31 goat management units except those who have drawn a permit in either of the previous two years. Although out-of-state residents may apply for a goat permit in Washington, the requirement of a current Washington hunting license limits the number of out-of-state applications. The mountain goat hunting season usually opens the second weekend of September and lasts until the end of October. A hunter can take only one goat and hunt only in the goat unit he or she applied for in the drawing. Mountain goats of either sex with horns 10cm (4 in.) long or longer can legally be taken in Washington. The statewide goat harvest is monitored primarily by the goat harvest questionnaire sent to each person purchasing a goat tag. One follow-up questionnaire is sent to those not responding to the initial questionnaire. Goat hunters in Washington have responded extremely well to this questionnaire and the return has been consistently about 88 percent.

All mountain goat hunting in Montana is administered on a permit and unit basis. For the past several years, season dates have generally been from early to mid-September through late November. The bag limit is one goat of either sex per hunter. For the past seven years, males have made up 55 percent of the harvest; while kids have constituted one to two percent of the kill. Goat hunter success has remained fairly consistent for the past 10 years with the annual kill ranging from 478 to 234. During this same 10 year period, the number of permits issued statewide dropped from 1,948 to 567, which is consistent with the reduced harvest noted. A total of 276 permits was issued for 63 different areas in 1976. The trend in recent years has been to reduce the size of goat units and increase the number of units to disperse hunter pressure in proportion to available animals.

Mountain goat hunting in Idaho is also completely on a permit basis and has been since 1966. In 1975, a total of 102 goats was taken in Idaho for a 40 percent hunter success. Although goats of either sex and age can be legally taken, each hunter is mailed instructions prior to the season encouraging the hunter to avoid taking nannies with kids. Idaho utilizes a voluntary hunter report card system to determine kill information on mountain goats. This report card, attached to each goat tag, requests information on harvest success and hunting effort.

Colorado regulates goat hunting by issuing a limited number of goat hunting licenses each year. Since goat hunting was initiated in Colorado in 1964, the number of licenses issued has increased from six to 48 in 1976. Colorado goat hunters have had an average success rate of 80

percent. Goat hunters attend hunter-orientation schools and are encouraged to take billies rather than nannies. The harvest has averaged 63 percent billies. A regulation prohibits the taking of kids. The prevalence of wounding loss and irretrievable kills is believed to be so low as to be insignificant. Mountain goats are classified as a once-in-a-lifetime trophy and future management regulations may require a mandatory check-in of the head and return of the questionnaire.

Those areas open to hunting in Alberta are situated in the northern portion of Alberta's goat range. A total of 50 goat permits was issued in 1976; 29 goats were harvested (Table 2). The hunting season was limited to the first two weeks of October. Since 1972, when Alberta first went to a permit system, the harvest has varied from 13 to 29 animals. The success rate has ranged from 33 to 65 percent. Alberta sets permit quotas at approximately 10 percent of the known goats inhabiting an area. The present level of harvest with 50 percent success is at the five percent level. Alberta has a 10cm (4 in) horn rule and a bag limit of one goat of either sex.

Since 1965, only 46 mountain goats have been taken by non-resident hunters in the Northwest Territories. Approximately 5 to 10 goats are killed by resident hunters annually. Goats are presently being taken as an "incidental" trophy. There is no lottery for goat permits in the Northwest Territories, but the holder of a big game hunting license can take one goat of either sex per year.

As a result of over-harvest of some goat populations, hunting in the Yukon has become the most restrictive of all states and provinces. In 1974, the following regulations were implemented: protection of female goats accompanied by a kid; protection of all goats with a horn length of less than 20cm (8 in); reduction of the hunting season to one month (September), and; submission of all heads of goats taken to the Game Branch for inspection and measuring. As a result of these regulations, the annual harvest during the past three years has been less than 50 percent of what it had been during the early 1970's (table 2). Prior to 1974, the sex ratio of the harvest was around 50/50, while during the past three years, it has been 65/35 in favor of billies. Although the Yukon does not have a permit system, non-resident hunters can hunt only with a registered outfitter. During 1975, the success rate was only six percent for non-residents.

Management Problems - Although no single management problem is universal to all states and provinces with mountain goats, most management agencies expressed concern with: accessability, harassment, and habitat destruction as a result of a spreading network of roads associated with logging and mining. Accessability has been a problem in many areas because new roads in goat habitat concentrates goat hunting, leading to over-harvest in localized areas. Logging and mining activities tend to harass goats. The result is a movement away from traditional ranges. Strip-mining and logging have contributed to habitat destruction. The impact of these activities has not yet been fully evaluated. Fire suppression in goat range has also been implicated in habitat deterioration and a reduction in carrying capacity. Most states and provinces indicated they lacked good information on mountain goat population dynamics as well as movement and migration patterns. Hopefully this paper fulfills one of the objectives of this symposium: that is, to collate some basic information on goats from many areas so that all states and provinces could better manage their respective goat populations.

LITERATURE CITED

Richardson, A. 1971. The Rocky Mountain Goat in the Black Hills. South Dakota Dept. Game, Fish and Parks. Pierre, South Dakota. 25pp.

STATUS AND MANAGEMENT OF THE ROCKY MOUNTAIN GOAT, *OREAMNOS AMERICANUS*, IN THE PROVINCE OF ALBERTA[1]

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HISTORICAL INFORMATION

Millar (1915), while conducting a federally commissioned big game survey along the east slopes of the Rockies, stated that the goat was "everywhere present along the East slope in numbers that it would be difficult to estimate, but certainly well up in the thousands". When you couple this reference and the review of bighorn sheep in the Canadian Rockies by Stelfox (1971), it is evident that goat populations did not greatly decline in the late eighteen and early nineteen hundreds as did the sheep and elk populations. Stelfox stated that during the period 1860 to 1915 sheep numbers declined from in excess of 10,000 animals to about 2,600 animals. Elk numbers decreased from a population in the thousands to a 1915 population of not more than 365 (Millar *op. cit.*). The primary cause of this great reduction in sheep and elk numbers was the indiscriminate hunting, with firearms, by resident indians, explorers, miners, railway builders and settlers (Quaedvlieg *et al.* 1973).

The mountain goat was not part of this massive harvest. Millar (*op. cit.*) stated that "the comparative remoteness of its range, the worthlessness of its hides, the small esteem in which it is held either as a trophy or as a source of meat, and the abundance hitherto, of other more desirable and more easily obtained big game have all attributed to save the goat from the rapid decline in numbers befallen most of the other big game of the Rockies".

Hunting Seasons - The first hunting season was legislated under the 1907 Alberta Game Act; actual hunting began in the fall of 1909, running from September 1 to October 14 (Table 1). It was an either sex season with no restrictions on age or size. The entire province was open and two goats could be taken. The season was extended to seven weeks in 1917. In 1921 only animals over one year of age or with a minimum horn length of 10cm (4 in) were legal game.

Many changes were implemented beginning in 1907 (Table 2); most were concerned with opening and closing of special areas and zones and season opening dates. The season was reduced to a 13 day for most of the goat hunting areas in 1968, with the Willmore Areas shown in Fig. 1 as the only area open to goat hunting in 1969. This constituted a sizeable reduction in the amount of area open for hunting. A complete provincial closure was enacted in 1970 and remained this way until 1972 when one area was reopened for two weeks with 75 permits being issued. From 1973 to 1976 the number of permits issued annually was 50.

Hunting Pressure and Size of Harvest - Non-residents were the principal hunter of mountain goats in the province from 1909 to 1949 (Quaedvlieg *et al.* 1973). This was mainly due to the fact that goat populations were inaccessible to residents. Also, residents did not value the goat either as a trophy or a source of meat. Goat hunting was probably not excessive except in localized areas close to settlements during this time. The average annual reported goat kill between 1909 and 1924 was 43; a high of 61 was harvested in 1914 and a low of 26 in 1916. Harvest figures for the years of 1924 to 1949 are not available.

The post-1950 period saw an increased hunting interest and resulting intensive hunting of all provincial goat populations. An estimated total of 3,251 goats were harvested from 1950 to 1972, with the greatest yearly harvest occurring from 1956 to 1966 (Table 3). There was a steady decline in the number of goats harvested between 1967 (126 goats) and 1969 (54 goats).

Permit hunting and short seasons has resulted in a stabilized harvest since 1972 (Table 4).

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[1] Editor's note. Paper not part of Symposium.

Table 1. A summary of hunting seasons for mountain goats of Alberta, 1907 - 1949.

Year	Season Opening & Closing Dates	Number of Days Open to Hunting	Bag Limit	Restrictions
1907 - 1908	No open season			
1909 - 1911	Sept. 1 - Oct. 14	38	2	
1912	Sept. 1 - Oct. 14	37	2	
1913 - 1916	Sept. 1 - Oct. 14	38	2	
1917 - 1918	Sept. 1 - Oct. 14	37	2	
1919	Sept. 1 - Oct. 31	53	2	
1920	Sept. 1 - Oct. 31	52	2	
1921 - 1922	Sept. 1 - Oct. 31	52	2	Over 1 year of age or a minimum of 10cm (4 in) horns
1923	Sept. 1 - Oct. 31	52	1	
1924 - 1925	Sept. 1 - Oct. 31	53	1	
1926 - 1929	Sept. 1 - Oct. 31	52	1	
1930 - 1931	Sept. 1 - Oct. 31	53	1	
1932	Sept. 1 - Oct. 31	52	1	
1933	Sept. 1 - Oct. 31	53	1	
1934	Sept. 1 - Oct. 31	52	1	
1935	Sept. 2 - Oct. 31	52	2	
1936	Sept. 1 - Oct. 31	53	2	
1937	Sept. 1 - Oct. 30	52	2	
1938	Sept. 1 - Oct. 31	52	2	
1939	Sept. 1 - Oct. 31	52	1	
1940	Sept. 2 - Oct. 31	52	1	
1941 - 1942	Sept. 1 - Oct. 31	53	1	
1943	Sept. 1 - Oct. 30	52	1	
1944 - 1945	Sept. 1 - Oct. 31	52	1	
1946	Sept. 2 - Oct. 31	52	1	
1947	Sept. 1 - Oct. 31	53	1	
1948	Sept. 1 - Oct. 30	52	1	
1949	Sept. 15 - Oct. 15	27	1	

Table 2. A summary of hunting seasons for mountain goats of Alberta, 1950 - 1976.

Year	Season Opening & Closing Dates	Number of Days Open to Hunting	Bag Limit	Restrictions and Areas Open[1]
1950	Sept. 15 - Oct. 31	40	1	Entire Province Open
1951	Sept. 1 - Oct. 15	38	1	
1952 - 1953	Sept. 1 - Oct. 15	39	1	
1954	Sept. 1 - Oct. 30	52	1	
1955	Sept. 1 - Oct. 31	52	1	
1956	Sept. 1 - Oct. 13	37	1	
1957	Sept. 2 - Oct. 31	53	1	Zone 8 Closed
1958[2]	Sept. 1 - Oct. 31	53	1	Special Areas 1, 2, 3
	Sept. 1 - Oct. 30	52	1	South of the Bow
	Sept. 1 - Oct. 18	42	1	North of the Bow
1959	Sept. 1 - Oct. 31	53	1	Special Areas 1, 2, 3
	Sept. 1 - Oct. 17	41	1	Zones 1 - 15
1960	Sept. 1 - Oct. 29	51	1	Zones 1-8, 12-15 & Special Areas
	Sept. 1 - Oct. 22	45	1	Zones 9 & 10
1961	Sept. 1 - Oct. 28	50	1	Zones 1-8, 12-15 & Special Areas
	Sept. 1 - Oct. 21	44	1	Zones 9 & 10
1962	Sept. 1 - Oct. 31	52	1	Zones 1-8, 12-15 & Special Areas
	Sept. 1 - Oct. 20	43	1	Zones 9 & 10
1963	Aug. 31 - Nov. 2	55	1	Zones 12-15 & Special Areas
	Aug. 31 - Oct. 26	49	1	Zones 1-10
1964	Sept. 1 - Oct. 31	53	1	S400 - 444
1965	Sept. 1 - Oct. 30	52	1	S400 - 444
1966	Sept. 1 - Nov. 30	78	1	S400 - 442 (S444 Closed)
	Sept. 1 - Oct. 29	50	1	S400 - 438
1967	Sept. 1 - Oct. 31	52	1	S400 - 438, S440 & 442
1968	Aug. 31 - Oct. 31	53	1	S440, 442 & 410
	Sept. 21 - Oct. 5	13	1	S412 - 438 & S408
1969[3]	Sept. 21 - Oct. 18	28	1	Willmore Special Area Only
1970 - 1971	Season Closed			
1972[4]	Oct. 2 - Oct. 15	14	1	Portion of S422
1973[5]	Oct. 3 - Oct. 13	13	1	To be taken in area of destination
1974	Sept. 30 - Oct. 12	13	1	
1975[6]	Sept. 29 - Oct. 11	13	1	Compulsory Registration
1976	Sept. 27 - Oct. 9	13	1	

[1] The over one year of age or a minimum of 10cm (4 in) horns restriction was in effect for the entire period. Also beginning in 1957, W.M.U. S410 was open to bow hunting.
[2] Bow and arrow hunting only was initiated in Zone 8.
[3] Sunday hunting in the green areas was initiated.
[4] The 1972 season was a permit season and a total of 75 permits was issued.
[5] The 1973-74 seasons - 50 permits were issued. [6] The 1975-76 seasons - 45 permits were issued.

Table 3. The estimated mountain goat harvest for Alberta, 1950 - 1976.

Year	Resident	Non Resident Canadian	Non Resident Alien	Total Estimated Kill[1]
1950	150	-	-	150
1951	90	-	-	90
1952	20	2	60	82
1953	70	-	40	110
1954	123	-	44	167
1955	74	-	54	128
1956	140	3	90	233
1957	(71.5)	(44.5)		(116.0)
1958	(96.6)	(60.1)		(156.7)
1959	(129.4)	(80.5)		(209.9)
1960	(138.9)	(86.0)		(224.9)
1961	116	65		181
1962	169	89		258
1963	131	123		254
1964	124	87		211
1965	98	96		194
1966	84	111		195
1967	57	69		126
1968	44	45		89
1969	22	32		54
1970 - 1971		SEASON CLOSED		
1972	22			22
1973	14			14
1974	13			13
1975	28			28
1976	29			29
PERIOD TOTAL	2054.4	1281.1		3335.5

[1] Annual reported goat kill estimates were obtained from the hunter questionnaire returns with the exceptions of the years 1957 - 1960 for which kill estimates were extrapolated and for the years 1967 & 1969 for which kill estimates were obtained from the Annual Reports (1968 & 1970). Figures for 1972 to 1976 are not estimates.

Table 4. Summary of goat hunting seasons in Alberta, 1972 - 1976.

Year	No. of Permits Issued	No. of Hunters Hunting	Successful Hunters	Unsuccessful Hunters	Females Killed	Males Killed	Success Rate
1972	75	40	22	18	12	10	55%
1973	50	36	14	22	7	7	33%
1974	53	32	13	19	6	7	40%
1975	55	43	28	15	18	10	63%
1976	48	44	29	15	13	16	65%
TOTAL	280	196	106	90	55	51	

Licensing and License fees (1909 - 1977) - During the period 1909 - 1949, the goat hunter was required to be in possession of a resident Big Game License or a non-resident General Game License. In 1942, the resident Big Game License fee was $2.00 and the non-resident General Game License fee was $50.00. This entitled the holder to take one male mountain sheep, one mountain goat (male or female), one deer, one male moose, one caribou (male or female), one male elk with head of eight points or over, two male antelope, and (subject to Section 7(c) of the Regulations) one bear of each species (Alberta Gazette 1942). In 1943, the resident Big Game License was increased from $2.00 to $3.00 and a non-resident Big Game License was introduced at a fee of $100.00. In 1944, a $25.00 goat royalty was introduced and was additive to the non-resident Big Game Licensing fee. In 1948, the Big Game License was free of charge. Royalties were removed in 1950 and the previous resident and non-resident Big Game Licenses were reintroduced. From 1950 to 1955, the goat hunter was required to be in possession of a Big Game License. In 1955, the Big Game License was available at a fee of $5.00 for residents, $50.00 for non-resident Canadians, and $100.00 for non-resident aliens. In 1956, the resident Big Game License was replaced and the resident goat hunter was required to purchase a $10.00 Sheep and Goat License. In 1961, this license was replaced by a $7.50 Resident Goat License. Up until 1969, the non-resident goat hunter continued to require a General Big Game License which permitted the taking of a sheep, antlered game, and black bear in addition to a goat. In 1972, permits were issued to residents only and the permit fee was $10.00. The permit and fee structure that was introduced in 1972 are still being used.

CURRENT DISTRIBUTION

Presently an estimated population of 1200 goats inhabit about 70 percent of its historical range (Fig. 1) in Alberta. Approximately 50 percent of this total are found between 53° - 54°N and 118° - 120°W in an area referred to as the Willmore Park. Other concentrations occur in the Whitegoat and Siffleur Wilderness areas, and the Kananaskis, Elbow, Sheep and Highwood rivers drainages (Fig. 1). Other isolated herds are scattered along the east slopes of the Rockies.

An unnatural or transplant herd is located on Shunda Mountain east of Nordegg. A total of 7 goats (2 males and 5 females) was transplanted during July and August of 1972. Two kids were observed on Shunda Mountain in 1975 and in 1976 signifying initial success of this transplant.

CENSUS TECHNIQUES

Censusing of goat populations was historically carried out with a fixed wing aircraft concurrent with censusing of mountain sheep populations. Helicopter surveys were initiated in the late 1960's replacing the fixed wing surveys. Since 1972 goat surveys have been conducted separate from sheep surveys. These surveys are conducted during the first two weeks of July on a yearly basis in hunted areas and every three years in areas closed to hunting.

Surveys are conducted in two ways. Watersheds of areas closed to hunting are flown at altitudes whereby the aircraft is about half way between the top of the mountain and tree line and far enough away from the mountain to give survey crews a good view of the entire area. Mountain ranges are surveyed in a clockwise direction giving total coverage of the area. When goats are sighted they are classified as adults (one year and older) or kids. The second method employed in the hunted areas and is similar to the first except that the classification is carried out from the ground. Upon sighting a herd of goats the crew is dropped off and with the aid of spotting scopes, classify the animals as to adults, yearlings and kids (Table 5).

Figure 1. Distribution of Mountain Goats in Alberta.

Table 5. Classification of goats within the hunting area.

Year	Yearlings	Young of Year	Adult Male	Adult Female	U/C[1]	Total	Kids/100 Adults	Yrlg./100 Adults
1976	20	54	21	53	131	279	26.34	9.75
1975	47	84	37	108	79	355	37.5	10.98
1974	34	43	21	25	111	234	27.39	21.65
1973		58	1	13	197	269	27.48[2]	

[1]Unclassified adults
[2]Number of kids per hundred goats

All goat surveys are done at present during the summer months because of observing difficulties in the winter. The reason for this is that goats occupy the more open alpine meadows during summer.

MANAGEMENT

Non-hunted populations - Attempts are made to collect the following data from goat populations in areas closed to hunting: population decrease or increase; sex ratio of young to adults, and expansion into surrounding areas. Number of goats in these areas is currently estimated at 600. Most goats in non-hunting areas are found in recreational areas of relatively high human use.

Hunted populations - Those areas open to hunting are situated in the northern portion of Alberta's goat range (Fig. 1). The area has been divided into six zones using locations of individual herds and drainage system as a base. A total of 50 permits is allotted for an either sex, one animal season which takes place during the first two weeks of October each year. The harvest has varied from 13 to 29 since 1972, while the success rate has varied from 33 to 65 percent (Table 4).

Our goal is to harvest our goats at a rate not higher than 10 percent of the known number of goats in any given zone. Our present level of harvest (1972 - 76) is five percent, which may be a more realistic level in light of the apparent high rate of mortality among kids and the low recruitment rate.

Management problems - Management problems as seen by the author are threefold: what is the mortality rate among kids, what is the recruitment rate and what are the goat's movement and migration patterns? One must have some knowledge about all three problems before good management can be carried out. Mortality and recruitment rates must be known so that harvest rates do not exceed the natural recruitment level. Movement and migration patterns are important when your management plan is based on the number of goats per drainage system.

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STATUS AND MANAGEMENT OF THE MOUNTAIN GOAT IN ALASKA[1]

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The mountain goat (Oreamnos americanus) is distributed along the coastal mountains of the Alaska mainland from Portland Canal in southeastern Alaska to Cook Inlet in southcentral Alaska (see Fig. 1, Johnson, these proceedings). Within recent times the goat has naturally extended its range northward and inland to the Chugach, Kenai, Wrangell and Talkeetna Mountains. Some evidence exists to indicate that the goat has extended its distribution into the Alaska Range (Klein 1953). Recent transplants have further extended the goat's distribution to Kodiak and Baranof Islands (Burris and McKinght 1973).

HISTORY

Mention of the mountain goat and its utilization can be found in accounts of early Alaskan history. The Tlingit Indians of southeastern Alaska were probably the first humans to have regular contact with this species in Alaska. De LaGuna (1972) documented the importance of the goat to this tribe for both ceremonial and ornamental purposes. Example included the use of the hair for blankets, use of the fat for perfume, and most importantly, utilization of the meat for sustenance. In addition, goats were also sold, as evidenced by the account of Tichmenew in Krause (1956) which refers to the selling of 2,774 goats to the Russians at the market in Sitka, Alaska during the winter of 1861.

The mountain goat was often referred to by early explorers. Initially, various accounts referred to the species as "white bear" (Cook 1784) or misidentified him as a Dall sheep (Ovis dalli) (Seton 1929). Mountain goats were occasionally relied upon for food by those seeking gold and by early Alaskan homesteaders (Klein 1953 and Moore 1968). Even today the goat occasionally serves as an important food item.

INTRODUCTIONS

Interest in establishing goat populations on various islands began early in the century (Elkins and Nelson 1954). The first transplant occurred in 1923 when 18 animals were moved from Tracy Arm on the southeast mainland to Baranof Island (Burris and McKnight 1973). The population expanded rapidly and by 1949 the first hunting season was initiated. Since that time the population has increased to approximately 200 to 300 animals allowing an annual harvest of 20 to 30 (Burris and McKnight op. cit.). Goat transplants to both Kodiak and Chichagof Islands were attempted in the early 1950's; however, apparently only the Kodiak transplant was successful as Department biologists have been unable to locate goats on Chichagof Island (Burris and McKnight op. cit.).

CENSUSING

Prior to statehood in 1959 management of the mountain goat was under the jurisdiction of the United States Territorial Government, Alaska Game Commission. Before statehood goats were censused only on a highly irregular basis with the use of fixed-wing aircraft. At that time goat populations were probably under no appreciable hunting pressure and public reports indicated they were present in abundant numbers (Merriam 1960), thus routine censusing was probably unnecessary.

Regular censusing of mountain goats from fixed-wing aircraft was initiated in 1959 (Merriam 1960). Since that time much of the goat's range in Alaska has been censused at least once. Surveys have traditionally been conducted with the use of either Piper (PA - 18) supercubs or Cessna 180's from late July through September. Some of the problems associated with such surveys and the resulting data are discussed in Appendix 1. Even with these problems, however, the survey data

[1] Editor's note. Paper not part of Symposium.

collected since 1959 appear to provide trends to population abundance. Data collected from the surveys indicate that statewide populations remained fairly stable up to 1970 when declines were first noticed on the Kenai Peninsula. It is noteworthy that the first signs of decline occurred in areas where goats overlapped range with Dall sheep. However, these areas also received the greatest hunting pressure. Early in the 1970's it became evident that populations had declined statewide. The statewide decline was suspected to be the result of severe winters.

In recent years helicopters have been used to census goats on an experimental basis. Results of these surveys have varied from good (Appendix 1) to rather poor counts (Didrickson, pers. comm.). Even if future studies indicate desirable results from helicopter surveys it is doubtful that their use would become widespread due to the high cost involved with censusing relatively large areas.

Ground surveys have been utilized to a limited extent to supplement data obtained from aerial counts (unpubl., and Smith, pers. comm.). Such surveys have provided higher counts and probably more accurate age composition data than those acquired with fixed-wing aircraft, but only for relatively small areas (unpubl.). To date, manpower and funding limitations have precluded their widespread application. However, as hunting pressure increases and more definitive population data are needed, their use will probably increase.

Based upon aerial survey data (McKnight 1976) it is estimated that Alaska's current goat population is between 15,000 and 25,000 animals. Approximately 5,000 of that total has actually been counted by fixed-wing aircraft (McKnight op. cit.).

MANAGEMENT

Alaska's sport hunting seasons and bag limits are determined annually by the Board of Game each spring on the basis of current harvest and goat population statistics as collected by the Department. Regulations are established on a game management unit (GMU) basis. There are 26 units in Alaska, some of which are divided into subunits. Mountain goats occur in 11 of these units (Fig. 1).

A review of Alaska goat hunting seasons and bag limits from 1925 through 1952 is contained in Klein (1953:103). During the 1950's and 1960's seasons and bag limits fluctuated somewhat according to unit and subunit but for the most part they remained fairly liberal. Beginning in the early 1970's goat hunting regulations were made markedly more restrictive: the January season was eliminated in 1972; seasons adjacent to popular access corridors were shortened and no hunting the same day airborne was initiated in 1974; statewide bag limit was reduced to one in 1975; and the Kenai Peninsula and surrounding area were placed on permit hunting in 1976.

Prior to 1972 the Department assessed annual harvests by conducting post-season hunter interviews in selected communities. Estimated harvests from 1962 until 1972 appeared relatively constant at between 500 and 600 annually (McKnight 1973). Beginning with the 1972 season, annual harvests were estimated by returns from a "mandatory" harvest report-ticket program. Based upon an average of 615 goats were annually harvested statewide (Table 1). Fifty-seven percent of this harvest was comprised of male goats. An unknown percent was comprised of kids since Alaska hunting regulations do not restrict age or sex of the harvest. Crippling loss and irretrievable kills occur but their significance is unknown.

Most hunting effort has occurred in the readily accessible portions of the goat's range (McKnight 1976). Airplanes, boats and highway vehicles are the most popular modes of transportation to hunt areas (McKnight op. cit.). In some cases easy access has resulted in excessively high harvests, particularly on the Kenai Peninsula which is connected to metropolitan Anchorage by an extensive road system.

Although annual harvests have appeared to be well within sustained yield levels statewide, in some areas harvests have appeared excessive. Reductions in season length and bag limits have reduced harvests to acceptable levels in most situations. In some cases, however, it was necessary to place goat hunting on a permit basis. Harvests on the Kenai Peninsula and surrounding area were limited by closing individual hunt areas when the kill exceeded approximately 10 percent of the numbers of goats observed on the most recently conducted aerial survey.

There is a paucity of data on total populations, sex and age composition, crippling loss, and percent of harvest comprised of kids. Initiation of permit hunts in southcentral Alaska, however, will help to acquire this much needed information. All successful hunters were required to bring their permit and goat horns to a Department office within five days after killing a goat. At that time Department personnel determined the sex and age of the animal according to methods described by Brandborg (1955). Hunters were asked questions related to their hunting success. Continuation of the permit system in future years will hopefully reduce harvests in heavily hunted areas and redistribute hunting effort to other lightly hunted areas. The system will allow flexibility in management and continue to provide hunting opportunity in areas which might otherwise be closed if management were on a unit basis.

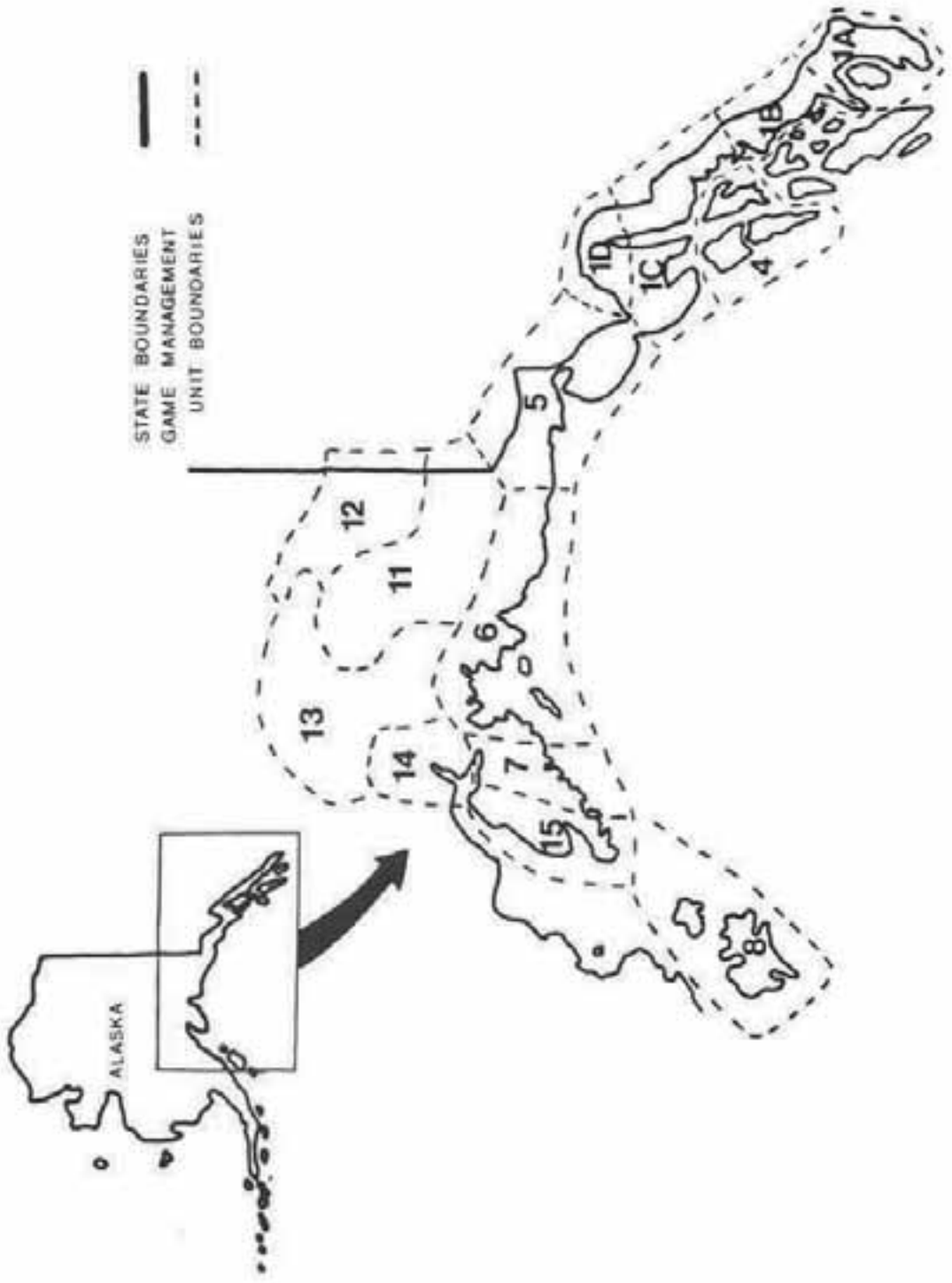

Figure 1. Alaska Game Management Units.

Table 1. Alaska mountain goat harvest statistics derived from harvest reports, 1972 - 1975.

	Harvest Year				
	1972-73	1973-74	1974-75	1975-76	1976-77
Total mt. goat hunters:	1,586	1,783	1,521	1,475	1,320
No. successful hunters:	556 (35.1%)	703 (39.4%)	539 (35.4%)	542 (36.7%)	436 (33.0%)
No. unsuccessful hunters:	1,030 (64.9%)	1,080 (60.6%)	982 (64.6%)	933 (63.3%)	884 (67.0%)
Total mt. goat harvest:	630	822	619	569	436
Males taken:	338 (53.7%)	472 (57.6%)	346 (55.9%)	329 (57.8%)	247 (56.7%)
Females taken:	293 (44.9%)	331 (40.4%)	260 (42.0%)	232 (40.8%)	188 (43.1%)
Unknown sex taken:	9 (1.4%)	16 (2.0%)	13 (2.1%)	8 (1.4%)	1 (0.2%)
No. harvest reports issued:	11,757	12,874	11,171	9,961	8,675
Outstanding harvest report holders:	3,123 (26.6%)	3,659 (28.4%)	3,363 (28.4%)	2,750 (27.6%)	2,579 (29.7%)

Non-consumptive use of mountain goats in Alaska has appeared to increase in popularity in recent years. Primary activities have been roadside viewing and photography. The Department maintains several areas which are closed to goat hunting. Although these areas serve as the focal point for year-around non-consumptive use, most such use occurs in areas open to hunting. Management for non-consumptive users to date has consisted of providing roadside pull-off areas and calling attention to the various opportunities which are available throughout the goat's range. Future management will probably consist of regulating numbers of non-consumptive users and providing interpretive literature. All non-consumptive use management is financed through revenues received from the sale of hunting licenses and non-resident tags and the State's apportionment of Pittman-Robertson funds.

Within the past decade Alaska's human population has grown significantly (Yankee 1974). In addition to increasing hunting pressure, the increased human population has resulted in increased commercial "development" which in many cases could prove detrimental to goat habitat. Currently large scale plans are proposed and being implemented for clear-cut logging in and adjacent to goat winter and summer habitat (U.S.D.A. 1973). Much remains to be learned about the goat's habitat requirements before the impact of land mangement practices can be predicted. The importance of mature forest to goats is not yet understood, but use of this habitat is documented. Relatively common observations of goats on saltwater beaches (Klein 1953, unpubl.) indicate, in many instances, movements of considerable distance through the forest zone. Clear-cut logging in goat travel corridors and in or adjacent to wintering areas may prove detrimental to goat populations.

Extension of road systems through or adjacent to goat habitat could result in at least two problems: the blocking of migration and/or goat automobile encounters, and secondly, overharvest if hunting is not tightly controlled or eliminated altogether. The latter situation has resulted in the closure of at least two areas prior to final road construction in an effort to assess impact (Ballard 1976 and LeRoux, pers. comm.).

Possibly of greatest importance to the hunter is the possible loss of large hunting areas due to the Alaska Native Claims Settlement Act. Federal withdrawals of 80 million acres, a considerable amount of which will be placed in the National Park System which prohibits hunting, and native withdrawals of 40 million acres will undoubtedly reduce public hunting opportunities.

Klein (1953) and Heljord (1971) have been the only two investigators to conduct in-depth studies of the goat in Alaska. Although their studies contributed significant knowledge about

certain facets of goat ecology much remains unknown. Better information on productivity, mortality, habitat requirements, influence of predation, census techniques, and effects of sport hunting is needed to insure proper management of this resource.

During fiscal year 1977 the Department initiated a long-term study on goat ecology and management on the Kenai Peninsula under the direction of Mr. Lyman Nichols, Game Biologist at Cooper Landing, Alaska. Results from this study should eventually provide for a more sound basis upon which to manage mountain goats.

Limited data suggest, and most Department biologists are of the opinion, that winter weather is the primary limiting factor on goat populations. In addition to limiting forage availability, it is thought that excessive snow accumulations contribute to mortality through avalanches and accidental falls. In some portions of the goat's range it is felt that wolf (Canis lupus) predation is becoming an increasingly significant goat limiting factor (Johnson and Ballard, unpubl.). Sport hunting except in limited, easily accessible areas is thought to result in an insignificant amount of mortality.

Future prospects for the mountain goat in Alaska appear good. Populations are expected to eventually rebound from their current low level; however, fluctuations will doubtless continue to occur. Hunter interest and harvest will probably increase in areas both closed and open to sport hunting. Research activities will probably be significantly intensified in an effort to manage goats on a more sound scientific basis and to more accurately predict the results of land management practices.

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APPENDIX I. Censusing of Mountain Goat from Cessna 180 Aircraft and Helicopter.

Effective management of any wildlife species depends upon the availability, reliability and validity of population indices. Since 1959 the Alaska Department of Fish and Game has conducted aerial surveys of mountain goats (Oreamnos americanus) using fixed-wing aircraft. Results of these surveys have varied greatly in total numbers and kid-adult ratios during the same survey year and between years thus creating doubt as to whether the data reflect true population trends.

Although considerable literature exists concerning accuracy and reliability of aerial censuses, few references concerning aerial censusing of mountain goat populations can be found. The purpose of this paper is to report on goat counts performed from Cessna 180 aircraft and helicopter over two study areas in Southeast Alaska. Counts were initiated to measure daily variation and to determine problems associated with such surveys. Counts were intended to duplicate normal surveying procedure and thus no attempt was made to control survey variables.

MATERIALS AND METHODS

During late July and August 1974, a series of flights with a Cessna 180 aircraft on floats, one flight with helicopter (Hiller 12E), and one ground count were conducted by the same observer over two study areas located on the lower Chilkat Range in Southeast Alaska: Area 1 - William Henry Mountain and Area 2 - Endicott River to Sullivan River: Area 1 encompassed about 41.3km^2 while Area 2 encompassed about 83.8km^2. Vegetation and topography of the study areas were similar to that described by Palmer (1942).

All aerial surveys were initiated at the highest point on each area. From that point the area was circled until completely surveyed, then the area of search was lowered 300 (92m) to 400 (122m) feet in altitude and another circle begun. Goats were aged as either adult or kid. If age composition was not readily discernible, the aircraft was circled over the animals until classified to the satisfaction of the observer. Each study area was surveyed until the observer felt adequate coverage had been obtained. Data on goat numbers and age composition at each location were recorded on standard forms and topographic maps. Presurvey records were made on percent cloud cover and air temperature.

Efforts were made to duplicate normal surveying procedures which meant initiation and conclusion of surveys were dependent on the availability of pilot, aircraft and flying weather.

RESULTS

The highest goat count for each study area was attained with the helicopter (Table 1). Counts from a Cessna 180 averaged 66 percent of those observed from a helicopter. Total counts from Cessna 180 ranged from 20 to 44 goats for Area 1 and 18 to 59 goats for Area 2. Mean number of goats observed from Cessna 180 was 36.6 and 39.6 for Areas 1 and 2, respectively. No significant difference between areas for mean number of goats observed was detected ($t=.47$, $df=12$, $P > 0.05$) even though Area 2 was larger and more time was expended surveying it. Also, no significant differences

between variances of the means were detected for number of adults (F=1.16, df=6, $P > 0.05$) and total numbers (F=3.52, df=6, $P > 0.05$), however, a significant difference was detected for numbers of kids (F=9.58, df=6, $P < 0.05$).

Table 1. Summary of mountain goat counts over two study areas in Southeast Alaska.

Date of Survey	Pilot Number	Initiation Time	Survey Time in Minutes	Percent Cloud Cover	Air Temperature	Number of Adults Observed	Number of Kids Observed	Total Number Observed	Kid per Hundred Adult Ratio
Area 1: William Henry Mountain									
7/28/74[a]	1	13:10	45	20	50	29	7	36	24.1
7/29/74[b]	2	12:15	40	40	48	38	17	55	44.7
7/31/74[a]	3	15:35	40	0	55	14	6	20	42.9
8/2-6/74[c]						33	15	48	45.5
8/10/74[a]	4	15:35	40	10	50	28	10	38	35.7
8/11/74[a]	4	15:38	52	0	59	25	10	35	40.0
8/19/74[a]	4	14:40	43	100	49	31	10	41	32.3
8/29/74[a]	4	14:20	45	0	65	35	9	44	25.7
8/30/74[a]	1	18:38	34	0	70	33	9	42	27.3
Area 2: Endicott River									
7/28/74[a]	1	14:05	40	20	54	26	9	35	34.6
7/29/74[a]	2	10:55	75	60	49	42	19	61	45.2
7/31/74[a]	3	16:15	55	5	50	17	1	18	5.9
8/10/74[a]	4	16:20	50	0	48	31	13	44	41.9
8/11/74[a]	4	16:33	80	0	55	44	15	59	34.1
8/19/74[a]	4	15:25	55	100	52	43	14	57	32.6
8/29/74[a]	4	15:15	70	0	65	21	6	27	28.6
8/30/74[a]	1	19:17	52	0	69	28	9	37	32.1

[a] Cessna 180
[b] Helicopter
[c] Ground Count

Ratios of total numbers of goats observed from Cessna 180 and helicopter surveys between each area were compared with a heterogeneity Chi-square analysis. No significant difference was detected (X^2=12.97, $P > 0.05$), indicating that the factors which influence fluctuation in total counts were operating at the same magnitude on both areas.

Ratios of adults to kids for each area were also subjected to a heterogeneity Chi-square analysis to determine if ratios from Cessna surveys were consistent regardless of fluctuations in total numbers. No significant differences were detected for either study area (X^2=3.81, $P < 0.75$ for Area 1 and X^2=4.23, $P > 0.75$ for Area 2). However, examination of Table 1 reveals that the kid-adult ratio for the survey conducted 31 July 1974 on Area 2 was totally unacceptable even though not statistically significant.

An attempt was made to correlate air temperature and percent cloud cover with numbers of goats observed each day. Such large variations were present that no significant ($P > 0.05$) trends were detected, although this may have been the result of small sample size. Gross examination of combined data for all surveys indicate that more goats were observed when cloud cover exceeded 20 percent.

The relationship between total goats observed versus initiation time and surveying time per Cessna 180 survey for each area were also assessed. No relationship was detected for initiation time, however, there appeared to be a relationship for amount of time spent surveying. Data for Area 2 indicated that as surveying time increased the numbers of observed goats also increased, while the reverse was true for Area 1; less goats were observed as surveying time increased.

DISCUSSION

Results from this study indicate that total counts from a Cessna 180 during July and August may not reflect annual trends in total numbers or productivity. Counts can only be considered as minimum population values. Management decisions based upon single Cessna 180 surveys alone must be viewed with skepticism.

Because helicopter surveys produced both the largest total counts and kid counts, it appears that helicopter surveys may provide more reliable population statistics than Cessna 180 surveys. During the helicopter surveys several goats were observed that were under a canopy of deciduous vegetation. They were noticed only because they shook the vegetation as they fled from the helicopter. During Cessna 180 surveys kids often hid under nannies but during helicopter surveys nannies were forced to run and thus more kids were observed. The ability to thoroughly search vegetated areas and get a closer look at all goats observed undoubtedly produces more complete counts. Daily variation associated with such surveys and their effects on goat behaviour have not been determined, therefore, the resulting data also should be viewed with caution.

Lowest goat counts were attained on 31 July 1974, two days after the helicopter surveys were conducted. Although there were no firm data indicating that helicopter surveys were the cause of the low counts, it does appear to be a possibility. Noted reactions of surveyed goats (Ballard 1975) indicated that goats respond adversely to helicopters. Chadwick (1973) reported that goats in Montana appeared to move out of areas which received frequent helicopter use. He also stated that helicopters seem to terrify goats. Conceivably this fear could alter goat behaviour for a period of time after a single encounter with a helicopter.

Except for one survey, considerably more time was expended surveying Area 2 than Area 1 because it was larger. Even so, as surveying time on Area 2 increased, the number of goat observations increased; the reverse appeared to be true for Area 1. Also, kid counts exhibited more variation for Area 2 than Area 1. It was felt that at least a portion of the differences between the results for the two areas could be attributed to differences in topography and goat reactions to the survey vehicle. Area 2 had more rock outcroppings with more potential places of concealment than did Area 1; therefore, more survey time resulted in a better count. On many occasions, goats appeared uneasy at the sight of the survey vehicle; although goat groups may not have fled, kids frequently would seek cover under the nanny and thus would be unobservable unless the nanny started to run. Goats on Area 1 reacted to aircraft more strangely than those on Area 2 (Ballard, 1975). Area 2 goats were not forced to run because of an abundance of cover, resulting in a lower opportunity to observe kids.

Other investigators have mentioned the importance of pilot experience in obtaining accurate and precise counts (Erickson and Siniff, 1963; Siniff and Skoog, 1964; LeResche and Rausch, 1974). The lowest counts during this study occurred with pilot number 3. Pilot number 3 had the most surveying experience and, thus, low counts based on pilot experience alone would not have been expected.

Merriam (1965) speculated that fixed-wing survey initiation time influenced the number of goats counted. He indicated that goats were more active and more observable in early morning and late evening hours. Data from this study indicated no such relationship, however, it is quite possible that surveys were not initiated early or late enough in the day to observe goats during their peak activity periods.

Both areas were open to hunting during August 1974. Minimum harvest based on a 60.8 percent response of hunter reports, indicated that 4 and 0 goats were harvested from Area 1 and Area 2, respectively. No doubt a reduction in goat numbers while the study was in progress accounted for some of the variation in total numbers. Also, the influence of disturbance by hunting upon goat behaviour is unknown.

Causes of variations in total numbers between Cessna 180 and helicopter counts were not determined in this study. Erickson and Siniff (1963) and LeResche and Rausch (1974) enumerated a variety of factors which they felt influenced the accuracy and precision of their surveys on brown

bears (Ursus arctos) and moose (Alces alces), respectively. LeResche and Rausch (op. cit.) believed all of the factors were interrelated and any statements concerning aerial counts must consider them all. No doubt the same situation applies to aerial censusing of goats.

In summary, the results of this study indicate that counts conducted from Cessna 180 aircraft may not reflect population trends and can only be interpreted as minimum population values. Higher counts occur on days when cloud cover exceeds 20 percent. Although two surveys were conducted, helicopters provided the highest counts and thus may be superior to other aircraft. Additional research into the refinement of aerial censusing of mountain goats is needed. Future studies should focus on determining percent of population actually observed, comparing the efficacy of various survey vehicles, and determining the season, time of day and weather conditions for optimum surveying.

ACKNOWLEDGEMENTS

This study was supported in part by Federal Aid in Wildlife Restoration Project, Alaska W-17-7, Job 12.2R. Appreciation is expressed to D. E. McKnight and D. H. Strode, Alaska Department of Fish and Game, Juneau, for providing editorial comments.

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STATUS OF MOUNTAIN GOATS IN BRITISH COLUMBIA

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Little information is available on early populations of mountain goats in British Columbia. The earliest recorded account of this species in British Columbia was by David Thompson in 1807. The "Inventory of the Natural Resources of British Columbia" (1964) gives an estimated population of 100,000 mountain goats in the province in 1961. Since that time, declines have taken place in many herds. The current 1977 estimated population is 63,000 (Blower 1977). In several areas the declines are attributed to over-hunting and in others due to severe winters or a combination of both over-hunting and sever weather (Phelps et al. 1975).

CURRENT DISTRIBUTION

Mountain goats are found in most of the mountainous areas of the province, except for Vancouver Island. They are found from sea level along the west coast to elevations over 2500m in the Rockies. Approximately 25 percent of lands of British Columbia support mountain goats (Fig. 1 and Table 1) in at least moderate numbers (Blower 1977).

Table 1. A summary of the distribution and relative abundance of mountain goats in British Columbia (Blower 1977).

	RELATIVE ABUNDANCE CATEGORIES						Population Projection Based on Abundance Categories	
	FEW		MODERATE		PLENTIFUL			
Resource Management Region Number	Area in km^2	% of Prov. Total	Area in km^2	% of Prov. Total	Area in km^2	% of Prov. Total	Estimated Number of Animals	% of Prov. Total
1	205	1	627	2	290	4	1770	3
2	1822	10	2285	7	157	2	3200	5
3	1640	9	1774	6	543	7	4060	6
4	1279	7	3583	12	483	6	5760	9
5	1762	10	3668	12	NIL	0	4110	7
6	5068	28	10660	35	5797	76	33390	53
7	6425	33	7915	26	362	5	10440	17
TOTAL ALL REGIONS	18201	100	30512	100	7631	100	62730	100

Categories: Few - 1 goat per 1.5 - 39km^2 (Est. avg. = 1 goat/12km^2)
Moderate - 1 goat per .3km^2 (Est. avg. = 1 goat/.9km^2)
Plentiful - over 1 goat per .3km^2 (Est. avg. = 1 goat/.3km^2)

[1]Editor's note. Paper not part of Symposium.

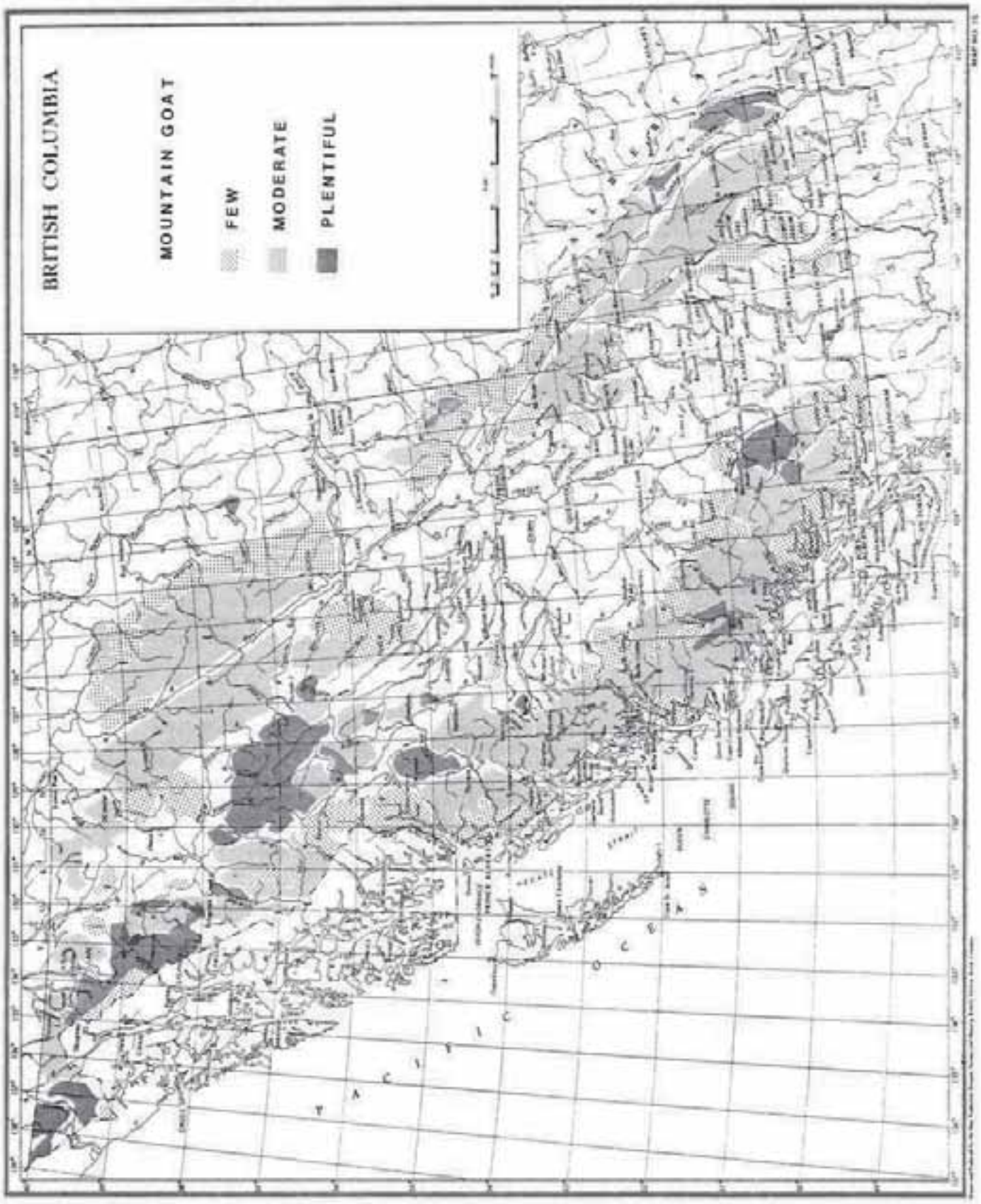

Figure 1. Mountain Goat Distribution in British Columbia.

INTRODUCTIONS

Only one introduction has been made in this province. In 1924, four mountain goats were transferred from Banff, Alberta to Vancouver Island. These animals were last reported in 1941. (British Columbia Game Comm. 1924 - 1943.) It appears that there is probably habitat that would support mountain goats on Vancouver Island. In view of the success of transplants in other areas, consideration is being given to the possibility of a transplant to this area.

CENSUS

Aerial surveys, usually by helicopter, are used to provide most of the information on goat distribution and numbers. Accessible herds are also counted from the ground. These data are supplemented by information on distribution provided by hunters and guides. The distribution information is far more reliable than the population estimates.

HABITAT

Mountain goats inhabit the roughest possible terrain in the mountain ranges of the province, from sea level to above timberline. Usually they are found within easy reach of rocky bluffs or crags for hasty retreat from any danger. They may travel short distances through forests and valleys, but will seldom linger there. Although deep snows may force them to lower elevations, they prefer to remain high in the mountains, seeking out windswept slopes of low snow depth, usually with southern or western exposures.

BREEDING BEHAVIOUR

Pre-mating activities begin when adult males slash brush with their horns and dig rut beds. Mating activity reaches a peak between November and early December. Parturition occurs from May to June. When she is about to give birth, the nannie seeks out a secluded, sheltered location, sometimes in a cave or under a large overhang of rock. Typically, it is the roughest piece of terrain in the mountain goat's habitat. Usually only one kid is born, but twins do occur. At birth, the kid is about 30cm long, weighs 2.5 to 3.5kg and is clothed in white wool. The nannie remains in this nursery area for about 10 days, until the young kid is able to follow her and join the herd.

MORTALITY

Survival of the mountain goat is greatly dependent upon the availability of suitable wintering areas. Kids and yearlings experience the greatest mortality. Deaths are attributed in part to adverse weather conditions in winter. Deep snows lower the availability of food and make the animal more susceptible to disease, parasites, predators and accidents. Mountain goats are subject to heavy infections of lungworms and intestinal parasites. These can be damaging, especially when combined with critical winter conditions of cold, snow and food shortage. Other diseases identified in mountain goats from British Columbia include: actinomycosis, pseudotuberculosis (Cowan 1951), contagious ecthyma (Samuel et al. 1975), and white muscle disease (Hebert and Cowan 1971).

Predation of mountain goats seems to be a minor factor in limiting goat populations. Cougars and coyotes have both been observed to prey on mountain goats and some reports credit eagles with taking kids, but the latter is probably a rare occurrence. Wolves, bears, bobcats, and wolverine also prey on them if given the opportunity. Although mountain goats choose to seek safety in retreating to escape terrain, they will meet an aggressor, and if necessary, will use their stilletto-like horns to inflict injury on the predator (Wright, undated).

Accidents are a major cause of death. Although they have been observed to fall short distances without apparent injury, many accidents do occur through fighting or slipping. Avalanches have been known to take several goats at a time (Wright, undated).

MANAGEMENT

Non-hunted populations - Hunting closures were established in British Columbia by authority of the Wildlife Act in 1963. Closures have increased in number and area since that time but often have been instituted after the goat populations had been reduced. Over-hunting of populations was often masked by the lack of detailed information on hunter take by area. The total kill in several large areas remained stable only because as one population declined from over-hunting a new population was made accessible to hunters (Phelps et al. 1975).

Since 1970, several accessible areas have been set aside by the Fish and Wildlife Branch for non-consumptive utilization. In addition to these areas, several National and Provincial Parks as well as Ecological Reserves have goat populations which are unhunted.

Hunted Populations - Seasons have become more and more restrictive to protect goat populations from over-harvesting. These restriction have consisted of: shortening the length of the season; reduction in bag limits; area closures; limited entry hunting; males only seasons; and, compulsory inspection of goat taken. Bag limits are now one goat of any age or sex per season. Most of the areas have a six week season. However, season length varies from 22 days to six months on one limited entry area. Because of the difficulty in distinguishing males from females under field conditions, male only seasons have not been satisfactory.

Hunting Pressure and Goat Harvests - In 1965, a maximum of 4340 resident goat hunters, plus and unknown number of non-resident goat hunters took an estimated 2517 goats. By 1975, the number of resident hunters had dropped to 2066, a 52% decline. During this period, the total harvest dropped to 1057 goats, a decline of 58%.

Table 2. Shows the harvest by residents and non-residents from 1965 - 1976.

Provincial Hunting Pressure and Harvest

1965 - 1976

Year	Resident Hunters	Resident Harvest	Non-resident Harvest	Total Estimated Harvest
1965	4340	1967	550	2517
1966	3501	1762	679	2441
1967	3438	1577	567	2144
1968	3681	1661	620	2281
1969	3995	1557	695	2252
1970	3991	1386	605	1991
1971	2355	921	557	1478
1972	5240	737	447	1184
1973	5791	965	537	1412
1974	2069	487	372	859
1975	2066	623	434	1057
1976	2131	498	386	884

The reported ratios in the kill as reported by hunters has averaged 57% adult males, 39% adult females and 4% juveniles.

Information From Hunters - Hunters are asked to report age, sex, location and date of each goat killed. Compulsory inspection was instituted in 1976. Successful hunters must bring the horns and lower jaw from any mountain goat killed to an employee of the Fish and Wildlife Branch. Horn measurements are made and an incisor tooth is removed for aging. Hunting effort by time and area is also recorded.

MANAGEMENT PROBLEMS

Overhunting - Increased access has resulted in many of British Columbia's mountain goat populations being overhunted. Maintaining an acceptable level of harvest without depleting the base breeding population is difficult. Goats utilize cliffs and bluffs for escape cover. This in addition to their low productivity make them particularly vulnerable to overhunting.

POPULATION INFORMATION

Obtaining the information necessary for sound management is often costly and difficult. Reliable information on herd size, composition, recruitment, and mortality is often lacking. Analysis of sex and age data obtained from compulsory inspections of hunter killed animals by the Fish and Wildlife personnel should yield valuable data on the sex and age composition of the harvest. This will be useful in regulating the take to prevent overharvesting.

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STATUS AND MANAGEMENT OF MOUNTAIN GOATS IN COLORADO[1]

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Abstract: Colorado's mountain goat population of approximately 600 animals is the result of importation and release in suitable habitats. The first release was in 1948, and the first open season was in 1964. During 10 seasons 2,148 hunters have applied for 202 authorized licenses, harvesting 158 animals for an 80 percent success ratio. The overall harvest sex ratio is 172 males per 100 females, with a minimum horn length of 15cm (6 in). Kids and aults accompanied by a kid are not harvested. Only Colorado residents are eligible for a license. Management problems pertain to limited licenses, some potential habitat impacts, possible competition with bighorn sheep, hunter questionnaire compliance, and obtaining adequate and reliable counts. Loss of goat habitat and poaching are not significant problems at this time.

HISTORY OF TRANSLOCATIONS

Mountain goats have never occurred naturally in Colorado, although Armstrong (1972) cited Coues and Yarrow (1875) as reporting one "seen in Colorado by Lieutenant Marshall's party," and Trippe (1874) as listing the mountain goat among the mammals of Clear Creek and Gilpin counties. Armstrong assumed that these early sightings were of bighorn sheep ewes.

The history of the mountain goat in Colorado is one of introductions (Table 1). The present distribution of mountain goats in Colorado is a reflection of the success of the translocation program. The details of the Collegiate Range (= Sawatch Range) herd (Fig. 1) are treated in depth by Bailey and Johnson elsewhere in these proceedings. Briefly, the introduction of the mountain goat in Colorado was initiated with the release of nine animals (four billies and five nannies) on the east slopes of Mt. Shavano in the Collegiate Range on May 24, 1948. These animals were flown in from Montana. One adult male died a few days after release.

The Mt. Evans herd (Fig. 1) originated from a release of six billies and nine nannies (total of 15 animals) from Idaho and South Dakota in July, 1961. A young adult male died shortly after release.

The Needle Mountains herd (Fig. 1) stems from two releases of goats. The first was in the Lake San Cristobal area on Cottonwood Creek, Lake Fork of the Gunnison River, in June, 1964. It was comprised of 10 animals from South Dakota (four billies and six nannies). Two adult females were found dead shortly after release. A supplemental plant of one billie and three nannies from British Columbia was made on June 19, 1971, in the Chicago Basin area.

The Gore Range goat herd (Fig. 1) originated with a release of two billies and three nannies from South Dakota on June 13, 1968, on Black Creek, which supplemented the two goats observed by Division personnel in the area in 1967. These two were presumably pioneering migrants from the Collegiates or Mt. Evans. Subsequently, on July 8 and 9, 1970, two males and two females from British Columbia were released in the same site, and on August 5, 1970, one additional nannie was released from British Columbia. On June 4, 1971, a billie was released from British Columbia. During June 27 and August 18 and 20, 1972, a total of one billie and four nannies was released on Black Creek from the Mt. Shavano herd. Thus, a total of 16 goats has been released on the Gore. This total is comprised of six billies and 10 nannies, one of which (a yearling male from the 1970 release) was found dead in 1971.

Six mountain goats (two billies, four nannies) were released in three phases on Marcellina Mountain in the West Elk Mountains (Fig. 1) in July and August, 1975. They were translocated there from the Collegiate herd on Sheep Mountain on Cottonwood Creek.

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[1] Editor's note. Paper not part of Symposium.

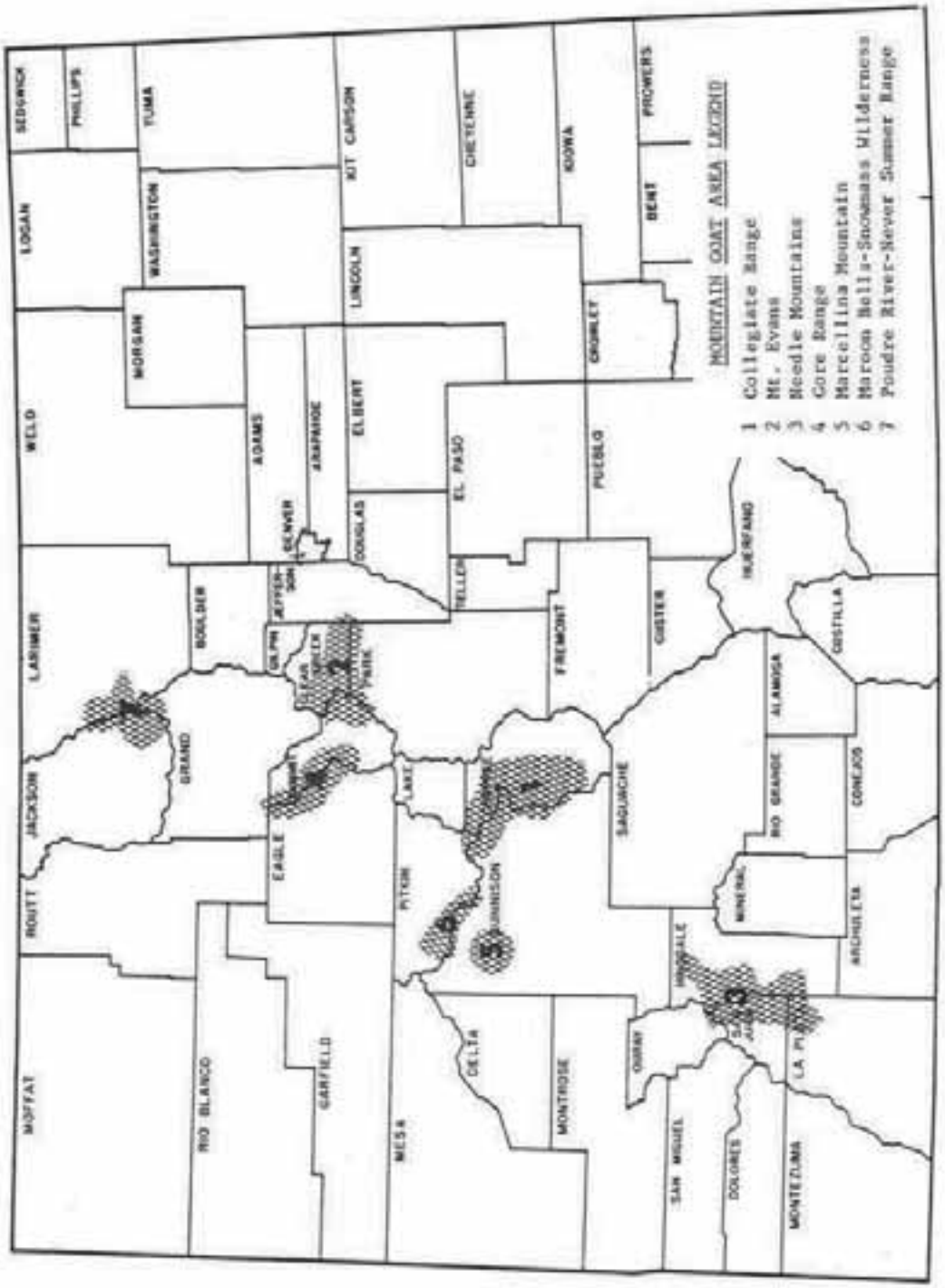

Figure 1. Mountain Goat Distribution in Colorado.

Table 1. Mountain goat translocation data in Colorado, 1948 - 1975. *

Date	Release Area	Male	Female	Total	Source
May 24, 1948	Mt. Shavano	4	5	9	Montana
June 30, 1950	Sheep Mtn. (Collegiates)	2	4	6	Montana
July, 1961	Mt. Evans	6	9	15	Idaho and South Dakota
June, 1964	San Cristobal, Lake Fork	4	6	10	South Dakota
June 13, 1968	Gore Range	2	3	5	South Dakota
July 8, 9, 1970	Gore Range	2	2	4	British Columbia
Aug. 5, 1970	Gore Range		1	1	British Columbia
June 4, 1971	Gore Range	1		1	British Columbia
June 19, 1971	Chicago Basin, Needles	1	3	4	British Columbia
June 27, 1972	Gore Range	1		1	Mt. Shavano
Aug. 18, 1972	Gore Range		2	2	Mt. Shavano
Aug. 20, 1972	Gore Range	2		2	Mt. Shavano
July, 1975	Marcellina Mtn.	2	2	4	Sheep Mtn., Collegiates
Totals	7 sites	27	37	64	

*Known mortality following release: Shavano, 1 adult male; Mt. Evans, 1 young adult male; San Cristobal, 2 adult females; Gore Range, 1 yearling male from 1970 release (total 5).

There are at least two goats in the Maroon Bells-Snowmass Wilderness area (Fig. 1), presumably representing a pioneering migration from the Collegiate Range herd.

In the Poudre River-Never Summer Range area of north central Colorado (Fig. 1), mountain goats have been reported for a number of years north of Rocky Mountain National Park but have never been observed in the Park itself. Early reports of goat sightings on the Poudre River are now considered to have been of female bighorn sheep in moult. During the summer of 1976, however, verified sightings of a young nanny were confirmed by Division personnel. She escaped as a kid from holding facilities at Colorado State University in the early summer, apparently traveled up the Poudre River, and survived. Beginning in 1972, a bighorn sheep hunter reported seeing 13 goats in the Never Summer Range. That same year a temporary employee of the Forest Service reported a nanny and kid in a volcanic outcrop above Zimmerman Lake. In 1973 a sheep hunter reported three goats on Mt. Cindy, and in 1974 a bighorn hunter reported six goats just south of Long Draw. In 1975 two sheep hunters reported watching eight goats on Mt. Cindy for several days, then the goats abruptly departed. Division personnel have not been able to observe or confirm any of these goats. It is logical that the goats could have come from the Mt. Evans herd.

PRESENT STATUS

The herd in the Collegiate Range area apparently is static at this point after a long period of increase. Approximately 320 animals live in this area, based on counts and hunter reports. This area is hunted, except for a small closed area, and is divided into three goat management areas.

The Mt. Evans herd is basically static at this time at around 100 head, after a period of increase. Though the population estimates do not indicate it, fieldmen feel that the population might be increasing slowly. It constitutes one goat management area for hunting.

The Needle Mountains herd is apparently still increasing, and is currently estimated at 75 animals. This area was opened for the first time to hunting (archery) in 1976. The Gore herd is also increasing. A total of 53 goats was counted in 1976, and the estimated population is 75. This unit has not been hunted, but may be open to five or six licenses in the near future, possibly for archery only.

Little data are available on the Marcellina Mountain herd, though it has been verified that some goats still remain in the area. This area is closed to goat hunting.

The Maroon Bells-Snowmass Wilderness area represents an early pioneering attempt from the Collegiate Range. Only two goats have been observed in this area, and the current status is not known. It is also closed to goat hunting.

CENSUS TECHNIQUES

The majority of Colorado's mountain goat counts are made during the summer when their coloration against a snowless and many times a vegetative background can facilitate their location and accurate enumeration. However, on one wind-swept alpine ridge in the Gore Range, counts have been conducted in the winter.

Most counts are from a helicopter, but limited ground surveys are conducted in portions of the Collegiate Range, Mt. Evans and the Gore Range. In addition, data are compiled from questionnaires collected from goat hunters in goat management units open to hunting.

The accuracy of goat counts and classification to adults, yearlings and kids is high on those components of populations counted, but admittedly represent only minimums. In selected herd areas these counts may represent the entire population, but generally in extensive or rough terrain the counts represetn an undetermined portion of the population. The propensity of goats to hide under rock outcrops and in timber further reduces the accuracy of the counts, particularly the aerial counts.

MANAGEMENT

Non-hunted Populations - The herds of mountain goats in the Gore Range, Marcellina Mountains, the Maroon Bells-Snowmass Wilderness, and the Poudre River-Never Summer Range (Fig. 1) have not been hunted. The introduced goats and the pioneering migrants in these areas may serve as a nucleus for the development of viable herds.

The goats in unhunted, as well as hunted, areas are of aesthetic interest and value to the public for viewing, study and wildlife photography. The presence of the goats brings a certain amount of income to local communities whether or not the herds increase to a huntable population.

Other than protection through closure to goat hunting, no special management is generally applied to these unhunted herd areas. Supplemental releases are made on occasion to stimulate or bolster marginal populations. On selected areas, such as the Gore Range, supplemental salt and essential mineral licks are placed to attract or hold the goats in a specific habitat area. All of Colorado's mountain goat release and management financing have been derived from Federal Aid in wildlife restoration and the Division's Wildlife Cash Fund.

Hunted Populations - The estimated population which is hunted is approximately 470 animals distributed in five management units totalling 5,242km^2. The Collegiate Range goat area is divided into three management units: G1, the Mt. Shavano area with about 125 goats in 440km^2; G2, the Antero-Princeton area with 75 goats in 440km^2; and G3, the Gladstone Ridge area with 120 animals in 769km^2. Mt. Evans is G4, with an estimated population of 100 goats in 1502km^2. G5 is the West Needles unit of approximately 75 animals in 2,090km^2. Figure 2 outlines the various goat management units which are open to hunting during selected mountain goat seasons.

Hunting season data - The season dates and lengths by years, by areas or goat management units are listed in Table 2. In general, seasons have been open in late August through early September, except in 1976 when the basic season began on September 18th and ran through October 10th. These later season dates may become the rule in the future, to ensure better condition of the pelage from a trophy standpoint. Season lengths have ranged from 23 days to 51 days, the latter in one unit in 1976, with a mean of about 29 days. Seasons were closed from 1970 through 1972.

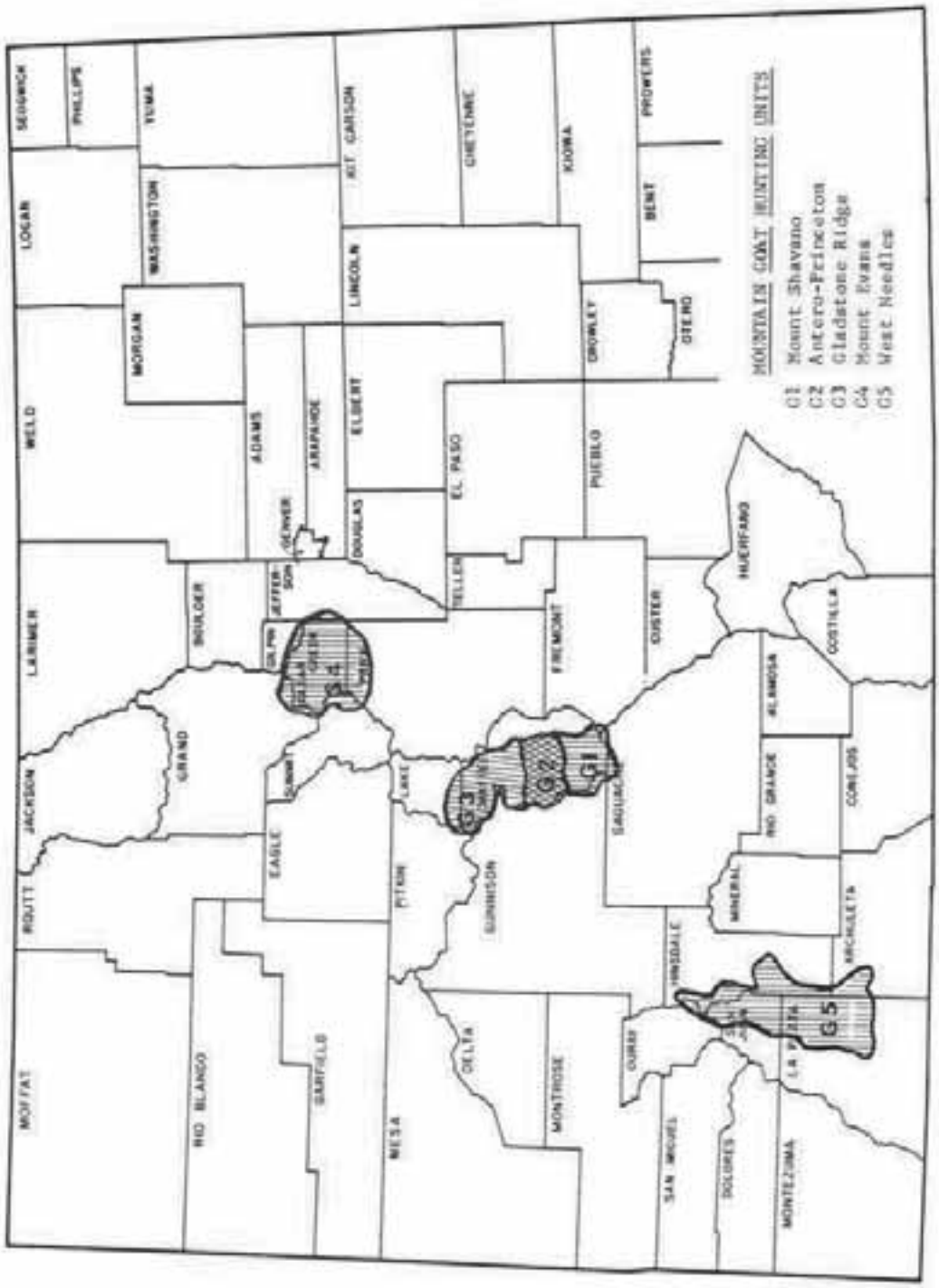
MOUNTAIN GOAT HUNTING UNITS
G1 Mount Shavano
G2 Antero-Princeton
G3 Gladstone Ridge
G4 Mount Evans
G5 West Needles
SEDGWICK
PHILLIPS
YUMA
LOGAR
WASHINGTON
KIT CARSON
CHEYENNE
KIOWA
PROWERS
BENT
MORGAN
LINCOLN
CROWLEY
OTERO
WELD
ADAMS
ARAPAHOE
ELBERT
EL PASO
PUEBLO
HUERFANO
LARIMER
BOULDER
JEFFERSON
DOUGLAS
TELLER
FREMONT
CUSTER
COSTILLA
JACKSON
GRAND
EAGLE
SUMMIT
LAKE
PITKIN
GUNNISON
SAGUACHE
ALAMOSA
RIO GRANDE
CONEJOS
ROUTT
MINERAL
HINSDALE
ARCHULETA
MOFFAT
RIO BLANCO
GARFIELD
MESA
DELTA
MONTROSE
OURAY
SAN MIGUEL
DOLORES
MONTEZUMA
LA PLATA
G1
G2
G3
G4
G5

Figure 2.

Table 2. Summary of Rocky Mountain goat hunting seasons, dates and areas or units, 1964 - 1976.

YEAR	DATES	DAYS	SEX	AREAS OR UNITS	NO. AREAS OR UNITS
1964	Aug. 22-Sept. 27	37	E.S.	Collegiate Range W. of Salida	1
1965	Aug. 28-Sept. 19	23	E.S.	Collegiate Range W. of Salida	1
1966	Aug. 27-Sept. 18	23	E.S.	Collegiate Range W. of Salida	1
1967	Aug. 26-Sept. 17	23	E.S.	Mt. Shavano, Mt. Evans, Sheep Mtn., Antero-Princeton	4
1968	Aug. 17-Sept. 8	23	E.S.	Collegiates and Mt. Evans	4
1969	Aug. 16-Sept. 7	23	E.S.	Collegiates and Mt. Evans	4
1970-1972			NO OPEN SEASON		
1973	Aug. 16-Sept. 7	23	E.S.	Collegiates and Mt. Evans	4
1974	Aug. 17-Sept. 8	23	E.S.	G1, G2, G3, G4	4
1975	Aug. 16-Sept. 20	36	E.S.	G1, G2, G3, G4	4
1976	Aug. 21-Oct. 10	51	E.S.	G4	1)
	Aug. 21-Sept. 26	37	E.S.	G5 (archery)	1) 5
	Sept.18-Oct. 10	23	E.S.	G1, G2, G3	3)

The number of hunters in Colorado is determined by the number of licenses authorized by unit each year by the Wildlife Commission, based on field recommendations. These licenses in total have ranged from six in 1964 to 48 in 1976. Part of the increase in license numbers has been due to the addition of new units open to hunting, such as in 1967, and one new unit in 1976 (Tables 2 and 3).

Table 3. Colorado mountain goat harvest data, 1964 - 1976.

Year	Applications Received	Licenses Issued	Number of Hunters	Total Harvest	Percent Success
1964	87	6	6	4	67
1965	84	6	6	3	50
1966	85	7	7	3	43
1967	127	18	18	14	78
1968	166	20	19	15	79
1969	107	22	21	20	95
1970 - 1972		NO OPEN SEASON			
1973	255	14	14	12	86
1974	267	20	20	18	90
1975	532	41	40	35	88
1976	438	48	46	34	74
Totals	2,148	202	197	158	80

The annual harvest has varied from three during two seasons (1965 and 1966) to 35 in 1975, and hunter success rates have ranged from 43 percent in 1968 to 95 percent in 1969. The overall success ratio has averaged 80 percent over 10 seasons.

Sex ratios of harvested goats have ranged from 67:100 in 1968 to all males in 1964, 1965 and 1966, but the overall sex ratio has been 172:100. Efforts have been made through goat hunter orientation classes to school them in field sex identification and to place the emphasis on the harvest of males (Table 4). Though there has nor been a regulation prohibiting the taking of nannies with kids, we have tried to instill the concept in hunters of not taking an adult goat accompanied by a kid. Kids are not taken because our regulations specify a minimum horn length of 15cm (6 in). The wounding loss on mountain goats is so low as to be insignificant, and no cases of irretrievable kills have been documented or are known.

Table 4. Colorado mountain goat harvest by sex and unit or area, 1967 - 1976.

	G-1 Mount Shavano			G-2 Antero-Princeton[1]			Sheep Mountain[2]			G-3 Gladstone Ridge			G-4 Mount Evans			G-5 West Needles[3]			Total Harvest		
Year	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.
1964				4	0	4													4	0	4
1965				3	0	3													3	0	3
1966				3	0	3													3	0	3
1967	3	1	4	3	0	3	1	2	3				1	3	4				8	6	14
1968	1	1	2	4	0	4	1	2	3				0	6	6				6	9	15
1969	4	1	5	6	0	6	2	3	5				1	3	4				13	7	20
1970-72									NO OPEN SEASON												
1973	1	2	3	4	0	4				4	0	4	1	0	1				10	2	12
1974	2	2	4	4	2	6	CLOSED			5	1	6	2	0	2				13	5	18
1975	7	4	11	6	3	9	-	-	-	5	6	11	2	2	4				20	15	34
1976	3	6	9	5	2	7	-	-	-	6	6	12	6	0	6	0	0	0	20	14	34
Totals	21	17	38	42	7	49	4	7	11	20	13	33	13	14	27	0	0	0	100	58	158

[1] Antero-Princeton and Sheep Mountain were one area prior to 1967.
[2] Sheep Mountain, formerly part of G-3, closed to hunting in 1974.
[3] G-5 opened to archery hunting in 1976.

Each successful mountain goat license applicant is sent a map of the hunting unit for which he has been issued a license, and a questionnaire to be completed after the season and returned to the Division of Wildlife. The information requested is whether they actually did hunt; the dates hunted; whether or not they were successful, and if so, what sex, relative age (young or fully adult), and the horn lengths; how many goats they observed while hunting (sex, age, unclassified, total), and marking the map with sighting locations; if they observed any dead goats other than those taken by hunters (and the relative date of any mortality); and other comments.

MANAGEMENT PROBLEMS

Obtaining a License - During the past 10 seasons, 2,148 applications were received for 202 licenses, representing 10.6 applications per available license. Beginning in 1974 applicants who were not successful in obtaining a license were issued a rejection slip indicating a preference point for next season. This practice was stopped in 1977 so that new applicants would have an

opportunity to obtain a license. However, it was decided to honor existing preference points for the next three years, beginning in 1977, after which, in 1980, obtaining a goat license will be subject to the chances of computer selection with an equal opportunity for every applicant.

After 1980 it is reasonable to assume that successful license holders, if they do not kill a goat, may be restricted to applying for a license every second or third year after obtaining one. Prior to the beginning of preference points in 1974, and starting with the first goat season in 1964, a hunter was eligible to apply for a license only every other year. Beginning in 1969 a successful goat hunter has not been allowed to apply for any further goat licenses, as mountain goats were declared a once-in-a-lifetime trophy. Mountain goat licenses are only available to Colorado residents.

Loss of Habitat - In occupied mountain goat ranges in Colorado there have not been any habitat losses due to highway construction or logging practices. In fact, there is as much or more area of potential goat range as is already occupied. In time, through immigration or translocation, several of the potential ranges will become occupied, particularly those near or adjacent to occupied ranges. The kinds and extent of competition between gibhorn sheep and mountain goat are not known, but are a matter of conern and controversy. At this time it appears that a conflict does not exist, at least not on winter ranges, because of the seeming lack of mountain goat seasonal movement.

A potential habitat loss problem, or at least an impact, may develop in relation to weather modification programs. Cloud seeding could result in heavy snowfall and drifting over of critical or essential winter habitats. Similarly, the extensive use of large, permanent snow fences could result in heavier drift accumulations if not sited with reference to mountain goat winter ranges.

High altitude mining in subalpine and alpine zones, such as has occurred in the Collegiate Range and is developing in the San Juan Mountains, could have a significant impact on goat herds and the habitats if developed or expanded extensively.

Poaching - Except for one unconfirmed possibility, illegal killing of mountain goats is not known or thought to be a problem in Colorado. Generally goat winter ranges are relatively inaccessible to man, and summer ranges are usually distant from fishing and backpacking activities. People pressure in itself may be a deleterious factor, although its impact appears to be extremely variable. An example is Mt. Evans, where high vehicle traffic and recreational uses do not appear to affect the goats adversely. Similarly, on Sheep Mountain (Cottonwood Creek) of the Collegiate Range, the goats occur year-round, even with high camper and fishing use in the area. On Needle Creek, however, backpackers are thought to be the cause of the goats moving to the more remote crags away from the trails in the valley.

Mandatory Check - Beginning in 1974 it became necessary for successful goat hunters to have their animals checked by a Division officer within 48 hours of the kill, and, ideally, near the location of the kill. Enforcing such a regulation is difficult, but under the once-in-a-lifetime trophy classification it is necessary. Similarly, getting full compliance on returning the questionnaire sent to each licensed goat hunter has not been successful. Though they could lie about it, and especially if they were not checked under the compulsory check regulation, the data from the returned questionnaires have management applications. One possible stimulation to return the survey form is to pass a regulation classifying hunters who have not responded as having filled their license and thus not being eligible to ever receive another license as a penalty for noncompliance.

Other Management Problems - An intra-Division problem is obtaining reliable counts, which is associated with priorities, limited time and restricted economic resources for inventory. Similarly, we have been particularly lax on monitoring and following up newly released animals and goats sighted or reported in previously unoccupied ranges.

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STATUS AND MANAGEMENT OF THE MOUNTAIN GOAT IN IDAHO[1]

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HISTORY

Historically, the distribution of Idaho's only subspecies (Oreamnos americanus missoulae) of mountain goats was restricted to suitable habitat from the Snake River Plains north to the Canadian border. This represents the most southern extension of the natural range for this species and Idaho is only one of three states of the lower 48 with a native mountain goat population. Consequently, being ranked behind Washington and Montana in total numbers, Idaho has always held their mountain goats with some esteem, resulting in a conservative management approach.

In 1903, Idaho's legislature established the first mountain goat hunting regulations to restrict the exploitation of this species. These restrictions created a 78 day hunting season for goats and allowed each holder of a one dollar hunting license to take a goat annually. By 1931, Idaho's goat season had been further reduced to 10 days and in 1943 a specific 10 dollar goat tag was required for each hunter. Cognizant of the impacts of hunting on our mountain goat populations, statewide hunting closures were ordered by the Idaho Fish and Game Commission in 1948, 1949, and again in 1951. Also, recognizing the tendency for hunters to congregate on accessible goat herds, Idaho created its first permit hunts in 1954 with an 11 day hunting season in popular goat areas in Central Idaho. Idaho held its last general mountain goat season in 1966. Since that year, Idaho has restricted the harvest of mountain goats with a permit system to disperse hunting pressure to available goats. During these early years when small accessible populations were identified as receiving excessive pressure, the practice by the Department was to segregate these herds by regulations from huntable populations.

In the conservative management years prior to the 1960's, Idaho hunters displayed little interest in mountain goats when other big game was plentiful. Consequently, Idaho's legal goat harvest exceeded 100 only twice (1933 and 1946) prior to 1960. However, in the 1960's, when hunting pressure increased throughout the state on all species, and armed with additional new information on mountain goat status acquired from helicopter survey, Idaho liberalized its approach to mountain goat management. Permit allocations were increased and the number of units was also increased to disperse hunting pressure. Also, to accommodate the growing interest in archery hunting, Idaho established its first general archery seasons for goats in 1967 for specific areas of the state. As a result, Idaho goat harvest increased significantly, reaching a peak in 1966, the last year portions of Idaho were still open to general goat hunting, and again in 1968. A total of 161 goats was taken each of these years. Permit allocations continued to increase until 1974 with an authorization of 303 permits. However, faced with apparent population declines and a growing awareness of this species' sensitivity to hunting, Idaho reduced the number of permits to 259 in 1976. In addition, several areas were closed to hunting.

INTRODUCTIONS

Despite these population declines, the present distribution of mountain goats in Idaho remains essentially the same as when the state was first settled by white men, with the exception of relatively recent introductions that have expanded the range of goats within Idaho. All of Idaho's mountain goat transplant attempts have been successful. Idaho first tried its hand at transplanting goats in 1960 when 20 goats were trapped on Snow Peak and Black Mountain in northern Idaho and released on the cliffs overlooking the eastern and southern shores of Lake Pend Oreille (Fig. 1). Since introduction, this population has increased slightly and stabilized at 30 animals. Restricted in size, readily accessible and within view of the popular lake, this population has not been hunted.

Idaho's most successful and only hunted introduced goat herd was initiated in 1962 when four goats of each sex were released into the Seven Devils mountain range in west central Idaho. This range provides ideal goat habitat, but isolated from other inhabitated goat ranges, the initial

[1]Editor's note. Paper not part of Symposium.

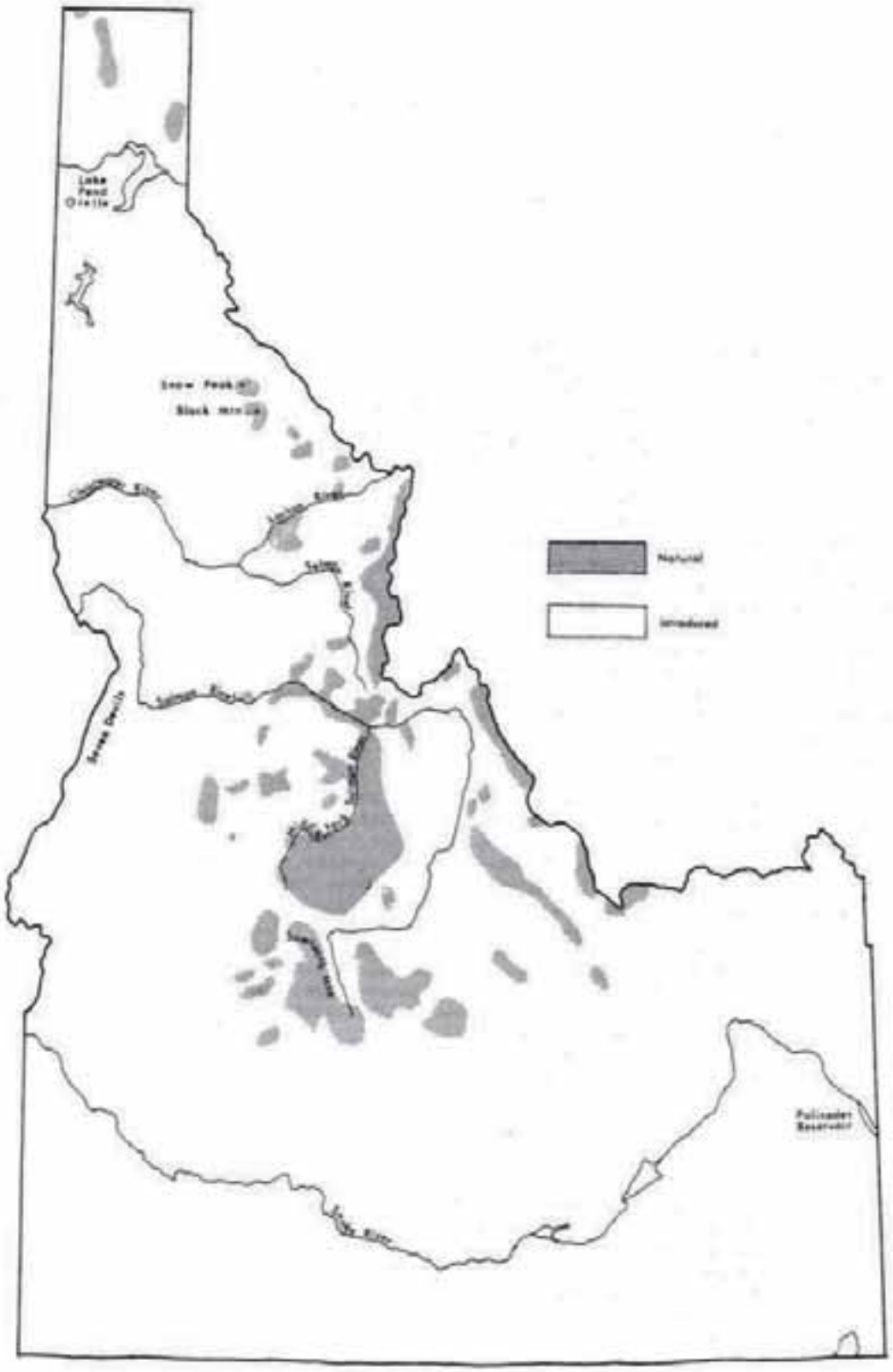

Figure 1. Mountain Goat Distribution in Idaho.

release was supplemented with an additional nine goats (seven females and two males) in 1974. This population has increased rapidly with a current population estimate of 70 animals. This herd has been hunted under a limited permit since 1974 with an annual allotment of five permits. Kid production has remained above average and this population is apparently still increasing.

Idaho's most recent introduction, in 1969, extended the southern extremity of goat range in Idaho when five goats (two females and three males) were released near Palisades Reservoir (Fig. 1) on the Idaho-Wyoming border. This initial release was followed with four additional goats (two females and two males) the next year. During the ensuing years, this population has increased to approximately 20 animals. Initiated from two release sites, the Palisades herd is extremely scattered, difficult to inventory and current trend is not known. There are no plans to exploit this population at this time. Additional transplants are proposed for Idaho, but the only suitable populations fro trapping, on Snow Peak and Black Mountain, declined drastically during the trapping program. The Snow Peak population has recovered sufficiently to allow the resumption of a trapping program in the near future.

CURRENT STATUS

Brandborg (1955) estimated a stable population of 2,785 mountain goats in Idaho in the early 1950's. This estimate was obtained primarily from an accumulation of admittedly liberal United States Forest Service estimates, but it does compare with a current estimated population of 2,200 to 2,500 mountain goats.

Although present Idaho Department of Fish and Game figures are not totally comparable with Brandborg's, general concensus of Regional Game Managers indicates that current population trends are down. The most significant declines have occurred in Idaho's panhandle goat populations found in the Selkirk and Cabinet ranges. Population estimates in 1950 exceeded 200 for this area but have declined to less than 40 animals today. These populations, some of the last goat populations to be hunted under a general hunting program, have now been closed to all hunting and have not shown any recovery at this time.

The Clearwater and Selway goat populations in north Idaho (Fig. 1), hunted under a general hunting system until 1966, also reflect population declines but not as severe as the Panhandle goat populations. Conversely, the major goat populations on the main Salmon River and the Middle Fork of the Salmon River (Fig. 1), the first goat populations to be managed under a conservative permit system in Idaho, have also declined significantly since the 1950's.

Idaho's southern goat populations found in the Sawtooths and associated mountain ranges (Fig.1) apparently have held their own or have increased. Even in these areas, several of the accessible populations along the fringes of these major mountain ranges have declined under present hunting schemes.

CENSUS TECHNIQUES

In recent years, the helicopter has been Idaho's principle inventory tool and most aerial censuses have taken place in winter during periods of peak concentrations. In a state managerially dominated by deer and elk, most information obtained on the status of mountain goats has been obtained secondarily while flying for deer and/or elk. Restricted by time and funding, most mountain goat inventories have been irregular and incomplete. Idaho's only exception to this indirect approach has been the monitoring of the Pahsimeroi mountaing goat herd located in east central Idaho. Since 1960, this herd has been inventoried annually by helicopter to ascertain population trends and to study the impacts of hunting on an individual mountain goat population. A maximum of 217 aminals was counted in the early 1960's, but numbers have declined to less than 100 under various levels of harvest management. As a result of the Department's mountain goat research program, hunting mortality appeared to be additive and not a compensatory form of mortality for this goat population. As a result this population was closed to hunting in 1975 and is being monitored annually to measure the population response to a total hunting closure.

Except for introduced populations, most of Idaho's mountain goat populations have been hunted in the past: however, in recent years, recognizing the senaitivity to hunting, many of Idaho's declining and/or vulnerable mountain goat populations have been closed to hunting. Today approximately 2,000 mountain goats are being hunted in Idaho. In 1975 Idaho authorized 276 permits, of which 268 were issued for 63 different controlled hunts. Permits per unit varied from 2 to 15 depending on the size of the unit and the number of goats available within each unit. The trend in recent years has been to reduce the size of goat units and increase the number of units to disperse hunter pressure in proportion to available animals.

Of the 267 permits issued in 1975, 32 of these goat hunters did not hunt. The remaining 235 goat hunters killed a total of 93 goats for a 40 percent hunter success. The sex ratio of the

kill was 1.4 billies to each nanny in 1976, but the average sex ratio in recent years has been nearly equal. Although nannies are legal game, each hunter is mailed instructions prior to the season wherin he/she is encouraged to avoid killing nannies with kids. Goat kids can be legally killed in Idaho, but because of reporting bias they usually don't appear in harvest analysis.

Idaho utilizes a voluntary hunter report card system to determine kill information on mountain goats. This report card, attached to each goat tag, requests county or state determining on residency, the number of days spent hunting and hunter success. In addition, each report includes the sex of the kill, date of kill, location, and management unit.

Idaho has two major mountain goat problems today: increased access and disturbance related to mining and logging activities, and the associated increase and improvement in off-road type vehicles. Probably more important has been the insufficient funds and manpower to properly monitor the trends and impacts of hunting on mountain goat populations. Consequently, game managers have not had the information available to make appropriate management adjustment rapidly enough to accommodate changes in population trends.

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STATUS AND MANAGEMENT OF THE MOUNTAIN GOAT IN WASHINGTON[1]

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HISTORICAL DISTRIBUTION

Mountain goats are native to the Cascade Mountains in Washington, (see Fig. 1, Johnson, these proceedings) and range over most of the same areas they occupied when white man first arrived. Reports of native mountain goat (Oreamnos americanus) in the Cascades were documented as early as 1805 and 1806 by Lewis and Clark (Burroughs 1961) who saw skins and blankets woven from mountain goat[2] wool by Indians along the Columbia River. The type locality is described as "Cascade Range near the Columbia River in Oregon or Washington". Almost certainly these goats were taken in Washington since Bailey (1936) indicated that there was no authentic record of mountain goat occurrence south of the Columbia River in Oregon. Dalquest (1948) believed that the type locality in Washington was near Mount Adams. Historic records and other references to mountain goat distribution since the turn of the century indicate that the native range of mountain goats extend throughout much of the Cascade Mountains from the Canadian border to Mount Adams except for a gap in the Snoqualmie Pass area (see Fig. 1, Johnson, these proceedings).

Goats have been reported from the Selkirks of northeastern Washington and the Blue Mountains of southeastern Washington. There is a single record for northeastern Washington (Dalquest 1948). He described this animal as "seemingly a rare wanderer from outside the state". Taylor and Shaw (1929:31) [in Hall and Kelson (1959)] and Dice (1919:21) report on the historic occurrence of mountain goat in the Blue Mountains of southeastern Washington. Dalquest (1948), however, believed that the reports of mountain goat in the Blue Mountians by Dice were based on erroneous identification. No native populations of mountain goat currently inhabit either the Blue Mountains or Selkirk Mountains of Washington.

Fossil remains of mountain goats were reported from Pleistocene deposits of Washtucknа Lake, Washington by Matthew (1902) [cited in Cowan and McCrory (1970)]. Matthew believed that these deposits represented a fauna characteristic of the first Pleistocene interglacial stage.

Historic uses of mountain goats have changed considerably from their initial exploitation by indians. Indians killed mountain goats not only for their meat, but also for their hair and hides. Early explorers in the state found that indians valued the wool of mountain goats for the making of blankets (Bailey 1936). Salish Indians from along the Fraser River sometimes hunted goats and traded hides on the coast. Indians of the Cascades, including the Skagits and Wenatchees gathered goat wool from hillsides during the spring and summer when goats were shedding, (Underhill 1945, Collins 1974, and Thompson 1970). Lewis and Clark discovered that indians along the Columbia River made the skin of a goat head (with horns remaining) into a cap and valued it as an ornament (Burroughs 1961).

The fact that indians of the Mount Baker district of Washington made a determined effort to take mountain goat was noted by Brooks (1930). Entire tribes took part in organized drives to harvest mountain goat shortly before the turn of the century in this area (Brooks 1930). Early settlers undoubtedly also took mountain goat for their meat and hides but the rugged terrain occupied by goats probably precluded utilization except in very accessible areas.

The history of mountain goat sport hunting in Washington began in 1897. At that time the hunter was limited to taking two goats during a three month season. In 1913 the hunter was restricted to one goat per hunting season. Hunting areas were restricted in 1917 and the hunting season closed completely in 1925. Mountain goat hunting resumed in 1948 after biologists determined that the goat populations were stable and had filled the carrying capacity of the range. Since that time mountain goat hunting has been sanctioned every year on a controlled permit basis.

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[1] Editor's note. Paper not part of Symposium.
[2] Unfortunately Lewis and Clark used the term "goat" to refer to antelope while "sheep" referred to mountain goats.

Concentration of hunting pressure on a few goat populations resulted in overharvest of these populations, while many other goat populations were not hunted. As a result, a unit system was established in 1957. Under the unit system, goat areas were divided into management units and permit quotas established among 10 units. Since that time the goat management units have been altered to regulate hunter distribution in proportion to goat populations. The unit system also allowed for an annual evaluation of permit quotas. A total of 930 goat permits was authorized among 31 goat management units in 1976. Although most of these units were open for rifle hunters, some units were open to archery only.

CURRENT DISTRIBUTION AND STATUS

Cascade Mountains - The current distribution of mountain goat in the Cascades is nearly identical to historic range. The only exception to this is probably at the southern end of their range on Mount Adams and Mount Saint Helens where native populations were extirpated. Although the type locality for O. americanus described by Lewis and Clark (in Miller and Kellogg, 1955) is probably Mount Adams, no authenticated sightings of mountain goat have been recorded in that area in the last century. Mount Adams is located on the Yakima Indian Reservation and hunting has never been regulated by the State.

In 1972 and 1973 a total of eight mountain goat from the Olympic Peninsula was restocked on Mount Margaret near Mount Saint Helens. These goats, taken from Mount Angeles, originated from transplants from Alberta in 1925 and Alaska in 1927 and/or 1929.

Another transplant of goats from the Olympic Peninsula to the Cascades occurred in 1975 and 1976 with the restocking of Mount Pilchuck. Although goats are currently found east of the area, none have been seen on Pilchuck for over thirty years. The transplant was made in Pilchuck State Park and it is hoped the non-hunting outdoor recreationists will be able to once again view these animals within the state park.

Population estimates of mountain goat in the Cascade Mountains were made for the first time in 1961 (Table 1).

Table 1. Mountain goat populations for Washington, 1961 (from Wadkins 1962).*

Area No.	Area Name	Number Goats	Closed Area Name	Number Goats	Total
1	Skagit River	400			400
2	North Methow	300			300
3	Okanogan River	300			300
4	Nooksack River	250	Mt. Baker Area	650	900
5	South Methow	200			200
6	North Lake Chelan	300			300
7	South Lake Chelan	250			250
8	Chiwawa River	450	Nason Ridge Area	250	700
9	Glacier Peak	300	Whitechuck and Sauk	250	550
10	Stillaguamish River	250	Long, Dickerman and Whitehorse Mtns.	50	300
11	West Stevens Pass	400	Baring and Grotto Mtns.	100	500
12	Snoqualmie	400	Mt. Si and Denny Creek	50	450
13	North Wenatchee Mtns.	225			225
14	South Wenatchee Mtns.	500	Cle Elum River Area	125	625
15	Naches Pass	750	Castle Mountain	50	800
16	Bumping River	475	Timber Wolf Mountain	80	555
17	Packwood	450			450
18	Tieton River	300			300
19	East Ross Lake	150			150
20	West Ross Lake	150			150
21	Stebekin River	150			150
State totals		6,950		1,605	8,555

*The above populations do not include any estimate of the goats on the Yakima Indian Reservation or in Mount Rainier and Olympic National Parks.

One of the objectives of a four year goat study initiated in 1976 was to re-evaluate goat populations throughout the Cascades. While it is premature to indicate what the results of our goat population estimates will be from this study, the total Cascade population is probably lower than it was in 1961.

The North Cascades National Park was established by an act of the 90th Congress in 1968. This park consists of north and south units of the National Park as well as Ross Lake and Lake Chelan National Recreation Areas. Mountain goat hunting is permitted in the two recreation areas, but closed in the park interior. Data from a questionnaire on mountain goat revealed that substantial numbers of goats were harvested from throughout the park prior to its establishment in 1968. Slightly over 20 percent of the annual goat harvest was taken in what is now North Cascades National Park. Since 1968, of course, only the two national recreation areas have been open to goat hunting. Mountain goat populations within North Cascades National Park have declined in some areas according to park records (Bruce Smith, pers. comm.).

Mountain goats are native to Mount Rainier and have been plentiful since records have been made of the Park's wildlife. Current distribution is similar to native range. All mountain goats within Mount Rainier National Park have been protected since the park was established in 1899. Mount Rainier National Park records (Stan Schlegel, pers. comm.) indicate the mountain goat population has been relatively stable for the last 10 years. The mountain goat population with Mount Rainier National Park is about 400 animals.

Olympic Peninsula - Mountain goats were not native to the Olympic Peninsula but were introduced from two or three transplants in the vicinity of Lake Crescent between 1925 and 1929. These introductions came from Alberta in 1925 and Alaska in 1927 and/or 1929. According to Olympic National Park records (Bruce Moorhead, pers. comm.) goats dispersed in an easterly and southerly direction following release in the Olympic Mountains. Ten years after the goats were introduced, most of the Olympic Mountains were included in Olympic National Park. By 1938, when the park was created, the goat population was thinly distributed through the northern half of the Olympic Mountains.

Since about 90 percent of the mountainous terrain on the Olympic Peninsula that is suitable for mountain goat is within the national park, nearly all goats have been completely protected. Olympic National Park personnel have prepared an unpublished report on mountain goat dispersal and population data (Bruce Moorhead, pers. comm.). This report indicates the goat population in Olympic National Park now numbers about 1,000. The current estimate of 1,000 goats from an original eleven animals is a ninety-fold increase over 50 years, or a net annual increase of about 20 animals per year, or 2 percent.

Selkirk Mountains - Mountain goats probably inhabited isolated mountains in the Selkirks at various times in recorded history but at no time was their population or distribution substantial. Dalquest (1948) referred to the sighting of a mountain goat in the Selkirks as a rare wanderer from outside the state. While mountain goats from Idaho probably wander into Washington occasionally, no native populations currently inhabit the Selkirks in Washington.

In the 1960's the Washington Game Department initiated a mountain goat stocking program in the Selkirks. Three releases were made but only one was successful. The release of seven goats near Flume Creek in Pend Oreille County in 1965 increased to a population of 30 mountain goats in 1972 when a limited hunting season was initiated.

CENSUS TECHNIQUES

Mountain goat populations are evaluated in a variety of ways throughout the state depending on climate, topography, and accessibility. In the Lake Chelan area a goat count is made by boat during January when goats are quite visible just below snowline. Goats are counted from roads in various areas of the state in March and April. In 1976 a goat count on Mount Angeles in Olympic National Park was conducted in September. In this area summer range is somewhat limited and a team of observers counted goats on hikes through preplanned census routes. Goat counts are made from fixed wing aircraft in other areas of the state. Washington is fortunate to have quite accessible goat range (compared to goat range elsewhere) and several census techniques are employed. While a study evaluating accuracy of goat counts has not been undertaken, ground counts have been superior to aircraft surveys in the more accessible areas.

Another method used to evaluate goat populations in Washington is through a questionnaire. Every goat hunter is sent a questionnaire requesting sighting information as well as harvest data, etc. Many goat hunters document goat observations extremely well and these observations are tabulated and compared to previous years. In this way a trend in percent kids or total observations may aid in determining a stable, declining, or increasing population.

MANAGEMENT

Mountain goat are managed both for hunting and non-hunting outdoor recreationists in Washington. The controlled permit system for limited geographical areas regulates the hunter harvest on all goat populations. In areas where goat hunting is permitted, goats are managed as a trophy animal. Goat harvest is not aimed toward a maximum sustained yield as in deer and elk management. Some areas adjacent to major highways are closed to hunting to allow motorists and non-hunters the opportunity to view these animals. Many non-hunters believe mountain goats have only aesthetic value and some areas are managed for their consideration.

While most mountain goat populations in Washington State are managed by the State Game Department, substantial goat populations are found in the North Cascades, Olympic, and Mount Rainier National Parks. Mountain goats in all three national parks and other very accessible areas are managed for non-hunting outdoor recreationists. Mountain goats in the three national parks are managed by preserving wilderness tracts and providing a place for outdoor enthusiasts to observe mountain goats in a pristine setting. Backpackers and climbers often see goats in the rugged backcountry and along trails to high lakes and mountain passes. The National Parks interpretive hikes and evening programs by park rangers provide information on the life history and ecology of mountain goats to visitors. Mountain goat populations in the National Parks total about 2,000 animals.

Mountain goat hunting is extremely popular and far more hunters seek a mountain goat hunting opportunity than the resource can accommodate. As a result, the Washington Game Department has an annual drawing for a limited number of goat permits. In 1976, a total of 6,814 persons applied for 930 mountain goat permits. All mountain goat hunting in Washington, therefore, is managed on a controlled permit basis and further regulated by goat management units. The goat unit system of selected geographical areas is designed to distribute the hunting pressure and harvest throughout the state. Any person with a current Washington hunting license may apply for a goat permit in any one of 31 goat management units except those who drew a goat permit in either of the previous 2 years. Although out-of-state residents may apply for a goat permit in Washington, the requirement of a current Washington hunting license limits the number of out-of-state applications.

The mountain goat hunting season usually opens on the second weekend of September and lasts until the end of October. (In 1976 the opening and closing dates were September 11 to October 31, both dates inclusive.) A hunter may take only one goat and hunt only in the goat management unit he or she applied for in the drawing. Mountain goats of either sex with horns 10cm (4 in) long or longer can be legally taken in Washington.

The statewide goat harvest is monitored primarily by the goat harvest questionnaire sent to each person purchasing a goat tag. One follow-up questionnaire is sent to those not responding to the initial questionnaire. Goat hunters in Washington have responded extremely well to this questionnaire and the return has been consistently about 88 percent.

The mountain goat harvest has declined in recent years from peak harvest years of 1964 through 1971. Three goat units in eastern Washington have been closed the last few years, however, as a result of declining survival of kids. Over the last ten years the average harvest has been 309 mountain goats while the 1976 hunter take was about 290. Table 2 lists the mountain goat hunter success in Washington from 1948 through 1976. Nearly half of all mountain goats taken in Washington are billies. While nannies are legally taken, hunters are encouraged to avoid taking nannies with kids.

In addition to harvest information recorded on mountain goat questionnaires, many sportsmen keep very good notes on sightings and other noteworthy observations. We are pleased that comments written on the questionnaire reflect a genuine interest by our sportsmen in the resource.

While most wildlife species have suffered from loss of habitat as a result of an increasing human population, mountain goats occupy the more inaccessible areas of the state and have lost little native range as a result of human habitation. There has been a loss of good goat habitat, however, from fire control and disturbances caused by new roads and logging activity. Wildfire burns at high elevations in the past have created excellent forage supplies for goats. In recent years with more efficient fire fighting techniques, the number and size of these burns has been drastically reduced. Our experience in the past has indicated goat populations are directly related to wildfire burns and have decreased with fire suppression.

Another management problem is the distribution of hunter harvest in relation to goat population. Concentration of hunting pressure on a few goat populations has resulted in overharvest in a few areas while many populations were not cropped at all. An expanding network of roads in goat areas has contributed to a shift in hunting pressure to the more accessible areas. Annual adjustments to goat unit boundaries and permit quotas are necessary to compensate for these changes in access and goat populations.

We believe our goat management program is adequate to preserve goat populations at the present time but more good, sound data is needed. After completion of a recently initiated goat study, we

will recommend refinements in management to assure the perpetuation of healthy mountain goat populations in Washington for the enjoyment of future generations. If this involves curtailment of some hunting opportunity, so be it. The goat comes first.

Table 2. Mountain goat hunter success.

Year	Permits Issued	Tags Sold	Percent Success	Goat Harvest		
				Eastside	Westside	Total
1948	150	---	37	31	24	55
1949	400	---	21	57	25	82
1950	400	---	25	83	16	99
1951	400	---	14	32	24	56
1952	400	---	18	39	32	71
1953	400	333	14	29	16	45
1954	400	329	16	46	8	54
1955	400	325	32	78	25	103
1956	400	302	35	64	13	77
1957	600	512	40	143	63	206
1958	600	516	39	132	67	199
1959	600	502	38	122	69	191
1960	800	692	39	162	108	270
1961	800	703	38	156	114	270
1962	880	773	34	162	103	265
1963	900	791	37	175	114	289
1964	970	870	40	191	153	344
1965	1,030	934	42	206	185	391
1966	1,005	943	37	200	147	347
1967	1,060	1,000	31	154	155	309
1968	1,065	986	34	168	171	339
1969	895	850	38	164	162	326
1970	925	870	39	155	185	340
1971	936	892	43	152	164	316
1972	930	876	35	118	135	253
1973	930	889	37	127	139	266
1974	961	899	38	123	149	272
1975	905	851	36	99	139	238
1976	915	872	41	109	179	288
Total	21,057	17,510		3,477	2,884	6,361
Average	726	730	33	120	99	219

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DISTRIBUTION, ABUNDANCE AND MANAGEMENT OF MOUNTAIN GOATS IN THE YUKON[1]

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Until 1972 the Yukon Game Branch was an agency concerned solely with enforcement and administrative matters. While there was a general impression about the distribution of big game animals over the Yukon Territory based on information obtained from outfitters and hunters, no actual game surveys had been made. Hunting regulations were adopted from those of neighbouring jurisdictions, and a Canadian Wildlife Service biologist served as special advisor to the Commissioner of the Yukon Territory on game management matters.

In 1972 the Yukon Game Branch followed the example set by the Northwest Territories Game Branch and began to hire its own biologists. A Territory-wide big game inventory was begun in 1973 and has so far covered about one-third of the Yukon. The Yukon is divided into 11 game management zones, and the present budget allows the Game Branch to cover one game management zone per year with this inventory. Aerial surveys are conducted twice a year; one in July to do classified counts, and one in February to locate and map winter ranges. Utilizing helicopters for summer counts, population estimates are considered fairly reliable, since all goats are at alpine elevations and their white coats show up very distinctly against the dark background of cliffs or alpine meadows.

DISTRIBUTION AND ABUNDANCE

Goat ranges extend only into the southern one-third of the Yukon Territory, and using the criteria of productivity and goat density, these ranges are marginal compared to those of British Columbia and the Alaska Panhandle.

With the exception of Game Management Zone 10, all game management zones that are known to have goat populations or have had them in recent times, have been covered by our big game inventories. Hence our population estimates for Yukon are considered fairly reliable. The estimates given for Game Management Zone 10 are based on information obtained from the big game outfitters in the area: R. Hassard, C. Martin and D. Smarch.

Figure 1 shows the distribution of goat ranges in the southern Yukon in relation to the game management zones. Table 1 summarizes the population estimates.

Table 1. Population estimates of mountain goats in the Yukon Territory.

Game Management Zone	Population Estimates	Hunting Season	Source of Information
6	900	Closed	Hoefs, 1973 Christiansen, 1973
7	100	Sept. 1 - Sept. 30	Hoefs, 1974
9	20	Closed	Hoefs, 1974
10	80	Aug. 1 - Oct. 31	Outfitters: Smarch, Hassard, Martin
11	300	Aug. 1 - Oct. 31	Hoefs and Lortie, 1976

[1]Editor's note. Paper not part of Symposium.

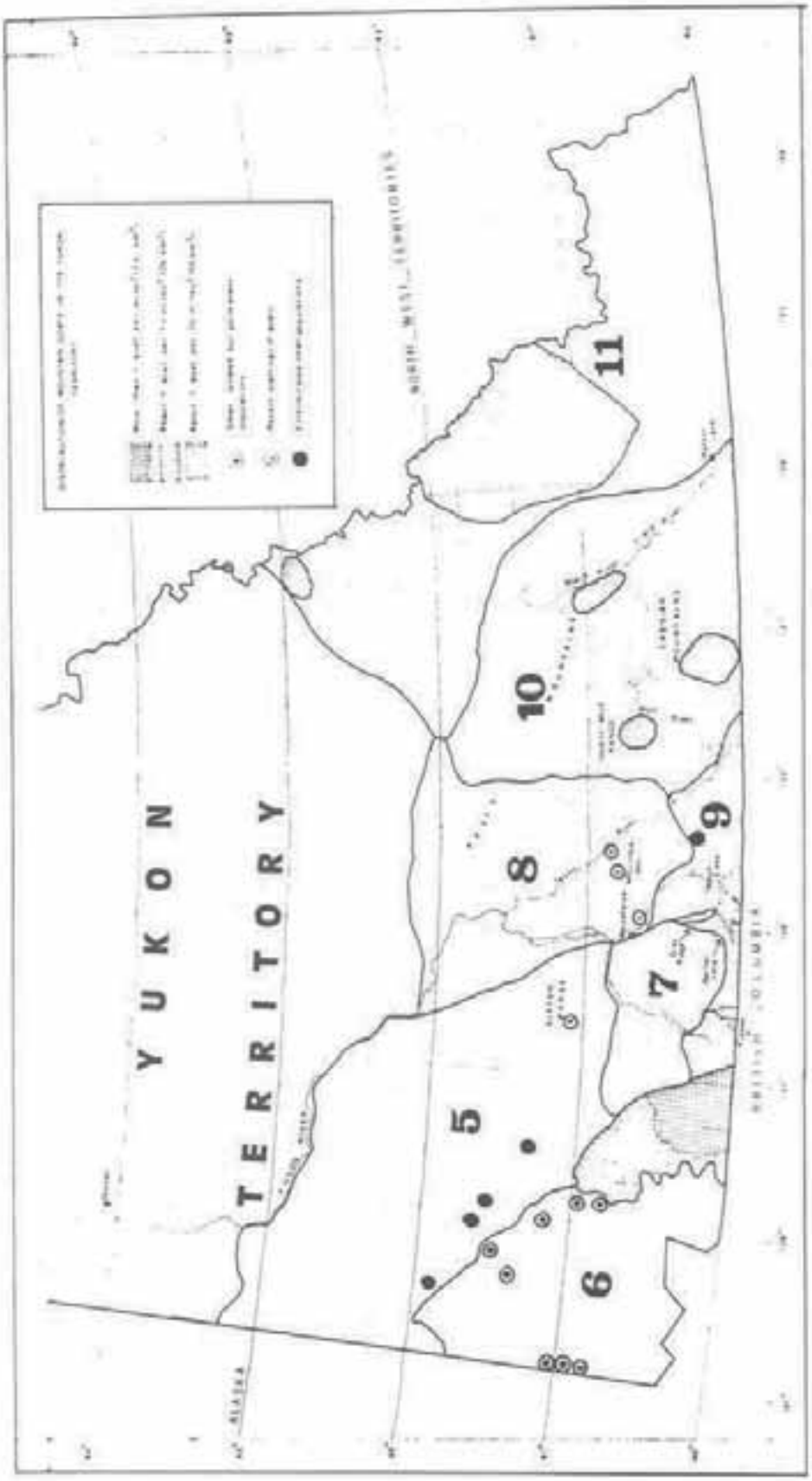

Figure 1.

Game Management Zone 6 - This zone comprises the newly-established Kluane National Park and the adjacent Kluane Game Sanctuary (Fig. 1). Detailed surveys conducted by Hoefs (1973) and Christiansen (1973) estimated the total goat population at about 900 with variable densities locally. Eight isolated small populations are found north and east of the Slims River (Fig. 1) while populations are more or less continuous at a density of 1 per 26km^2 south of the Slims River to the Kathleen Lake - Sockeye Lake valley. These areas are prime habitats for dall sheep. Goat populations are continuous and dense in the southernmost portion of the Kluane area, from the Kathleen Lake - Sockeye Lake valley south to the British Columbia border. This is the best goat habitat in the Yukon with an average density of more than 1 goat per 2.5km^2 and a considerably higher density around "Goatherd Mountain". Goats are the most abundant ungulates in this southern portion of the Kluane area, with dall sheep represented only in small, discontinuous populations (Hoefs, 1973).

Game Management Zone 7 - This area (Fig. 1) contains good goat ranges along its southern border, however, populations have been decimated by heavy hunting. Present estimates indicate a total population of not more than 100 (Hoefs, 1974). Remnant, small populations are found around Bennett Lake and in isolated area in the southwest portion.

Game Management Zone 9 - Goat ranges in this zone (Fig. 1) are restricted to its southwest corner, around Tagish Lake (Windy Arm) and Grey Ridge along the Carcross Road. The total population is estimated at about 20 (Hoefs, 1974).

Game Management Zone 10 - This area (Fig. 1) has not been surveyed yet and information on goat distribution was obtained from the outfitters in this area. Small populations are reported for the Cassiar Mountains, the Pelly Mountains along Black River, and the "Thirtymile Range" west of Wolf River. The total goat populations in this area appear to be not more than 80 to 100.

Game Management Zone 11 - This area (Fig. 1) includes extensive goat ranges in the Logan Mountains and a small population in the Itsi Range, the northernmost population (63° N) in the Yukon. Detailed surveys were conducted last year and the total population is estimated at about 300 (Hoefs and Lortie, 1976). However, it appears that goat habitat in this area is marginal, with densities as low as 1 goat per 52km^2, extremely low if one considers that there are no sheep in this range to compete with goats as in other areas of the Yukon. Productivity appears also to be very low in this range. Of 208 goats classified during our survey, only 22 (11.8 percent) were kids. This is hardly enough to compensate for adult mortality.

In addition to the "resident" populations described above, individual goats or small groups have been observed in recent years in the following locations: Grey Ridge east of Whitehorse, McClintock Mountain and Tealin River area east of Whitehorse, and Sifton Range northwest of Whitehorse.

There are a number of other locations where goats are known to have existed in small populations in recent history, but where they apparently have been exterminated. These areas include: White Mountains near Jakes Corner, Rockslide Creek in the Kluane Range, Mineral Creek in the Kluane Range, Tincup Lake area in the Kluane Range, and an unnamed mountain east of Pickhandle Lake along the Alaska Highway. Youngman (1975) lists unconfirmed records from Carmacks, Tombstone Mt., and even Lapierre House.

In summary, the goat population in the Yukon is presently estimated at about 1400. A slightly modified estimate may be established once game inventories have been carried out in Game Management Zone 10. Of the total of 1400 goats, 900 are under full protection in the Kluane Park area, as is a small population of perhaps 20 goats in Game Management Zone 9. Goats in the other areas are subject to hunting pressure of varying degrees.

MANAGEMENT OF GOATS IN THE YUKON

It appears that all goats in the Yukon, at least all hunted populations, are of the subspecies Oreamnos americanus columbiae. Game management practices therefore can concentrate on the status and performance of goat populations and need not accommodate taxonomic questions.

In spite of the fact that mountain goats are the rarest big game species in the Yukon with only about 500 subject to hunting, game laws until 1974 were very liberal. There was a Territory-wide open season of three months duration (Aug. 1 to Sept. 30), and goats of either sex could be shot as long as their horns were 10cm (4 in) long. This provision only protected the kids of the year, since yearling goats already have horns longer than 10cm by the time the hunting season starts in August.

When big game inventories were started in 1973 and 1974, it soon became apparent that the relatively small goat populations were subject to severe hunting pressure and that goats in some areas were definitely over-harvested. Table 2 lists the annual harvest statistic for goats over the past 25 years. While 50 to 60 goats per season in the early 1970's may not appear excessive

from a total population of about 500, one has to realize that hunting pressure was not evenly distributed, being concentrated in accessible areas. In particular, Game Management Zones 7 and 9, south of Whitehorse, were heavily hunted with at least 20 goats taken out of a population of about 100 animals in 1973.

Table 2. Goat harvest statistics for the Yukon Territory.

Season	Non-Residents	Residents	Trappers	Total Kill
1976/77	9	7	1	17
1975/76	16	8	1	25
1974/75	20	10	0	30
1973/74	27	15	0	42
1972/73	32	20	2	54
1971/72	42	17	3	62
1970/71	19	23	6	48
1969/70	19	18	1	38
1968/69	6	14	2	22
1967/68	26	18	1	45
1966/67	28	6	4	38
1965/66	17	19	3	39
1964/65	17	7	1	25
1963/64	9	21	4	34
1962/63	13	11	0	24
1961/62	5	13	0	18
1960/61	9	4	3	16
1959/60	7	9	0	16
1958/59	6	13	2	21
1957/58	6	8	1	15
1956/57	5	8	1	14
1955/56	9	7	4	20
1954/55	6	3	3	12
1953/54	3	5	4	12
1952/53	2	3	2	7
SUM	358	287	49	694
PERCENT	51.7	41.3	7.0	100.0

A number of restrictions were imposed for the 1974 hunting season with the objectives of reducing the harvest, particularly that of female goats, and allowing the depleted populations in Game Management Zones 7 and 9 to recover. In 1974 with the establishment of Game Management Zones

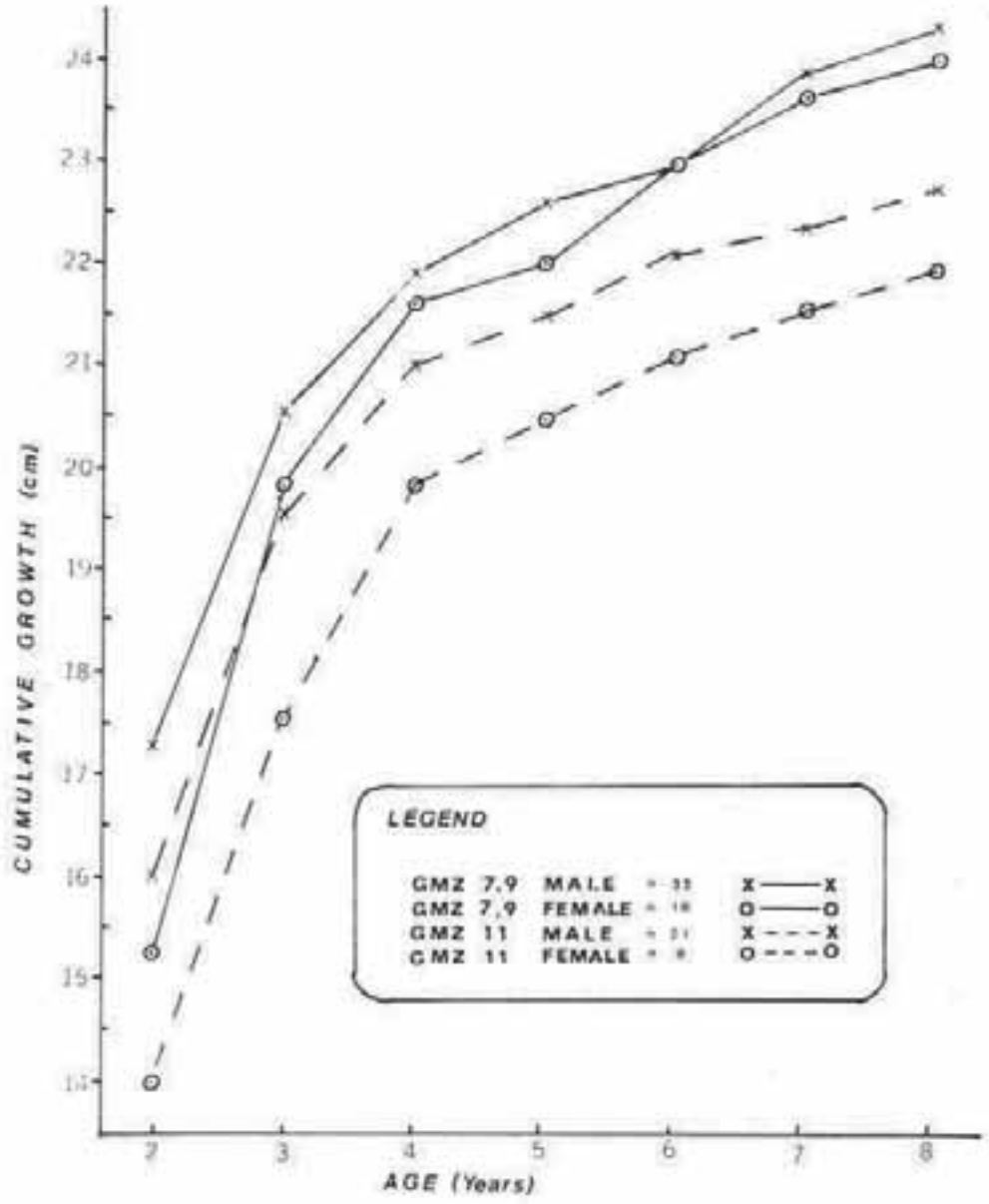

Figure 2. Horn growth of males and females.

the Game Branch was able to deal with these depleted populations separately from those of other areas, largely inaccessible, and hunted primarily through outfitters guiding non-residents.

The following new regulations came into effect in 1974: female goats accompanied by a kid were protected; all goats with a horn length of less than 20cm (8 in) were protected; the length of the open season in Game Management Zone 7 was reduced to one month (Sept. 1 to Sept. 30); Game Management Zone 9 was closed to goat hunting, and; all heads of the goats taken had to be submitted to the Game Branch for inspection and measuring.

Even though there was considerable opposition by the hunting community to the new regulations, in particular to the "8-inch (20cm) rule" the objectives of the Game Branch were achieved. The annual harvest during the past three years is less than 50 percent of what it had been during the early 1970's, and more importantly, there is more protection of the breeding stock. Prior to 1974 the sex ratio fo the harvest was around 50:50, while during the past three years it has been 65:35 in favour of billies.

The effects of the "8-inch (20cm) rule" are shown in Figure 2 in which the cumulative horn growth is plotted against the age of the goats. This rule protects all goats less than three years old and females in certain populations (GMZ 11) until they are in their fifth growing season.

The fact that it is now compulsory to submit skulls for measurements allowed the Game Branch to do a number of statistical tests. Only those factors found to be significantly different (95 percent c.l.) are mentioned below.

1) Goats shot in GMZ 11 are significantly older than those shot in GMZ 7.
   GMZ 11: $\bar{x}$ = 7.3 years $\pm$ 2.6, n = 29
   GMZ 7: $\bar{x}$ = 5.2 years $\pm$ 2.3, n = 41
   This further substantiates the different degree of hunting pressure to which these two populations are exposed.

2) Males have significantly larger horn bases than females.
   ♂: $\bar{x}$ = 13.39 $\pm$ 0.8cm, n = 43
   ♀: $\bar{x}$ = 10.59 $\pm$ 0.5cm, n = 27
   While this is a known fact, exact statistics were previously not available for Yukon goats.

3) Male horn growth in the first two years is significantly larger than female horn growth.
   ♂: $\bar{x}$ = 16.6 $\pm$ 1.4cm, n = 43
   ♀: $\bar{x}$ = 14.7 $\pm$ 1.9cm, n = 27

4) Female horn growth during the third growing season is significantly larger than male horn growth.
   ♂: $\bar{x}$ = 4.4 $\pm$ 0.6cm, n = 27
   ♀: $\bar{x}$ = 3.4 $\pm$ 0.6cm, n = 39

5) To date sample sizes are not large enough to show a significant difference in horn growth rates between the females of GMZ 7 and those of GMZ 11, even though indications are in that direction (see Figure 2).

Because of the limited distribution of goats in the Yukon, their economic importance to the Territory is not very large. Resident hunters who want to bag a goat need to obtain, in addition to their hunting licenses ($5.00), a goat tag for $3.00. Non-resident hunters can only hunt through a registered outfitter. In addition to their license of $100.00 ($50.00 if Canadian) and the goat tag ($3.00), they have to pay a trophy fee of $100.00 after completion of a successful goat hunt.

During 1975, 140 resident hunters obtained a goat tag but only eight were successful for a success rate of only 5.7 percent. During the same year 72 non-resident hunters obtained a goat tag of which 16 were successful for a success rate of 22.5 percent. Total revenues collected by the Game Branch for goat hunting during that season therefore was less than $2,000.00. The economic importance of goat hunting to the Yukon outfitters' industry is very low also. Even though five outfitting areas have goats in them, only one - located in GMZ 11 - depends heavily on goats as there are very few sheep in this area. This outfitter's harvest of goats has averaged 12 per season and at times has been as high as 22 (1972).

The Game Branch feels that the present regulations may be sufficient to allow the goat populations to maintain themselves. Poaching so far has not been a problem. To date re-introductions into formerly occupied ranges have not been attempted in the Yukon.

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STATUS OF INTRODUCED MOUNTAIN GOATS IN THE SAWATCH RANGE OF COLORADO

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Abstract: Mountain goats were introduced into Colorado in 1948 and now are established in four areas. In the Sawatch Range, herds on Mt. Shavano and Sheep Mountain have increased since last studied in 1964. On Sheep Mountain, goats congregated into larger groups and moved from south aspects below tree line to north and west aspects on alpine tundra as the summer progressed. The late-summer diet consisted of about two-thirds graminoids, one-fourth forbs and 7 percent shrubs. Age ratios from the Sawatch Range and from studies reported in the literature suggest a density-dependent decline in reproductive success as introduced herds of mountain goats have grown larger. In addition, age ratios in the Sawatch Range have been negatively correlated with depth and persistence of snow above timberline.

Rocky Mountain goat (Oreamnos americanus) populations have been established in four areas of Colorado by the Division of Wildlife. In the Sawatch Range, also referred to as the Collegiate Range, goats from Montana were transplanted onto Mt. Shavano in 1948 and onto Sheep Mountain in 1950. Goats from Idaho and South Dakota were released on Mt. Evans in 1961; goats from South Dakota and British Columbia were released in the San Juan Mountains in 1964 and 1971; and goats from South Dakota and British Columbia were transplanted to the Gore Range in 1968 and 1970 (Rutherford 1972). These populations are now the southernmost in North America.

This paper is based upon three summers of field work with mountain goat populations in the Sawatch Range. Objectives were to determine the status and summer ecology of two of these populations. Richard D. Schultz observed the population on Mt. Shavano in 1973. In 1975, the junior author concentrated his observation in the Sheep Mountain-Gladstone Ridge area, but also observed the Mt. Shavano population. In 1976, Robin L. Henry repeated the 1975 observations. Summer food-habits of goats were measured by Schultz and Johnson.

Funding has been provided by the International Order of Rocky Mountain Goats, Salida, Colorado. Personnel of the Colorado Division of Wildlife, especially Stanley Olgilvie, provided advice, logistical support, laboratory space and access to Division records.

STUDY AREA

The Sawatch Range (39°N, 106°W) contains 13 peaks over 4250 m. Hibbs (1965) inventoried goats on the Sheep Mountain area and intensively studied the population on Mt. Shavano in the early 1960's.

Sheep Mountain, 3612 m, with Gladstone Ridge, 4022 m, Jones Mountain, 4012 m, and Mt. Kruetzer, 3879 m was the primary study area. Mt. Shavano, 4310 m is 20 km south of Sheep Mountain.

Tree line in the area occurs around 3500 m. Tundra vegetation consists of grasses, sedges and forbs with patches of bristlecone pine (Pinus aristata), Engelmann spruce (Picea engelmannii) and willow (Salix sp.). Common plants include Trifolium dasyphyllum, T. nanum, Kobresia bellardi and Geum rossii. Immediately below tree line is a spruce-fir forest zone including Engelmann spruce, Abies lasiocarpa, Populus tremuloides and Pinus contorta. In the Sheep Mountain area, goats descend to 2750 m on steep, south-facing outcrops having sparse vegetation including pines and mountain mahogany (Cercocarpus montanus).

METHODS

Field observations occurred primarily during June-August. For each observation of mountain goats, location, aspect, elevation, and group size were recorded. Goats were classified as kids, yearlings, nannies, billies, or unidentified. Criteria for sex determination were genitalia, urinating position, horn shape, association of kid and/or yearling with an adult, and behaviour (Brandborg 1955). Animals were classified as yearlings by size, horn shape, and behaviour; i.e., if they followed a nanny consistently. Yearlings could not be consistently identified after early August.

Billies are probably underrepresented in the data for two reasons: billies were more likely to be in small groups during summer and these groups had a lower probability of being observed than did large groups consisting mostly of kids, yearlings, and nannies; and, once observed, an adult female had a high probability of being classified because maternal behavior occurred frequently. In contrast, adult males were more apt to be classified as unidentified adults. Yearlings were overrepresented in data from June when they tended to be in large, obvious groups while nannies tended to be isolated with new kids.

Considering these sources of bias, we selected kid:yearling:adult ratios from July and early August for analysis. In these ratios, adults are nannies, billies, and unidentified adults. We also analyzed kid:older animal ratios. Older animals are adults as described above plus yearlings.

Age ratios obtained on the ground and during aerial flights in the Sawatch Range in August and September 1964-74, were compared to values reported in the literature. They were also tested for correlation with snow conditions during each previous winter and spring. Snow data (Washicheck et al. 1972) were obtained from a weather station at Monarch Pass, about 14 km from Mt. Shavano and 33 km from Sheep Mountain. Snow parameters tested were snow depth and water content at the start of each month, February-May.

During mid-August to mid-September, hunters collected samples of rumen contents from 5 goats in 1973 and 12 in 1975. Samples were frozen or fixed in formalin solution. In the laboratory, they were washed over an 8-mesh wire screen (3.15 mesh/cm). For the 12 samples from 1975, small particles passing the 8-mesh screen were retained in a 16-mesh screen (6.3 mesh/cm) and saved for microhistological analysis (Sparks and Malechek 1968). Results of these analyses are reported briefly here and will be reported in more detail elsewhere.

RESULTS

Habitat and Group Size

On Sheep Mountain in 1975, goat distribution changed during summer from south aspects below tree line to north and west aspects above tree line (Fig. 1). In June, goats used steep, south aspects as low as 2750 m, 63 percent of observations being in south aspects. Increased use of north and west aspects during July and August may be correlated with the declining area of snowpack and changing availability of green forage.

Average herd size increased as the summer progressed (Fig. 2). In June, 58 percent of groups observed contained 1-3 animals. Groups of 3 animals usually consisted of a nannie, kid, and yearling. A hunter has reported seeing a herd of 100 goats on the Sheep Mountain area in September 1975.

Minimum Populations

Minimum populations have been reported as the largest number of goats seen on each study area without duplication. Hibbs (1965) reported minimum populations of less than 40 goats on each study area in 1964. Recent observations indicate at least 138 goats on the Sheep Mountain-Gladstone Ridge area in 1975 and at least 81 goats on the Mt. Shavano area in 1974 (Fig. 3).

Age Ratios

Age ratios are used here to indicate reproductive success in goat populations. We are aware of hazards in interpreting age ratios in this way (Caughley 1974). However, these are the only available data and we feel they can be used, with caution, to detect large differences in reproduction.

Review of literature indicates large differences between age ratios reported for recently introduced mountain goat herds and those reported for native herds and for herds observed more than 15 years after introduction (Tables 1, 2). In Tables 1 and 2, 15 years is an arbitrary division and no precise biological significance is intended. Recently introduced goat populations have had age ratios between 36 and 100 and averaging 59 kids per 100 older animals.

Table 1. Age ratios from summer studies of mountain goat herds that were less than 16 years old since transplantation.

Area	Period	Year	N	Number per 100 Adults: Yearlings	Kids	Kids per 100 Older Animals	Source
Alaska, Kodiak Islands	Summer	1962	22	-	-	57	Hjeljord 1973
		1963	26	-	-	44	
		1964	26	-	-	100	
		1965	35	-	-	60	
		1966	54	-	-	42	
		1967	58	-	-	48	
Colorado, Mt. Shavano	July-Aug.	1963	22	22	122	100	Hibbs 1965
Gore Range	Sept.	1976	53	-	-	47	McCloskey[1]
Montana, Crazy Mountains	Aug.	1952	252	-	-	36	Lentfer 1955
				Average		59	
				Range		36-100	

[1] Personal Communication, Bruce McCloskey, Wildlife Conservation Officer.

Table 2. Age ratios from summer studies of native mountain goat herds and from herds that have been established at least 16 years.

Area	Period	Year	N	Number per 100 Adults: Yearlings	Kids	Kids per 100 Older Animals	Source
Alaska							
Kodiak Islands	Summer	1968	47	-	-	51	Hjeljord 1973
		1969	88	-	-	20	
		1970	81	-	-	33	
Alberta							
Waterton Lakes	Aug.-Sept.	1947	35	-	-	9	Banfield 1947
Idaho							
Selkirk Range	Summer	1951	90	12	36	32	Brandborg 1955
Selway River	Summer	1951	59	9	31	28	
		1952	97	17	33	28	
Salmon River	July-Sept.	1949	71	5	24	23	
	June-Aug.	1952	88	21	63	52	
Pahsimeroi River	July	?	134	-	-	17	Kuck 1970
Montana							
Flathead-Sun River	Summer	1946	317	16	20	17	Brandborg 1955
Red Butte-Sun River	Summer	1947	468	8	40	37	
Mission Range	Aug.	1947	38	10	17	15	Casebeer et al. 1950
Glacier Park	July-Aug.	1947	132	-	-	42	Petrides 1948
Crazy Mountains	Summer	1960	151	-	-	21	Foss 1962
	Summer	1961	327	-	-	26	
Spanish Peaks	late June	1970	68	-	-	28	Peck 1972
South Dakota							
Black Hills	July-Aug.	1950	76	21	25	21	Richardson 1971
	July-Aug.	1951	208	26	27	22	
	Summer?	1964	176	33	38	28	
	Summer?	1967	136	33	39	30	
Washington							
Okanogan County	Summer	1939	84	13	43	38	Anderson 1940
	Average Ratios:			17	34	28	
	Range:			5-33	17-63	9-52	

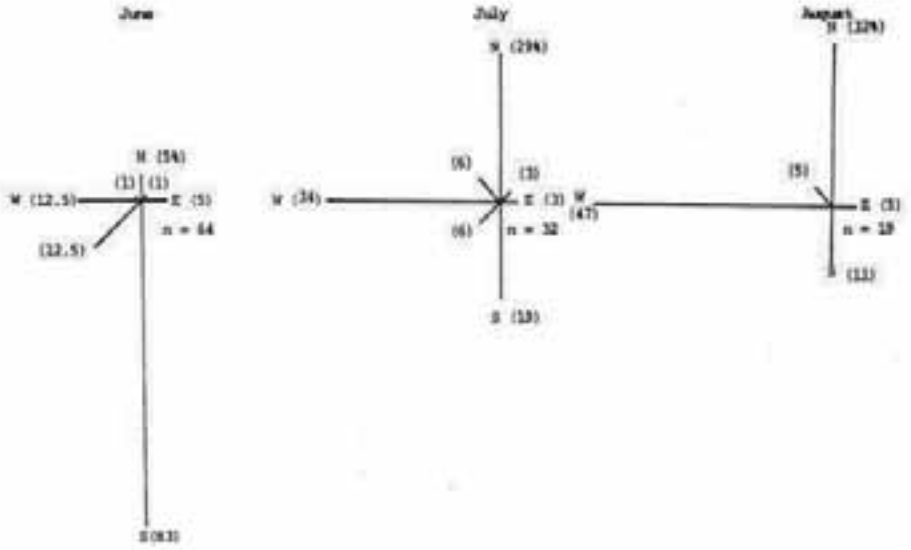

Figure 1. Aspects used by mountain goats on the Sheep Mountain Study area, 16 June - 21 August 1975. Lengths of bars and numbers in parentheses indicate percentages of each month's observations on each aspect; n = number of goat observations each month.

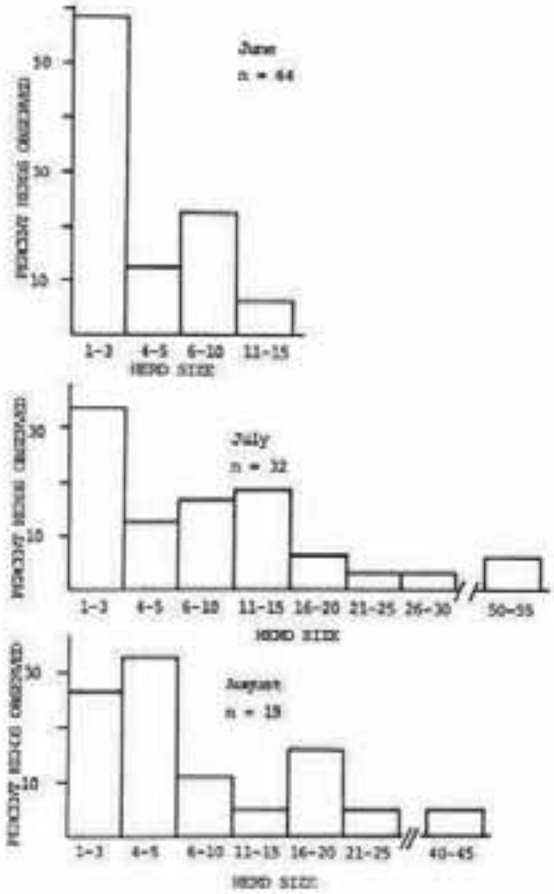

Figure 2. Sizes of goat herds observed on Sheep Mountain study area 16 June - 21 August 1975. (n = number of goat herds observed each month.)

It thus appears that reproduction is influenced by density as an introduced mountain goat population grows and presumably makes increasing demands upon habitat resources which become limiting. Age ratios of goats introduced onto Kodiak Islands in 1952 suggested this trend, although not conclusively. The lowest age ratio, in the 17th year after introduction, was recorded following a severe winter and age ratios were not published for beyond the 18th year after introduction (Hjeljord 1973).

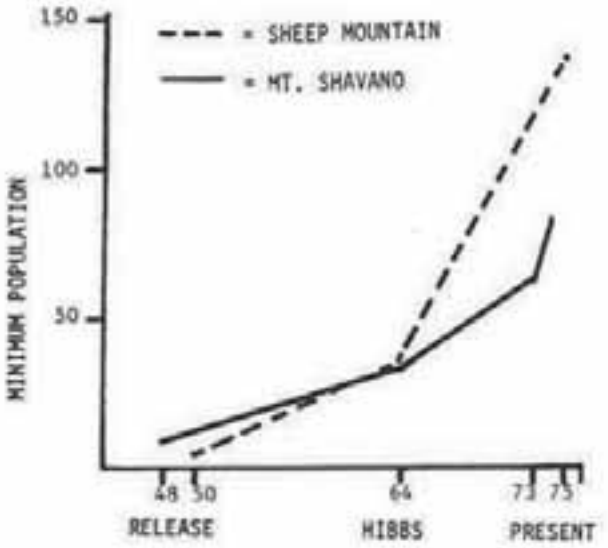

Figure 3. Minimum populations of mountain goats on two Sawatch Range study areas, 1948 - 76. The data from 1964 are from Hibbs (1965).

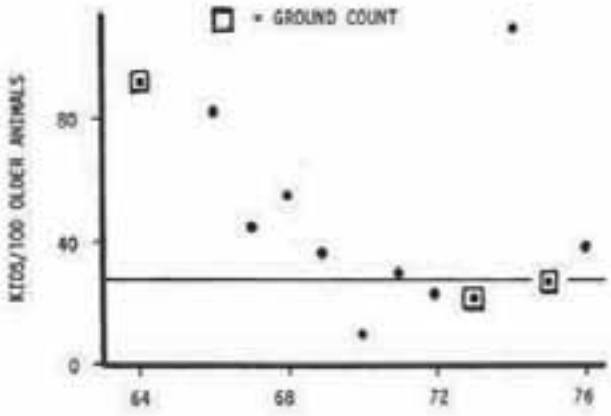

Figure 4. Observed age ratios of mountain goats on Mt. Shavano, 1964 - 76. The line at 28 kids per 100 older goats is the average reported for native and "established" herds.

In the Sawatch Range, age ratios of goats on Mt. Shavano have declined since Hibbs (1965) reported 100 kids per 100 older animals in 1963 (Fig. 4). With the exception of 1974, age ratios on Mt. Shavano have recently been similar to those of native and established herds, averaging near 28 kids per 100 older animals. In contrast, age ratios on Sheep Mountain have not shown this decline (Fig. 5).

Kid:yearling:adult ratios for goat herds in the Sawatch Range have been mostly above the average ratios in the literature for native and established herds (Fig. 6).

Considerable variation exists among age ratios reported for the Sawatch Range (Figs. 4, 5) and among ratios reported in the literature (Tables 1, 2). Brandborg (1955) and Hjeljord (1973) suggested that low age ratios tend to follow severe winters. In the Sawatch Range, kid:older animal ratios from the Sheep Mountain area have been negatively correlated ($P < 0.05$) with snow depth at Monarch Pass on the previous May 1 (Fig. 7). Age ratios from Mt. Shavano have been negatively correlated with snow depth at Monarch Pass on April 1, although not with statistical significance (Fig. 8). The high ratio from Mt. Shavano in 1974 is an unexplained outlier.

These correlations must be viewed cautiously since eight related variables were tested to identify the largest correlations. However, they suggest that snow depth and persistence have a negative influence upon goat reproduction, possibly by reducing food availability during late gestation.

FOOD HABITS

Graminoids occurred in all rumens of mountain goats collected from the Sawatch Range in late summer and accounted for about two-thirds of the diet (Fig. 9). Forbs and woody plants accounted for about one-fourth and 7 percent of the diet, respectively. Sedges (Carex and Kobresia) were especially important. Festuca, Agropyron scribneri and Poa were important grasses.

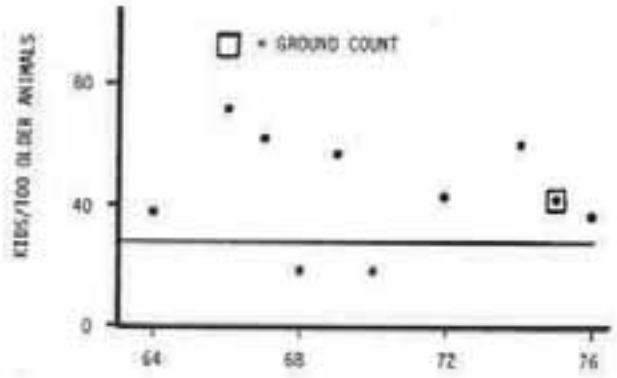

Figure 5. Observed age ratios of mountain goats on Sheep Mountain and vicinity, 1964 - 76. The line at 28 kids per 100 older goats is the average for native and "established" herds.

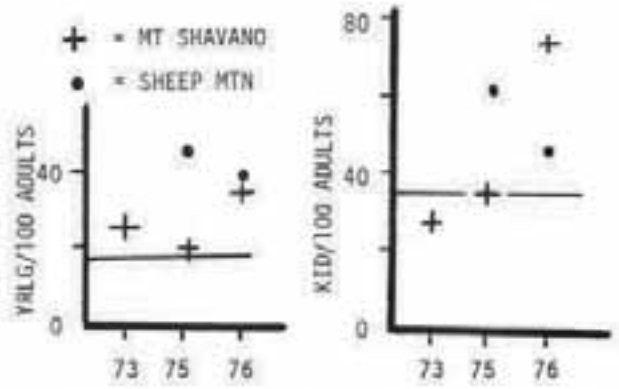

Figure 6. Observed age ratios of mountain goats on two Sawatch Range study areas, 1973 - 76. Lines at 17 yearlings and 34 kids per 100 adults are averages for native and "established" herds.

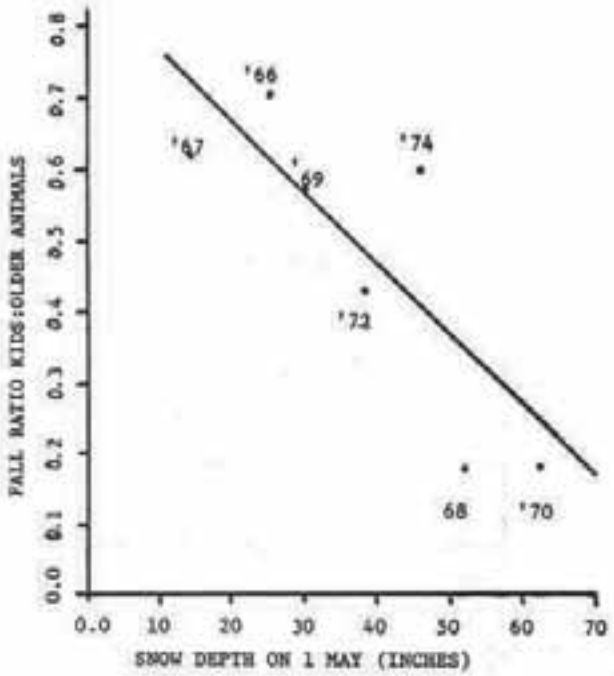

Figure 7. Relationship between 1 May snow depth from the previous winter at Monarch Pass and kid:older animal ratios from fall aerial surveys of mountain goats on Sheep Mountain and vicinity.

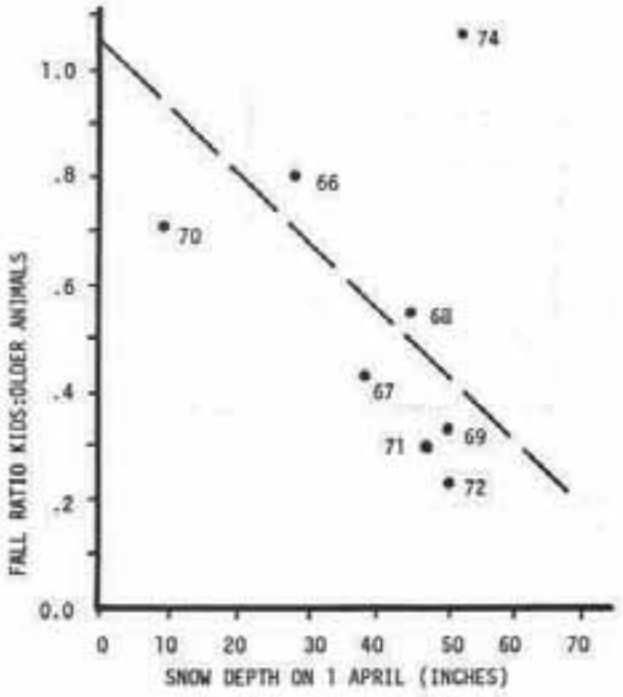

Figure 8. Relationship between 1 April snow depth from the previous winter at Monarch Pass and kid:older animal ratios from fall aerial surveys of mountain goats on Mt. Shavano.

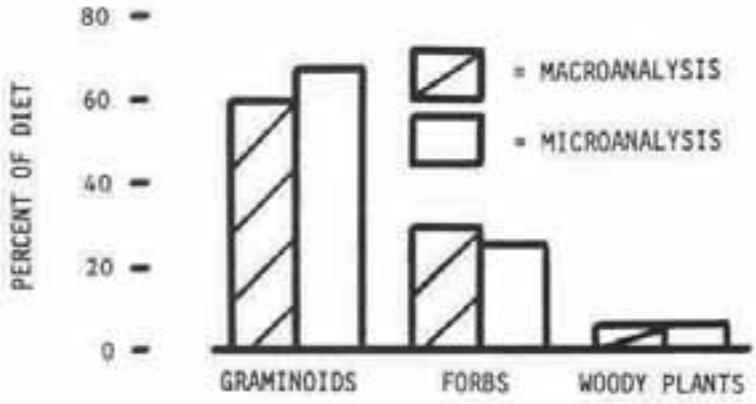

Figure 9. Summer forages of mountain goats in the Sawatch Range, Colorado.

Mertensia, Geum rossii, Ribes, Cercocarpus montanus and Sambucus were important forbs and shrubs in the diet.

DISCUSSION

While goat populations on Mt. Shavano and Sheep Mountain have increased since 1964, there is evidence that reproductive success has declined and is approaching levels common in more stable populations. Density-dependent reproduction implies that maximum harvestable surpluses can be maintained by controlling population density at some intermediate level rather than allowing a herd to grow to numbers controlled by natural mortality and poor reproductive success (Gross 1969). The precision and success with which Colorado mountain goats might be managed for maximum production will depend upon (1) having continuing and better population data than now exist, (2) controlling sexes and ages of harvested goats to maintain a high proportion of productive females in the population, and (3) adjusting harvest levels to variation in reproductive success that seems to be due largely to variation in severity among winters. If control of sexes and ages of harvested goats proves impossible to achieve, alternating 1-2 year periods of harvest with 1-2 year periods of non-harvest may be useful in controlling numbers without persistently limiting the proportion of prime-age females below optimum levels.

If the management objective is to maximize harvestable surplus, there may be considerable value in controlling an introduced goat herd at intermediate population density before goat numbers increase to levels determined largely be natural mortality and poor reproduction. Delay of a decision to manage numbers until a herd must be reduced from maximum abundance to intermediate density may result in years of lag before reproductive success responds to lowered density. This lag could occur due to the slowness with which high-alpine vegetation may respond to a reduction in utilization by goats on critical areas with limiting forage resources.

Very little is known of the winter ecology of Colorado's mountain goats. Winter ranges have not been adequately located. Winter food habits are virtually unknown. This information will be necessary for improved understanding and management of the State's mountain goats.

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THE IMPACT OF EXPLORATION FOR COAL ON MOUNTAIN GOATS IN NORTHEASTERN BRITISH COLUMBIA

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Abstract: Coal mining and related activities conflict with the maintenance of mountain goat (Oreamnos americanus) populations. In northeastern British Columbia, coal exploration has correlated with a decline of mountain goat populations. Depressed populations have shown no sign of recovery.

Imminent coal developments including nine open pitmines, two underground mines, several preparation plants, one completely new town, highways, railways, and airports will affect approximately 15,000km^2. Within this area lie 1,900km^2 of coal license and 1,200km^2 of mountain goat range. Twenty percent of the mountain goat range is under license by coal companies.

The precise mechanism of the mountain goat population decline is not known but appears to be related to easy human access. Habitat destruction is not an important factor in known losses but may be a factor in attempts to re-establish populations after mining.

New approaches to management may have to be developed for mountain goat populations with intact habitat but easy human access. High populations still exist in remore parts of the coal block but present management techniques based on manipulation of open season length will not protect these populations if their habitat is explored for coal using road dependent equipment.

In 1976 intensive studies of mountain goat (Oreamnos americanus) distribution, abundance and habitat were initiated as part of a general environmental impact assessment of proposed coal development in northeastern British Columbia. These studies were undertaken by the Environment and Land Use Secretariat (now the Resource Analysis Branch) in co-operation with the Fish and Wildlife Branch.

In this paper we assess the effects of past coal exploration and development on mountain goats and suggest how detrimental impacts can be avoided in future. We acknowledge assistance in data collection or writing from Dr. J. Elliott and Messrs. F. Harper, R. Crook, A. Edie, R. Bonnar and B. Fuhr.

STUDY AREA

The study area included 15,000km^2 on both sides of the Rocky Mountains (Fig. 1), but in this paper we emphasize the east slopes of the Rocky Mountains in the vicinity of the coal licenses and known goat ranges. Coal licenses include 1,879km^2 in a 270km strip from Williston Reservoir south east to the Alberta border. Goat habitat varies from steep river banks in forested foothills to rugged peaks of the central Rockies. Some of the best goat habitat is on flat-topped or rolling mountains in the eastern part of the range. These mountains have large expanses of alpine meadow bounded by cliffs which provide escape terrain.

METHODS

Fig. 1 delineates goat habitat from Canada Land Inventory (C.L.I.). CLI methodology and its application in British Columbia is explained by Klohn (1973). CLI information for goats was supplemented recently by Goat Distribution and Abundance Maps (Klohn, 1976). We excluded habitat with more than 50% CLI class 6 and 7 (lands with severe limitations to and no ungulate production respectively). This procedure demonstrated that all but extremely marginal goat habitat in the

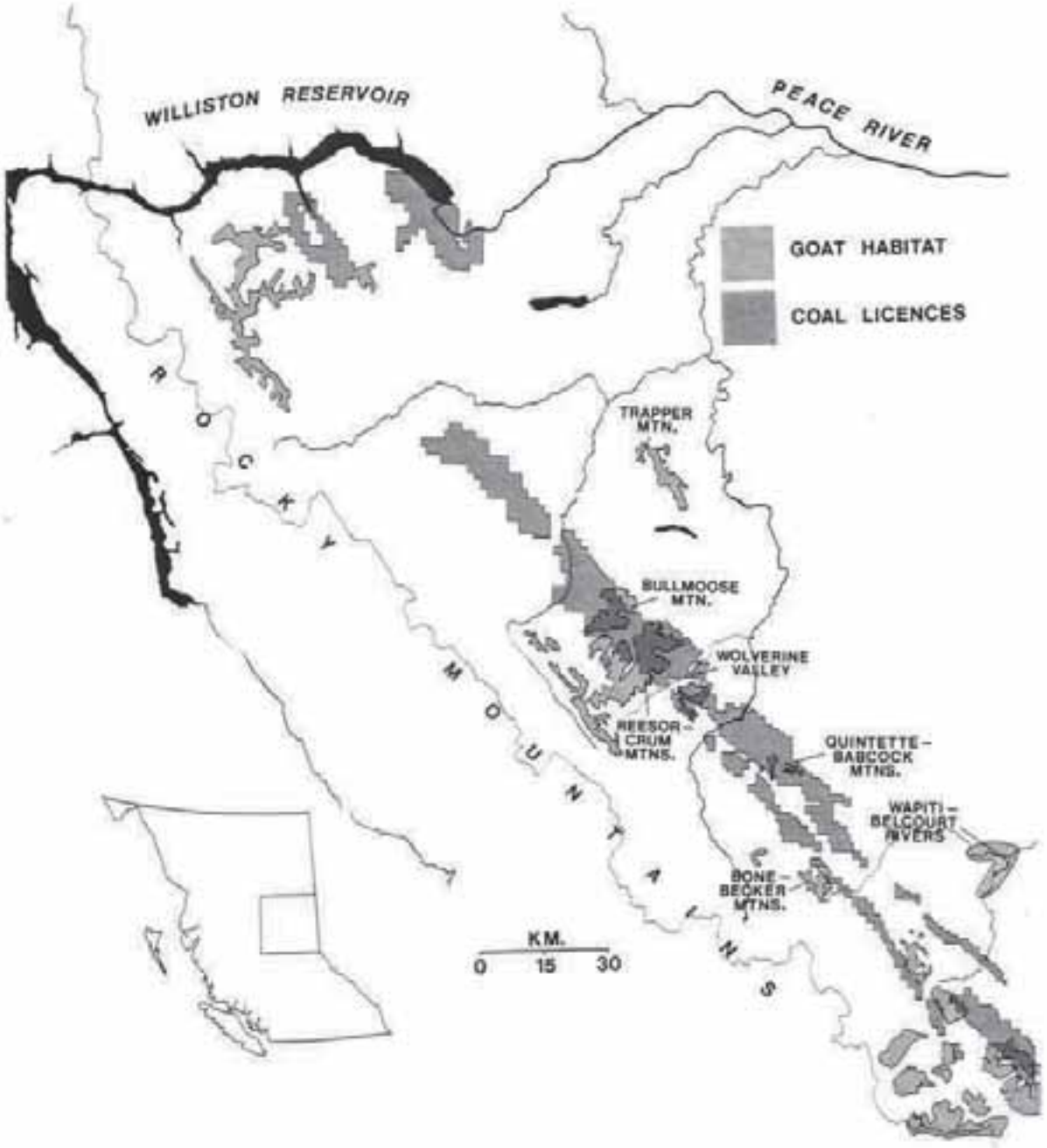
WILLISTON RESERVOIR
PEACE RIVER
GOAT HABITAT
COAL LICENCES
ROCKY MOUNTAINS
TRAPPER MTN.
BULLMOOSE MTN.
WOLVERINE VALLEY
REESOR-CRUM MTNS.
QUINTETTE-BABCOCK MTNS.
WAPITI-BELCOURT RIVERS
BONE-BECKER MTNS.
KM.
0 15 30

Figure 1.

study area was on the east slopes of the Rocky Mountains where snow fall is relatively moderate.

Information on historical population levels was obtained by interviewing trappers, guides, forestry personnel and Fish and Wildlife Branch staff. Previous populations are subjective estimates based on concensuses of several sources of information. Current population levels are based on estimates by people familiar with the area or estimates based on aerial counts. Maximum counts on record are listed and can be considered minimum populations. Aerial surveys included 12 hours by fixed wing aircraft by Fish and Wildlife Branch in 1974, and 54 hours of helicopter surveys by the Resource Analysis Branch in 1976.

Hunting data is from Fish and Wildlife Branch hunter return files. Road exploration data were obtained from Mines Department reclamation files.

RESULTS AND DISCUSSION

Mountain goat range occupies about 1,200km^2 of the area. The excellent quality of habitat in the coal block is well documented. Soper (1970) concluded that the whole east slope of the Rocky Mountains from Jasper Park north to the head of the Narraway and Wapiti Rivers (in the southern coal block) was unexcelled goat habitat. The best habitat shown by CLI is in the northern coal block and is rated class 2, an extremely high rating for mountain goat range. These sites have had high population levels reported as well (Table 1).

Table 1. Present and historical populations of goats in different parts of the North East Coal Block of British Columbia compared to presence of road access for coal exploration.

	Early 1960's		Present			
	Estimated population	Actual count	Estimated population	Actual count	Estimated population loss	Road access
Quintette - Babcock Mtns.	13	13	10	7	3	Yes
Wapiti - Belcourt R.	50	NA	50	40	0	No
Trapper Mtn.	80	60*	14	14	66	No
Ressor - crum Mtns.	60	NA**	15	8	45	Yes
Bullmoose	250	166	1	1	250	Yes
Bone - Becker Mtns.	90	NA	90	56	0	No
Wolverine Valley	200	162*	80	37	120	Yes

*Counts by ground observers
**Not available

Good mountain goat habitat closely approximates coal license areas (Figure 1). Twenty percent of the mountain goat range, including some of the highest capability habitat, is under license by coal companies. Present and historical estimates of populations show that mountain goat numbers declined drastically in areas accessed by road, but remained stable is most other areas (Table 1). Trapper Mountain is an exception in that its population is also depressed but it was not explored for coal. However, this area is near a farming community, possibly a source of harassment to the mountain goats.

Future developments of areas already explored include nine open pit mines, two underground mines, several preparation plants, and one completely new town. A sour gas field immediately adjacent to the coal block is also slated for development. Attendant facilities will include powerlines, highways, and railways. Development of these resources will stimulate forest use in the area and generate further pressures for subdivisions and other developments. These projects and increased human populations associated with them will complicate efforts to maintain or re-establish goat populations.

Proposed explanations for the decline in goat numbers include: 1) movement of entire populations to other ranges because of hunting and/or harassment associated with easy access after exploration, 2) loss of habitat because of exploration, 3) overhunting resulting in depression of populations, and 4) poaching.

The notion that goat populations move to new habitat when harassed was commonly expressed by guides and outfitters during interviews, but is an incomplete explanation for the following reason. In the area concerned, Canada Land Inventory confirms that the sites with the highest capability for mountain goat production have shown the greatest losses in observed populations. No adjacent areas match the quality or size of goat range on Bullmoose and Trapper Mountains. This means there are no areas to which the once large goat populations of these mountains could go which would have sufficient carrying capacity to sustain them. In any case, if such habitat existed it would probably be already occupied. Further, aerial surveys haven't found the goats missing from Bullmoose and Trapper Mountains, thus if emigration occurred it must have been accompanied by die offs.

Considerable surface disturbance frequently accompanies coal exploration. Closely spaced roads are needed to provide access for drill rigs, pits are dug for sampling and trenches are made to trace coal seams. Bullmoose Mountain has a total area of approximately 80km^2 and has over 320km of roads and trenches. Though this disturbance is sufficient to give the area a very cut-up appearance, the roads are narrow, and, even allowing for sidecast and slumping, the surface area disturbed is much less than 1%. Although this loss could be significant if concentrated in critical areas we feel it is insufficient to explain the drastic population declines observed in the area under consideration.

The effect of goat hunting in the coal block area is difficult to document. A bag limit of one and an open season from early August to mid-December was applied to the entire area until 1972. Then the season in the area with the most depressed populations (Bullmoose and Trapper Mountains) was closed. Present hunting season in the area still open was from August 15 to October 15. Table 2 shows resident goat kill in Management Area 28 and non-resident kill in the study area for the period of greatest decline in numbers. Goat populations in Management Area 28 are in the coat development area with the exception of some populations north of the Peace River. However, Mr. F. Harper, Regional Biologist in the area during the period under consideration, indicated that the northern region would account for few of the resident goats taken because access in this area is primarily by horseback. Superficially the kill, which never exceeded 74 animals per year, does not appear sufficient to produce the decline observed. However, hunting effort was undoubtedly concentrated in areas newly accessed by roads. This factor may have greatly magnified the impact of hunting by concentrating kill on accessible herds while others went unharvested. Such overexploitation following progressively increasing access has been singled out as the cause of drastic declines of mountain goat population in the East Kootenay area of British Columbia (Phelp et al. 1976).

Table 2. Mountain goat harvest from 1967 - 1976 in Management Area 28.

Year	Resident Harvest in Management Area 28 (includes study area)	Non-Resident Harvest from study area	Total
1967	11	21	32
1968	16	15	31
1969	29	19	48
1970	24	21	45
1971	20	18	38
1972	6	9	15
1973	38	36	74
1974	14	8	22
1975	11	9	20
1976	NA*	6	NA

*Not available.

The effect of illegal hunting by its nature is almost impossible to evaluate. Rumors of high illegal kill persist, however, no prosecutions are on record. Illegal hunting seems most likely in areas such as Bullmoose Mountain which has a large flat top and numerous roads that can be travelled

by motor vehicle above goat escape terrain on the mountain sides.

Whatever the precise mechanism of the decline of goat populations in the N. E. coal block, there is a clear relationship between access and goat numbers. Nowhere in the boal block is there a healthy goat population with nearby road access. Very close monitoring of goat numbers in remaining populations will be necessary to assess the impact of hunting relative to the impact of other factors which may be involved in the decline of goat populations. The effect of long hunting seasons and easy access documented by Phelps et al. (1976) in other areas warrant careful examination here. If hunting is demonstrated to be a major factor in population losses, a management rather than habitat protection problem is implied.

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MOUNTAIN GOAT SURVEYS IN YOHO NATIONAL PARK, BRITISH COLUMBIA

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Abstract: About 570 mountain goats occur in Yoho National Park, an area of 1313km^2 on the west slope of the Main Ranges of the Rocky Mountains at latitude 51° 30'. In contrast to the east slopes of the Rockies at this latitude, goats are the most common ungulate. Most goats occur between 1524m (5000 ft.) and 2516m (8250 ft.) elevations. About 30 percent of the park, or 370km^2 is potential goat habitat with an unevenly distributed density of about 1.5 goats per km^2. Aerial and ground methods of estimating numbers of goats are compared. The most reliable census method combines intensive ground surveys over a period of several years with occasional helicopter surveys. Population density in five regions of the park varies considerably. Observations on productivity, mortality, seasonal habitat selection and other habitat relationships are presented.

This study was part of a two-year inventory of all mammals in Yoho National Park, initiated for Parks Canada in April, 1975. The objective of this report is to provide baseline population information for unhunted goat herds in a pristine environment. Goats were hunted in Yoho until 1919 when the Federal Government gained jurisdiction from the province of British Columbia. The Park is adjacent to large areas on which goats are or have been harvested. Thus it was felt that the park population could provide a valuable baseline against which to compare densities and structures of hunted herds.

METHODS

Field methods combined systematic ground surveys, random sightings and aerial surveys. Ground surveys were done with a 20X spotting scope, usually from the Trans-Canada Highway, fire roads or trails. Cross country skiis and snowmobiles were used as access to the back country in the winter. Random sightings were recorded by Park Wardens and Naturalists on Observation Cards.

Aerial surveys were conducted in the falls of 1975 and 1976 covering potential goat habitat throughout the park. A Bell Jet Ranger was used with three observers. The flight path followed mountain contours just above treeline, but when necessary more than one pass was made of an area at varying elevations.

Potential goat habitat was determined by planimetric estimation of most of the mountain mass in the park between 1524m (5000 ft.) and 2515m (8250 ft.) elevations. A few areas of known goat range below 1524m were also included. Total area of potential goat habitat was determined with a dot grid on a 1:126,720 topographic map with 76m contours. The park was divided into five major goat ranges made up of mountain masses separated by forested valleys.

THE STUDY AREA

Yoho National Park, an area of 1313km^2, lies on the west slope of the Main Ranges of the Rocky Mountains at latitude 51° 30' N. It is bordered by national parks and provincial lands. The mountains in the park are steep, deeply etched, with narrow glaciated valleys and are predominantly of sedimentary origin. Elevations vary from 1006m to about 3568m and 28 peaks exceed 3000m.

The park has three Biogeoclimatic Zones: Alpine, Interior Subalpine and Interior Douglas Fir (Krajina, 1965). Coniferous forest is the predominant plant cover (50 percent of the total park

area); 30 percent is bare rock; 10 percent glacial ice; and 10 percent non-forest vegetation.

About 30 percent of the park, mainly between 1524m and 2515m elevations, is considered potential goat habitat although some of this is very sparsely vegetated and has been classified as bare rock. There is no true grassland in the park and no extensive scrub area. Kuchar (1974) described 21 "Vegetation Types" in the park. Non-forested types of importance to goats include Chionophilic Meadow, Mountain Heather, Dryas Tundra, Avalanche Chutes (slide paths), and Lichen Tundra. Of these, the Chionophilic Meadow type is most important in summer and fall. It is best developed around timberline, and contains a large number of communities. The "Grassy Alpine Meadow" is an important community within the Chionophilic type. Open or scrubby coniferous stands near timberline or at the edges of Avalanche Chutes are also used by goats. Those habitats are largely encompassed by Kuchar's Ribbon Forest vegetation type - a biotic landscape organized into a series of narrow lateral bands of coniferous forest, alternating with Mountain Heather Tundra. Other high elevation coniferous types occasionally used by goats include Whitebark Pine and Alpine Larch. Goats also frequent broken fringes of typical subalpine forest dominated by white spruce, lodgepole pine or even Douglas fir.

RESULTS

Population Size - Two methods were used to arrive at an estimate of the total numbers of goats in Yoho Park. Both methods involved a subjective estimate of the numbers of goats possibly missed during the counts used.

The first method combined the best aerial counts for each of the five regions of the park (Table 1) for a total of 287 goats. Assuming that 10 percent of the population was missed in each of the helicopter surveys, the estimated total population is 316 goats. The 10 percent was an arbitrary figure chosen at the time of each survey.

The second method combined the best ground and aerial counts for each separate herd or group of goats in the park. Separation of herds was based on association with winter and spring ranges and in some cases, summer ranges. Care was taken not to allow overlap of counts. A total of 453 goats was determined using this method. A subjective correction factor was added for each herd based on observability of the goats, and size and quality of the range on which they were observed. In some drainages the best counts made were during the winter. A correction factor was sometimes used in isolated areas where no goats were observed, but goat sign was present. The correction factor varied from herd to herd but amounted to about 26 percent of the total, giving a population estimate of 570 goats for the park.

Table 1. Densities of mountain goats in five regions of Yoho National Park.

Region	Potential Habitat (km^2)	Aerial Sept. 1975	Aerial Oct. 1976	Ground and Aerial (1974 - 1977) Counts	Ground and Aerial (1974 - 1977) Est. Tot.	Goats per km^2
1. Ottertail Range (Ice R.)	72	107	133	178	220	3.1
2. Cathedral - McArthur	67	19	33	84	116	1.7
3. Van Horne - Amiskwi	101	35	70	106	130	1.3
4. President - Waputik	114	23	19	53	68	0.6
5. Burgess - Wapta	18	28	7	32	36	2.0

As shown in Table 1, the population density on potential goat habitat varied considerably from region to region in the park. While an in-depth analysis of goat habitat from region to region was not done, regional differences in goat densities seem to be related to the quantity and quality of winter range. Two of the regions with lower densities (Cathedral - McArthur and President - Waputik) border the Continental Divide where most goats winter on sparsely vegetated slopes from about 1823m to 2432m in elevation. In the two regions of highest densities (Ottertail Range and Burgess - Wapta) goats winter on timbered slopes well belwo treeline as well as in the alpine zone. The area with the highest density (Ottertail Range) also has winter ranges with a much greater forage biomass such as broad, grassy slopes above and below treeline. While this area has about 20 percent of the total potential goat habitat in the park, it has about 40 percent of the total goat population.

The density of goats, for the whole park (1313km^2) and potential habitat (370km^2) was .45/km^2 and 1.5km^2, respectively.

Population Structure - Young:adult ratios were determined from ground surveys with little or no duplication of counts (Table 2). The "adult" class includes yearlings (12 - 24 months old), other subadults and billies. Young:adult ratios were similar for both years with an average of 29 kids:100 adults (includes yearlings) and 19 yearlings:100 adults. Approximately 36 percent of the kid crop of June 1975 did not survive the winter. An adult sex ratio of 62.5 males per 100 females was determined for this unhunted herd based on 286 animals classified as either adult male or adult female during 1975 and 1976.

Table 2. Ratios of young to adult mountain goats in Yoho National Park, 1975 and 1976.

Month	Total	Adults	Yearlings	Kids	Kids or Yearlings as % of Totals	Young:Adult Ratio
May 1975	110	92	18		16.4%	20:100
June 1975	145	113		32	22.0%	28:100
May 1976	71	60	11		15.5%	18:100
June 1976	188	144		44	23.4%	30:100

Mortality causes were difficult to determine but the main ones, based mainly on park reports over the years, were starvation, avalanches, and predation. Lynx and wolverine frequented some of the goat winter ranges and there was some evidence (observations by Park Wardens) of predation or scavenging on goats weakened by starvation or killed in accidents. There is one record of a goat having been killed by a cougar at the Ottertail lick, based on circumstantial evidence (Cowan 1945). There are no records of grizzlies preying on goats although they both co-habit some alpine areas. Sign noted during the study indicated that grizzlies travelled some of the valley bottoms in spring seeking goats that were killed by avalanches.

Habitat Relationships (Seasons) - Winter range was found from windswept alpine slopes at 2438m down to timbered bluffs at about 1371m elevation. These slopes were generally on west and south facing aspects. Where both high and low elevation winter habitats were available, goats utilized both. For example, in the Porcupine Valley, goats wintered on the brushy slopes and bluffs in an old burn as well as in the alpine.

In early May, some goat herds descended to low elevation bluffs, gullies and slide paths which were not utilized during the winter. Some of these bluffs were north and east facing and were only utilized by goats from early May to late June. In some areas, goats moved some distances over extensive snowfields from their winter range to low elevation bluffs. The movement onto spring range has several advantages: new spring growth is available; the bluffs provide safety from avalanches (the avalanche "season" is usually over at low elevations at this time); and, the steep bluffs afford maximum escape terrain for the kidding period. Low elevation bluffs were not available in all valleys so some goat populations remained on wintering areas for the kidding period where they sought out more rugged areas.

Movement to summer ranges, generally areas of lush alpine growth, was more of a drift or dispersal. However, some goat herds remained on the same general slopes all year round. Most goats drifted back to their wintering areas by late October.

These seasonal movements by goats in the park cannot be considered migrations but are more shifts from one preferred seasonal habitat to another. Seasonal changes in elevation are shown in Table 3. Goats utilized the lowest elevations during spring when about 60 percent were below 1829m and when only 10 percent were above 2134m. There was a progressive movement upward through summer into fall, when the highest elevations were reached. In fall, only 8 percent were below 1829m whereas 80 percent were above 2134m and 23 percent above 2438m. Various elevations were used in winter when factors such as steepness of terrain and exposure to wind seemed more important than elevation.

Table 3. Percent of goats observed at different elevation ranges in the park in each season (1975 - 1977).*

Elevation	% of all goats observed			
	Winter (131)	Spring (486)	Summer (262)	Fall (578)
<1524	26	24	2	1
1524 - 1798	41	34	19	7
1829 - 2103	28	31	18	13
2134 - 2408	41	10	52	57
2438+	3	41	10	23

*Numbers in parentheses refer to the total numbers of goats observed.

Goats in Yoho Park did not show strong seasonal changes in their selection of slope aspect (Table 4). South through west exposures were occupied by 80 percent of goats seen in the winter compared to 63 percent in spring, 64 percent in summer and 72 percent in fall. A slightly greater predilection for southeast and east orientations was shown in spring and summer than at other seasons. Northeast through northwest slopes were little utilized at any season.

Table 4. Aspects of mountain slopes used by goats in various seasons (1975 - 1977).*

Aspect	% of all goats observed			
	Winter (115)	Spring (484)	Summer (259)	Fall (342)
SW	28	29	28	22
S	28	8	6	19
SE	8	15	2	12
E	4	9	28	9
NE	0	2	1	6
N	0	4	2	0
NW	10	8	4	0
W	23	26	30	31

*Numbers in parentheses are sample sizes, including some duplication.

Natural licks - There are four known natural licks used by goats in the park. All four are at lower elevation (1246 - 1371m). To use the licks, goats must travel for some distances along well-worn trails through forests from their alpine summer range. All four licks are susceptible to human interference as two have fire roads built near them and two have well used hiking trails built through them.

The location of three, as well as a moose lick, within a 3km radius of the only known prehistoric Indian campsite in the park (Loy, 1971), suggests that goats using the licks may have been a food source for early Indian inhabitants.

Use of old mines - Goats make regular use of old mine portals, abandoned in 1952, on Mt. Field and Mt. Stephen. These extensive workings are located on traditional goat winter and spring range

and occasional summer range, at about 1371m elevation in the Kicking Horse Valley. Goats appear to use the mine portals for water and to lick white deposits from the walls, but the main use appears to be for shelter from inclement weather, particularly during rain and snow storms. For example, in January, 1972, a herd of 24 goats were observed (Stachera, pers. observ.) wading through deep snow on Mt. Field and entering a mine portal prior to a three day snow storm.

The heaviest use by goats of each of the mines on Mt. Field and Mt. Stephen is about 25m inside the main portals where the aerial tramway assemblies are located. The most preferred areas at this location are under the large winch drums where goat droppings are 5 to 8cm deep. Only a few goat tracks were noted more than 100m inside the portals.

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THE INFLUENCE OF MOUNTAIN GOAT SOCIAL RELATIONSHIPS ON POPULATION SIZE AND DISTRIBUTION

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Abstract: Sexual, agonistic and leadership relationships of the mountain goat (Oreamnos americanus) were studied from 1971 through 1976 in native Montana populations. Adult females were socially dominant over all other classes outside the rut. Females with young organized most group activities, mainly through strong following tendencies which they elicited from other females and subadults. Maturing males experienced difficulty interacting successfully within female-subadult groups and subsequently began utilizing ranges peripheral to or separate from them. Yearlings (not distinguished by sex) were solitary 3 percent of the time; two-year-old males 36 percent, and adult males 50 percent; revealing increased isolation of the male population segment with age, which further reduced range competition with breeding females. Social instability, measured as rates of agonistic encounters/goat/hour, increased in groups of increasing size. This proved to be an important factor in the dispersion of herds into groups of small average size. In resultant groups, competition mediated by the social hierarchy magnified resource shortages for subordinate animals. Juvenile mortality, characteristically high, was found to vary markedly with winter conditions while the proportion of adult females in the population remained fairly constant. Social mechanisms, particularly in a species such as the mountain goat with strong home range traditions, thus appear to play a critical role in population stability and distribution within habitats.

Populations of mountain goats are intimately associated with early stages of high elevation geologic succession - cliff outcropping and fellfield structures. Within its narrow, topographically defined niche, the species has evolved unique morphological characteristics, climbing abilities and food habits. Complex social relationships have also evolved. Adaptive aspects of mountain goat social behavior were investigated from 1971 through 1976 as part of a study of mountain goat ecology. Because factors which control mountain goat numbers are poorly understood at present, special attention was paid to the possible role of social mechanisms in regulating population size and distribution within ranges.

STUDY AREA AND METHODS

Investigations from 1971 through 1973 focused on a single herd of approximately 30 animals. The herd occupied a limited and well-defined year-round range of 25km^2 near Bunker Creek in the Swan Mountains of northwestern Montana. From 1974 through 1976, investigations concerned a population of about 360 goats inhabiting a 310km^2 central portion of Glacier National Park, Montana, 125km north of the Swan Mountains study area. The Glacier Park study population was composed of herds from 10 separate wintering areas including ranges east and west of the continental divide. Glacier Park goats generally occupied higher and more extensive cliff terrain than those in the Swan Mountains. Descriptions of physiographic features and plant communities for Bunker Creek and Glacier Park may be found in Chadwick (1974) and Habeck (1970), respectively. Both study areas contain indigenous goat populations. Those in the Swan Mountains are subject to hunting; those in Glacier Park are not.

Studies of movements, grouping patterns, and behavioral development were aided by the presence of individually recognizable animals. The Bunker Creek herd included five animals with radio collars, five wearing braided nylon collars, and two marked with dye. Additional goats could be identified by natural markings such as scars or horn deformities. Since the herd was observed daily for up to 18 continuous months, other goats could be distinguished for various periods of time through familiarity. In Glacier Park, recognition of naturally marked animals was supplemented by dye-marking 12 individuals. Certain park herds could be approached to within 10m, permitting detailed identification and behavioral study.

Observed goats were separated into kid, yearling, two-year-old female, two-year-old male, adult female, and adult male classes. Kids and yearlings are collectively referred to as juveniles. Kids, yearlings, and two-year-olds are collectively termed subadults. Data recorded for each sighting include pertinent structural and biotic habitat information, geographic location relative to a Universal Transverse Mercator (UTM) 100m grid, and location relative to other goats, predators,

and competitors.

Alertness was measured in different social classes by recording amount of time (in seconds) spent surveying surroundings in an alert posture during five-minute intervals. Aggressive rates were examined in groups of different size and composition by recording number of agonistic interactions observed between group members over a given period of time. In the Swan Mountains, intervals were variable and corresponded to complete feeding or bedding period durations in most instances. All group members were not always simultaneously visible, so number of encounters observed was less than actually occurred. In Glacier Park, 15-minute intervals when all group members were simultaneously visible were selected and include all encounters, yielding absolute aggressive rates rather than relative rates as in the Swan Mountains.

Efforts were made to measure relative frequency of potentially harmful climbing events. Subjective assessments of climbing 'danger' were related to events causing goats to yield overall balance and position relative to the substrate.

Percentage figures in tables may not total exactly 100 due to rounding.

RESULTS

Alertness - Mountain goats raised their head to survey their surroundings at frequent but irregular intervals. Unquantified observations indicated that lone animals were more wary than group members and less likely to perform uninterrupted maintenance activities such as foraging or resting.

Measurements of alertness were carried out which confirmed these impressions (Table 1). Mountain goats with at least one companion (other than a kid) were substantially less alert than solitary animals. Individual alertness continued to decrease with increasing group size to a point where goats in groups larger than five spent only a fraction of the surveying time that solitary animals did. However, the combined surveying time of individuals in groups increased with increasing group size and nearly always exceeded alertness of solitary animals. Group alertness was further increased in holistic fashion by the tendency of members to feed and bed facing different directions. Bedded goats often rose, surveyed their surroundings, then rebedded facing the opposite direction. Rebedding activity of this type was more common in large groups than in solitary animals or small groups, partly as a consequence of more frequent social interaction.

Table 1. Relationship of alertness to group size in foraging mountain goat classes. ( ) denotes small sample size.

		Ave. Surveying Time (No. Seconds/5 Minutes)										
		Group Size										
Class	Sample Size	Solitary 1	2	3	4	5	6	7	8	9	10	≥10
AM	29	38	16	25	(5)	(5)		(2)		(6)	(6)	
AF without K	193	50	15	20	(19)	61	5	(0)	(11)	(2)		10
AF with K	62	40	*	30	22	23	5	(17)	(20)		(0)	6
2M	23	32	(14)	(8)	(16)	(18)	(12)	(11)				(5)
2F	45	35	21	16	(26)	(9)	(5)	(6)	(21)	(2)	(0)	(0)
Y	47	25	(32)	14	29	(0)	8	(6)	(2)	(0)	(8)	(2)
Mean	399	37	20	19	20	19	7	7	14	2	4	5
Mean x Group Size = Total Group Surveying Time		37	40	57	80	95	42	49	112	18	40	

*Nanny-kid pairs in the absence of other goats were classified as solitary.

Alertness develops with age (Table 1). Kids surveyed their surroundings so infrequently that they were not included in Table 1. Yearlings were less alert than two-year-olds as solitary animals,

and adult classes were more alert than two-year-olds. Two-year-old and adult females were somewhat more alert than males of equivalent age. Contrary to expectations, adult females with kids spent less time surveying than adult females without kids.

Leadership - Mountain goat neonates are followers rather than hiders. They undergo precocial locomotor development and frequent reinforcement of maternal-infant bonds following parturition (Chadwick 1974). Kids typically followed within 2-20m of their nanny until 10-11 months of age, at which time maternal care terminated. Mountain goat females were extremely attentive and protective toward their young during this entire 10-11 month period, even though documentation of nursing durations indicate that weaning is effectively accomplished by 6-8 weeks of age (Brandborg 1955, Chadwick 1974).

Subadults older than kids strove to maintain contact with older females. Adult females retained strong following tendencies in relation to other, usually older, adult females. Adult females with kids at heel elicited stronger following tendencies than adult females without kids. This was also noted by Singer (1975) in a separate study of mountain goats in Glacier Park. I found this relationship to hold regardless of relative dominance. It was not unusual to observe an adult female without kid following an adult female with kid to which the former was clearly dominant during agonistic encounters. Darling (1939) observed that leaders of red deer (Cervus elaphus) hind groups were usually older females and that "a female which ceases to be a regular breeder soon ceases to be a leader." A lack of correlation between leadership and dominance in the domestic goat (Capra hircus) was found by Stewart and Scott (1948).

Adult mountain goats showed little interest in the behavior of subadults, particularly juveniles, even when juveniles were escaping predators. Followers were highly attentive to older leaders. As Gilbert (1974) found in fallow deer (Dama dama), older females waited longer in assessing situations, acted with more deliberate and decisive movements, and were less reliant upon the behavior of companions than were other classes.

Leaders determined the type, tempo, and direction of nearly all activities among female and subadult mountain goats. Followers were reluctant to initiate activities when in the presence of a leader. The role of leadership was further emphasized by observations of subadult groups, particularly those composed solely of juveniles. These groups commonly exhibited undirected movements and appeared to spend considerable time searching for other goats.

Maturing males showed increasing independence of activity within female-subadult groups. Within male groups, adult males tended to follow older males, but no positive correlation between leadership and dominance, such as Geist (1971) found in bighorn sheep (Ovis canadensis) ram bands, could be clearly established.

Group Structure - Groups composed solely of subadults were rare (Table 2), again emphasizing the role of adult leadership. Two-year-old females were nearly as likely to occur in mixed groups as were yearlings. Two-year-old males, by contrast, began to exhibit a tendency toward the solitary habits of adult males. Whereas yearlings (not distinguished by sex) were solitary only 5 percent of the time, 36 percent of all two-year-old males and 50 percent of all adult males observed from May through September were alone (Table 3). Males began limited association with exclusively male groups at two years of age (Table 2). As adults, most male associations were with other males. Males were most gregarious with other males during May at the same time that all other classes were most solitary due to separation of parous females from herds and disruption of leadership patterns.

Group Size - Mountain goat groups were considered separate if further apart the 50m and not oriented toward one another or engaged in related activity. Mean monthly group size varied between 1.9 and 3.3 in Glacier Park, with an overall average of 2.5; and between 2.1 and 4.6 in the Swan Mountains, with an overall average of 3.2 (Chadwick 1976). This is in agreement with data from Brandborg (1955), Lentfer (1955), Kuck (1970), and Smith (1976).

Close to 50 percent of all mountain goat groups sighted in Glacier Park were solitary animals and an additional 25 percent were pairs (group size 2). In terms of number of goats sighted, 20 percent of the population occurred alone and an additional 15 percent occurred in pairs from May through September (Table 3). The most common pair group was an adult female with a kid, a group behaviorally equivalent to a solitary animal in many respects. Thus the mountain goat assumes the status of a semi-gregarious species rather than a true herd animal. However, since groups tended to occupy the same general portion of available range at any given time, they retained certain herd qualities.

Table 2. Occurrence of mountain goat social classes in groups of different structure in Glacier Park from May through September.

Month	Class	Sample Size	Percent Occurrence: Solitary	With Subadults Only	With Males Only	In Mixed Group
May	AM	237	30	2	51	17
	AF*	308	47			53
	2M	33	61		3	36
	2F	36	25	4	2	70
	Y	114	12	12		77
	Ave.	748	35	3	11	51
June	AM	137	55		27	18
	AF	199	34			66
	2M	18	22			78
	2F	19	10	5		84
	Y	43	7	5		88
	Ave.	416	26	2	5	67
July	AM	76	64		12	24
	AF	209	25			75
	2M	21	14		5	81
	2F	20	10	10		80
	Y	65	5	3		92
	Ave.	391	24	3	3	70
August	AM	125	28		43	29
	AF	290	20			80
	2M	21	28	5		67
	2F	37		3		97
	Y	52	4			96
	Ave.	525	16	2	8	74
September	AM	118	46		48	6
	AF	374	21			79
	2M	34	20	3	9	68
	2F	47	13	2		85
	Y	96	4			96
	Ave.	669	21	1	11	67

*Nanny-kid pairs in the absence of other goats were classified with solitary adult females.

The kid class is not analysed since, with the exception of orphans, they were alwasy associated with adult females.

Table 3. Occurrence of mountain goat social classes in groups of different size in the Glacier Park study area from May through September, 1975.

Class	Sample Size	Group Size*										
		1	2	3	4	5	6	7	8	9	10	>10
AM	362	50	18	8	8	2	3	3	1	1		6
AF	592	18	18	9	10	7	5	5	4	5	2	18
2M	60	36	7	2	1	3	8	2	11	12		18
2F	83	12	12	8	8	3	8	7	24	1		17
Y	136	5	9	19	12	15	5	2	12	1	2	18
K	284	1	27	12	14	8	6	2	5	2	2	21
Ave. all Classes	1517	20	15	10	9	6	6	3	10	4	1	16

*Expressed as percent occurrence.

Description of Agonistic and Sexual Behavior Patterns - Most postures associated with behavior patterns of the mountain goat have been described by Geist (1964), DeBock (1970), Petocz (1973), and Rideout (1974). These will be redefined in terms of a scale from high intensity threat to high intensity avoidance for agonistic behavior, and from initiation of courtship to completion for sexual behavior, respectively.

A Present Threat (PT) is a broadside orientation toward an antagonist during which apparent size is enhanced through arching of the back and further erection of prominent dorsal ridge pelage. It is accompanied by tense, exaggerated movements, extreme tucking of the tail between the legs, and often a high, humming vocalization. High intensity PT involves conspicuous arching of the back and drawing in the head and neck toward the sternum. Moderate to low intensity PT incorporates less arching and some aversion and extension of the head and neck. The PT is associated with protracted agonistic interactions during which antagonists circle one another in antiparallel position.

A Weapon Threat (WT) involves display or actual use of the sharp, potentially injurious horns. Horns are displayed and aimed by lowering or cocking the head, and thrusts may be delivered through quick upward or lateral swipes.

A separate form of behavior involving the horns was recognized. Jousting (WTJ), so called because it involves a head-on orientation toward the opponent rather than head-to-tail, is distinguished from typical WT by its rapid, shorter, and repeated horn swipes. It is more a nodding or shaking of the head than preparation or delivery of a powerful thrust. WTJ was accordingly considered a less intense form of threat than WT.

The Rush Threat (RT) involves leaping, galloping, or trotting toward an antagonist. Like WT and WTJ, it may be accompanied by grunting and snorting vocalizations.

An Orientation Threat (OT) is simply a lower intensity form of RT effected by walking, turning, or staring fixedly toward an antagonist.

The Head-Elevated Orientation Threat (OTE) is the least intense form of threat. It is an approach or orientation toward an antagonist in which the head and neck are extended and slightly upraised.

Orientation Avoidance (OA) is essentially the converse of OT; that is walking, turning, or staring fixedly away from an antagonist. It is the least intense form of escape behavior. OA, like OT, grades into normal spacing-maintenance behavior of non-interacting group members. Therefore low level behavior of this type was recorded only when it caused other goats to abruptly modify ongoing activities and spatial relationships.

Rush Avoidance (RA) is the converse of RT; that is, leaping, galloping, or trotting away from antagonistic.

Most intense expressions of avoidance are specifically related to removal of target areas, particularly the rump and flank, from the horns of an aggressor. Collectively termed Weapon

Avoidance (WA), these postures involve crouching and, in extreme cases, squatting. Squatting, sometimes accompanied by urination, was observed mainly in instances where a subordinate animal was prevented from escaping an aggressor because of steep terrain or the presence of other dominant animals. Squatting appeared to inhibit further attack and sometimes stimulated similar behavior in the aggressor(s).

Most avoidance behavior, especially when performed at high intensities, incorporates certain common elements such as flattening of the ears and tail erection. Subordinate behavior is known to consist of postures and movements that are the antithesis of threat displays (Darwin 1872) or mimic either juvenile features (Wickler 1972) or female features (Geist 1971). Examples in the goat would be use of tail erection, a signal also displayed by neonates and developing juveniles to solicit nursing or other maternal care, and bleating vocalizations also used by kids to solicit maternal care.

During agonistic encounters behavioral sequences are often interrupted by vigorous performance of apparently unrelated bedding or comfort-related activities such as shaking, scratching, and dustbathing. Such activities were recorded as Non-Specific Displays (ND). ND also includes overt agonistic behavior not directed toward an opponent, such as horn-swiping inanimate objects and whirling. Whirling is a combination of rearing on the hind legs and random horn-tossing and has been described in detail by Dane (see these proceedings). Normally associated with exuberant play in juveniles, whirling may occur with intermittent running and leaping. It was observed in solitary animals as well as those in groups.

This paper is primarily concerned with social relationships outside of the rutting period. However, mountain goats exhibited sexual behavior throughout the year and used the same basic postures both during and outside of the rut.

The Low Stretch (LS) is the basic male courtship approach posture. The male moves directly toward the female in a crouch with the neck highly extended and lowered and the ears directed forward. The tail is usually elevated to a horizontal position. When performed at high intensity, the LS may include tongue-flickering, lateral jerking of the head, and a muted, buzzing vocalization. As Geist (1964) pointed out, the LS is the antithesis of the broadside PT. Threat elements are minimized to facilitate entry of the male within critical personal space defended by the female. When directed toward females and most subadults, the PT of fully mature males usually contains sexual elements from the LS. Described by Geist as a distinct 'conflict posture', the male PT amounts to a broadside display with some arching of the back and stiff movement, in which the neck is fully extended and lowered. Because an effective WT cannot be delivered when neck musculature is extended, threat potential of the pale PT, or conflict posture, is less than that of a typical PT as expressed by females and immature males, or by males toward other males.

Additional male sexual postures, described in the sequence in which they are usually expressed following positioning at the rear of the female, include Sniffing and nudging the anogenital area (SN), often followed by a lip curl (flehmen); delivery of a foreleg kick (K) to the female side or inguinal region; placing the Chin (CH) on her rump or back; placing one or both Forelegs (FL) over her rump or back and rising to Mount (M); then firmly Clasping (CL) her hindquarters and performing rapid, rhythmic pelvic Thrusts (TH). Other courtship behavior includes grooming activities similar to those seen in maternal-infant relationships. Males rub their muzzle along the back and flant of the female and, less often, the face. They may also lick these areas.

No unique female sexual postures other than standing for the male (lordosis) were observed.

Analysis of Agonistic and Sexual Interactions - Behavioral postures exhibited by mountain goat social classes outside of the rutting season were summarized. Results of kid-kid interactions are not included due to association of agonistic and sexual postures with play behavior in this class. The PT category includes male conflict postures.

Overall use of PT rose slightly from juvenile to adult classes. Adult males, expressing the PT as a conflict posture, utilized this more frequently than any other agonistic posture (Table 4). The proportion of PT was greatest in the behavior of each class toward members of the same or adjacent age classes and lowest toward disparate age classes. Adult females, two-year-old males, and yearlings expressed PT toward members of their own class most frequently (Table 5, 6 and 7, respectively). Two-year-old females displayed PT toward two-year-old males slightly more often than toward other two-year-old females (Table 8). The few instances of PT observed in kids, apart from interactions with other kids, were directed to yearlings (Table 9).

As with PT, proportion of WT use in overall behavior did not vary greatly between yearlings, both two-year-old, and adult female classes. Kids and adult males were least likely to employ WT during interactions. Yearlings, two-year-old females, and adult females all showed increased use of WT toward age classes younger than their own, most of it directed toward the kid class.

Table 4. Behavior of the mountain goat kid class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 395)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic: Intense Avoidance	WA							
	RA		82	18	52	54		62
	OA		11	63	23	13		20
	DB			2	2	5		2
	OTE		2		2	.9		2
	OT		3	14	13	4		6
	RT					2		.5
Intense Threat	WTJ		2		8	17		7
	WT			3		4		1
	PT					2		.5
Courtship: Initiate	LS							
	SN							
	K							
	CH							
	FL							
Complete	M							
	CL							
	T							
% of All Patterns*			45	13	13	29		100

*Kid-kid interactions not included due to association with play behavior.

Table 5. Behavior of the mountain goat yearling class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 1218)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic: Intense Avoidance	WA		.8					.2
	RA	20	64	30	42	17	.8	36
	OA	30	19	26	17	9		15
	DB		3	5	7	9	7	6
	OTE	20	2		1	.6		1
	OT	30	3	8	7	15	21	10
	RT		1	3	2	9	18	5
Intense Threat	WTJ		3	9	7	9	12	7
	WT		2	12	6	16	36	11
	PT		2	5	7	11	4	6
Courtship: Initiate	LS				3	.3		.7
	SN				.4			.1
	K					.3		.1
	CH				.4	2		.6
	FL					.6		.2
Complete	M					1		.3
	CL					.3		.1
	T							
% of All Patterns		.8	30	11	19	29	10	100

Table 6. Behavior of the mountain goat two-year-old female class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 734)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic: Intense Avoidance	WA			1		.8		.4
	RA		60	27	19	.4		27
	OA	10	16	20	5	10		13
	DB	10	5	4	10	9	6	7
	OTE		3	4	2	.4		2
	OT	80	4	13	21	26	29	17
	RT		8	1	11	22	22	13
	WTJ		1	5	6	7	10	5
	WT		2	9	15	18	33	12
Intense Threat	PT		1	17	11	6		6
Courtship: Initiate	LS		.4					.1
	SN							
	K							
	CH							
	FL							
	M							
	CL							
Complete	T							
% of All Patterns		1	36	14	8	33	7	100

Table 7. Behavior of the mountain goat two-year-old male class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 570)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic: Intense Avoidance	WA		.9					.4
	RA	10	26		.9	.8		11
	OA	3	16	11	4	4		9
	DB	10	7		10	12	10	9
	OTE	3						.2
	OT	35	18		17	27	40	22
	RT	23	2	6	10	19	5	9
	WTJ		5	22	4	4		4
	WT	10	3	33	10	8	17	8
Intense Threat	PT	3	5	28	18	10	3	9
Courtship: Initiate	LS	3	3			.8		1
	SN		9		6	4		5
	K					.8		.2
	CH				9	3	14	4
	FL		3		.9	2		2
	M		3		10	4	10	5
	CL							
Complete	T							
% of All Patterns		5	39	3	20	22	10	100

Table 8. Behavior of the mountain goat adult female class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 2369)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic — Intense Avoidance	WA		.6	.5				.3
	RA	13	18	6	.8		.5	11
	OA	18	14	24	1	.3	1	11
	DB	7	6	2	2	1	2	4
	OTE	6	1	1				.8
	OT	33	28	34	45	42	24	33
	RT	9	12	18	31	43	38	21
	WTJ	1	.4	2	.8	.3	1	.6
Intense Threat	WT	9	6	5	8	9	33	9
	PT	5	14	8	10	3		9
Courtship — Initiate	LS					.3	1	.1
	SN							
	K							
	CH							
	FL							
	M							
Complete	CL							
	T							
% of All Patterns		4	53	9	11	15	9	100

Table 9. Behavior of the mountain goat adult male class during social interaction outside of the rutting period.

		Relative Frequency of Expression (Each class total = 100%)						
		Class Interacted With						
Behavior Pattern (N = 237)		AM	AF	2M	2F	Y	K	% of All Patterns
Agonistic — Intense Avoidance	WA							
	RA	9	3					3
	OA	18	21	30	47	8		23
	DB	4	6	17	6			7
	OTE	4						.8
	OT	31	15	10		17	100	16
	RT	7		5		17		3
	WTJ		2					.8
Intense Threat	WT	4	.8					1
	PT	18	27	34	41	42		28
Courtship — Initiate	LS	4	17	5	6	17		12
	SN		2					1
	K		.8					.4
	CH		5					3
	FL		.8					.4
	M							
Complete	CL							
	T							
% of All Patterns		19	51	17	7	5	.4	100

WTJ was less frequent than WT in the behavioral repertoire of all classes except the kid class. Adult classes rarely employed WTJ, while two-year-olds used it slightly less often than juveniles. Two-year-old females, yearlings, and kids directed most WTJ toward juveniles.

Table 10 is a summary of actual horn contact resulting from all observed use of WT and WTJ outside of the rutting period, and it includes social interactions not analysed in Tables 4 - 9. It is evident from Table 10 that only a small proportion of weapon-related threat behavior resulted in actual contact. Table 10 data illustrate further the gradual shift from WTJ to WT with age. Kids and yearlings exchanged most of the horn contacts to the anterior body area; older animals oriented contact more toward the rump and flank. Thus with increasing age and ability to inflict serious injury, weapon use orientation changes from the poorly protected cephalic region toward posterior dermal shields described by Geist (1967).

Table 10. Summary of horn contact resulting from weapon threat behavior of mountain goats outside of the rutting period.

Body Area Receiving Horn Contact	Class Receiving Horn Contact						
	AM	AF	2M	2F	Y	K	Total
Head		2			10	17	29
Side	1	1	1	2	1		6
Flank		2		4	7	2	15
Rump		3	3	6	80	56	148
Total	1	8	4	12	98	75	198
Class Effecting Horn Contact							
AM					2		2
AF		8	3	5	15	26	57
2M			1	7	4	4	16
2F					32	1	33
Y	1				43	44	88
K					2	*	2
Total	1	8	4	12	98	75	198

*Kid-kid interactions excluded due to association with play behavior.

Kids effected only 1 percent of all horn contact while receiving 38 percent, mostly from yearlings. Yearlings effected 44 percent and received 49 percent, again mostly from yearlings. Adult females delivered 29 percent of all horn contact but received only 4 percent, despite better numerical representation in the population than any other class. Behavioral changes in maturing males are suggested by the fact that two-year-old males regularly employed WT and WTJ (Table 6) and delivered 16 horn contacts while adult males, at least three times as numerous as two-year-old males in typical population structures, rarely exhibited either WT or WTJ (Table 4) and effected horn contact only twice. Geist (1971) documented waning overt aggression and increasing display within mountain sheep ram bands.

RT was employed by adult females more often than by other classes; 21 percent of all behavior patterns as compared to 13 percent for two-year-old females, the class expressing RT next most frequently. This is significant because use of RT by an individual indicates that the animal 'expects' to dominate the individual toward which it directs the behavior. Adult females exhibited RT toward adult males but received none from them. The opposite situation was evident among two-year-olds, with males directing RT toward females but receiving RT from them rarely.

OT was exhibited more commonly by all classes than RT. With the exception of kids and adult males, goats utilized OT as the most common threat posture. OT was directed toward all classes by adult females. Other classes employed it most often in interactions with classes younger than their own. Percent of OT shown adult females by adult males was about half that shown adult males by adult females; 15 percent and 33 percent, respectively. Among two-year-olds, the situation was again reversed, as with RT. OT comprised 17 percent of male behavior toward females and 13 percent of female behavior toward males in the two-year-old class. Two-year-old males used OT toward adult females 18 percent of the time; two-year-old females used OT toward adult females 4 percent of the time.

OTE was not common in the behavior of any class. Since it was employed by each class primarily toward goats of the same age class or older, it might best be termed a subordinate threat form.

As expected, use of OA was highest in juvenile classes and lowest in adult classes. A similar relationship was evident in RA. Subadults used RA more frequently than OA. Adults used OA more than the higher intensity RA. Adult males were the least likely to express avoidance behavior more intense than OA. Among two-year-olds, female OA and RA toward males were 20 percent and 27 percent, respectively; male OA and RA toward females, 4 and 0.9 percent respectively. Two-year-old female OA and RA toward adult females were 16 percent and 26 percent, respectively. Two-year-old males are therefore seen to show the same amount of low intensity avoidance toward adult females as do two-year-old females, but less than half as much higher intensity RA. Adult females showed 24 percent OA and 6 percent RA toward two-year-old males, but only 1 percent OA and 0.8 percent RA toward two-year-old females.

No obvious pattern emerges from analysis of ND between classes. ND was generally most likely to occur in conjunction with high intensity behavior patterns and in approach-withdrawal situations.

Data from Tables 4 - 10 suggest that higher social status or dominance may be correlated with increasing age in mountain goats. Using data from Tables 4 - 9, relative dominance in mountain goat social classes is described in Table 11 as percentage threat behavior in the total agonistic behavior recorded for each class. The ability of older classes to dominate younger ones is clearly evident in Table 11. Increasing age in this species is in turn related to increasing size, strength, and horn development. Measurements by Brandborg (1955), Rideout (1974), and Moorhead (pers. comm.) show substantial differences in these parameters between successive age classes. Among goats known to be of the same age and sex, my observations consistently showed that individuals of greater size/strength/horn development were able to dominate smaller goats.

Table 11. Relative dominance of mountain goat social classes outside of the rutting period.

	No. Threat Behavior Patterns/ Total No. Agonistic Behavior Patterns[1]					
	Class Expressing Behavior					
Recipient Class	AM	AF	2M	2F	Y	K
AM	.70	.67	.85	.88	.50	-
AF	.67	.65	.44	.20	.13	.07
2M	.62	.69	.89	.30	.39	.17
2F	.47	.98	.92	.73	.34	.23
Y	.91	1.00	.93	.88	.64	.32
K	1.00	.98	1.00	1.00	.98	

[1]Using data from Tables 4-9. DB is excluded from total number of agonistic behavior patterns.

Relationships between sexes were more complex. Where marking or close-up observation permitted sexing of juveniles, males were found to be somewhat thicker-horned, larger, more exploratory, and more aggressive than females of the same age. Sexual postures appeared very early in the development of neonates (Chadwick 1974) and were more common than agonistic postures in play up to four to six months of age.

Kid-kid, kid-yearling, and yearling-kid sexual behavior was not analysed due to its inclusion in the context of play. Kids were not seen to direct sexual postures toward any goats older than yearlings (Table 9). Yearlings used courtship postures during interactions with other yearlings and two-year-old females. Yearlings used the LS, a posture not observed during juvenile sexual play, more often in courtship of two-year-old females than in interactions with other yearlings (Table 7). Although older males directed some courtship toward unresponsive yearling females during the rut, no active participation in breeding by either sex of yearling was noted. Yearling breeding has not been reported by other investigators, even under conditions stimulating unusually high productivity (Lantfer 1955).

Developing two-year-old males begin to approach adult females in size, weight, and horn development by the end of August. Two-year-old males clearly dominated two-year-old females (Tables 6, 8 and 11). They were also considerably more agressive toward adult females than any other subadult class was. Between July and October, two-year-old males began to utilize the male conflict posture to the exclusion of typical PT during interactions with females and with adult females in particular. At the same time, two-year-old males began to direct courtship toward older females and 25.9 percent of postures used in interaction with two-year-old females were sexual. Sexual interactions with adult females involved use of LS while interactions with two-year-old females did not.

Relative dominance of adult males and adult females toward one another was quantitatively identical in terms of agonistic behavior (Table 11). Qualitative comparison of Tables 4 and 5 reveals that males exhibited a high percentage of PT toward other classes while adult females did not. Aside from PT, which, it should be remembered, is expressed by the male toward females and subadults as a unique conflict posture, containing subordinate sexual elements, adult males directed little threat behavior toward females and subadults. Adult females, on the other hand, showed high percentages of typical threat behavior toward all other classes, including adult males. Excluding PT, 17.8 percent of adult male agonistic behavior toward adult females involved threat postures compared to 58 percent of adult female behavior toward adult males. An additional 21.1 percent of adult male behavior toward adult females involved sexual postures. The highly subordinate LS was used by adult males toward all other classes except kids. Additional courtship postures were shown only toward adult females outside the rut.

Total adult male behavior patterns, N, is 237 (Table 4), compared to 2,367 adult female patterns (Table 5) during the same time period. In the Bunker Creek herd, in which three-year-old males could consistently be distinguished from older adult males, 85 percent of adult male interactions with other classes were performed by three-year-old males. Most adult males in Glacier Park mixed groups outside the rutting season appeared to be no more than three or possibly four years of age. Thus, males older than two years of age are not only less likely to direct threat behavior toward other goats than are the immature males; they are less likely to have any social interaction with females and subadults. Most interactions which do take place between adult males and the female-subadult herd component involve young adult males. Table 4 should be interpreted accordingly to be more representative of young adult males than of older adult males. Older adult males very rarely threatened females or subadults. During interactions with these classes, older adult males typically assumed a rigid PT conflict posture and withdrew. Older males were observed to retreat in this fashion from yearlings and even from kids in the Swan Mountains (these interactions were not included in Table 4).

Agonistic Rates - Frequency of agonistic encounter/goat/hour increased with increasing group size during foraging, bedding, and salt licking activities (Table 12). As expected, rates were lowest in bedded groups and highest at salt licks where activity was related to a spatially limited resource. Number of encounters/group/hour (that is, the number of encounters/goat/hour x group size) is shown for foraging mountain goats in Galcier Park to illustrate magnitude of social interaction in large groups compared to small groups. Agonistic rates were found to be markedly higher in mixed groups than in a small sample of male-only groups. Observation of marked animals indicated that both frequency and intensity of agonistic interaction were lowest between individuals which regularly associated and highest between individual which appeared unfamiliar with one another.

Agonistic encounters were evident in all activities and in all habitats, including precipitous cliff terrain. Data from 4,400 goat-hours (number of goats in a group x number of hours that group was observed) of observation in the Swan Mountains is presented in Table 13. During that time, 291 out of a total of 3,435 agonistic encounters occurred in what was judged to be a dangerously steep climbing situation from the perspective of the animals. Thirty-nine of these encounters resulted in a potentially harmful climbing event. Data from Tables 13 and 10 are similar in that most of these encounters in dangerously steep terrain involved WT and primarily affected juveniles. Kids sustained 44 percent and yearlings 36 percent of 39 aggression-related climbing events. Aggression-related climbing incidents occurred with greater frequency than normal climbing mishaps; .89 per 100 goat-hours, compared to .66 per 100 goat-hours.

Table 12. Relationship of mountain goat group size and structure to frequency of agonistic behavior (modified from Chadwick 1976).

A = All Groups M = Male Only E = Excluding Male Groups

	No. Agonistic Encounters/Goat/Hour						No. Agonistic Encounters/ Group/Hour
	Swan Mountains			Glacier Park			Glacier Park
Group Size	Bedded A	Feeding A	Licking A	Feeding A	Feeding M	Feeding E	Feeding A
2*	.06	.26	1.47	1.08	0	1.08	2.16
3	.06	.63	3.04	.94	.44	1.16	2.84
4	.39	.83	4.17	2.75	.66	2.78	11.00
5	.22	.82	3.69	1.83	.80	1.65	9.16
6	.52	.89		2.47		2.48	14.80
7	.47	.65		4.64		4.64	32.48
8	.80	1.30	6.06	5.20		5.32	41.60
9	1.25	1.50		3.01		3.28	27.09
10	.44	1.82		1.12		1.12	11.20
>10	.54	1.87		4.24		3.04	46.16
Sample Size	549	1055	43	95	14	109	95

Data from the Swan Mountains and Glacier Park are not quantitatively comparable due to different sampling techniques.

*Nanny-kid pairs are not included in group size 2.

Table 13. Potentially harmful climbing events recorded during 4,400 goat-hours (number goats in group x number hours group observed) of observation of mountain goats in the Swan Mountains.

		Number Events in:								No. Events/ Goat-Hour
	Type of Event	AM	AF	2M	2F	Y	K	Unid.	Total	
	Climbing misstep		9	3		5	5	7	29	.0066
Events from 291 agonistic encounters in dangerously steep climbing situations	Knocked, pushed, or prodded over edge		1	1		9	7		18	.0041
	Forced to leap over edge to avoid goat		2	1		5	10		18	.0041
	Knocked or forced to leap over edge as result of another encounter (innocent bystander)		1		1				2	.0005
	Aggressor loses footing during pursuit		1						1	.0002
	Total aggression-related events		5	2	1	14	17		39	.0089
Total All Events		0	14	5	1	19	22	7	68	.0155

DISCUSSION

Benefits of Aggregation - The fundamental unit of mountain goat society is the prolonged mother-infant association. Lent (1974) states that a major function of maternal behavior if facilitation of learning processes in the infant through provision of potimum levels of stimulation and a relatively stable social environment. Stabilization of the social environment relative to young of the year is particularly important in the mountain goat. All other classes are aggressive toward the kid class and, as pointed out by Geist (1964, 1974), all older classes possess potentially injurious horn weaponry. The present study revealed that even with maternal protection, the kid class sustained 38 percent of all horn contact and 44 percent of agonistic behavior leading to potentially harmful climbing events. Weapon threats and other aggressive behavior exhibited toward kids probably reinforced the prolonged close following tendencies of the kid class.

That kids experienced relatively less social interaction with other classes than any other class except adult males did is a measure of the extent to which aggressive maternal protection stablilized the social environment of kids. If agonistic behavior were adjusted according to percent representation of classes in total population figures, it would be evident that the yearling class, without benefit of maternal protection, received proportionately more horn contact and agonistic behavior leading to potentially dangerous climbing events than did the more numerous kid class. Yearlings also received a far greater actual number of threat postures than did any other subadult class.

In addition to buffering a rigorous social environment, maternal care mitigates the demands of the harsh physical environment of the mountain goat niche. For several weeks subsequent to partuition, adult females positioned themselves between their unstable offspring and the outer edge of available footing to prevent accidental falls by the neonate. Parous females also assisted neonates in negotiating precipitous terrain by trial and error selection of the least difficult routes. Kids experienced considerable difficulty obtaining forage beneath deep snow and icy crusts. They obtained a substantial portion of their forage during the critical winter-early spring period within feeding craters pawed by their mother and not yet utilized by classes dominant to the kid dur to continued presence of the mother nearby. The small (12 - 20kg) kids were further able to conserve relatively limited energy reserves by following the mother's path through deep snows and by bedding in sheltered sites defended by her against other classes. Kids generally bedded on the leeward side of the nanny in contact with her body during winter (Chadwick 1974). Without maternal protection from dominant animals, kids would be relegated to the least desirable forage and shelter situations.

Following tendencies of older goats appear to be extensions of the durable mother-kid relationship. After kids, yearlings, the two-year-old females were the most gregarious class. Altmann (1963) states that post-weaining bonds function by affording guidance in choice of feeding site, shelter, and decisions regarding safety and flight. Within the relatively small, traditional home ranges occupied by mountain goats, knowledge of key winter feeding areas, protected bedsites, escape terrain, and efficient daily travel routes may confer important survival advantages. Such advantages would accrue to yearlings of both sexes, two-year-olds of both sexes to a slightly lesser degree, and thereafter primarily to females since they are more likely to inherit ranges than males. Information about salt licks and migration routes must be transmitted to all classes.

A primary stimulus to aggregation is the selective advantage enjoyed by individuals in groups when predators are present. It was demonstrated that goats in groups were more collectively alert to potential danger than solitary animals while expending less individual time and energy surveying their surroundings. Group members would therefore have more time available for maintenance activities. Greater foraging time permits animals to be increasingly selective for forage of the highest digestibility. Estes (1974) suggests that in African bovids, isolated individuals and small groups spend a greater proportion of time watching and listening for danger than do members of larger herds. Walther (1969) states that individual Thompson's gazelles (Gazella thompsoni) may be unalert for periods extending up to 15 minutes, but because they inhabit large herds, there is a high probability of one animal always having its head raised. Because alertness increases with age in mountain goats, subadult group members are able to share the advantages of greater alertness in older animals.

In a similar sense all group members benefit from the abilities of those animals with the most acute senses (shared genetic traits) or experience (shared learned behavior). Bergerud (1974) points out that herding reinforces escape behavior since naive animals can learn without having to experience attacks directly. During actual predator attack, group members benefit from group defensive abilities and predator difficulties in isolating targets. An excellent general discussion of the values of grouping in animal societies is available in Wilson (1975).

Factors Limiting Group Size - Ewer (1968:99) states "Large societies are only able to exist in situations where members can easily keep in contact ... and only in adequate food can be found for all within the normal feeding period ... Terrain and type of food are thus the two external factors which have the most influence on the evolution of social relations." Habitat utilization data demonstrate that precipitous terrain is favored throughout the year by mountain goats (Brandborg

1955, Geist 1971, Feck 1972, Chadwick 1976, Smith 1976). That large goat groups experience difficulty coordinating activities on steep cliff faces and narrow ledges may be confirmed by direct observation and by data from Chadwick (1976) showing that large groups were more often observed on moderate slopes than on steep slopes. Large groups size can also lead to crowding which in turn restricts maneuverability on cliffs. All group members are then forced to share to some degree the genetic and experienceable limitations of the poorest mountaineers. Seton (1927) relates an incident in which goats crowding onto a thin ledge were unable to turn past one another and eventually fell to their death.

Another factor, also topographic, which may select against aggregation in the mountain goat is catastrophic downslope movement of rocks, ice, and snow. Holroyd (1967) commented that because goats generally occur in small groups, avalanches are not likely to affect more than a small part of a herd at any one time. Such evidence as is available (Brandbor 1955, Chadwick 1976) points to avalanches as a major source of mortality and therefore an important selective agent in evolution of mountain goat social characteristics.

Severe winter storms, deep snows, and icy crusts can remove potential forage in some habitats and reduce its availability throughout wintering areas independent of the condition of range forage per se. Duration of winter conditions becomes critically important during March and April as available forage is reduced. Deep snow also restricts movement between available forage sources. Goats were observed to remain in areas no more than 100m in diameter for over a week on occasion under severe snow regimes (Chadwick 1974).

The ability of native goat populations to exploit a wide variety of food items has been documented by Casebeer (1948(, Brandborg (1955), Saunders (1955), Hibbs (1967), Hjeljord (1973) and others and has been related to compensation for narrow habitat preferences (Geist 1971). It follows that small groups and individuals would be capable of obtaining sufficient forage in microhabitat refugia under severe winter conditions by utilizing all available edible plant species from lichen to conifer. Larger groups, however, would be more likely to exhaust the limited resources of a small area during confinement, thereby causing all group members to suffer shortages. Similarly, sheltered sites such as overhanging ledges and caves or crevices are also a limited and highly localized resource most efficiently and equitably utilized by individuals and small groups.

Houston (1974) points out that conditions of deep snows and scattered forage set an evolutionary premium on small group size in the moose (Alces alces) since single moose or small groups would be more successful at finding and utilizing forage than larger groups. Small group size in the mountain goat also minimizes general animal impact such as trampling and heavy grazing within fragile alpine and subalpine plant communities.

The value of groups as anti-predator devices has been discussed briefly. However, mountain goats as a species are insulated by the exclusive nature of the terrain which they favor from most predators. The advantages of grouping are thus somewhat diminished, particularly for mature animals whose defensive abilities in relation to medium-sized predators such as lynx (Lynx canadensis), coyote (Canis latrans), and wolverine (Gulo gulo) were observed to be formidable.

Optimum group size in any species represents an appropriate balance between beneficial aspects of aggregation and disadvantages of intraspecific competition for limited resources relative to individual survival. Though ultimately determined by the nature of the terrain and food supply, grouping characteristics in the mountain goat appear to be directly mediated by social mechanisms involving agonistic, sexual, and leadership behavior. Analysis of behavior patterns suggests that aggression is the primary device through which social tendencies are limited and defined.

Since exploitation of montane habitats involves both horizontal and vertical movement between seasonal ranges, a social hierarchy based upon defense of a mobile personal space rather than fixed territory characterizes mountain goat society. Personal space is maintained at all times under normal conditions including resting periods. Agonistic interactions are essentially contests over personal space which ultimately determine the right to occupy a particular site, and the resources contained therein, at any given time.

Trespass of personal space was common in large groups as a result of temporary crowding which inevitably occurred during the course of group movements. It was noted that high intensity agonistic threat behavior was most common between goats of similar rank. Larger groups were generally more likely to include goats of similar status than were small groups. Furthermore, status rivalry appeared to lower aggressive thresholds in onlooking goats, predisposing them to agonistic behavior. Group members were also subject to frequent redirected aggression from one or both contestants following encounters. The consequence of these different factors was a notable increase in social instability, measured as rates of agonistic interaction, with increasing group size. Large groups were characterized by numerous social interactions and disruption of maintenance activities. Larger groups usually separated into smaller, more durable, and more efficient social units. Average size of these typical, more highly ordered units was between one and five. Stable groups of females and subadults were more structured along a linear rank order than larger groups.

Stable female-subadult groups therefore assumed a family-like appearance, containing, for example, an adult female, two-year-old, yearling, and kid. Observations of marked animals suggested that such associations were merely stable aggregations and, except for the nanny-kid pair, not necessarily composed of related individuals.

With sexual maturation, males underwent a transition from agonistic to largely sexual modes of interaction with females. Thus an increasing ability to successfully contest relative rank, seen in two-year-old males, was countered by developing use of sexual behavior which emphasizes submissive signals and minimizes threat content. Overall use of threat postures by males became less common after two years of age. At the same time, however, maturing males showed no increase in avoidance behavior and rarely exhibited high intensity avoidance postures or signs of fear during withdrawal. That males remain capable of effectively intimidating smaller classes when sufficiently motivated is implied by observations of male dominance at salt licks in Glacier Park (Singer 1975, Bansner 1976) and elsewhere (Rideout 1974, Moorhead pers. comm.).

Neither clearly dominant nor obviously subordinate under normal conditions, yound adult males were unable to establish stable rank relationships within mixed groups. It is hypothesized that unsatisfactory social interactions and stress generated by conflicting sexual and agonistic drives, exemplified in the unique male FT, caused maturing males to develop grouping and movement patterns independent from those of females and subadults. Beginning at two years of age and established as a general pattern by three years of age, males tended to occupy ranges peripheral to or separate from those of females and subadults. Those adult males which were observed in mixed groups remained in them for shorter durations and exhibited greater independence of activity than other classes. Most adult males occurred alone, being more solitary than any other class, or in small bachelor bands. Bachelor bands were often stable over a period of several days or more, compared to daily changes of composition in typical mixed groups. This greater stability of male groups may be correlated with lower rates of agonistic interaction which in turn suggests that resource competition between adult males outside the rut may be less significant than within mixed groups.

Consequences of the male social relationships described are twofold. First, the potential for injury to other classes by the large, powerful billies is reduced. Secondly, resource competition between adult males and the female-young population component is minimized. Foss (1962), DeBock (1970), Geist (1974, 1975), Rideout (1974), and Smith (1976) have suggested that males occupy more marginal range than females and subadults. In both Glacier Park and the Swan Mountains, males were observed in more rugged terrain at higher average elevations with greater snow depths than females and subadults. Adult male:adult female ratios typically vary between 70:100 and 90:100 in native goat populations (Hibbs 1966), indicating slightly lower survival of adult males relative to adult females. Similar figures were recorded in present studies (Chadwick 1974, 1976). Higher than average male:female ratios have been recorded wher production of young was also above average (Anderson 1940, Hanson 1950). Rideout (1974) found adult male:adult female ratios to be lowest following a heavy winter. All male:female ratios are likely to contain some bias toward adult females since the more solitary and dispersed habits of males and the more rugged terrain favored by them can lower survey success for this class.

Females and subadults occupied optimum habitats within available range. Within typical female-subadult groups such as were observed dispersed throughout winter ranges, the highly aggressive, socially dominant adult female class enjoyed prior access to resources. Agonistic relationships within the social hierarchy, based upon threat behavior ultimately involving the horn weapons, promoted dispersion of herds into relatively small, ordered groups. Within these groups, intra-specific competition was minimized, again to the advantage of adult females. Under chronic conditions of resource scarcity, therefore, the resource base available to adult females, the breeding segment of the population, should remain relatively constant while subordinate animals suffer socially magnified resource shortages.

First year mortality varies between 30 and 80 percent in studies of mountain goats summarized by Hibbs (1966) and Vaughan (1975). First year mortality was found to be variable in Glacier Park (Bansner 1974, Singer 1975, Chadwick 1976). By distinguishing two-year-old classes, it was discovered that mortality in the yearling class may also be high; close to 50 percent in certain Glacier Park herds east of the continental divide (Chadwick in prep.). Gains in size and energy reserves from the previous year are apparently offset to some extent by loss of maternal protection in the yearling class. Juvenile mortality has been shown to vary with winter conditions in Glacier Park (Chadwick 1976) and elsewhere (Rideout 1974, Smith 1976).

Within optimum goat habitat, it is expected that adult male and juvenile mortality will vary while the proportion of adult females in the population remains more or less constant under different winter regimes. Productivity of three-year-old females is expected to be somewhat lower than that of older, more dominant females, but overall production of young should not vary greatly between winters. In marginal range situations, adult male and juvenile mortality should show fluctuations of greater magnitude under different winter regimes. Production of young should be more dependent upon winter conditions, particularly in young adult females. Alternate year production of young may occur.

In summary, mountain goats are characterized by occupation of a narrow, topographically defined niche; utilization of stable alpine and subalpine post-Pleistocene habitats; slow maturation; and retention of juveniles on traditional home ranges. Social mechanisms have evolved to facilitate transmission of learned home range behavior and, in the absence of significant predation of competition from other species, to maintain population size (N) within the carrying capacity of the environment (K). Reduced sexual dimorphism and the aggressiveness of adult females in this species have been attributed directly to the evolution of sharp horns by Geist (1974). It is hypothesized that a rigorous social environmnet influences mountain goat distribution both within and between ranges and acts to regulate population size through differential vulnerability of social classes to the physical environment.

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MOUNTAIN GOAT SOCIAL BEHAVIOR:

SOCIAL STRUCTURE AND "PLAY"

BEHAVIOR AS AFFECTED BY DOMINANCE

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Abstract: A small population of mountain goats in southwestern British Columbia has been studied to determine the factors affecting social structure. The study has revealed that the population is undergoing a drastic decline, and that the loss of younger age class goats is altering the types of behavior seen in social interactions; particularly aggressive and play behaviors.

Most of the social interactions that take place among members of the herd appear to be aggressive in nature. In many situations when there are twenty or more goats in one group, aggressive behaviors are seen every 15 or 20 seconds. The analysis of hundreds of these interactions reveals that males tend to dominate females, and that older goats usually dominate younger goats. One of the behaviors observed, referred to as "whirling", involves animals leaping into the air and twisting their bodies through one or more turns before landing. This behavior is practiced by goats of all ages, and is usually performed on steep snow slopes, apparently as part of play. I suggest that the situations which elicit this behavior indicate that in some circumstances, at least, it is motivated by aggression as well as a tendency to play. Considering the relative rarity of "normal play" behavior in the goats that I have studied, this possible connection between aggressive behavior and rare, but stereotyped, forms of "play" behavior is of particular interest.

One of the most important problems in the study of behavior is the elucidation of the function of play behavior. Play has been claimed to contain elements of sexual behavior, aggressive behavior, and curiosity (as well as many other motivations), but so far both its evolutionary and individual significances remain speculative. There is, however, general agreement that play behavior is extremely important to the development of most mammals and that play assumes a more and more important role as one ascends the evolutionary scale (Wilson 1975, Aldis 1975). The effects of social deprivation early in the life of a variety of mammals lends further credence to the idea that early behavioral interactions, whether play or other behaviors, are cirtical to the normal development of the individual. The fact that play cannot be easily or precisely defined should not, then, hinder the study of activities which most investigators would agree are a vital part of the animal's behavioral development and would generally be called "play" even without a precise definition.

The present study is part of a long-term investigation of the social behavior of the mountain goat (Oreamnos americanus). This work was started in 1965 and has been carried out by observing goats for a limited period of time each year during the spring, summer, and fall months. My objective has not been to investigate intensively a particular herd of goats or the goats living in a particular area, but rather to record the behaviors and demographics of a small population over a relatively long period of time. As the general study has progressed, I have concentrated my attention on the following aspects of mountain goat sociobiology: aggression, communication signals, daily activity patterns, feeding, herd division and cohesion, injuries, leadership, mother-young relationships, play, predation, the goats' reaction to me, travel, and a peculiar aggressive-play behavior I cal "whirling". I have also observed closely an changes which might be induced by man's increasing utilization of the study area and the surrounding mountain ranges.

This paper concerns one of the aspects of mountain goat behavior that I have studied most intensively: the interaction between "play" behavior and aggressive behavior. Of course, play in most animals has strong elements of aggressive behavior, so it is entirely expected and predictable that the same would be true of these goats. What is unexpected is the extreme amount of aggressive behavior directed at younger, and therefore relatively defenseless, members of the group, and the relative rarity of what would normally be considered play behavior. The "pure" aggressive behaviors are rather predictable in their outcome, since older animals are usually dominant over younger ones, and males are usually dominant over females. One behavior called "whirling" violates these predictions, however, apparently because it is controlled by a combination of play and aggressive motivations and may in some instances be performed as an almost pure aggressive behavior and in other instances be performed as an almost pure play behavior. Such close associations between

aggressive and play motivations are probably common to most mammals (Wilson 1975, Hinde 1966), but the use of a "play" movement in an aggressive encounter may not be.

Although play behavior has not been studied nearly as extensively as many other behaviors detailed studies of play in many primates and other mammals are fairly common (see, for example, Wilson 1975). The play of ungulates has been thoroughly described by, among others, Darling (1937), Geist (1971), Muller-Schwarze (1968), Walther (1964), and Welles and Welles (1961). In all of these studies there is a clear connection between the movements used in fighting and those used in play. For example, Geist finds mounting and butting behavior as the most common elements of play in mountain sheep (Ovis canadensis), but sees many behaviors involving twisting, leaping jumps, which seem at least superficially similar to mountain goat behavior. Unfortunately, a lack of quantitative data on play makes it almost impossible to compare Geist's findings with mine, although there seems little doubt that elements of mountain sheep and mountain goat play are analogous.

DESCRIPTION OF THE STUDY AREA

The study area (Fig. 1) is a relatively isolated plateau and associated mountains in southwestern British Columbia, approximately 48km north of Mt. Waddington, in the Coast Range. As can be seen in the figure, there are steep, high cliffs on the southeast, southwest, and northwest sides of the area, while a relatively gentle slope goes down to the northeast. Calwell Creek to the southwest and the Kleena Kleene River to the northwest hinder travel in those directions. The Kleena Kleene River is a large, swift and usually deep river, which is difficult to cross, while Calwell Creek is smaller, but still very swift and also difficult to cross. Goats almost certainly travel easily to the southeast, crossing a series of swamps and small streams to reach Perkins Peak and other mountains beyond it. The gentle, heavily timbered slope to the northeast provides easy access to the area for most large animals, but is presumbaly avoided by the goats.

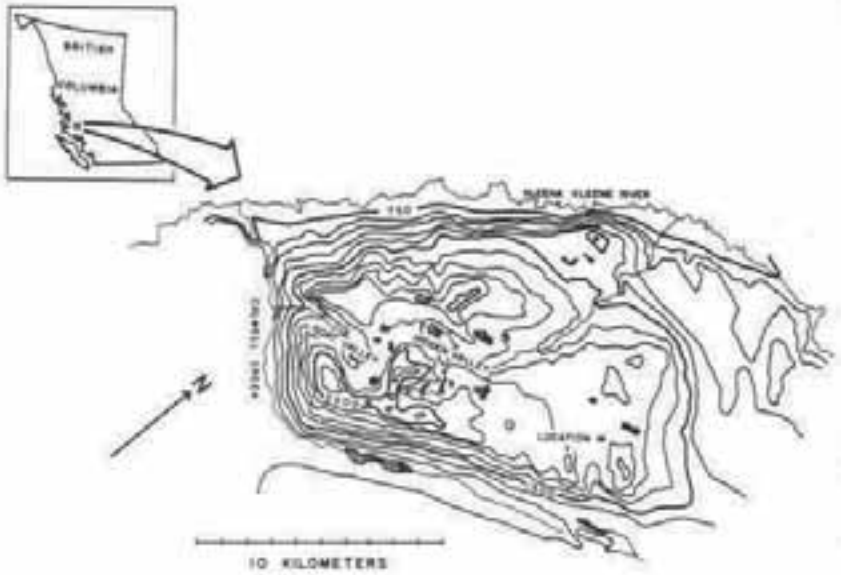

Figure 1. Contour maps of the study area. Elevations are in meters.

The high plateau and mountains making up the study area are approximately 16km long and six and a half km wide. Between location M and the mountains to the southwest is a flat, barren plateau five kilometers long and three kilometers wide. Another broad, flat area is found at the upper, northwest end of Hidden Valley, and on a small plateau on the northern edge of Goat Valley. All of these flat areas are heavily utilized by the goats during at least part of the summer months. They also, however, spend a remarkable amount of time in the heavy timber at the lower end of Goat Valley, and in the draws going down to the southeast of location M. The mountains on the southern and northern parts of the area are between 2300 and 2500m high and are generally bare rock or snow. Although the goats travel over these mountains, they spend little time on them except during unusually hot summer days, when insects are prevalent. Most of the time the bases of the mountains are utilized as bedding areas, but usually the chosen bedding sites are only 90 - 225m above the valley floors.

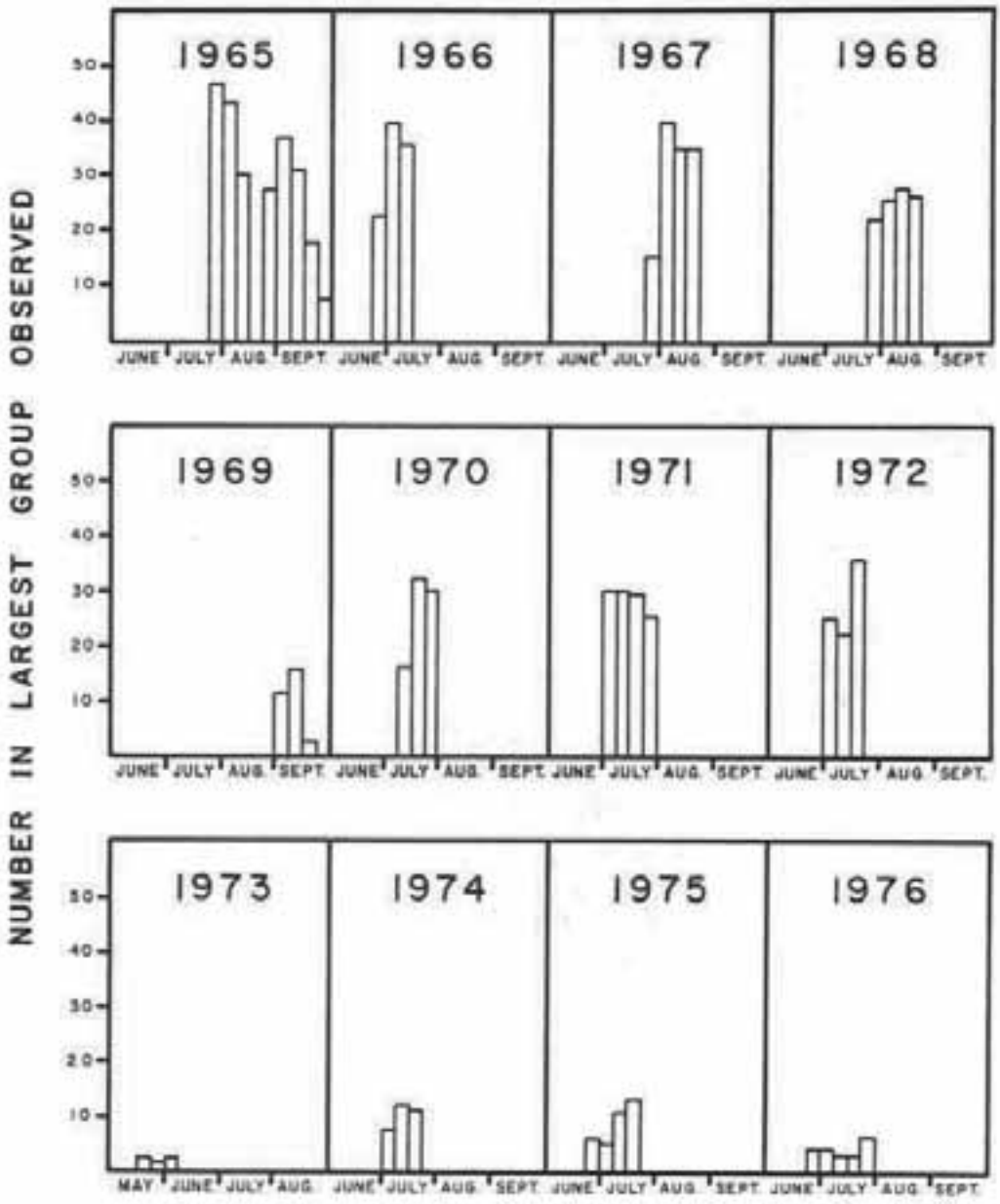

Figure 2. Largest group of goats observed during each week of the study.

MATERIALS AND METHODS

Observations were made with either an 8 x 30 binocular or a 30 x 60 telescope. Although in many cases the animals showed little fear even when 5 - 10m away, I tried to stay at least 100m away in most situations. Notes were tape recorded to allow continuous observation of the animals, and in virtually all cases were transcribed that evening.

Table 1 lists the times of observation over a 12 year period, including the total number of hours during each field season. These figures include only the amount of time when I was directly observing the goats with either a telescope or binocular. Approximately 800 additional hours were spent close to goats, but not directly observing them. These data can be summarized as follows: 214 days in the field; 642.6 hours of direct observation. Particularly in 1969 and 1973, I tried to go to the area both early and late in the year to obtain information on the sociobiology of the herd. Data from these two years indicate that in general the goats leave the area in the middle of September and return during June, depending on the severity of the weather and the depth of the snow.

Table 1. Periods during which goats were observed from 1965 - 1976.

Year	Date	Hours Observed
1965	July 29 - August 9, August 28 - Sept. 4 Sept. 10 - Sept. 18, Sept. 27 & 28	67.5
1966	June 28 - July 10	37.8
1967	August 6 - 16, August 20 - 23	49.5
1968	August 1 - 12, August 16 - 21	50.3
1969	September 5 - 21	28.4
1970	July 16 - 30	41.8
1971	July 14 - 24, July 31 - August 6	68.3
1972	July 1 - 12, July 16 - 21	62.5
1973	May 18 - June 7	37.8
1974	July 2 - 18	68.7
1975	June 26 - July 9, July 14 - 30	69.1
1976	July 8 - 26	60.9

Between 1965 and 1974, 15,000 feet of 16mm motion picture film was taken. This was done to produce accurate records of behavioral sequences which would later allow careful analysis of changes in behavior over time and possibly accurate identification of individuals from their horn structure and general physical appearance. A disastrous fire in April, 1975, destroyed all of the film and all of the data which had been analyzed. The original field notes were preserved, allowing a reanalysis of the written material.

RESULTS

Before discussing specific aspects of play or aggressive behavior, it is necessary to discuss the way in which the herd has changed over time. Even the most superficial examination of the data indicates a drastic decline in the size of the main herd and of the numbers of goats inhabiting the study area. Since the size of the group has a marked influence on the amount of aggressive behavior and on the opportunities for play and other social activities, a clear picture of any reduction in the number of animals must be presented before trying to explain the relationships between different social activities. Therefore, the sections that follow will discuss changes in herd size, the way in which goat societies are structured, an analysis of play behavior as seen in young individuals, and an analysis of "whirling" behavior, an apparently aggressive-play behavior.

Herd Size - The data presented in Table 2 indicate the numbers of goats in the study area each year. Where possible, the figures are broken down into the goats of different age classes. Much of the data on herd composition was lost (fire), thus details of herd composition can no longer be made for 1965, 1966, and 1967. I have also indicated the number of adult males in the study area, although this figure is certainly not exact. Adult males frequently spend their time together with other adult males, or alone, but relatively infrequently are they a part of the main herd. Since all available time was spent observing the main herd, I did not systematically search out these isolated goats. Probably the numbers given for adult males is correct in relative terms, and many air searches indicate that the total numbers of adult males is approximately correct.

Table 2. Number of goats in each age class in each year.

Year	Age Class* 0.3	1.3	2.3	Adult Female	Adult Male	Total
1965	10	---------- 34 ----------			3	47
1966	3	10	---------- 25 ----------		2	40
1967	11	2	---------- 28 ----------		1	42
1968	3	6	2	23	2	36
1969	3	-	2	11	2	18
1970	7	4	2	20	3	36
1971	7	6	3	14	2	32
1972	8	5	5	16	3	37
1973	0	1	-	2	1	4
1974	0	4	2	10	1	17
1975	2	0	1	10	1	14
1976	0	1	2	4	1	8

* The approximate age of the goats during the months when most of the study was conducted (July, August, September).

There has been a decline in the goat population, but the decline has been irregular. The first year of the study, 1965, saw the highest population, with a slight decline over the next two years. Remembering that in 1969 I was in the study area late in the fall, making the numbers for that year difficult to assess, it seems that the population was relatively static from 1968 to 1972. Again, 1973 is a difficult year to assess, because I was there very early in the spring. However, 1974, 1975, and 1976 show a dramatic decline in the goats, when observations were made largely during July, a time of high population in other years. These same data are seen in more graphic form in Fig. 2, which shows the largest groups of goats seen in each time period that I was in the area. In order to simplify the comparison of each year's data, I have lumped the data together into blocks, each block representing approximately one quarter of a month. The blocks are from the first to the seventh day, the eighth to the fifteenth day, the sixteenth to the twenty-second day, and the twenty-third day to the end of the month. Again, a dramatic decline in the population is seen, although it must be remembered that here the figures are not representing the total number of goats in the study area, but rather the maximum size of any grouping observed.

If the data for 1969 and 1973 are once again considered inconclusive, the other years show an initially gradual and then very sharp decline in the number of young goats - kids and yearlings. Since the females keep their young with them for at least two years, they mate only every other year. During the first four years of the study, there was a sharp imbalance in the number of young produced each year, apparently due to this staggered breeding. The data for 1970, 1971, and 1972, however, show a consistent number of kids, while the data for 1974, 1975, and 1976 show almost no kids.

These data also indicate that the same group of goats visit the area each year. Neglecting 1969 and 1973 the numbers of kids, yearlings, and two-year-olds are consistent from year to year, in most years of the study. Inconsistencies are seen in later years probably indicating that only part of the herd was observed each year. Animals not observed either failed to migrate to the study area or did not arrive during my field season.

When it became apparent that the herd was decreasing in size, I felt reasonably sure that the reason for the decline was the drastic change in the weather seen in the Kleena Kleene area and throughout the northern hemisphere (Kukla and Kukla 1974). Reconnaissance both by air and snowmobile (Roger Dane pers. comm., Allan Bittner pers. comm.) indicate that no goats spend the winter months in the study area. Most apparently migrate approximately 25km southeast, although some evidence indicates that there may have been a shift in the migratory pattern so that more animals may now move southwest. Since the goats definitely leave the area during the winter, I felt that heavy summer snow and cold weather might prevent their return. Certainly my weather records show unusually deep snow in 1972, 1973, 1974, and 1976, with a gradual increase in the size of the snow banks in the study area. Particularly in 1974 and 1976, the snow was deep until the end of July. (In contrast to the cold, late years, 1975 was a dry year, with little snow in the mountains, and the temperatures recorded at my base camp were the highest that I have seen in 12 years.) This shift to generally cold, late years, with heavy snow, may be responsible for the herd decline, but there are no weather stations near the study area, and my records are kept for such short periods each year that their data are not conclusive.

Social Structure - When mountain goats are together in a group, there is a surprisingly large amount of aggressive behavior. Since they appear to use a comparatively small repertory of communication signals, I propose that these frequent aggressive encounters are one of the most important elements in establishing the structure of the group. Furthermore, aggressive behavior has clear connections with play behavior, which strengthens the view that aggression is important in shaping the relationship between individuals.

During the twelve years of this study, I have tried to record large numbers of aggressive, or seemingly aggressive, interactions to find out how predictable the outcome of such encounters may be. Although 774 encounters have been analyzed, data on many more encounters were lost (fire). Nonetheless, the remaining data do show certain trends in these social interactions (Fig. 3). Actions used by dominant individuals are grouped into four categories, although in some cases (13 out of 774) actions in two categories were used during a single interaction. The division of aggressive behavior into four categories is, of course, subjective, but is based on the following assumptions. Movements involving moving toward another individual at a walk, slight motions of the head toward another individual, or circling around another individual at a walking pace have all been included in the category "Head Movement or Circle" (abbreviated H.M. or C. in Fig. 3). All of these behaviors are "low intensity" in that they involve interactions of short duration and relatively slight amplitude (Hinde 1970). The next category, "Hook" (abbreviated H.) is also variable, but inevitably involves the aggressor hooking its horns toward the individual to be displaced. In violent hooks the fron feet of the animal may lift off the ground and the body may twist through up to 180 degrees. Chases have been rather arbitrarily divided into two categories usually on the basis of the length of chase. "Chase" (abbreviated Ch.) refers to chases of usually less than 10m and a duration of less than 5 seconds. "Extreme Chases" (abbreviated E. Ch.) often last for 15 - 20 seconds, sometimes as much as 300 seconds, and routinely cover 20 or more meters.

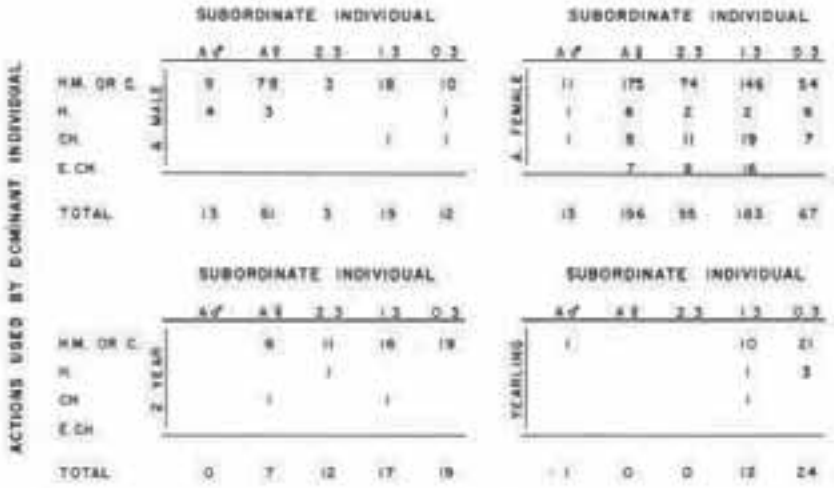

Figure 3. Analysis of aggressive encounters (A♂ = adult male, A♀ = adult female, 2.3 = two-year-old, 1.3 = yearling, 0.3 = kid; H.M. = head movement, C. = circling, H. = hook, Ch. = chase, E. Ch. = extreme chase).

The data in Fig. 3 show that out of 774 interactions, males were the aggressors in 132 instances (17 percent), females in 561 instances (72 percent), two-year-olds (sex not specified) in 44 instances (6 percent), and yearlings in 37 instances (5 percent). Male aggression further shows virtually no chasing behavior and a preponderance of interactions involving males displacing adult females. Female aggressive interactions are almsot equally directed at adult females and yearlings, while two-year-olds and kids are less commonly attacked. Two-year-olds and yearlings are not particularly aggressive, but usually follow the rule of attacking only animals in the same or a younger age class.

However, the analysis of male/female interactions is not as clearcut as it appears. As Geist (pers. comm.) has correctly observed, the fact that a goat withdraws after an encounter does not necessarily mean that that goat is submissive; it may withdraw even if it is dominant. Apparently, in these situations, the withdrawal is based on a motivation to avoid conflict, rather than to participate. Furthermore, young males (two-year-olds) are often more aggressive than adult males, and therefore may disobey the normal conventions of being subordinate to older individuals. My data show some of this ambivalence when females are dominant over males, and when two-year-old males are dominant over adult (four years or older) males. Part of this difficulty has been overcome by eliminating any encounter from consideration where I was unsure of the outcome, but decisions on this point are not absolute, and should not be viewed as such. It is also important to state that unlike Geist's goat herds (Geist 1964), my herds frequently contain adult males, who may remain with the herd for days at a time, and are clearly very dominant over all females.

Play Behavior - There is still no satisfactory definition of play behavior. Inevitably, each investigator must make decisions about which activities will be classed as play, as opposed to purely exploratory, agonistic, etc., behavior. These decisions are partially based on subjective criteria. This has been as much of a problem with mountain goats as with any animal, because play is so intimately associated with aggressive behavior. The definition used by Bekoff (1972): "social play is that behavior which is performed during social interactions in which there is a decrease in social distance between the interactants, and no evidence of social investigation or of agonistic (offensive or defensive) or passive-submissive behaviors on the part of the members of a dyad (triad, etc.) although these actions may occur as derived acts during play", is appealing in its simplicity, but may well eliminate most activities from being categorized as play. There is no way that I can deduce the underlying motivation when a young mountain goat goes through a behavior which appears to me to be play. What I have done instead is to establish 10 categories of activity which appear not to be either purely exploratory or purely aggressive, but which often involve a decrease in social distance. These actions have usually been performed in social situations, but are sometimes performed by single animals. In cases where there was doubt in my mind about whether a behavior should be classed as play as compared with aggression or exploration, I have deleted the data from further consideration. Such apparently confusing behaviors have been seen rarely.

The 10 movements seen regularly in play behavior are: Butting, Circling, Head Over, Head Under, Hooking, Jumping, King of the Castle, Mounting, Running Away, and Whirling. Before discussing the parameters of play, I will describe each of these actions. Beside the name of the action are figures showing the number of times each action has been seen and its approximate duration. The number of times each behavior has been observed is very low for two reasons. First, many of the data were destroyed by the fire. Aggressive and play behaviors were the focus of much of the film, and were recorded with the obvious intention of later detailed analysis. Second, the longest and most intense play bouts seen were very early in the morning, when the light was poor and the goats were about 2km away. At that distance in the dim light prior to sunrise, many behaviors were recorded only in general terms, and not in detail.

Butting: observed 75 times, duration 2-5 sec. This action involves one individual lowering its head and butting another individual. When accompanied by "circling", the butts are usually directed at the side or rump of the other goat, since the two goats are in a head-to-tail orientation. At other time, butting may be directed at any part of the other goat, although about 70 percent of the time the rear part of the body is chosen. Many times butts are given repeatedly.

Circling: observed 80 times, duration 5-25 sec. As already stated, circling occurs in a head-to-tail orientation with the sides of the two goats anywhere from a few centimeters to a meter apart. The few data available for analysis indicate that there is an almost even division in the direction of circling behavior and indicate that the direction of circling alternates quite regularly. A typical play sequence shows circling clockwise for two full turns, counterclockwise for one turn, clockwise for two turns, clockwise for one and one half turns, counterclockwise for two turns, and clockwise for one turn. Circling may be rapid of slow, depending on the intensity of play.

Head Over: observed 20 times, duration 2-20 sec. This is a variable behavior as one goat may put its head over almost any part of the other goat. In 9 instances, the head was put over the back, in 8 instances over the rump, and in 3 over the neck. Head Over may precede Mounting.

Head Under: observed 8 times, duration 5-40 sec. Like Head Over, this action is variable. In 6 instances, the head was put under the belly, in one instance between the hind legs, and in one instance under the neck. Head Under was accompanied by butting in 6 cases. The action is very forceful and on three occasions the body of the goat receiving the action was lifted partially off the ground. Once, the butting activity seemed to cause pain, and the kid being butted repeatedly sat down on its haunches, apparently trying to the individual with its head under to stop the behavior.

Hooking: observed 4 times, duration 2-5 sec. Hooking in young goats looks like that seen in adults, with one animal usually hooking at the side or rump of the other. The action is so rare in the bouts of play analyzed that little can be said about it.

Jumping: observed 88 times, duration 2-3 sec. When two or more young goats are on a rock or a mound of earth, one will often leap off the elevation, usually with a highly exaggerated jump. I define exaggerated as a jump that carries the animal far from the start of the jump and often in a long "sailing" arc. Such behavior has been seen in other situations, particularly when young goats are crossing streams. The most intense performance of jumping that I have observed was part of a game of "King of the Castle", in which each of the participants alternately jumped off a series of large rocks.

King of the Castle: observed 13 times, duration 10 sec. to 3 min. This is a form of the classical game wherein one animal ascends a projection and tries to keep others from gaining a position at the top. Although seen rarely, some of the games were long, involving up to 13 different scalings of the rock by the two participants. As will be seen, this complex game is interspersed with Butting, Circling, Jumping, Head Over, Head Under, Running Away, and Whirling.

Mounting: observed 93 times, duration 3-45 sec. In all cases, the goats mounted each other from either the side or the rear, with rear mounts being much the most common. Sometimes pelvic thrusting was seen, though rarely, and when thrusting was seen, the mounts tended to last for at least 10 seconds. When one goat succeeded in mounting another, it usually, but not always, put one front foot on each side of the other individual.

Running Away: observed 64 times, duration 3-10 sec. One goat runs away from another, which may be followed by the other one chasing it. Obviously a highly variable behavior.

Whirling: observed 25 times, duration 1-4 sec. In a sense, the most interesting of all play behaviors, because it is performed by adults as well as young individuals and sometimes by single goats. The action varies in its intensity. In a low intensity whirl, the goat tosses its head while partially twisting its body and usually raises its forefeet off the substrate. At greater intensities, the head toss becomes extreme, lifting the body into a vertical position until the hind legs leave the ground. The twisting motion that accompanies the initial head toss is continued so that the animal may make at least one complete turn, in the air, before landing. During play bouts, Whirling is less common than Jumping or Running Away, but is frequently associated with these activities.

What I classify as play behavior has been seen rather rarely among members of the group. Out of 214 days in the field, I observed goats on 191 days and saw some form of play behavior on 37 days. On those 37 days, 89 "bouts" of play were observed. A bout as defined here means any continuous sequence of play behavior, with the realization that under field conditions precise marking of the end of a bout is difficult. Usually such problems do not arise, since play bouts tend to be very short and occur at widely scattered times of the day. There are no instances where I feel that two bouts have been separated where they were actually one bout, but in the few instances where the goats played for long periods of time (10 minutes or more), there is some likelihood that the play periods were made up of more than one bout. If play stopped for more than 30 seconds, the resumption of play was classified as a new bout.

The data on the frequency of play are biased to some degree by the almost total absence of young goats in the group in 1969, 1973, 1974, 1975, and 1976. No play was seen in 1973 and 1976, one bout in 1969, two bouts in 1974, and two bouts in 1975. This bias can be eliminated by considering only data obtained during 1965-1968 and 1970-1972. Doing so shows that out of 114 days when goats were observed, play was seen on 32 days and 84 bouts were recorded. Of these 84 bouts, durations were recorded in 77 cases, revealing an average duration of 261 seconds with a standard error of 66 seconds. The very large standard error is explained by the fact that 38 bouts had a duration of 20 seconds or less, while there were 7 bouts that lasted from 10 minutes to 52 minutes. Out of a total play period of 5 hours 40 minutes recorded in 1965-1968 and 1970-1972, 3 hours 20 minutes were consumed by 7 long play periods, the specifics of which are as follows:

Time of Day	Duration	Group Composition
4:50 - 5:34 a.m.	44 min.	2 kids
5:00 - 5:52 a.m.	52 min.	4 kids
9:46 - 10:05 a.m.	19 min.	3 kids
1:44 - 1:55 p.m.	11 min.	2 kids
2:03 - 2:22 p.m.	19 min.	2 kids
3:50 - 4:40 p.m.	40 min.	2 kids
10:15 - 10:30 p.m.	15 min.	2 kids

Further analysis of the data indicates the frequency with which play was seen each day and is shown below.

No. of bouts/day	No. of days when seen
1	11
2	9
3	1
4	2
5	5
6	4

Usually, then, only one or two bouts of play were seen on any given day, but on 11 days 4 or more bouts were observed (Table 3). There does not seem to be a particular pattern to these data, except that all of the days when play was common were either in July or August (the months when I was usually in the study area, and when the goats reach their peak number in the study area) and the bouts of play tend to occur during the middle of the day.

Table 3. Days on which four or more bouts of play were seen.

Date	Time of Play Periods	No. of Bouts Observed
July 9, 1966	11:20 - 3:20	5
August 16, 1967	11:30 - 3:30	5
August 21, 1968	10:40 - 12:00	6
July 18, 1970	11:10 - 9:00	5
July 19, 1970	9:45 - 10:50	6
July 21, 1971	10:30 - 7:30	4
July 23, 1971	1:30 - 3:00	4
August 4, 1971	12:00 - 2:50	5
July 3, 1972	1:25 - 3:15	6
July 4, 1972	1:30 - 2:15	5
July 18, 1972	3:00 - 4:45	6

Most bouts of play occur when two kids are playing: 67 percent of all bouts seen. Bouts containing three and four kids are fairly common, (16 percent and 5 percent respectively) but all other groupings, including instances where yearlings played with kdis, are rare. In three cases there were two yearlings who played together without kids.

Two other major aspects of play were observed in detail: the reaction of other individuals in the group to those playing, and the number of times when two or more kids were together without play occurring. Other individuals reacted to play on 13 occasions. Seven times adults in the group, not related to any of the playing participants, came toward the playing group and forced all members of the group to move away. Out of these seven instances, there were three times when the kids were playing on top of a rock and the adult made them jump down, once when an adult ran after two playing kids, and three times when the adult simply walked toward the kids. On two occasions, mother's kid, and on two other occasions a mother came toward playing kids and forced the kid, or two kids, not belonging to her, to move away. Once a yearling and once a two year old also forced two playing kids to move away from the rock on which they were playing.

There were 30 times when two or more kids were within two meters of each other for two minutes or more and failed to show any play. On one occasion, six kids were "together" for 40 minutes without playing. The data on the behaviors used to initiate play were contained on the film, so it is impossible to tell whether eliciting signals were never given or whether the other member(s) of the group failed to respond to such signals.

Whirling Behavior - Whirling has been described previously in this paper as a play movement, so I will not describe it again. It is important, however, to reiterate that this jumping, twisting behavior is highly variable both in form and in duration. A low intensity (small movement, short duration) Whirl consists of nothing more than a toss of the head which partially raises the forward part of the body, while in a high intensity (large movement, long duration) Whirl, a goat will jump several feet in the air and twist around through more than 360 degrees.

The first question to be investigated with Whirling was the size of the group when some members of the group Whirled. Whirling was most common in large and small groups and rare in medium-sized groups (Table 4) ($x^2 = 14.1$, $p = 0.05$). Whirling occurred on any terrain, although 63 percent of the 61 bouts occurred on steep slopes (Table 5). When Whirling did occur on steep slopes, the benefit to the animal was considerable, since about 20 percent of the time when Whirling was intense, the animal slipped as it landed. While it may be more likely to slip when landing on a steep slope, the likelihood of injury is far less. Although once again the sample is very small, the table shows that 75 percent of the time Whirling which was part of play occurred on steep slopes. (Note that although goats whirled 25 times while playing, this occurred in 8 bouts).

Table 4. Size of the group when at least one goat whirled.

Group size:	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
# instances:	11	8	8	2	2	8	13	9

Table 5. Conditions under which Whirling took place.
(The general behavioral categories of Whirling are shown in the left column, while the types of terrain on which it took place are shown horizontally.)

	General Terrain Features				
	Steep Snow	Flat Snow	Steep Earth or Rock	Flat Earth or Rock	Total
Aggressive	10	2	2	7	21
Non-aggressive	16	2	6	10	34
Play	3	2	3		8
Total	29	6	11	17	63

Whirling was considered to be aggressive when one individual approached another and directed the Whirl at that other goat. When animals perform this action, they may do so in direct contradiction of the expected dominance hierarchy; that is, a younger animal may direct the action at an older animal and still not suffer the consequences that would ensue if the younger individual attacked the older one in a more definatively aggressive fashion. Usually the movement of the head which started the Whirl was toward the other goat, but in some situations one would approach another and whirl when one or two meters away. This behavior seemed to be part of a "greeting ceremony" which is seen when one individual approaches one or more other individuals after being separated from them for apparently long periods of time (unpub.). The decision that such a behavior is directed at another goat is not subjective, since in all cases aggressive Whirling was accompanied by other aggressive behaviors, particularly Head Movements and Circling. Since much aggressive Whirling behavior involves only one goat Whirling, I further investigated all instances involving a single individual Whirling (Table 6). This was done to determine whether all instances involving single goats Whirling were aggressive in nature, or whether goats Whirl singly as a play movement. These interactions show that kids and yearlings usually whirl alone when no aggression is involved, while two-year-olds and adults often whirl alone when aggression is involved. (Particularly in the kids and yearlings these Whirling bouts may involve more than one Whirl.) It is somewhat surprising to see that adults whirl alone almost as often without aggression as with agression, and leads me to believe that even in adults, Whirling is often a type of play behavior. Although the data on kids may appear to violate the principle stated earlier that young individuals may only be aggressive to animals of the same or a younger age class, the two times when kids whirled "aggressively" were actually times when the kids had just been displaced by adults. The kids, then, were apparently whirling in response to adult aggression. Most of the time, however,

kids and yearlings whirled singly either as part of play bouts, or in situations which were probably motivated by play and not by aggression.

Table 6. Analysis of Whirling when only one goat Whirled.
(The general behavioral categories of Whirling are shown in the left column, while the age classes of the goats are shown horizontally.)

	Age Class of Whirling Individual (in years)				
	0.3	1.3	2.3	Adult	Total
Aggressive	2	3	5	5	15
Non-aggressive	9	5	1	4	19
Play	2	2			4
Total	13	10	6	9	38

The final aspect of Whirling to be investigated is the identity of individuals who whirl when most, or at least a large percentage, of the group whirls. Without the film, only four cases could be analyzed where five or more individuals participated in a Whirling bout. Apparently adults participate as much as young goats in these mass Whirling bouts. While it is true that the adults do participate in Whirling, the kids and yearlings usually whirl many times per Whirling bout, while the adult females often whirl only once. In terms of total Whirls per bout, then, the young age class goats (kids and yearlings) are far more active than older individuals.

DISCUSSION

The preceding data on mountain goat social behavior and demographics indicate that the group under study has undergone a severe population decline during the past three years, and a gradual decline during the preceding nine years. Reasons for the decline may well rest on changing weather patterns, but several other possibilities should be mentioned; namely predation and man's increased utilization of the area. My data on predation are sketchy, at best, but indicate an essentially stable population of predators. Figures are based on actual sightings of predators and on measurements of tracks. These show that except in 1970-1972, there have been between one and three wolves that periodically visit the area, a family of grizzly bears in 1965 and 1967, but otherwise only single grizzlies passing through at infrequent intervals, and usually no black bears except in 1965, when there were five families, and two single individuals. (In 1970, 1971, and 1972 no wolves were known to have visited the study area). Mountain lions have never been seen, and tracks have been observed on only two different years. In 1967, the family of grizzlies killed an adult goat, (sex unknown) and in 1974 I watched two wolves attack three goats: two adults and one two-year-old. My data, then, do not indicate that at least in this study, predators have caused the population decline, but data are sparse.

Man's presence may have had greater effect. Unfortunately, in 1969, a dirt road was constructed to Perkins Peak, the next mountain to the south of the study area. This greatly facilitated transport into the general area and multiplied enormously the number of people affecting the goats. Limited data suggest that much of the group migrated over Perkins Peak up to 1969, while in later years goats seemed to enter the area from the southwest. Again, these data are very poor and can serve only as a suggestion, but it may be that the road and its concommitant increase in numbers of people has contributed to the herd's decline. Of interest, in this regard, is the density of the other two ungulates who inhabit the study area: moose (Alces alces) and mule deer (Odocoileus hemionus). During the course of the mountain goat study I have kept records of all sightings of these two species. The data are inconclusive, but indicate a substantial decrease in the deer population while the moose population has apparently remained stable. Whether the apparent decrease in the number of mule deer is correlated with weather changes remains unknown.

Clearly the dramatic decline in the mountain goat population has greatly affected all parts of the study. The almost total absence of young age class goats during the period 1973-1976 has been so drastic that few instances of play or Whirling have been seen. During 1977 I plan to visit the area in August, the month of greatest density in other years, to make certain that the goats are not simply arriving in the area later than they used to. Such a possibility seems relatively unlikely, since the population was so small in 1975 when the snow cover had largely melted by July 1st.

The analysis of aggressive behavior, although greatly reduced by the lack of film and the reduction of herd size in recent years does show some significant trends. As was found by Hibbs et al. (1969), adult females were usually the aggressors. Most of their aggressive interactions were of the type described by Geist as weapon-threat or present-threat (Geist 1964), and often involved only walking toward another individual or slightly lowering the head at another individual. It is also apparent from the data in Fig. 3 that females are rarely dominant over males, but that when males exhibit dominance it is usually toward an adult female. Geist (1964) found that females were dominant over males, but does not give enough data to make a comparison with this study viable. Possibly since his study was conducted late in the fall, during the rutting period, there had been a change in dominance status. I have never observed my herd in October and November, so I have no idea whether they might change the clear male dominance seen during the spring and summer months. Since females are the aggressors 72 percent of the time, it may make sense that they are virtually the only individuals who perform either "chase" or "extreme chase" actions, but the result seems surprising to me. I had expected to see male Chases as well as female Chases, but the actual situation only reinforces the view that in this herd, at least, females are the really aggressive individuals. The exact relationships between known individuals and between different classes of adult females (females with kids, females with yearlings, and females without young) are being analyzed (unpub.).

Geist (1964, 1966, 1967) emphasized properly the danger involved in the primitive type of aggressive encounters engaged in by mountain goats. In the present study, fur was dislodged in 4 of 29 instances of Hooking. Although none of these actions appeared to injure the recipient, the possibility of severe injury was clearly present. During the 12 years of the study, 18 injured goats were seen. Three of the injured individuals were kids and all appeared to have been hurt by horn punctures; all apparently recovered. There were also four injured two or three-year-old individuals who seemed to have been hurt in aggressive encounters. The other 11 goats were older individuals and in only three cases was it reasonably certain that the injury was inflicted by another goat. Such evidence adds at least some credence to the idea that fighting in goats is often overt aggression rather than a series of displays.

Since aggression plays such an important role in the formation and maintenance of mountain goat societies, one would almost predict the presence of a movement like Whirling. This action is almost certainly controlled by a variety of motivations. It has been seen in isolated single individuals, where it is difficult to imagine that aggression is important, and in groups where it either preceded, alternated with, or followed more clearly aggressive behavior, such as Hooking and Chasing. The action seems at least superficially like leaping seen by Muller-Schwarze in black-tailed deer (Odocoileus hemionus columbianus) (Muller-Schwarze 1968), the threat jump in bighorn sheep (Ovis canadensis) (Geist 1971), cavorting in the wildebeest (Connochaetes taurinus) (Estes 1969), the jumping, turning, twisting movements seen in various cavimorphs: the degu (Octodon degus), the chor-chor (Octodontomys gliroides), the salt desert cavy (Dolichotis salinicola), and the harbor seal (Phoca vitulina) (Wilson and Kleiman 1974), and possibly like stotting, as exemplified by Grant's and Thompson's gazelles (Gazella granti and G. thompsonii) (Estes 1967). Like many of these actions, seen in a variety of different species, Whirling often seemed to be "pure" play behavior: that is, there were no connecting aggressive actions. Its use as an aggressive behavior, however, is also reasonably clear. The fact that single adults, single two-year-olds, and single yearlings will approach another goat, perform Head Movements or Circling, as well as possibly Hooking and Chasing, and then Whirling leads me to think that in those situations the Whirl is largely aggressive.

The question then becomes, why Whirl instead of performing some other more usual aggressive behavior? I believe that the answer lies in the interpretation that other animals give to a Whirl. If it is most often used as a play behavior, or at least as a non-aggressive behavior (Tables 5 - 7) then the animal performing such an action during an aggressive encounter may indicate an ambivalence in its behavior. The kids and yearlings in Table 6 who whirled aggressively could not have circled an adult or two-year-old without being immediately attacked. The same may apply to older goats; a subordinate two-year-old or adult apparently can whirl at a dominant without fear or retribution.

Little has been said about the mass Whirling bouts shown in Table 7. Although details have been lost (fire), it is clear that in these bouts of Whirling, most of the Whirls are performed in undirected fashion, and that considering all of the Whirls that have been seen in 12 years, most are performed in large groups when many goats Whirled. Most of the time, the Whirls are given under circumstances where the goats are separated from one another by distances of 8-10m. The two largest Whirling bouts for which data were not stored on film both took place on July 21, 1971. In the first one, occurring at 12:06 p.m., the group of 22 individuals had just unbedded and was coming down a steep (25 degrees) snow slope. All of the goats whirled, although as usual, the kids and yearlings tended to whirl multiple times, while the adults tended to whirl only once. In most cases a goat would run down the slope, leap into the air whirling, and stop after landing. The behavior was intermittent, each goat whirling as it neared the bottom of the slope. Usually at any given moment only one goat was whirling. At 1:30 p.m. the goats crossed another snow slope, in this case the slope being only about 10 degrees, and again intermittently whirled as they ran down the last section of the slope. As before, each goat was well separated from other members of the group, and

each appeared to wait until no other goats were whirling before it whirled. There was some overlap in the Whirling, but remarkably little considering the density of the group (here, 20 instead of 22 individuals). Such behavior is difficult to construe as aggressive in nature, seeming more like "contagious" play behavior. Small bouts of Whirling were apparently seen by Lentfer (1955), but the descriptions do not provide more than an indication of what was happening. Mass Whirling bouts may be analogous to bighorn sheep huddles (Geist 1971).

If such behaviors are play, they are apparently rather different from what has been recorded in other ungulates. Geist (1971) notes that adult bighorn sheep play "rarely", but that when they do, the play tends to occur early in the day, just after the sheep have unbedded. This may be an interesting parallel with goat behavior, since the longest kid play bouts were seen at first light. Whirling was also observed very early in the morning (4:40 - 5:00 a.m.) which effectively ruled out the possibility (which I had earlier considered) that Whirling was a response to heavy concentrations of insects. When seen early in the day, the temperature at base camp varied from -5 - 2 degrees celsius, and was probably similar where the goats had spent the night. It is hard to imagine that under these conditions the animals were bothered by insects. Estes (1969) also saw adult wildebeests play rarely, but did see cavorting (similar to Whirling) frequently when adults ran away from a predator. In this case cavorting becomes a high intensity threat display.

Such connections between play behavior and aggression or threat are probably common (Aldis 1975). Aldis does not believe, however, that dominance relationships are established during play, but instead in more "serious" situations. My data are not complete enough to either support or oppose this conclusion.

Poole and Fish (1975) found that in rats 81 percent of all play actions were variations of adult behavior, 16 percent were purely playful, with no adult equivalence, and 3 percent were like adult behaviors. Most of the adult behaviors or variations of adult behaviors were aggressive in nature. In mountain goats, Circling and Hooking appear to be like adult behaviors (20 percent), Butting, Head Over, Head Under, Jumping, Running Away, Mounting, and Whirling seem to be variants of adult behavior (70 percent), while King of the Castle seems unique to play (10 percent). This last category is perhaps misleading since King of the Castle (seen also by Darling 1937, in red deer) is really a complex of many behaviors, combined into one game. The game is unique to kids and yearlings, but the elements making up the game are variants on adult behavior or seem not to change as the animal develops.

In most situations, mountain goat play can be carried out among two or more members of the same age class, even if one is much larger, and apparently stronger, than the other. Similar situations have been recorded in polecats (Poole 1966) and, as already mentioned, in bighorn sheep (Geist 1971). In these situations where individuals of different size are playing, the larger individual could presumably overpower the smaller individual and thus act in a rather pure aggressive fashion as opposed to playing. As already noted, various play actions may be performed by yearlings and kids together, but such play is rare, and it is difficult to tell whether the yearling is motivated primarily by aggression or play.

Whatever the motivation for play, it was seen on only 30 percent of the days when the goats were observed, and occurred during only 2 percent of the observation time. These figures are for the group as a whole, and would be much lower for any individual animal. Such figures seem low when compared to other species, but most of the data are from primates and so may not be at all comparable. Aldis (1975) specualtes that "advanced species" may play for approximately 30 - 60 minutes per day, but this figure is for each individual. The possibility remains that the goats play more frequently than the data indicate, because they may play commonly very early in the day when they are usually not seen. There have been two occasions when I did watch them very early in the day (4:30 - 5:00 a.m.), when there were either 7 or 8 kids present and no play occurred. These data are not helpful in establishing whether play normally occurs before sunrise. The observations were made primarily before the time when the two long play bouts (observed on two other days) started. Goats may, then, play more often than the data indicate. There is an indication, though, that play is often not a strong motivation, since there were 30 occasions when kids were within a few meters of one another for two or more minutes, and no play occurred. Normally the kids are scattered throughout the group, remaining relatively close to their mothers. Whatever factors drew them together were apparently not motivated primarily by play.

One aspect of play which has not been considered is the role of sex. Aldis (1975) believes that mounting is not part of play and that it normally disrupts the smooth flow of play behavior. Interruptions in play as brief as one second which occur during the transition form other actions to mounting, he considers as constituting such a disruption. Without analyzing film, I cannot begin to interpret such short intervals of time, but do feel that mounting behavior is part of the normal play sequence. The following excerpt is from my notes of July 18, 1972, and shows an apparently smooth transition from other play actions to Mounting. (Part of the sequence has already been included in the analysis of circling behavior)

3:54 - Butting, then one pushes the other off the rock. Back up. Circle left. Neck over back, pushing other down off rock. Back up. Pushes one on top onto rump, almost pushes off. Circle clockwise two turns. Neck over back - pushes down. Now other does same thing, so are alternating pushing each other down. Neck over back, forefoot and shoulders pushing. Pushes one down who did pushing last time. Comes back up. Circl counter-clockwise one turn. Mounting. Butting. One pushed down. Back up. Mounted. One who is mounting almost gets pushed off. Circle clockwise two turns. One pushed down, gets pushed down again as tries to climb back up. While at bottom jumps up at other. Then goes around to other side of rock and again jumps at other on hind legs. Back up. Is mounted. One who mounted is pushed off. Circle clockwise one and one half turns. One pushed down. Back up. Circle clockwise two turns. Mounting. Butting. One in awkward position, other has head between hind legs and is lifting off rock. Does not quite fall. Circle clockwise one turn. One huge jump off rock landing at least 10 feet from base. Then back up.

Such data are not very quantitative or exact, but lead me to feel that Mounting is part of the play routine.

The most complex play movement seen is certainly Whirling. Furthermore, it is probably the dominant play action seen in adults. Such "rotational" actions may be preactice for emergency manoeuvers (Aldis 1975), or they may be practice for aggressive interactions. I rather like Bekoff's statement that complex play behaviors may be performed because they are "pleasurable" (Bekoff 1976). Whatever its motivation, Whirling is a fascinating variable activity, which remains enigmatic.

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DOMINANCE, LEADERSHIP AND GROUP COHESION OF MOUNTAIN GOATS AT A NATURAL LICK GLACIER NATIONAL PARK, MONTANA[1]

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Abstract: Social behavior of mountain goats (Oreamnos americanus) visiting a natural mineral lick along U. S. Highway 2 in Glacier National Park was observed in 1975. Group size during 118 observed movements ranged from 1 to 47 and averaged 6.7 goats. Nannies with kid at side led more groups during movements (47.5 percent) than other classes. They were the most important leaders since they led larger groups of mixed classes. Billies, nannies, and nannies with kid at side were the dominant classes of goats at the lick. Nannies, two-year-old females, and yearlings were involved in more dominance interactions at the lick than expected by their proportion of the observed population. Dominance and leadership were not equivalent; nannies with kid at side were dominant less than they were leaders, while nannies and adult billies were dominant more than they were leaders. Group cohesion was low in movements to and from the lick; marked goats were re-observed in the same group only 21 percent of the time. Learning was suggested by choice of crossing routes, altered crossing routes after a disturbance, and leadership by adult nannies with kid at side.

A study was made of the behavioral reactions of mountain goats (Oreamnos americanus) to U. S. Highway 2 and a viewing area for visitors in Glacier National Park, Montana (Singer 1975). Mountain goats cross the highway and pass near the viewing area to visit a natural mineral lick located along the banks of the Middle Fork of the Flathead River (Fig. 1). Information on leadership, dominance relations, and group cohesion of goats was gathered incidentally to the highway study. The study period was from March through mid-September 1975.

Some aspects of social behavior in mountain goats have been described by Brandborg (1955), DeBock (1970), Chadwick (1973), and Rideout (1974). Rutting behavior was described by Geist (1964). Geist (1974) theorized that exploitation by ungulates of plant communities with characteristic stability selects for varying levels of cohesion between individuals, leadership, gradual disassociation of mother and young, and home range traditions. Quantitative data are lacking on these aspects of social behavior in mountain goats.

Group characteristics and social interactions of mountain goats at natural licks undoubtedly differ from behavior on the range. For example, male groups visit licks earlier than female/young groups (McCrory 1975, Singer 1975), and visits to licks by many goats results in larger concentrations in a small area than would occur on feeding ranges. Visits to a lick are an important aspect of the ecology of mountain goats. For example, Hebert and Cowan (1971) felt that all or most mountain goats over one year of age travel to natural licks. Therefore, the social behavior of goats at a natural lick is presented here as a special but important aspect of mountain goat ecology.

METHODS

Mountaing goats were observed over a period of 90 days (280 hours) at the Walton Goat Lick from inside a vehicle parked in the viewing area, with use of a 20 - 60X spotting scope. Twenty-seven goats were recognizable; 14 by natural deformities, and 13 by artificial dye. Mountain goats were classified as adult billy, two-year-old male, yearling, kid, adult nanny with kid at side, and adult nanny (without kid).

Licking times and dominance/subordinance interactions were recorded for each sex and age class of mountain goats. Dominance displays included "present-threat", "rush-threat", and "attack", as

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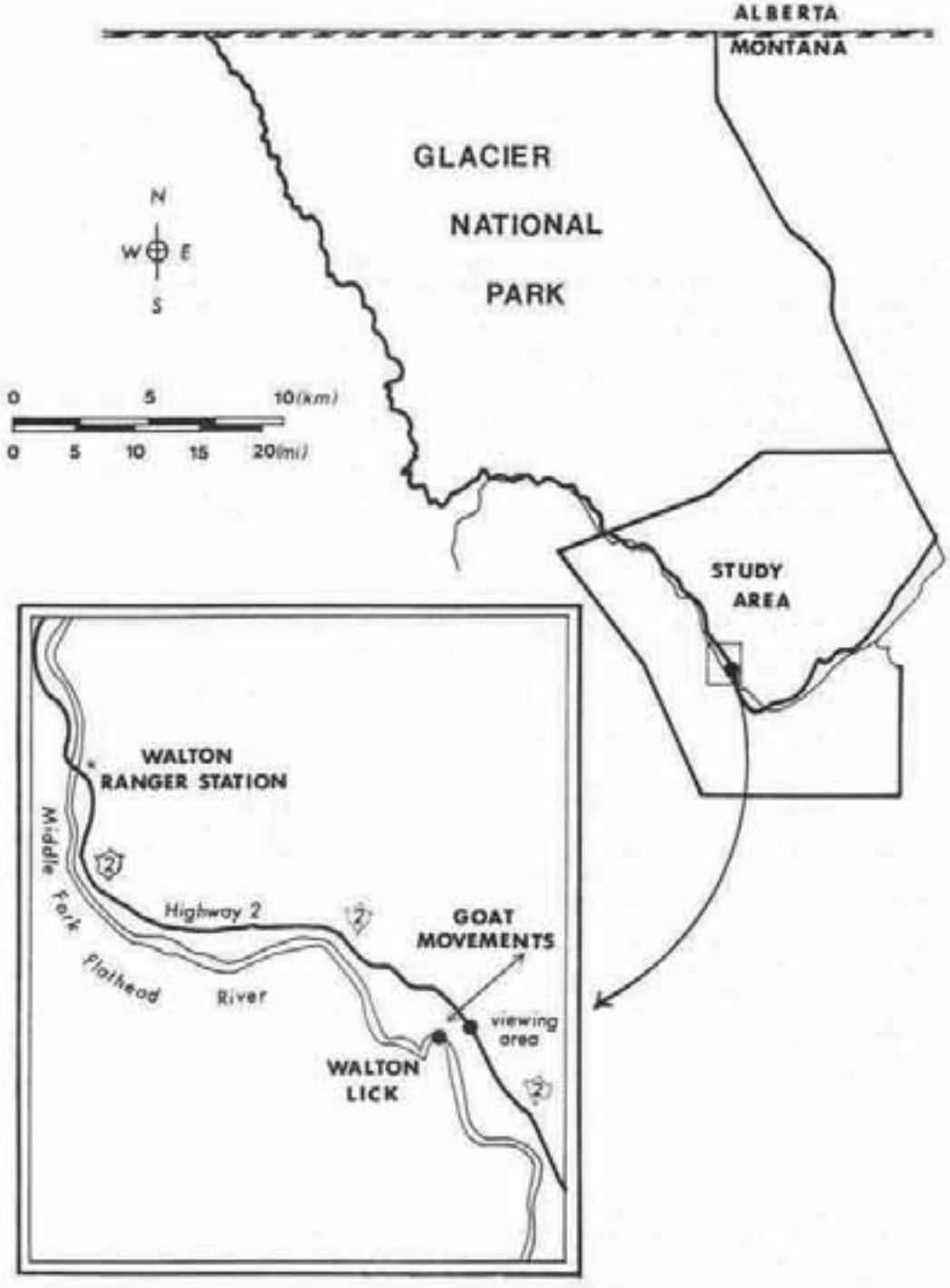

Figure 1. Map indicating study area in the Middle Fork of the Flathead River drainage and primary movement area for mountain goats visiting the Walton Goat Lick.

described by Geist (1964). Only decisive aggressive encounters, where one animal retreated, were recorded as indicators of dominance.

STUDY AREA

The Walton Goat Lick, elevation 6,343m, is an exposure of the Roosevelt Fault which parallels the Middle Fork of the Flathead River and is composed primarily of gypsum, kieserite, and other sulfates. Topography of the area is precipitous, with the floors of steep, narrow valleys at 1,030 to 1,280m elevation, and the peaks and ridges of uplands at 2,133 - 2,048m elevation. Valley sides are mantled by soil, talus, and glacial debris, and outcrops are topical, often occurring only at higher elevations on peaks and ridges (Ross 1959). Outcrops and mountain goat habitat are more abundant to the east along the Lewis overthrust.

Mountain goats pass near the visitor viewing area in regular movements between the Walton Goat Lick and feeding areas at higher elevations (Fig. 1). The lick is located 300m from the viewing area and 100m below the highway.

RESULTS

Mountain goats migrated to the Walton Goat Lick primarily along traditional, well-worn trails on upland crests that stretched up to 10km from the lick. Goat use of these trails and the lick has been regularly observed by Park Rangers at nearby Walton RAnger station since the park's creation in 1910 (Glacier National Park records, 1910 - 1975). Observations were also made (n = 16 goats) of mountain goats arriving at the lick through extensive forested cover. A total of 118 movements to and from the lick by 793 goats were observed in 1975. Observational evidence indicated that a minimum of 89 different goats used the lick, while transiency of the use suggested that as many as 200 different goats may have used the lick; recognizable goats visited the lick for an average period of only 8.6 days (n = 62 observations, range 1-35, SD = 8.2) (Singer 1975).

Mountain goats known to be migrating to the lick region for the first time were in small groups ($\bar{X}$ = 1.6 goats, n = 10), but while at the lick integrated into larger but still tightly-spaced groups ($\bar{X}$ = 6.7 goats, n = 118) in local movements at the lick region. The only goats which did not integrate into the larger groups were first arrivals at the lick and yearlings. Goats just arriving at the lick and apparently yearlings (Chadwick 1973) experience a greater lick drive.

Nannies with kid at side led more groups during movements than any other classes, leading 47.5 percent of the total observed movements. Nannies with kid at side were also the most important leaders, since they led the larger groups of mixed classes (Table 1). Mountain goats moving off the lick often hesitated and waited to join a group, particularly when the group was led by a nanny with kid at side. When groups were split by a passing vehicle, the remainder, hesitating near the road, often waited until a second nanny with kid at side assumed leadership. Other classes were observed standing above the highway crossing area for long periods when traffic volumes and visitor levels were high, but would immediately follow behind the first nanny with kid at side that moved by. Ability of a group to successfully cross the highway versus reluctance to cross or unsuccessful crossing was significantly associated (X^2 = 8.39, $P < 0.025$) with sex and age of the leader, the most successful leaders being adult nannies with kid at side.

Nannies with kids did not solicit companions, although other classes, particularly juveniles (i.e. yearlings and two-year-olds) often did. Soliciting of companions was apparent when goats led away but frequently hesitated and looked back towards other goats. In five observations, yearlings that were unable to solicit companions returned to the lick. Nannies with kid at side were often aggressive leaders and would threaten or chase other goats which attempted to shift position and assume leadership.

DOMINANCE

Dominant classes of goats or those goats which won more interactions than they lost were adult billies, nannies with kid at side, and nannies (Table 2). Classes of goats which were involved in more interactions than would have been expected by chance (X^2 = 87.2, $P < 0.001$) included nannies, two-year-old females and yearlings. These classes were regularly approached by all other goats, including those in their own sex/age class. Nannies with kid at side and adult billies interacted as often as expected, but interactions tended to be between or within their own classes; most other classes clearly avoid interactions with adult nannies with kid at side and adult billies by moving away after staring at them. Kids were sheltered from many interactions by their nanny.

Table 1. Comparison between groups led by the various sex and age groups of mountain goats during 118 crossing attempts of Highway 2.

Sex and Age of Leader	GROUP TYPE							
	Kid	Yearling	Female	Nanny with kid	Male	Mixed	Unidentified Group	Total
Kid	1							1
Yearling		3				1		4
2-Yr Female			2					2
2-Yr Male					8			8
Adult Billy					26		3	29
Adult Nanny			7			4		11
Nanny with kid					15	35	6	56
Unidentified Adult							7	7
Total								118

Table 2. Comparison of the percent of dominance interactions won and the number of interactions involved in between sex and age classes at the Walton Goat Lick. Expected values are based upon sex and age ratios in the lick population. An "*" indicates a statistically significant difference between the observed and expected values ($P < 0.05$).

Sex and Age Class	Number Won	(Percent)	No. of Interactions Involved in (expected)
Kid	0	(0)	63 (72)*
Yearling	3	(6.3)	48 (31)*
Two-year-old Male	3	(16.7)	18 (13)
Two-year-old Female	3	(18.8)	16 (8)*
Adult Nanny	26	(58.7)	46 (25)*
Adult Nanny with kid	53	(84.1)	63 (72)
Adult Billy	60	(89.6)	67 (49)
Total	148		270 (270)

Aggression and dominance interactions increased as the lick area decreased. The entire lick deposit was utilized during or after a rain. By late summer, the active lick area had decreased from 3.600m to only wet seeps (about 360m^2); consequently competition and dominance interactions increased. Five goats, including one adult billy and four two-year-olds, were actually excluded from the lick at a time when 57 goats were present. Chadwick (1973) found that aggression rates in mountain goats increased as group size increased.

Dominance appeared to infulence leadership, but the two factors were not entirely correlated. For example, adult billies and nannies with kids were two most dominant classes (Table 2) and

these two classes led more groups than others (Table 1). The dominant goat was also the leader in 13 (68 percent) of 19 movements wher the complete dominance relations of the group were known. In some cases, subordinate classes led dominant animals; for example, in two instances I observed two-year males leading adult billies, and in one case, a yearling leading an adult billy. Leaders were likely to lead groups of the same class as themselves, with the exception of adult nannies with kids, which led 35 (87.5 percent) of the mixed groups observed (Table 1).

GROUP COHESION

New arrivals to the lick initially avoided other goats but eventually integrated into the group(s) present and adopted their regular movements. Cohesion was low in these groups of goats. Marked goats re-observed in groups (n = 48) were in different groups 38 (79 percent) times and in the same group only 10 (21 percent) times. In some cases small groups remained apart from larger groups; nine observations were made of small cohesive groups passing intact through larger groups. A single adult billy never joined a group during four days he was present at the lick.

Goats were likely to be re-observed in the same group type; i.e. kid, yearling, female, nanny with kid, male, or mixed group. Marked goats were re-observed in the same group 35 (73 percent) times and in a differnet group type 13 (27 percent) times.

DISCUSSION

Traditional use of the Walton Goat Lick by mountain goats was indicated from National Park Service records and regularly-used trails leading to the lick. Animals older than three years of age led most (96 percent) of the observed movements. Similar results have been reported for bighorn sheep (Ovis canadensis), and camels (Geist 1971, Gauthier-Pilters 1974: 547). Older sheep lead groups to traditional ranges while older camels lead groups to traditionally used water wells along trails.

The stress of passing vehicles and visitor disturbances may have caused a greater reliance upon adult nannies with kid at side for leadership; however, this reliance upon productive females is also reported for undisturbed mountain goat populations (Chadwick 1973, Bannner 1976). Adult female reindeer (Rangifer tarandus), often productive females, are typically leaders in wild herds; aspects of maternal behavior appear to parallel the leader role (Thompson 1975). The capabilities of experienced leaders makes leadership a highly adaptive process in reindeer and, similarly, in mountain goats. The oldest of females probably predominate in leadership roles in wild deer (Taylor 1956), moose (Altmann 1956), and red deer (Darling 1937) and may be the leader to emerge in critical situations in reindeer (Naumov and Baskin 1969).

Several sources of evidence suggested habitation by mountain goats to the traffic and visitor disturbances at the Walton Goat Lick: 1) the rate of successful crossings increased as the season progressed; 2) goats rapidly shifted to routes with better cover, or routes that were otherwise shielded; and 3) goats rapidly became conditioned to associate the highway and highway noise as a threat (Singer 1975). Child (1975) reported that crossing success of caribou (Rangifer tarandus granti) repeatedly crossing a simulated pipeline in Alaska suggested that, through learning, the caribou were beginning to recognize crossing facilities as avenues of access to the other side.

Leadership and dominance were not directly correlated at the Walton Goat Lick, although both dominant classes and dominant individuals were more likely to lead. In a small number of groups where the dominance relations were known, the dominant animal was also the leader in 68 percent of the cases. Stewart and Scott (1969) found that while age was a factor favorable to dominance in domestic goats (Capra hircus) and of somewhat lesser importance in leadership, the two phenomena were largely independent in individual cases. Similar lack of relationship between dominance and leadership has also been found in domestic sheep (Scott 1945) and cattle (Kilgour and Scott 1959).

Group sizes in movements to and from the natural lick were significantly larger than for goat groups on the range or for groups of goats migrating to the lick. Increase in group size in elephants (Loxodonta africana) was related in a direct way to increasing frequency of contacts at higher densities (Laws 1974).

Little cohesion was observed in groups of mountain goats at the natural lick. This may have been related to the differences in lick drives between sex and age classes and individuals, which would tend to split groups migrating to the lick and groups leaving the lick. In addition, mountain goats arriving at the lick followed a stronger leader stimuli, which tended to split groups. For example, juveniles arriving at the lick together rapidly shifted to follow larger groups led by adult nannies with kid at side. The groups were tightly spaced and well integrated and for those reasons were not considered mere aggregations. The social situation at the lick is a unique but very important part of the yearly biology of mountain goats in this region. Lick use significantly mixes mountain goats from different locations, and thereby might serve to increase

genetic interchange.

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THE IMPACTS OF HUNTING ON IDAHO'S PAHSIMEROI MOUNTAIN GOAT HERD[1]

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Abstract: The ecology of the Pahsimeroi mountain goat herd, located in east central Idaho, was studied between June, 1969 and February, 1975, to ascertain the factors contributing to this herd's decline. As part of the study, the impact of hunting was measured. Goat distribution, productivity, and intensity of forage utilization were studied during the first three years when harvest levels were constant. These years were followed by three years of manipulated harvest, the intent being to harvest enough animals each year to equal the previous year's kid production. An evaluation of distribution and movement patterns of 27 marked goats (6 with collars, 21 with radios) demonstrated that adult nannies dominated the winter social structure. The dominant nannies consistently selected the same winter ranges which were steeper, having greater snow shedding characteristics, than adjacent shallower cliffs which were utilized by subordinate animals. The key factor controlling winter range selection appeared to be physical (snow shedding) characteristics of the area and not the availability of food. Dominant animals, when shot, were replaced on their winter ranges by subordinate individuals from adjacent ranges. Although basic kid production appeared to be a function of available food supplies, increased kid production and suvival did not occur with increased harvest. Food supplies available to unharvested animals were not utilized as goats tended to redistribute themselves in favor of physical terrain instead of available food supplies. Therefore, harvest mortality for this goat herd was considered additive to natural mortality and compensatory increases in goat productivity were not observed.

Without adequate research on the ecology of mountain goats, past hunting programs for this species have been justified by extending the same concepts and principles used by North American game managers to justify harvest programs for other ungulates (see Eastman, these Proceedings). These principles, which have evolved primarily from the study of deer and small game, imply that a carrying capacity exists for each species and each population tends to adjust its numbers toward this capacity. The underlying basis for this approach to game management is the concept of habitat. Both the quality and quantity of habitat are considered the primary limiting factors, with habitat often being considered the only suppressant on game populations. Ungulate managers have extended this habitat approach to winter range and the condition of winter forage as the ultimate limiting factors controlling ungulate populations.

Although habitat may be the ultimate controlling factor for the existence and maintenance of each species, the habitat approach to game management only considers one aspect of the total biology of each species (Geist 1971). The uniform application of this approach to ungulate management, although previously untested for mountain goats, is founded on the concept of intercompensation. This concept assumes that, when population numbers are low or reduced below carrying capacity through hunting, the production and survival of young tends to increase; conversely, the rate of production and survival of young declines when population numbers are high or the animals are unhunted and the population is at or above the carrying capacity of the habitat (Errington 1946).

The Pahsimeroi mountain goat herd, located in east central Idaho, has been hunted under the traditional principles of game management. Faced with a declining number of goats on the Pahsimeroi, the Idaho Department of Fish and Game initiated a mountain goat research program in June of 1969, to investigate the factors contributing to this decline (Fig. 1). The underlying objective of this study was to ascertain the causes for the population decline with particular emphasis placed on determining the intrinsic role between mountain goats and their habitat and the response of this population to standard game management practices.

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[1]Contribution of the Idaho Federal Aid in Wildlife Restoration Project W-160-R.

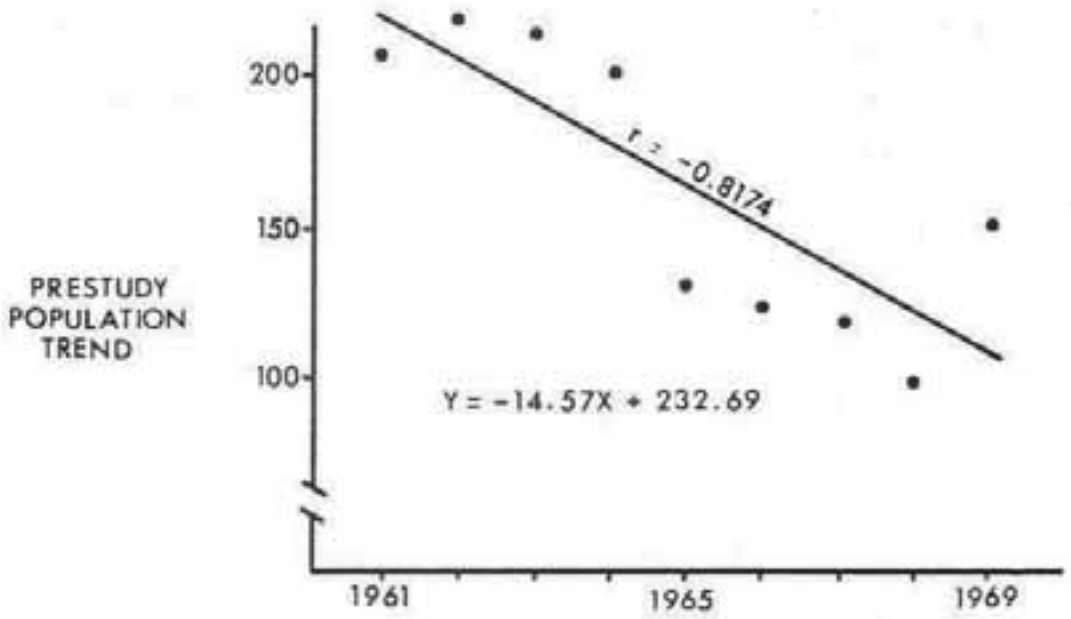

Figure 1. Prestudy population trend from 1961 to 1969 for the Pahsimeroi mountain goat herd. Data were obtained from annual winter helicopter trend counts on the study area.

STUDY AREA

The Pahsimeroi mountain goat herd, a population near the extreme southern extension of this species' natural range, occupies the Lemhi mountain range in east central Idaho. This range, remarkably long and narrow, divides two broad intermountain valleys, the Pahsimeroi and Lemhi, both major tributaries of the Salmon River. Glaciation accentuates the physiography of the Lemhi range and the trend of this range is dissected perpendicularly by a series of narrow, glacially cut canyons. Relatively recent post-glacial faulting and uplifting of this range, with associated accelerated erosion, have formed extremely rugged steep walled cliffs along the lower reaches of the Pahsimeroi and Salmon drainages. Concentrations of wintering mountain goats utilizing these broken cliffs were named the Pahsimeroil mountain goat herd by early inhabitants of the valley. Elevations of the long crest of the Lemhi range average nearly 3,048 m, the glacially cut canyons break through the range front and emerge at the valley floor between 1,829 and 1,980 m in elevation.

The vegetation on the study area reflects both the exeric condition at the valley floor, where the average annual precipitation rarely exceeds 20 cm, and the extreme topography which is in excess of 1,370 m from the valley floor to the alpine tundra found on the more mesic timberless ridges. The cold desert shrub, curl-leaf mountain mahogany (Cercocarpus ledifolius), an indicator of the dry climatic conditions on the study area, is the dominant vegetative species found on the steep southern exposed cliffs utilized by the wintering Pahsimeroi mountain goat herd (Kuck 1970). The area has been described in greater detail by Kuck (1971).

METHODS

Helicopter trend counts, initiated in 1959, were continued annually through this study in the same manner and intensity as previously established. Each winter, between January and March, a total of 12 to 15 hours of flying time was utilized to inventory all known or suspected mountain goat winter ranges on the study area, to establish minimum population numbers, trend, distribution, and productivity. Range use patterns and distribution for goats were determined through direct observation. Each animal, or group of goats that behaved as a unit, was classified as an observation. For each observation, the habitat type, elevation (by 152 m (500 f) units), aspect, percent slope, snow depth and distance from nearest known water source (including snow) were noted. Environmental conditions and individual goat activity were also recorded for each observation. Each observation was plotted on a quarter section grid map of the study area and the grid location quantitatively described for computer analysis by a numerical coordinate system to establish distribution patterns.

When time is sufficient for careful classification, the slow maturation and the differential size between age classes of mountain goats, allows for division of goats into three age classes: adult, yearling, and kid. Since the data presented in this paper are dominated by aerial classifications, to eliminate error, goats were classified only to adults or kids and yearlings were grouped with adults to reduce bias. Production was expressed as percent of kids in the total population.

Trends in winter range conditions and forage utilization were determined by the key browse survey method developed by Cole (1963). Each spring, estimates were made of the percentage of annual growth browsed from individual shrubs of curl-leaf mountain mahogany and the degree of hedging or the removal of the previous year's growth from each browse plant. Permanently marked transects, each sample unit consisting of 50 plants, were established at the base of individual winter ranges. Each transect ran vertically based upon the closest plant sample technique within 180 degrees of the next vertically closer plant. In the spring of 1970, six transects were established and evaluated annually. Each transect was placed on a major mountain goat winter concentration area with terrain which was reasonably traversable by man. Following the 1971-1972 helicopter trend count, four additional transects were established to compensate for changes in population distribution and to replace one of the original transects destroyed by insect infestation.

The surface area and steepness of slope were determined for all winter ranges. All snow shedding terrain, with mountain mahogany used by wintering mountain goats, was delineated and plotted on black and white aerial photos. These delineations were transposed onto USGS 7.5 or 15 minute topographic maps and the steepness in slope was determined in degrees of calculation of the ratio between the vertical map width of the winter range to the vertical rise, as determined by the number of contour lines traversed. The map acreages of each winter range were then converted into actual surface acres.

The Pahsimeroi mountain goat herd was intentionally manipulated through legal sport hunting programs to measure the response and impact to hunting following the 1971 hunting season. Since 1954, after a six year hunting closure on Idaho mountain goats, the Pahsimeroi goat population has been exploited under a controlled permit system. Permitees were restricted to a specific

hunt area which was allocated by a lottery system. Since initiating the intensive mountain goat harvest program on the Pahsimeroi in 1960, the Pahsimeroi and Salmon River sides of the Lemhi Mountain range were divided into four separate hunting areas to disperse hunting in proportion to available animals.

Prior to the initiation of this study in 1969, the number of allotted permits varied from 15 the initial year, up to 40 for several years and then down to 20 in 1967. The distribution and allocation of the 20 permits previously set for the 1968 season were held constant for the first two years of this study, the 1969 and 1970 harvest years. In 1971, the study area was further divided into five units with five permits being issued for a previously unhunted area. The remainder of the study area was hunted under the same intensity as previously hunted the first two years. During these three years, mountain goat productivity, habitat use, distribution and forage utilization under this constant harvest level were documented.

The practice of arbitrarily setting permit levels (20 in 1969 and 1970, 25 in 1971) was discontinued following the 1971 season to implement an increase in harvest programs on the Pahsimeroi herd. Prior to increasing the number of permits, the study area was further divided into seven hunting units then, for the 1972, 1973, and 1974 goat seasons, the number of permits issued each year was directly proportional to available goats and kids produced on the study area. Available permits for each unit were determined by multiplying the total number of goats observed by helicopter within each unit by the average hunter success for the previous three years. The intent of this permit system was to remove goats in proportion to the number of kids produced the previous year. Goat harvest was documented through direct contact with hunters in the field and through the department's voluntary report card system.

The movement patterns of the Pahsimeroi mountain goat herd were determined by trapping and tranquilizing goats from the ground or from helicopters. In the absence of natural licks, four artificial salt licks were established in 1964 for trapping sites. After establishing goat use, four and six goats were trapped with drop nets during early summer of 1971 and 1972, respectively. The 21.4 by 21.4 m net was constructed of Number 72 knotless nylon with a 15.24 cm mesh. The net was suspended 3.0 m from the ground at the corners and 4.6 m at the center. Nets were hand triggered from a blind after goats were lured under the net with the salt. The 1971 goats were marked with easily recognizable collars and ear tags. Relocation of marked animals was attempted semi-weekly from fixed-wing aircraft through June of 1972 and during the annual winter helicopter surveys. Goats trapped in 1972 were instrumented with radio transmitters (47MHz) similar in design described by Seidensticker et al. (1970). Radios were affixed to goats with a 7.6 cm wide, white neoprene impregnated nylon collar painted with black neoprene symbols for identifcation. Goat trapping was discontinued following the 1972 summer because predictable numbers of goats could not be attracted to the salt licks to justify the time and expense for this technique.

Between October, 1972, and July, 1973, 17 goats were immobilized from the ground or helicopter with intramuscular injections of etorphine hydrochloride (M99, 1mg/cc, American Cyanimid Company, Princeton, New Jersey) in three mg doses for adults and yearlings of both sexes. M99 was administered to free ranging goats with a Cap-Chur Gun and projectile syringes (Palmer Chemical and Equipment Company, Atlanta, Georgia). Fifteen of the 17 animals immobilized with M99 were tranquilized from a Bell GJ 82 helicopter. These animals were drugged in late October or late June when the animals concentrated on spur ridges above timberline. After immobilization, each animal was aged and instrumented with a radio. Recovery was induced with six mg. of the antagonist diprenorphine (M50-50, 2mg/cc, American Cyanimid Company) intramuscularly. The remaining two goats immobilized with M99 were approached on the ground while the animals were restricted to cliff winter ranges. The instrumented goats were located weekly from the air with a Cessna 182 (Seidensticker et al. 1970). Radios were first located in general areas at higher elevations; specific locations were established flying at lower elevations utilizing terrain to block out signals and attempting to pass directly over the marked animal. Each relocation was plotted on a topographical composite map of the study area. Habitat characteristics, date, time, and activity for each location were also recorded.

RESULTS AND DISCUSSION

Constant Harvest

The Pahsimeroi mountain goat herd is migratory utilizing a variety of habitat types at the higher elevations throughout the summer months (Kuck 1971). During the summer, the primary habitat type used is the open, gentle ridge tops at elevations of 2,895 m and above. These unique ridges are actually remnants of the original surface prior to faulting and glaciation of the Lemhi Range. Relatively uneroded when compared to adjacent glacial formations, the soils on these ridges provide for the ample establishment of a variety of important summer forages that are utilized by this goat herd. This herd, essentially a two-season goat herd, is sensitive to major snow accumulations. They remain on the higher ridges throughout the warm summer months but move directly off the ridges with the first major snow fall. The downward movement from the summer

ranges to the winter ranges is direct, with minimal time spent on the transitional ranges. Usually, by late October or early November, all available forages on the higher ridges are made unavailable to the goats by heavy snow and thus, they are forced down onto their winter ranges until spring.

Typical winter ranges on the Pahsimeroi are extremely steep, rocky, and are southern exposed. Although often thought of in terms of escape habitat, the tendency to select extremely precipitous terrain, particularly in winter, is probably the evolutionary results of interspecific competition from the more mobile, aggressive mountain sheep, and not an avoidance of predators (Geist 1971). Throughout their evolutionary development, due to strong, interspecific pressure, mountain goats were forced into niches where winter habitat was physically and/or climatically too severe for other ungulates but still physicially situated to prevent the heavy accumulation of snow.

The selection of winter habitat was determined by the physical, snow shedding characteristics of an area and not the forage types present. Through the evolutionary development toward a specialized mountaineering species, which can function within the narrow physical parameters of their winter habitat, this species, consequently, has evolved to survive on a variety of forage types (Geist 1971). The snow shedding characteristic of mountain goat winter ranges on the Pahsimeroi are induced by isolation and gravity resulting in considerably lower snow accumulation on these steep southern exposures that are utilized by this mountain goat herd. The surrounding more shallow terrain is avoided by goats throughout the winter period.

In the winter period of 1969-1970, when this population was at its peak for the study period (166 animals), the herd was pushed down into 12 canyons along the Pahsimeroi and Salmon River drainages. These subpopulations, ranging from groups of 52 animals to lone billies, were restricted within these isolated canyons on critically small islands of snow free habitat for up to six months.

Under the traditional concepts of game management, if the habitat on the Pahsimeroi was controlling this goat population, as has been generally assumed for most other game populations, it would appear that food supplies on these small winter ranges, which were carrying this population half of the year, should be the ultimate determinant in the decline in goat numbers on the Pahsimeroi.

Through the examination of mountain goat feeding sites, Kuck (1971) demonstrated that browse provided the dominant class used by this goat herd throughout the winter period at 87 percent, followed by grasses and forbs at six and seven percent, respectively. Of all the forages utilized by mountain goats on the Pahsimeroi, curl-leaf mountain mahogany provided 75 percent of all the forages taken by goats throughout the winter period. Again, under the accepted criteria of ungulate management, the condition and trend of this mountain mahogany (key species) on the small, rocky cliffs (key area) and the ultimate balance between mountain goat population levels and the carrying capacity of these winter ranges should determine the trend in goat numbers.

After the Pahsimeroi goat herd declined from 217 goats to 95 animals in six years, the number of authorized permits was set at 20, with the stated purpose being to allow this population to recover. At the pre-study level of 20 permits, established in 1968, goat numbers appeared to increase to 166 goats on the Pahsimeroi. However, during the first three years of this study, when harvest levels remained essentially constant, the population started to decline after the documented peak of 166 goats during the 1969-1970 helicopter inventory (Fig. 2). Following the high of 166 animals in 1970, the population declined to 105 animals in 1971, and to 108 by 1972 despite a consrant and conservative harvest level. During this period, 13 goats were legally taken in 1969, prior to the population peak of 166 animals, followed by 14 goat kills in 1970, and an increase to 16 when the number of permits was increased to 25 for the 1971 goat season (Table 1).

Under these levels of exploitation, the utilization of the key browse plant, curl-leaf mountain mahogany, which was presumed to be carrying this population through the critical winter period, was constantly being severely utilized in excess of 60 percent. The percent of utilization on curl-leaf mountain mahogany for the first three years of the study was 70, 62, and 65 percent for the years 1970, 1971, and 1972, respectively, suggesting that this goat population was over utilizing its available winter forage and in danger of reducing the carrying capacity of its habitat.

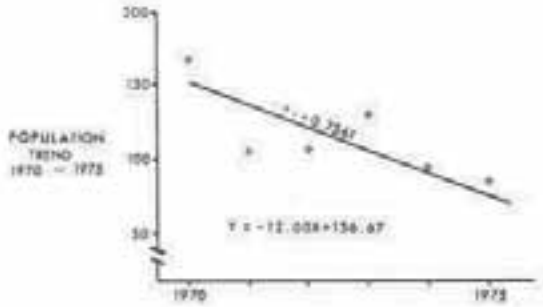

Figure 2. Population trend of the Pahsimeroi mountain goat herd from the winters of 1969-1970 through 1974-1975.

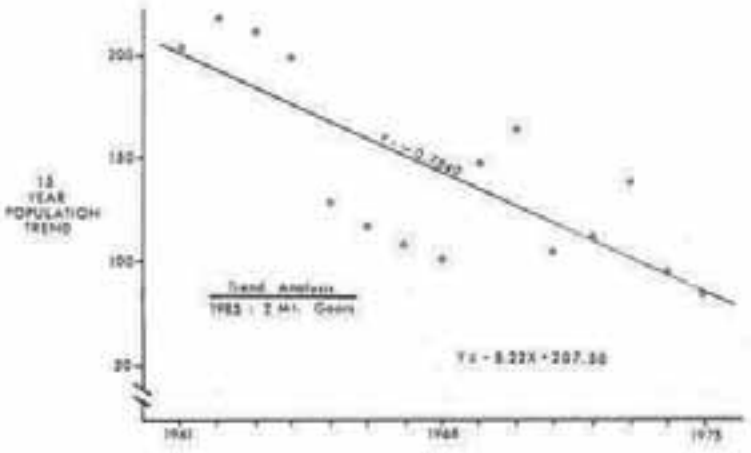

Figure 3. Fifteen year population trend, regression correlation, and trend analysis to 1985, for the Pahsimeroi mountain goat herd from 1961 through 1975.

Table 1. Authorised permits and harvest by year for the Pahsimeroi mountain goat herd during the course of this study.

Harvest Year	Authorized Permits	Documented Harvest
1969	20	13
1970	20	14
1971	25	16
1972	40	19
1973	36	17
1974	26	9

A reflection of the apparently low forage supplies on occupied winter ranges was the low production and survival of kids. Theoretically, under the law of compensation, this population should have responded with an increase in kid production in response to exploitation. However, the highest production of kids on the study area, 19 percent, corresponded with the peak population of 166 goats in 1970 (Fig. 3). This peak production year was followed by a reduction to 13 percent in 1971, and declined further in 1972 to only 11 percent kids in the total population.

After three years of presumably conservative harvests, during an era when the approach to game management was dominated by a philosophy being more advantageous to over harvest than under harvest, the Pahsimeroi mountain goat herd was still declining, forage utilization on occupied winter forages was severe, and kid survival was poor. Viewed from the traditional parameters of game management, the Pahsimeroi goats still appeared to be exceeding the carrying capacity of their habitat, and additional harvest was justified to prevent the continued destruction of their own habitat.

Manipulated Harvest

The broad application of contemporary game management principles to mountain goats assumes that, in the absence of significant natural predation, the artificial regulation of ungulate populations, through human exploitation, is justified to maintain these populations within the carrying capacity of their habitat to protect the range resource and to stimulate production of young through compensation (Cole 1971). The increase in authorized permits and corresponding harvest is presented in Table 1. These levels of harvest reduced this population from 131 animals in 1973 to 84 by 1975 (Fig. 2).

Under a sustained yield approach, this population declined over the five year study period by 82 animals. Through reducing the number of goats on the Pahsimeroi below winter range carrying capacity, our intention was to improve the production and condition of the winter range resource, thereby stimulating the production and survival of kids by providing abundant food supplies for remaining nannies. However, contrary to the law of compensation, kid production did not respond as expected; instead it dropped in proportion to the total number of goats. The production of kids declined significantly ($r=0.7649$) from the peak population of 166 goats with 19 percent kids, to a low of 7 percent kids in 1975. This corresponded with the low ebb in goats on the Pahsimeroi at 84 animals. The directly proportional decline in the ratio of adults to kids during this period was highly significant ($r=0.9834$).

Although the population was significantly reduced during the course of the study, the highly significant decline in kid production indicates that this goat population reacts contrary to traditional game management practices. After five years of manipulated harvest without an increase in kid production, the Pahsimeroi was closed to all forms of hunting following the 1974 season. In the absence of intercompensation to offset exploitation, a trend analysis of the 15 year history of the herd indicated that under past rates of exploitation, the Pahsimeroi goat herd would have been reduced to two animals by 1985 (Fig. 3).

This population apparently does not produce a surplus of harvestable goats as do deer and small game and, therefore, hunting mortality on the Pahsimeroi goat herd appears to be additive and not compensatory. Despite an apparent stable goat habitat on the Pahsimeroi, this population declined by 82 animals during the study. Most of these losses can be directly attributed to hunter mortality (Table 2). Seventy-five goats were taken legally during controlled hunts, 15 goats were taken by archery hunters during general archery seasons that overlapped a portion of

the study area, and 3 goats were killed due to other causes for a total exploitation of 93 goats. Considering the inherent inaccuracies of aerial surveys for estimating population size, as indicated by Caughley (1974), the evidence presented indicates that the goat decline on the Pahsimeroi can singularly be attributable to hunter mortality and the lack of compensation for this mortality.

Table 2. Documented exploitation by type from 1970 through 1975.

Exploitation Type	Documented Goat Kill
Gun Harvest	75
Archery Harvest	15
Other	3
Total	93

Caughley (1970) considers minor yearly population fluctuations of 5 to 10 percent to be normal for most ungulate populations. However, under contemporary principles, a continuing population decline in the excess of 50 percent over a five year period, such as found on the Pahsimeroi, would have to be induced by severe weather influences and/or an abrupt decline in available food supplies. Although winter conditions during this study were considered mild (Kuck unpubl.), major depletion or ecological alteratnion in available food supplies would normally be suspect for this population trend. However, the dominant winter food source for this population is curl-leaf mountain mahogany, a climax species, highly preferred by many ungulate species (Daley 1975). Yet, despite intense forage utilization, mountain mahogany and ungulates have evolved together, resulting in mountain mahogany being a browse resistant species, which invalidates the need to harvest goats to protect this particular forage resource.

Behavior

An analysis of the movement data for the 27 marked goats, 15 females and 12 males, displays a strong homing instinct in adult nannies but not in billies or young nannies (Kuck unpubl.). Characteristically all mature nannies returned each winter to the same winter range used the previous winter. Conversely, billies inconsistently selected different winter ranges from year to year. Differential mobility between sexes was minimal throughout the year except during the rut. Nanny movement during this period was directed toward traditional winter ranges, while billy movement highly intensified during the rut in search of receptive nannies. It was not uncommon for billies to shift from one canyon to another then back within a two or three day period. Individual winter range selection by billies appeared to be determined by its location at the cessation of the rut. In addition to location, a common difference in winter range selection between sexes was severity of terrain. Winter habitat utilized by marked nannies was consistently steeper having greater snow shedding characterisctics than habitat utilized by billies.

Behaviourally, a definite social order exists in mountain goats. This ranking has evolved through social aggressiveness which is based on dominance and submissiveness that is enhanced by the presence of horns on all adult mountain goats (Geist 1964, Chadwick 1973). Adult nannies, particularly those with kids at side, have obtained the dominant position within this social order. Through evolutionary necessity this dominant position has been obtained by nannies to protect their young defenseless kids from other socially aggressive goats. Also of equal evolutionary importance is the tendency by dominant nannies to consiatently select winter habitat with characteristically lower snow accumulation to reduce the energy expenditures in the obtainment of life sustaining nourishment for the nanny and her fetus. The aggressive intolerant nature displayed by dominant nannies permits the selection of the most favorable habitat (snow shedding terrain) within the typically harsh environment by the productive segment of a goal population to insure the continuation of the species. Food supplies are maintained in balance for the survival of dominant nannies on preferred winter cliffs by the dispersion of subdominant individuals, billies and young nannies, through aggressive behavioral mechanisms. Consequently, this aggressive behavior tends to disperse mountain goat populations in relation to both physical habitat and available food supplies. Therefore, mountain goat populations tend to self-regulate themselves without the need for artificial control by game management agencies. During periods of plentiful food supplies goat densities are high; however, when food supplies diminish through intraspecific competition, the rate of encounters between individuals increases. Therefore, faced with reduced food supplies, subordinate individuals are expelled from preferred cliffs through behavioral mechanisms to insure adequate food supplies for the survival of the productive segment of the population. Thus, mountain goats appear to disperse themselves in relation to both food and space, which prevents

the self-destruction of their habitat and eliminates production of surplus goats for harvest by sportsmen.

As a result of this aggressive behavior to disperse themselves in relation to food and space, goats on the Pahsimeroi at the peak population of 166 goats in the winter of 1970 occupied most of the suitable winter range within 12 different canyons (Fig. 4). However, following exploitation by 1975, this population had been reduced to 84 animals, and the proportion of habitat being used by these remaining goats was significantly smaller than in 1970 and was found in only 6 canyons compared to 12 canyons in 1970.

The primary determinant for the selection of these residual winter ranges following exploitations appeared to be physical snow shedding characteristics and not the available food supply. The steeper winter ranges tended to draw mountain goats following exploitation. The regression correlation between calculated steepness of slope and population change by canyon, display a direct significant correlation. During the five year period, the steeper the winter range, the less likely the goat population would decline ($r=0.7423$). Consequently the shallower unpreferred cliffs in terms of physical characteristic and not food supply, were more likely to be abandoned, over the five years of exploitation, while cliffs exceeding 40° or more suffered little or no population losses.

The validity of contemporary game management is based on the assumption that unharvested animals will redistribute themselves following exploitation in relation to available food supplies, in order to increase available foods for remaining individuals to stimulate the production of young. However, on the Pahsimeroi, when dominant animals were removed from preferred cliffs by hunters, these voids were refilled by subordinate animals from adjacent but shallower cliffs. This recessional behavior by the Pahsimeroi mountain goat herd therefore precludes the resting of available range resources and corresponding stimulation of young normally expected following exploitation.

The inherent tendency for mountain goats to select steep or snow shedding winter range in preference over food supplies, is analogous to yarding behavior documented in white-tailed deer (Severinghaus and Cheatum 1956). During the five years of the study, forage supplies on winter ranges still occupies in 1975 were as intensely utilized by goats in 1970 (84 percent) as in the spring of 1974 (88 percent) despite the heavy exploitation incurred by this population (Table 3). However, the intensity of utilization on abandoned winter ranges declined significantly but provided few benefits to remaining goats because of the recessional behavior toward steeper cliffs. Thus, remaining goats were continuously faced with depleted forage resources on preferred winter ranges, resulting in a direct proportional decline in the production of kids as this population regressed further each year following exploitation into steeper cliffs with constantly suppressed food supplies. Although the selection of steep cliffs precludes the production of young, when food supplies are low, this behavior does insure the survival of the individual.

Table 3. Changes in forage utilization on curl-leaf mountain mahogany from 1970 to 1974, for winter ranges abandoned by 1975 and still occupied in 1975.

Year	Winter Ranges Abandoned by 1975	Winter Ranges Occupied in 1975
1970	62.2 %	84.1 %
1974	45.2 %	87.7 %

As a result of these depressed food supplies on preferred cliffs, kid production was not stimulated, consequently, hunter mortality was additive and not compensatory. Thus, in 1970, winter ranges that were later abandoned, produced 22 kids or 69 percent of the goats produced that year, with the remaining 10 kids (34 percent) being produced on the steeper cliffs that were still occupied in 1975 (Table 4). However, following exploitation and the abandonment of the shallower cliffs which were producing most of the kids in 1970, only three kids were produced in the occupied steeper cliffs in 1975. In response to exploitation, kid production had declined from 19 percent in 1970 to 7 percent in 1975.

Relative population density and distribution for the Pahsimeroi mountain goat herd for 1970 and 1975.

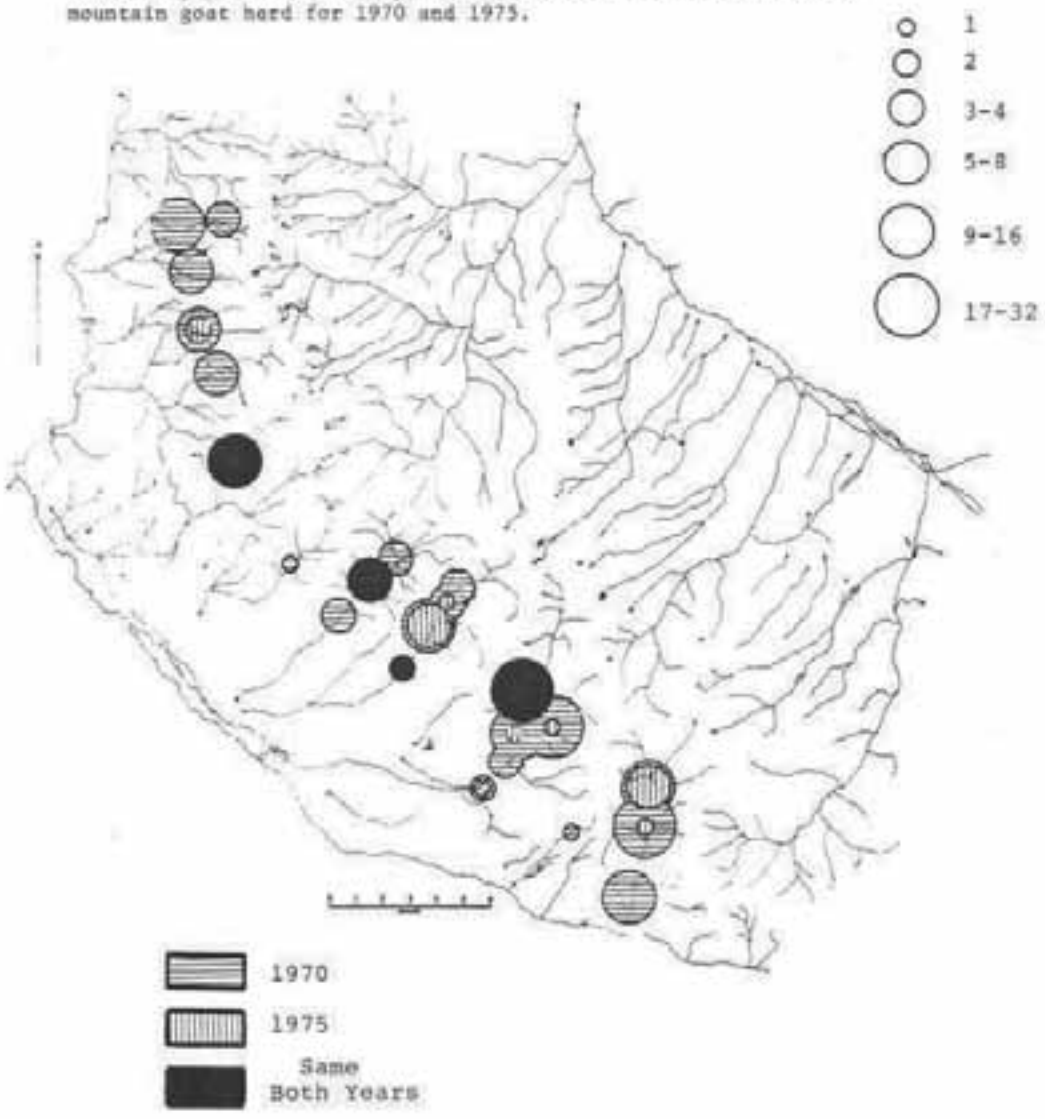

Figure 4. Circle size indicates relative size of mountain goat subpopulation by canyon. Horizontal distribution in 1970; vertical 1975. Black indicates populations remained constant both years.

Table 4. Changes in kid production from 1970 to 1975, on winter ranges abandoned by 1975 and still occupied in 1975.

Year	Winter Ranges Abandoned by 1975	Winter Ranges Occupied in 1975
1970	22 (69%)*	10 (31%)
1975	0	3 (100%)

* No. kids (% of total goats)

The creation of mountain goat habitat is a function of glaciation, therefore, during periglacial periods, goat habitat is relatively stable. Consequently, in the absence of dynamic expansion of goat habitat, there is little need for the production of surplus young. Without a natural mechanism to suppress the production of young, the limited goat habitat would rapidly be over-saturated leading to the self-destruction of their own habitat and potential extinction of the species. It appears, as goat populations reach the saturation point of their habitat or are exploited as on the Pahsimeroi, the over-imbalance between the popualtion levels and forage supplies proves inadequate for the production of viable kids as in white-tailed deer (Verme 1962).

Conclusions

Mountain goats in Idaho have traditionally been hunted conservatively under a controlled permit system. The intensive manipulated harvest system tested and evaluated in the present paper exposed less than two percent of Idaho's mountain goats to this excessive harvest rate. However, the response of the Pahsimeroi goat herd to the intentional increase in harvest demonstrated that many of the assumptions previously used to justify the harvest of mountain goats are not valid, at least on the Pahsimeroi. Because when exploited, this herd progressively selected steeper winter ranges, consequently, the traditional concepts of stimulating the production of young, the increased forage supplies were not realized. Consequently, hunter mortality proved to be additive and not compensatory as expected. As a result of this study, Idaho's future approach to mountain goat management will be considerably more conservative.

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A DESCRIPTION OF SOUTHERN INTERIOR AND COASTAL MOUNTAIN GOAT ECOTYPES IN BRITISH COLUMBIA

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Abstract: Recently, the three subspecies of mountain goat found in British Columbia have been consolidated into a single species. Ecological data suggest that coastal and interior ecotypes exist within the present classification. The development of management systems for mountain goats must depend upon population, social and habitat characteristics within each ecotype. A comparison of productivity and recruitment data for mountain goats of the interior and coastal mountains reveals major differences in the vulnerability of these populations to harvest. Information on group size, frequency distribution of groups and family group status suggests the separation of ecotypes. Determination of animal density revealed clines in mountain goat populations in the outer coast mountains and that actual winter habitat utilized was limiting to the population. A preliminary determination of summer food habits indicates a browsing habit by coastal goats and a grazing habit by interior goats. A comparison of natural salt lick characteristics suggests a physical control of the physiological maintenance of sodium levels.

The drastic declines in Rocky Mountain goat populations described for southeastern and south central British Columbia (Phelps et al. 1976, Foster 1976, Fish and Wildlife Branch 1976) were characterized by: traditional reasoning in biology which did not allow biologists to recognize important differences in species biology; the lack of inventory data describing relative population size and trends, distribution, productivity and recruitment level; the lack of age structure information; the difficulties associated with sexing mountain goat during aerial surveys; the inability of hunters to differentiate sexes in a population; the hesitancy with which biologists accepted queries from hunters and guides regarding population levels and, the inability of resource management systems to control access and resource users. Further, past management prescriptions were based almost solely on harvest information (primarily sex class data and age data mainly limited to the yearling class) with little regard to population productivity and recruitment, spatial and temporal distribution of the harvest, or to biophysical factors which may have been limiting to one ecotype more than another.

Recently, Cowan and McCrory (1970) consolidated the three subspecies found in British Columbia into a single species. However, they did not mention that ecotypes exist within the classification. Population, density and habitat related information collected in south coastal and southeastern British Columbia and presented in this paper, exemplified specific differences between coastal and interior populations and possibly within coastal populations. It is suggested that present and future management presecriptions should attempt to incorporate as many of the ecological points discussed here as possible during the development of regional management plans.

During the last 10 years many people contributed to the collection, preparation and collation of this information: K. Hebert, D. Hebert, J. Hebert, S. Leigh-Spencer, Dr. I. McT. Cowan, D. Janz, S. Fleck, G. Smith, L. Stanlake, S. Lord. In particular, I would like to thank British Columbia Forest Products for its support of much of the coastal portion of this project and Miss B. Scheeker and Mrs. B. Mackie who typed the manuscript under severe time limitations.

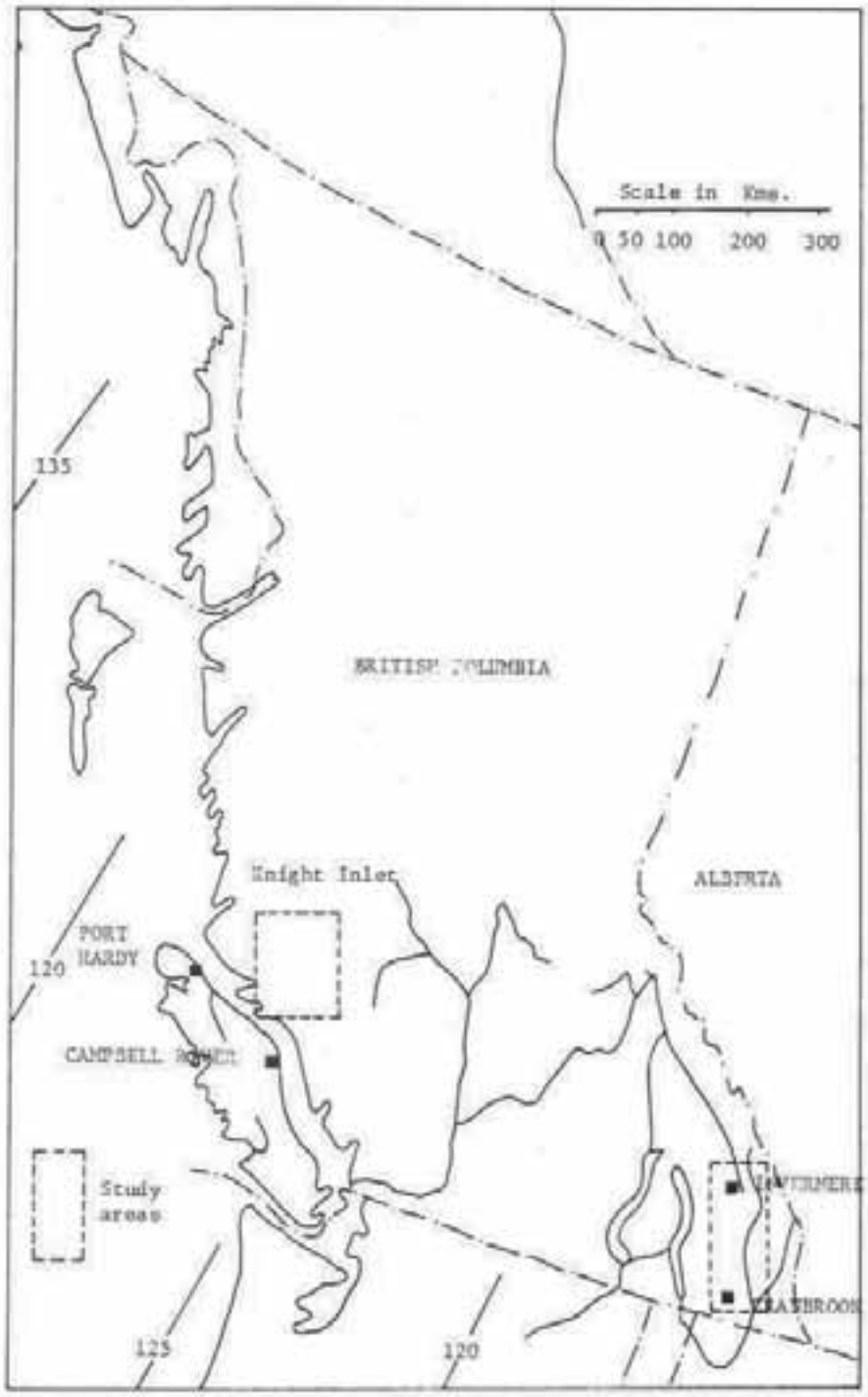

Figure 1. Outline map of British Columbia showing the location of the study areas, in the East Kootenays and Coast mainland.

STUDY AREA

The East Kootenay study area is centered in the Rocky Mountain Trench between Cranbrook and Radium Junction (49° 30' to 50° 45' north latitude). Information was collected in the Purcell Range on the west side of the Trench and in the Rocky Mountains on the east (Fig. 1). The coastal study area centers in the coast mountains of Region 1, encompassing the main drainages entering Knight Inlet (Fig. 1). Associated information was collected in Wakeman Sound. Coastal watersheds fall into three categories (mountain block A, B and C) according to the total area of the elevational class of winter and summer range, the general physiography of the watershed and the actual amount of winter habitat within the elevational class 305 m (1,000 f) above the river bed to 1,525 m (5,000 f).

The majority of the coastal study area is composed of the Coast Crystalline Complex containing granitic, metamorphic and volcanic rocks (Souther 1967). Within it are large portions of granodiorite, quartz diorite, diorite and gabbro and diorite. Much of the aerial survey information was collected on areas composed of dacitic and basaltic flows (Silverthrone formation), migmatite and schists, gneisses, quartzite and crystalline limestone. In contrast, the majority of the East Kootenay study area is composed of sedimentary formations.

METHODS

Information collected in the East Kootenays came from ground surveys using binoculars and spotting scopes. The coastal data were collected from a Jet Ranger helicopter using two observers. Transects were flown at 152.5 m (500 f) intervals beginning at about 1,200 - 1,372.5 m (4,000 - 4,500 f) in mountain block C drainages and at 762.5 m (2,500 f) to 915 m (3,000 f) in mountain block A and B drainages (Table 1). They were flown in proportion to the amount of each aspect present in each watershed. The sex ratio established for the Stanton Creek population was determined by observing goats at close range (12.2 - 22.9 m) (40 - 75 f) from a helicopter for up to 30 seconds with a 200 mm. telephoto lens or a pair of binoculars. It was possible to establish sex in approximately 70 percent of the goats observed because they had not previously been disturbed by man.

Food habits were determined by rumen analysis according to standard procedures. Coastal goats were collected as biological samples while East Kootenay goats were harvested by hunters.

Analysis for ruminal and fecal nitrogen was done according to AOAC methods for macro-Kjeldahl and for fecal and soil sodium using an atomic-absorption spectrophotometer.

Area for population density calculation was taken from .305:76250 (1:250,000) scale maps using a planimeter. Winter range population densities were calculated using the contour line 305 m (1,000 f) above the riverbed, not the 305 m (1,000 f) contour line.

RESULTS

Summer Range Distribution

Mountain goats inhabiting the western slopes of the coastal mountain range tend to favour south aspects during the summer months. Approximately 62.9 percent of the goats observed in 1974 occupied south slopes (Table 1), while 20.0 percent occupied west facing slopes, 14.6 percent occupied north facing slopes and only 2.4 percent occupied east slopes. More specifically, approximately 91 and 71 percent of the goats in the coastal watersheds of Stanton and Hoodoo Creeks, respectively were observed on south slopes in 1974. Due to the high proportion of animals occurring on south aspects in these two drainages, only the south aspects were surveyed in 1976. As a result of two mild winters, changes in distribution and aerial survey discrepancies, the goat population changed from 33 to 44 in Stanton Creek and from 28 to 35 in Hoodoo Creek between 1974 and 1976.

In certain drainages, such as the Franklin and Klinaklini River, direct south facing aspects are not abundant. In these cases, mountain goats summer on S-SE slopes and W-SW slopes, respectively.

There appears to be an elevational cline in summer range utilization from block C to block A (Table 1). Block C watersheds at the head of Knight Inlet supported goats at an average elevation of 1622.9 m (5,321 f) during the two survey years, while block B watersheds averaged 1303.4 m (4,280 f) and block A watersheds averaged 1220 m (4,000 f) elevation.

Interpretation of coastal inventory data indicated that goat densities were moderate to high wherever the Silverthrone formation was exposed. This geologic formation is composed of dacitic and basaltic flows, tuffs and breccias. The past glaciation and weathering pattern has developed steep slopes and loose material in this formation, similar in structure to the sedimentary formations of interior British Columbia.

Table 1. Utilization of coastal mountain goat summer ranges according to physical characteristics.

Area	Mountain Block	Survey Date	Average Elevation In Meters	Aspect	Terrain	Total Goats
Hoodoo	C	Aug./74	1,819	S-NE	Talus Ridgetop	28
		Aug./76	1,708	S	Talus Slope	35
Klinaklini		Aug./74	1,386	SW	Slide Rockbluff Timber	33
Franklin River		Aug./74	1,522	S	Ridge Bluff Timber	25
Stanton Creek		Aug./74	1,472	S	Alpine Bluff Timber	(57)* 33
		Aug./76	1,830	S	Alpine Rockbluff	44
Ahnuhati River Hills Creek Sim-McMynn Creek	B	Aug./76	1,374	S, W, E, N,	Alpine Rock Slide	48
Matsiu River Sallie Creek Kwalate River	A	Aug./76	1,220	S, SW	Rock Timber	5
Catto Creek, Atwaykellessee Creek	D	June/76	931	E, S,	Rock Timber	24

* - includes ground count at natural salt lick.

Insufficient quantified information is available for southeastern British Columbia; however, much of the early summer distribution centered on south aspects and appeared similar to that determined by Hjelford's (1971) examination of feeding sites and Casebeer's (1948) observations in Montana.

Mountain goats appear to prefer high elevation alpine ranges, containing high quality forage (Hebert 1972) and associated escape terrain, where they occur.

Winter Range Distribution

Preliminary investigation of coastal mountain goat winter range indicates that goats winter from sea level (along the channels) to about 1,372.5 m (4,500 f) elevation in side drainages such as Stanton Creek. The majority of the coastal winter ranges appear to occur on south slopes from about 366+ m (1,200+ f) to 1,372.5 m (4,500 f) in elevation. Ground inspection of several ranges indicated that they are characterized by a mature canopy (often Douglas fir) overhanging a steep bluff area. The majority of goat movement occurs along the top of the bluff; however, movement between winter ranges appears restricted (track counts).

Coastal snow conditions are harsh. Goat winter ranges receive excessive snow which is heavily packed due to the high water content. This situation makes most or all of the ground vegetation unavailable for much of the winter. Within approximately 30 - 50 km of the ocean, mountain peaks, talus slopes and rock faces remain covered by a deep snow pack for the entire winter. Beyond 30 - 50 km of the ocean and at higher elevations (1,830+ m; 6,000+ f) snow is removed from mountain tops and rock areas by wind and mountain goats are seen to winter at these high elevations.

Characteristic goat winter ranges predominate many of the block C drainages, occur in moderation in the block B drainages and are scarce in block A drainages, within the elevational class 305 m (1,000 f) above the watercourse to 1,525 m (5,000 f), of the coast. Although quantiative evidence is lacking, it appears that the lower elevation, "U" shaped valleys of mountain blocks A and B may provide less servere snow and temperature regimes than do the higher elevation mountain block C drainages.

In the East Kootenay, mountain goats often winter on snow free ridge tops (2,135+ m; 7,00+ f elevation) and mountain peaks and in the Englemann spruce-subalpine fir biogeoclimatic zone (1,525-2,135 m; 5,000-7,000 f elevation) (pers. observ., Phelps et al. 1976) on south aspects. In the Okanagan portion (south central) of the interior of British Columbia they appear to winter at approximately 915-1,220 m (3,000-4,000 f) elevation in the upper ponderosa pine and lower Douglas fir (Krajina 1965) biogeoclimatic zone (pers observ.).

Food Habits

Few, if any, studies have documented food habits of coastal mountain goats, and seasonal food habits studies of goats in British Columbia are lacking completely. However, Rocky Mountain goat food habits have been documented by several workers from the southern to the northern extremities of its range. These studies indicate that the summer food habits of the goat are largely composed of grasses, sedges and forbs (Foss 1962, Kerr 1965, Hjelford 1971, Kuck 1972). The associated winter food habits appear to consist mainly of browse species with lesser amounts of herbaceous material occurring in the diet (Kerr 1965, Kuck 1972, Brandborg 1955).

This food habit information is preliminary and of limited value due to the small sample size; however, it does indicate a difference in summer food habits of coastal and interior mountain goats (Tables 2 and 3).

Table 2. Estimated summer food habits of five mountain goats in the East Kootenay region of British Columbia.

Animal	Grasses %	Browse %	Forbs %	Trace Species
Adult Female	61.5	38.48	- -	Rock, Fir Needles
Adult Female	98.0	2.0	- -	- - -
Adult Female	88.0	12.0	- -	- - -
Yearling Male	53.3	46.6	- -	Fir Needles, Grouseberry
Adult Male	69.0	25.0	6.0	- - -
Average	73.96	24.82	1.20	

Goats of the Rocky Mountain region of British Columbia appear to utilize approximately 74 percent grasses and sedges (August - September sample) and only 25 percent browse species (Table 2), while coastal goats utilize about 53 percent shrubs and only 23 percent grasses and sedges (August sample) (Table 3).

In addition to a comparison of food habits between coastal and interior mountain goat populations, quality of the summer diet of coastal goats can be compared to that of East Kootenay mountain sheep populations (Hebert 1973). Hebert (1973) established regression equations for migratory mountain sheep populations (captive) which relate fecal nitrogen values to crude protein intake as an index of animal condition. Initial collections of goat fecal samples in summer (August) and late winter (April) produced values similar to those for mountain sheep on alpine and winter range diets, respectively (Table 4). The crude protein values of the feed were established from the regression $Y = -.9400 + 1.034 \times \pm 4.58$; $p = .0008$ using crude protein values of the fecal sample as x. The August values for mountain goats are only slightly higher than those for captive bighorn sheep on natural alpine range forage. This difference could be attributed to selectivity by free ranging mountain goats. Similarly, the April values for mountain goats and captive mountain sheep are comparable and just below the protein maintenance values established by Hebert (1973). Gasaway and Heimer (1976) determined fecal nitrogen values of 1.7 - 1.8 percent (11 percent crude protein) for Dall sheep collected in April in Alaska.

Based on this preliminary information future work will entail simultaneous collection of seasonal fecal samples from mountain blocks A, B and C in order to relate differences in protein

intake to productivity, recruitment and density.

Table 3. Estimated summer food habits of two mountain goats from coastal British Columbia.

Sample	Sex	Age	Volume (ml)	Plant Species	% Occurrence	Total % Shrubs	Grasses	Forbs
1	F	6.5	650	Vaccinium spp. (2 spp.)	41.1			
				Lonicera utahensis	14.2			
				Cassiope mertensiana	1.2			
				Phyllodoce glanduliflora	.8			
				Unidentifiable leaves	1.2	58.5		
				Grasses & grass-like spp.	22.9			
				(Festuca sp., Carex sp., Luzula sp.)			22.9	
				Arnica latifolia	15.0			
				Fern (unidentifiable to genus)	1.6			
				Pedicularis racemosa	.8			
				Luetkea pectinata	.8			
				Moss	.4			18.6
2	M	5.5	450	Vaccinium (2 spp.)	37.0			
				Unidentifiable leaves	9.1			
				Cassiope mertensiana	1.6			
				Phyllodoce glanduliflora		47.7		
				Grasses & grass-like spp.	23.9			
				(Festuca sp., Carex sp., Luzula sp.)		23.9		
				Arnica latifolia	14.0			
				Luetkea pectinata	9.1			
				Pedicularis racemosa	2.5			
				Fern (unidentifiable to genus)	2.5			
				Moss	.4			28.5
TOTAL (average):								
Shrubs						53.10		
Grasses							23.40	
Forbs								23.55

Density

Determination of mountain goat density has not been accomplished, with the exception of that by Hjelford (1971). Difficulties associated with mountain goat inventories on both summer and winter range and the lack of knowledge concerning movement and migration patterns, have precluded the use of this statistic. Data collected in coastal British Columbia during 1974 and 1976 allowed calculation of density by watershed and by elevational class corresponding to general summer and winter range distribution (Table 5) but not by specific habits utilized within each elevational class.

Within the coastal study area, the land area below 305 m (1,000 f) elevation above the riverbed declines from 29 percent in block A watersheds which are generally "U" shaped to 3.1 percent in block C watersheds which are generally "V" shaped. Concomitantly, the area within elevational class 305 - 1,525 m (1,000 - 5,000 f) which includes winter habitat, declines from an

Table 4. Fecal and ruminal nitrogen values of mountain goats as compared to those for mountain sheep on known diets.

Animal or Group	Collection Date	Sex	% Fecal N	% Fecal Protein	% Crude Protein CP	% Ruminal N	% Ruminal CP
Goat	8/76		3.52	22.0	21.81	4.11	25.66
Goat	8/76		3.46	21.6	21.4	4.46	27.84
Goat	4/76		1.19	7.44	6.75		
Migratory Sheep Group	7 & 8/70		2.86	17.9	17.57		
	3 & 4/70		.89	5.6	4.85		

average of 64.2 percent in blocks A and B to 28.6 percent in block C. However, the actual amount of winter habitat utilized varies considerably among watersheds within this elevational class but generally increases from block A to C in association with the increase in density shown in Table 5. To date, it has not been possible to completely delineate and map specific winter habitat utilized within the elevational class 305 - 1,525 m for each watershed.

Summer ranges in all block C watersheds are continuous within each watershed, are approximately similar in biophysical characteristics and do not appear to be limiting in nutritional quality and quantity required for population growth. The summer density of the Klinaklini River watershed reaches 2.41 goats per km^2 (6.23 goats per mi^2) when summer range comprises only 13.1 percent of the watershed while summer range densities of Stanton Creek reach only 182 goats per km^2 (2.13 goats per mi^2) when summer range comprises 61.2 percent of the watershed. Therefore, the Stanton Creek south slope summer ranges could accommodate 129 goats at Klinaklini summer densities. This would produce a wintering density of 6.14 goats per km^2 (15.90 goats per mi^2) on Stanton Creek winter range. Presently, the Klinaklini River winter range elevational class contains only 0.50 goats per km^2 (5.43 goats per mi^2) but does not approach the hypothesized 6.14 goats per km^2 (15.90 goats per mi^2). The quality and quantity of actual winter habitat utilized is greater in the Stanton Creek watershed than in the Klinaklini watershed and accounts for the increased winter densities when summer ranges are similar in biophysical characteristics. However, insufficient winter habitat is available to allow densities to approach 6.14 goats per km^2 (15.9 goats per mi^2). This information indicates that summer ranges are not limiting and that carrying capacity within a watershed is limited by the amount of winter habitat available. This relationship is exemplified in the Franklin River drainage where the winter habitat utilized is likewise reduced and summer range densities are dramatically reduced to .10 goats per km^2 (0.27 goats per mi^2) although available summer range comprises 89.4 percent of the watershed.

An adjacent drainage, Block D, is used for comparison, and although the winter range class (305 - 1525 m) comprises about 70 percent of the watershed, it does not contain a high proportion of good winter range. Thus, total watershed and winter range densities are similar to block B figures. Summer range densities are comparable to some block C drainages.

On the basis of total watershed densities, block C drainages rate one to four in density (Table 6), block B rates five (as would Gatto-Atwaykellease) and the low elevation, rounded valley bottom drainages follow (block A).

It has been determined that mountain goat densities vary among watersheds, based on physical parameters of the watershed and on qualitative descriptions of their component summer and winter ranges.

Group Size

Group size data has been regularly collected for mountain goat populations over many parts of their range (Brandborg 1955, Kerr 1965, Hebert 1967, Cowan, pers. comm., Holroyd 1967, Kuck 1973, 1976). There has been little or no management application of this type of information.

Table 5. An estimation of mountain goat density in Knight Inlet and Wakeman Sound according to the area of the total watershed and elevational designations of winter and summer range.

Mountain Block	Watershed Group	Elevation In Meters	Area (Sq. Km.)	% Of Area	% Of Area Below 305 M	No. Goats	Density 1974 (Sq. Km.)	No. Goats	Density 1976 (Sq. Km.)
A	Natsiu River	Watershed	214.7						.02
	Sallie Creek	305-1525	150.5	70.1	28.7			5	.033
	Kwalate River	1525+	2.59	1.2					1.93
B	Ahnuhati River	Watershed	592.9				.097		.08
	Hills Creek	305-1525	345.8	58.3	23.9	58	.17	48	.14
	Sim-McMynn Creek	1525+	105.7	17.8			.55		.45
C	Klinaklini River	Watershed	104.6				.32		
		305-1525	65.8	62.9	24.0	33	.50		
		1525+	13.7	13.1			2.41		
	Hoodoo Creek	Watershed	110.3				.25		.32
		305-1525	28.5	25.8	16.5	28	.98	35	1.23
		1525+	63.7	57.7			.44		.55
	Stanton Creek	Watershed	146.9				.22		.30
		305-1525	33.4	22.8	18.5	33	.99	44	1.32
		1525+	86.5	58.7			.38		.51
	Stanton Creek (South Aspect Only)	Watershed	87.5						.31
		305-1525	21.0	24.0	14.8			44	2.10
		1525+	53.6	61.2					.82
	Franklin River	Watershed	272.5				.09		
		305-1525	20.5	7.5	3.1	25	1.22		
		1525+	243.7	89.4			.10		
D	Catto Creek	Watershed	332.6						.07
	Atwaykellessee Creek	305-1525	233.6	70.2				24	.10
		1525+	49.7	14.9	14.9				.48

Table 6. Importance of the watershed based on density.

Watershed	Area (Sq. Km.)	Year	Number Goats	Watershed Density (Sq. Km.)	Order by Density
		1974	28	.25	
Hoodoo Creek	110.3	1976	35	.32	3
Klinaklini River	104.6	1974	33	.32	1
Franklin River	272.5	1974	25	.09	4
Stanton Creek	146.9	1976	44	.30	2
Sim Creek Hills Creek McMynn Creek Ahnuhati River	592.9	1976	48	.08	5
Matsiu River Sallie Creek Kwalate River	214.7	1976	9	.02	6
Catto Creek Atwaykellessee Creek	332.6	1976	24	.07	5

A comparison of mountain goat information from coastal British Columbia, the East Kootenay and northern British Columbia (Foster 1976) indicates that group size and the proportion of family groups to total groups may relate to the productivity of the ecotype. In addition, group size appears to relate to the winter range type found in the three regions and especially to the snow conditions of each area.

The relationship of social organization to productivity indicates that block C drainages of coastal British Columbia have low productivity (13.9 percent kids) associated with a reduced group size of 1.69 (Table 7) and a low proportion of family groups (19.8 percent). In the East Kootenay, higher productivity (21.3 percent kids) is associated with a larger group size of 2.29 (2.75 if aggregations are included) and a higher proportion of family groups (34 percent).

Similar relationships between productivity and social organization from other areas of the Rocky Mountains compare to those of the East Kootenay. Kuck (1976) found that productivity of Idaho mountain goat populations was 20.1 percent kids when group size approached 2.1 goats per group while Holroyd (1967) found an average group size of 6.3 goats associated with a productivity of 33.7 percent in Kootenay National Park.

This relationship with an ecotype may allow stratification of harvest regimes by watershed groups. For example, the low elevation block B watersheds which are generally "U" shaped and have milder winters have an average group size of 1.85 and contain approximately 31 percent family groups in relation to productivity of 16.7 percent.

A comparison of band size frequency between the coast and East Kootenay (Table 8) indicates major differences in the smaller group sizes. Approximately 67 percent of the groups observed on the coast were single animals whereas only 39 percent of the groups in the East Kootenay were single animals. All group size categories above one are larger for the East Kootenay populations than for the coastal population. There are minor differences between the single group category of block C (67 percent and that of block A and B (60 percent) of the coast.

When aggregations are included in the East Kootenay group sizes the smaller group sizes decline slightly while the intermediate group sizes increase above those of the East Kootenay groups without aggregations.

With the exception of two groups the largest group size on the coast is six animals. In the East Kootenay there is a representative number of groups from six to nine.

Productivity

The establishment of productivity and recruitment rates should be prerequisite to development of harvest rates and harvest regimes. A comparison to southern British Columbia ecotypes indicates

Table 7. A comparison of group size between the Rocky Mountains and the Coastal Mountains and within mountain blocks of the Coastal Mountains in British Columbia.

Area	Mountain Block	Survey Date	Number				Average Group Size
			Groups	Adult Groups	Family Groups	Goats	
Hoodoo Cr. Klinaklini R. Franklin R. Stanton Cr.	C	1974	106	85	21	181*	1.70
Hoodoo Cr. Klinaklini R.	C	1975	9	7	2	15	1.66
Klinaklini R. Stanton Cr.	C	1975	22	19	3	30	1.35
Hoodoo Cr.	C	1976	8	5	3	20*	2.50
Stanton Cr.	C	1976	27	22	5	44	1.62
TOTAL OR AVERAGE			172	138	34	290	1.69
Ahnuhati R. Hills Cr. Sim Cr. Glacier Bay	B	1976	26	18	8	48	1.85
Matsiu R. Sallie Cr. Kwalate R.	A	1976	3	2	1	4	1.33
Wakeman R.	D	1976	13	9	4	24	1.85
TOTAL OR AVERAGE			42	29	13	76	1.81
Matsiu R. Sallie Cr. Kwalate R. Ahnuhati R. Franklin R.	A, B, C	April 1976	18	16	2	22	1.22
East Kootenay	Purcell Rockies	1965-67	249	165	84	569	2.29
East Kootenay**	Purcell Rockies	1965-67	207	123	84	569	2.75

* - Omitted one aggregation
** - Included aggregations

(Table 9) that recruitment of coastal goat populations is 13 percentage points lower than that for the Okanagan (south central) but only 2.5 percentage points lower than for the East Kootenay study area. Similarly productivity for the coastal area is 7.4 percentage points lower than that for the East Kootenay.

In the Rocky Mountain chain, the East Kootenay results are similar to the Willmore Wilderness area of Alberta (Hall, pers. comm.) and Idaho (Kuck 1976) but productivity is 12.4 and recruitment 21.5 percentage points lower than that found by Holroyd (1967) for an unhunted population in Kootenay National Park. However, due to the nature of the range in the Park, family groups may be more visible than males or solitary females.

Considering the difficulties associated with establishing sex ratios in mountain goat populations it is presently more appropriate to compare productivity and recuitment figures by ratios based on 100 adults. The East Kootenay and Willmore data collected along the Rocky Mountain chain are comparable (29.6, 9.5, and 31.0, 12.4, respectively) and approximately twice as high as those

Table 8. Frequency distribution of mountain goat group sizes in the Rocky Mountains and within Coastal Mountain blocks of British Columbia.

Area	Mountain Block	Survey Year	Band Size Frequency Percent									
			1	2	3	4	5	6	7	8	9	10
Hoodoo Cr. Klinaklin R. Franklin R. Stanton Cr.	C	1974 - 1976	(115)* 66.9	(31) 18.0	(11) 6.4	(7) 4.1	(3) 1.7	(3) 1.7			(1) 0.6	(1) 0.6
Hotsiu R. Sallie Cr. Kwalate R. Ahnuhati R. Sim Cr. Glacier Bay Wakeman R.	B + A Wakeman	1976	(22) 59.5	(8) 21.6	(3) 8.1	(3) 8.1	(1) 2.7					
East Kootenay	Purcell Rockies	1965 - 1967	(98) 39.4	(80) 32.1	(31) 12.4	(15) 6.0	(9) 3.6	(8) 3.2	(2) 0.8	(2) 0.8	(4) 1.6	
East Kootenay**	Purcell Rockies	1965 - 1967	(73) 35.3	(52) 25.1	(30) 14.5	(15) 7.2	(12) 5.8	(9) 4.3	(6) 2.9	(4) 1.9	(6) 2.9	

* Number of groups
** Includes aggregations.

Table 9. A comparison of sex and age ratios between regions in British Columbia and within Coastal Mountain blocks.

Area	Mountain Block	Survey Date	Total Goats	Adults: Male	Adults: Female	Adults: Unid.	Yrl.	Kid	Percent: Ad.	Percent: Yrl.	Percent: Kid	Kids/ 100 Ad.	Yrl./ 100 Ad.	Kids/ 100 Female	Yrl./ 100 Female
Mutsiu R. Sallie Cr. Kwalate R.	A	1976	5												
Ahonhati R. Hills Cr. Sim Cr.	B	1976	48	5 (19)	10 (19)*	23	2	8	79.2	4.2	16.7	21.1	5.3	42.1	10.5
Hoodoo Cr.	C	1974	28	-- (13)	-- (13)	26	--	2	92.8	----	7.2	7.7	----	15.4	----
		1976	35	2 (14)	11 (14)	15	1	6	80.0	2.9	17.1	21.4	3.6	42.9	7.2
Klinaklini R. (East & West)	C	1974	69	-- (30)	8 (30)	52	1	8	87.0	1.4	11.6	13.3	1.7	26.7	3.3
Franklin R. Crevice Cr. Fissure Cr.	C	1974	42	2 (17)	2 (18)	31	2	5	83.3	4.8	11.9	14.3	5.7	27.8	11.1
Stanton Cr.	C	1974	33	2 (14)	4 (14)	22	2	3	84.8	6.1	9.1	10.7	7.2	21.4	14.3
		1976	44	19	19	--	--	6	86.4	----	13.6	15.8	----	31.6	----
TOTAL OR AVERAGE - C BLOCK			251		205		11	35	81.7	4.4	13.9	17.1	5.4	34.0	10.7
Wakeman	D	1976	24	-- (9)	1 (10)	18	--	5	79.2	----	20.8	26.3	----	50.0	----
East Kootenay**		1965-67	569	244 (284)	165 (285)	--	39	121	71.8	6.9	21.3	29.6	9.5	73.3 42.5	23.6 13.7
Okanagan		May 1976	69	-- (28)	-- (29)	57	12	--	82.6	17.4	----	----	21.1	----	41.4
Willmore		1973-75	856	60 (298)	150 (299)	387	74	185	69.7	8.6	21.6	31.0	12.4	61.9	24.7

*50:50 Sex Ratio Based on 1976 Stanton Creek Survey. **Male - Female Ratio - 147.9/100

collected in block C drainages (17.1 and 5.4, respectively) of the coastal mountains. However, the recruitment figure for the Okanagan (21.1 yearlings per 100 adults) is approximately four times greater than that for the coast and twice as great as that for the Eeast Kootenay area of British Columbia. This may result from milder winters, better wintering conditions in general and lack of hunting pressure (closed season) and human harassment.

A 50:50 adult sex ratio was established in the Stanton Creek drainage (Table 9) and was used to calculate kid and yearling ratios for every 100 females in the remaining coastal drainages. Sufficient animals were identified in the East Kootenay ground surveys to establish an adult sex ratio of 147.5 males per 100 females. By comparison, (Table 9) there were approximately twice as many kids and yearlings per 100 feames in the East Kootenay population as in the coastal population.

If the East Kootenay population contained a 50:50 sex ratio, there would be 25 percent more kids and 28 percent more yearlings for every 100 females, as compared to the coastal goat population. Similarly, if the Willmore population contained a 50:50 adult sex ratio, the productivity and recruitment ratios would be approximately double those of the coast. A basis for comparison of productivity and recruitment ratios per 100 females must depend on establishment of accurate sex ratios among adults.

Harvest

In order to adequately assess population status, it is necessary to relate sex and age ratios obtained from survey information, to harvest and natural mortality rates for the same land unit. Unfortunately, the two systems of data collection have not been tied to the same land unit for most, if not all, of British Columbia. In addition, the British Columbia hunter questionnaire requested hunters to locate their kill to the nearest watershed, landmark or post office. The post office designation is completely inadequate as these goat kills cannot be allocated to a specific watershed. It is not known what portion of the sample is lost because of this system of location.

Hunter harvest information is particularly important for mountain goat management, because sex categories are difficult to ascertain in the field except by an experienced observer, and age categories are impossible to differentiate above the yearling age class. In addition, the great disparity in productivity and especially recruitment rates for British Columbia mountain goat ecotypes necessitates that mortality rates be monitored and be in proportion to recruitment. Dramatic declines have occurred in the goat populations of the Okanagan (British Columbia Fish and Wildlife records 1976), the East Kootenay (Phelps et al. 1976) and Alberta (Quaedvlieg et al. 1973) when these criteria have not been considered.

Unfortunately, British Columbia regulations, season lengths and bag limits were consistent for most of the Province and excessively liberal.

Recruitment rates of coastal goat populations are exceptionally low (4.4 percent yearlings), indicating that the growth rate of the population would be extremely sensitive to the form of the mortality curve and to the effects of hunter harvest on the integrity of the family groups. Considering the inability of hunters to differentiate sex and age categories, it is suggested that hunter harvest should be no more than 4 percent of the total population or less than 5 percent of the adult population. As an example, a maximum of nine animals could be harvested from the 1974 surveyed coastal population of 205 mountain goats (179 adults), using a crude level of knowledge of population structure and assuming natural mortality was insignificant. Known causes of natural mortality include snowslides, falling and wolf and cougar predation all of which may account for 2 percent of the adult mortality (above yearling class). Therefore, only five animals remain to be taken by hunter harvest. If natural mortality accounts for 4 percent, then only two animals remain for hunter harvest.

Natural mortality in coastal goat populations may occur at a constant rate from age 1.5 to 10 - 15 or be concentrated in the oldest age classes. If female and male mortality occurs at a constant rate from age 1.5, potential productivity (3.5 - 10.5 years) would be reduced as would the availability of trophy males. If female and male natural mortality is concentrated in the oldest age classes (10 - 15 years), the availability of trophy males would be higher and the impact on production and rate of growth of the population would be lessened. In either case, the removal of potentially productive females by harvest may lower productivity and recruitment through disruption of the family group. If coastal goat populations are maintaining themselves at somewhat static levels, the form of the mortality curve may be relatively insignificant considering the low recruitment, and therefore, the low natural mortality. In either system, hunter harvest should be concentrated in the oldest male age classes (although not possible under current regulations) if compensatory mortality is involved.

According to group size characteristics (Table 7) and winter range descriptions, the integrity of the family group appears to be an important consideration in maintenance of recruitment to the

population. If dominant females in the family group are removed during the fall hunting season, it is possible that winter survival of yearlings and kids may be lowered, especially under the harsh, restrictive coastal conditions.

Available data (Table 10) suggest that both recruitment and productivity may decline when hunting pressure shifts from light to heavy. The observed male and female ratio shifts from 156 per 100 to 65 per 100 females in response to hunter harvest. Since the ratio changes by a factor of 1, the ratio of kids per 100 adults remains approximately equal. The proportion of males in the population declines about 10 percentage points while the female segment appears to increase about 20 percentage points. However, productivity declines 37 percent and recruitment 55 percent in response to an increase in hunter harvest, a resultant change in population structure and a possible realignment in use of winter habitat. Unfortunately, accurate harvest data are lacking for these specific areas and for a sufficient time period to allow assessment of the relationship.

Analysis of the East Kootenay hunter harvest data from 1963 - 1968, inclusive, (Phelps et al. 1976) suggested that 138 males were harvested for every 100 females, with an average yearly harvest of 183 animals. Concomitantly, average age of the harvested animals declined with time and as the population declined. These figures indicate that sufficient potentially productive females were extracted each year to produce a negative effect on the population through changes in productivity and disruption of family groups (recruitment). The information in Table 10 supports this contention; however, it should be tested experimentally through removal of dominant females or by closer land unit alignment of inventory and harvest information.

On the basis of low recruitment rates, the inability of hunters to sex and age individuals of a goat population and a minimum 2 percent natural mortality rate, it is questionable that hunter harvest can be considered compensatory even in the most generous sense.

It has been estimated recently that there are approximately 9,400 (maximum) mountain goats in Region 4 (East and West Kootenay) based on subjective density estimates (Blower 1977). If the population consisted (Table 9) of 21 percent kids (1,974 kids), 7 percent yearlings (658 yearlings) and 72 percent abuldts (6,768 adults, regardless of sex ratio) the basic recruitment can be compared to the average annual harvest. The post-hunting density estimate (Blower 1977) is undoubtedly below the population available during the peark harvest of the 1960's. Therefore, if the population was arbitrarily increased by 30 percent (14,100), harvest and recruitment can be compared to give a range of possible population trends. These calculations are conservative in that they assume harvest was distributed evenly throughout the population. As shown by Phelps et al. (1976) hunter harvest was concentrated by watershed with time.

In order to formulate a harvest-recruitment relationship for the East Kootenay population a recruitment rate of 7 percent of the total population is suitable, rather than the ratio of 9.5 yearlings per 100 adults, since yearlings formed a portion of the harvest. Concomitantly, approximately 680 mountain goats per year (including both sexes and all age classes) were harvested in Region 4 (Hunter sample, British Columbia Fish and Wildlife Branch).

At 7 percent recruitment, approximately 520 animals could be harvested per year, from a population of 9,400 animals. Therefore, about 160 animals per year were harvested in excess of the possible recruitment rate of 7 percent.

Since Phelps et al. (1976) have shown that individual watersheds or areas were harvested intensively over short periods of time, the harvest effect above recruitment increases. If heavy hunting pressure can reduce both productivity and recruitment (55 percent) (Table 10) in addition to hunter harvest, it is obvious why populations in specific watersheds crashed after two to three years of hunting.

If the original population was 14,000 animals and 21 percent were kids (2,940 kids), the harvest, based on recruitment, could be approximately 775 animals (at 7 percent recruitment) which would be about 95 animals above the actual harvest rate of 680 animals. However, as potentially productive females and yearlings were being harvested, an evenly distributed harvest would soon outstrip recruitment. An intensive harvest by watershed (the effects of heavy hunting pressure) would increase the population decline accordingly.

There is speculation that harvest of adult animals, especially males, could stimulate greater productivity in mountain goat populations. There are a variety of factors which prevent this from happening:

(1) age and sex classes are indistinguishable for most hunters;
(2) distribution of hunter harvest is difficult and expense to control;
(3) removal of potentially productive females disrupts family groups and reduces productivity;
(4) winter range distribution, especially on the coast indicates that removal of adult males and females may not allow utilization of that range by other animals in most winters.

Table 10. A comparison of sex and age ratios in lightly and heavily hunted goat populations in the East Kootenay.

Class	All Salt Licks			Unhunted and Lightly Hunted Areas				Heavily Hunted Areas			
	n	: 100 Adults	: 100 Females	n	Percent	: 100 Adults	: 100 Females	n	Percent	: 100 Adults	: 100 Females
Males	210		126.5	175	37.1		156	35	28.2		65
Females	166			112	23.7			54	43.5		
Yearlings	40	11	24	33	6.9	12	29	7	5.6	8	13
Kids	120	32	72	92	19.5	32	82	28	22.6	31	52

Analysis of inventory and harvest statistics has indicated that regulations and harvest regimes must differ according to the ecotype, that traditional biological reasoning for other species must be discarded in relation to goat biology, that population stimulation through removal of adult animals may not be viable at this time, that the role and integrity of the family group must be researched more thoroughly and that experimental manipulation of populations must take place in order to better understand the effects of hunter harvest on mountain goat populations.

Habitat Protection

In British Columbia few activities are detrimental to mountain goat summer ranges. However, certain East Kootenay and northeastern British Columbia goat summer ranges are being destroyed by strip mining for coal. Harrassment, associated with strip mining operations, and currently regulated and unregulated hunting activity often produce detrimental impacts on goat populations. At present, this is not an important consideration in much of the coast mountain ranges.

Timber harvest activities in the East Kootenay and coastal regions of British Columbia can often produce detrimental effects on goat winter ranges. In most areas of south coastal British Columbia logging per se does not reduce goat winter ranges because logging access is restricted by the steepness of the valley and number of bluffs paralleling the valley floor.

However, upon termination of logging below the bluffs most areas are slash burned to remove debris and reduce the fire hazard. Often, slash fires escape and fringe burn goat winter ranges above the bluffs, destroying the snow shedding canopy and the ground forage.

Protection of coastal mountain goat winter ranges entails correct placement of roads and cutting blocks away from goat ranges where access is possible and control of post-logging activities.

In the East Kootenay, logging per se can destroy goat winter ranges on steep bluff areas in the subalpine spruce-fir biogeoclimatic zone. Slash burning is not prevalent and fringe burn does not usually occur in high enough frequency to affect goat ranges. Extensive access often promotes overbunting, especially where inventory data, regulations and designation of hunter kill is inadequate to monitor the situation.

In order to protect these ranges and associated populations, wintering populations must be identified through aerial surveys, ground counts or through concentration of pellet groups. In addition, summer surveys will allow assessment of total numbers per area and assessment of priorities during protection of winter ranges.

Salt Licks

Analysis of salt lick material and studies describing lick use by several species of ungulates (Carbyn 1975, Hebert 1967, Dalke et al. 1965, Jordan et al. 1973) have been undertaken in interior areas of North America for many years. There are few instances where natural salt licks have been found adjacent to salt water (Hebert 1967, Heimer, pers. comm.). During the 1974 aerial survey in Knight Inlet a salt lick was discovered on the lateral moraine of a receding glacier in Stanton Creek, approximately eight miles from salt water. The area containing the lick is mainly composed of quartz diorite material.

Early investigators (Stockstad 1953, Smith 1954) found that sodium compounds, especially sodium bicarbonate, were preferred by big game animals. Other workers examined licks for their chemical content and suggested that sodium compounds were prominent in most licks and appeared to be the source of attraction to big game (Knight and Mudge 1967, Heath 1942). Recent work (Weeks and Kirkpatrick 1976, Blair-West et al. 1968, Hebert and Cowan 1971) provides physiological evidence that sodium is the primary source of attraction. Jordan et al. (1973) suggested that sodium may be a limiting factor in Isle Royale moose and attempted to calculate the sodium balance. Noting the lack of sodium in most plant species, except some aquatics, they postulate that sodium balance in moose is aided by mineralized storage in hard tissue and substituion of potassium for sodium in saliva, and therefore, in rumen fluid. This has recently been questioned by Weeks and Kirkpatrick (1976).

Development of a conceptual model is required to display the physical and chemical determinants of sodium balance (Fig. 2). It has been determined that sodium values of alpine and winter range vegetation available to mountain goats in the East Kootenay are extremely low (Hebert and Cowan 1971) and that sodium probably serves little or no function in most plant species (Lehr 1941, Harmer and Benne 1945, Epstein 1972). However, certain coastal forage species (Vaccinium, Rubus, Oplopanax) may contain 100 - 900 ppm sodium while plant species growing in or near seepage sites may contain 1,000 - 8,000 ppm sodium (Klinka 1976).

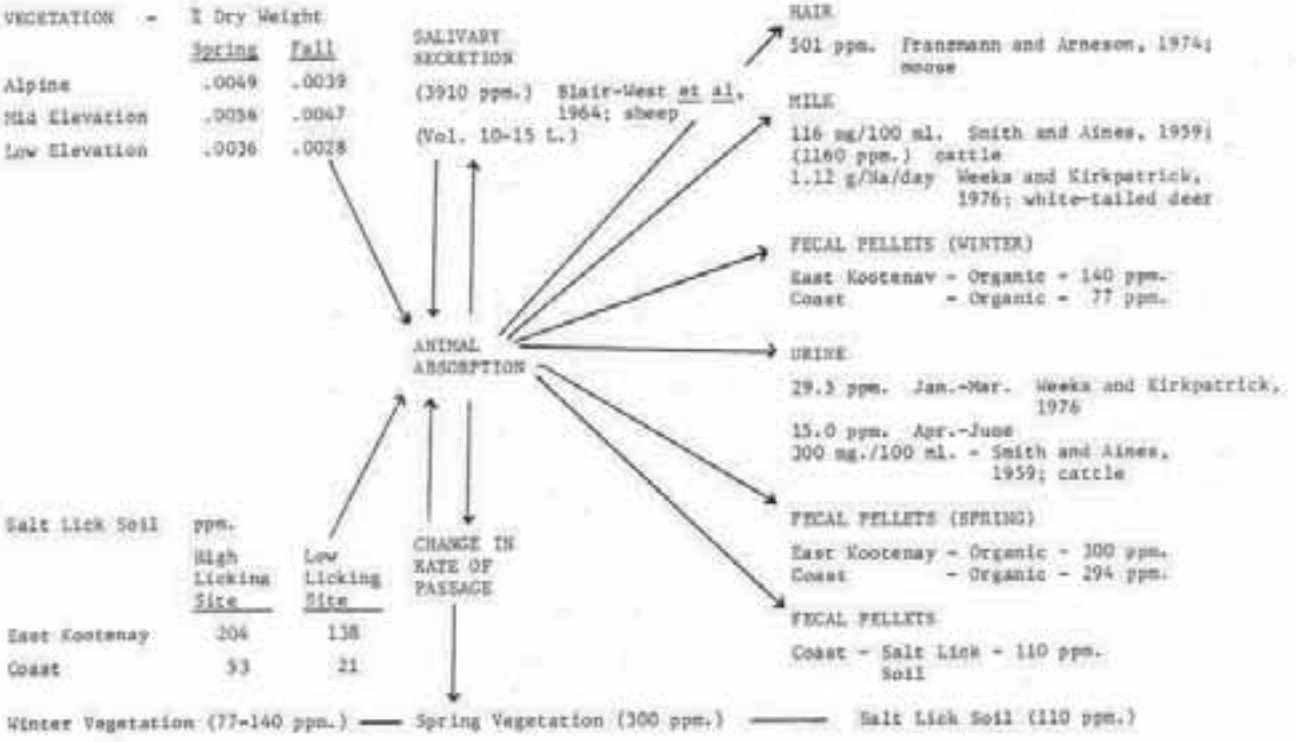

Figure 2. A physical and chemical mechanism for regulation of sodium balance in mountain goats.

Salt lick soil samples for the East Kootenay range from 204 ppm to 138 ppm in high and low licking sites, respectively. Thus, the sodium intake available to wild ungulates may be extremely low with the exception of some coastal vegetation and certain high licking sites. Comparison of the interior and coastal salt licks indicates that chemical content alone may not be sufficient to prevent a negative sodium balance. Thus, postulation of a physical mechanism was necessary to explain control of sodium balance.

Frens (1958) demonstrated that sodium depletion in cattle could result from excessive sodium loss in the fecal material during an increased rate of passage in the spring. Experimental work with East Kootenay mountain goats indicates an increased rate of sodium loss (an increase from 140 to 300 ppm) during a potential increased rate of passage when winter range forage was changed to succullent spring forage. Fecal material was collected near the coastal salt lick in 1976 from goats utilizing winter range forage (hard fibrous pellets) (77 ppm sodium) and from those utilizing new growth forage (294 ppm sodim). The similarity in sodium values between regions while goats are utilizing succullent forage may indicate similarities in the physiological process. It is likely that much of the sodium loss occurs when salivary sodium (3,900 ppm) (Smith and Aines 1959) is removed during the increased rate of passage.

It would appear that the sum of potential sodium loss (milk - 1,160 ppm; hari - 500 ppm (Franzmann and Arneson 1974); urine - 25-29 ppm (Weeks and Kirkpatrick 1976); organic fecal pellets - 300) during the spring and early summer seasons cannot be counterbalanced by the available sodium in the soil and vegetation.

Thus, the chemical process cannot maintain sodium balance.

However, if salivary sodium contributes to sodium loss during increased rate of passage, then a reduction in that rate of passage, regardless of the chemical content of either soil or vegetation, could reduce sodium depletion through an increased rate of absorption (Figure 2).

Thus, when goat fecal material contains 300 ppm when the animal is utilizing succulent vegetation it contains only 110 ppm when the animal is utilizing salt lick soil.

It can be postulated that this system (salt lick soil) reduces the rate of passage at a time when mountain goats are approaching or have reached negative sodium balance. Therefore, as rate of passage is reduced, absorption of salivary sodium, soil sodium and vegetation sodium is increased and fecal sodium loss is reduced.

The sodium balance concept in moose differs from that of mountain goats. Moose can obtain more sodium through their feed (1,000 - 9,000 ppm in submerged and floating plants) and less

through their lick material (25 ppm). It would appear that balance by chemical means is more prevalent in moose than in interior goats. If mineralized storage and potassium substitution are functional systems, both could be operative in goats.

Discussion and Conclusions

The development of management systems for mountain goat must depend upon the recognition of population and habitat characteristics of each ecotype. The establishment of productivity and recruitment rates should be prerequisite to development of harvest rates and harvest regimes. The preceeding sequence did not occur in British Columbia for mountain goat during the period 1950-1975 and occurred only infrequently in adjoining States or Provinces. Harvest systems for goats, instituted under traditional biological reasoning appropriate to other species, produced dramatic declines in East Kootenay (Phelps et al. 1976) and Okanagan (Fish and Wildlife Branch 1976) goat populations. Similar harvest systems may now be affecting goat populations of northern British Columbia. Goat populations of coastal and interior ecotypes have significantly different productivity and recruitment rates but have been subjected to standardized liberal seasons and bag limits. In conjunction with an increase in access to interior populations, severe declines resulted. Under similar regulations, most coastal goat populations were spared through limited access to the coastal mainland.

Consideration of all forms of natural mortality indicates that hunter harvest in coastal populations was probably additive rather than compensatory. Extremely low recruitment rates of four to five percent would likely allow declines in most coastal goat populations under existing levels of natural mortality and limited hunter harvest.

Similarly, the relationship of population estimates by density calculation, harvest rates from the hunter sample and inventory information on recruitment for the East Kootenay area indicated that hunter harvest exceeded recruitment. In addition, hunter harvest was concentrated by watershed through time, rather than distributed evenly throughout the population; therefore, harvest greatly exceeded the estimated recruitment. Populations were lowered so substantially in each watershed that recovery was not possible except over long time periods. If intensive hunting pressure reduces producitivity and recruitment rates, then the hunter harvest experienced in the East Kootenay was further damaging to the population.

Winter surveys indicate that mountain goats inhabit winter ranges from sea level to about 1,372.5 m (4,500 f) elevation within 30 - 50 km of the coast. Further inland, goats can winter at higher elevations where the moisture content of the snow is reduced and where wind can remove the snow. Preliminary analysis of goat survey data from the west and east slopes of the coast range (Forbes, pers. comm.) indicates that productivity may be lower within the narrow coastal band and higher on the east slopes.

Concomitantly, the small group sizes of the outer coast (block C) mountains are associated with harsh and restrictive winter conditions, whereas in the interior, larger group sizes are associated with snow free high elevation winter ranges and less restrictive snow conditions of the subalpine zone. The large group sizes of the northern populations (average group size: 8 - Foster 1976) are associated with extensive high elevation snow free areas and reduced areas of subalpine spruce-fir winter ranges.

On the coast, at least, summer range group size appears to be a function of the restrictive nature of the winter range. The majority of summer range on the coast is continuous, similar to that of the East Kootenay. Therefore, it is not likely that the reduced group size is determined by summer range conditions. The number of family groups, as well as family group size may be reduced if harsh winter conditions reduce carrying capacity on individual ranges and restrict productivity. This should result in a reduction of average group size. The separation of family groups and single males and females appears to continue throughout the summer.

Coastal data indicates that summer range is unlikely to be limiting, that a minimum of 10 - 15 percent of an area as summer range is adequate, that most summer ranges are underutilized and that winter range densities are dependent on specific habitat characteristics rather than on an elevational class. The utilization and association of specific winter habitat types with the integrity of the family group appears to be an important point in the maintenance of goat herds. Clearer depiction (quantification) of the specific characteristics and actual amount of winter range utilized within each mountain block will allow a more accurate estimate of winter range distribution and density (based on surveys of summer populations) and categorization of the carrying capacity of various drainages and mountain blocks.

A series of secondary factors can also be considered during the management of mountain goats. Mountain goat distribution in the coastal study area is partially related to geological formation.

Within any geological group, however, both summer and winter distribution is dependent on south aspects. A comparison of group size between the coastal and interior ecotypes indicates that it may be related to productivity and may be useful in determining harvest regimes. The relationship of adult to family groups may be especially important. For example, actual numbers of goats and density estimates for blocks A, B and D were considerably lower than for block C, yet it appears that group size and percent family group information indicates higher productivity. Actual productivity for these low elevation and low density areas is higher and is supported by lower group size frequency of the single animal class. Density levels appear to be controlled by the actual amount of winter habitat available while productivity may be related to the differences in snow type and depths, temperature regimes and forage availability in each mountain block. However, the determination of group size must be standardized among workers. To date, group size information has been collected seasonally, by physiographic unit and by behavioral characteristic. This has produced data which is a combination of individuals, groups and aggregations and which has had little use for management.

The formation of group size in goats can be a function of the sex ratio of the population. Males occur as single animals more often than females (family groups), and therefore, the establishment of group size relationships with producitivyt and winter range conditions can be nfluenced by sex ratios. Thus, part of the difference in group size between the coast (unhunted populations) and East Kootenay (hunted) may be attributed to the effect of hunting on the sex ratio. Similarly, within the East Kootenay ecotype, Holroyd (1967) determined a group size of 6.3 for goats in Kootenay National Park. This elevated group size could be a function of lack of standardisation during determination of groups and aggregations and the unhunted status of this particular population.

Mountain goats in the East Kootenay make extensive use of natural salt licks in the early spring and summer. A comparison of sodium values of coastal and interior lick soils indicated that chemical content alone was probably insufficient to maintain sodium balance. The sodium content of aquatic forage utilized by moose and certain browse species possibly used by coastal goats while on the winter range indicates that they could supply a sizeable portion of the sodium requirements. However, physical control, through the rate of passage has the potential to regulate salivary sodium loss and aid in the maintenance of sodium balance.

The majority of accessible goat populations has been affected by an abundance of access and harvest pressure and a dearth of population and habitat information. Until a more complete understanding of goat ecology is available managers should maintain a conservative approach to extraction rates.

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HISTORICAL PATTERNS OF MOUNTAIN GOAT HARVEST IN BRITISH COLUMBIA[1]

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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).

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[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 Stoney 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?	25.00	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[a]	Harvest Restrictions: Sex	Harvest Restrictions: Age	Season Length (Maximum days/ Minimum days)	GMA's with Bag Limit of One[afg]
1958	1,5	7	None	1 yr(7.6cm horn)	123/4	7,8,11
1959	1,5	7	"	"	123/3	7,8
1960		7	"	"	122/3	
1961	1,5,7a	7	"	"	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	"	"	134/2	5,6,7,8,10,11
1969	1,24	2,3,7,10,11,25[b]	GMA 11: ♂ 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: ♂ only GMA 11: ♂ only	>1 yr (7.6cm horn) "	134/2	1-11,20-28
1971	1,7,10,24	2,3,8,11,25	GMA 11: ♂ 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	≥1 yr (7.6cm horn)	121/8	"
1973	1,6,7,10,11,15, 18,24	2,3,4,5,8,9,13,20,25, 27,28	"	"	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[c]	"	"	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 (MMA) 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 Nass Special Limited Entry area (M.U. 6-15) allow 193 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. Finegan (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 checking station. These data represent mostly the northern portions of the Province. Hunting regulations 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 $Y = \arcsin\sqrt{Y}$.

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.

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[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.

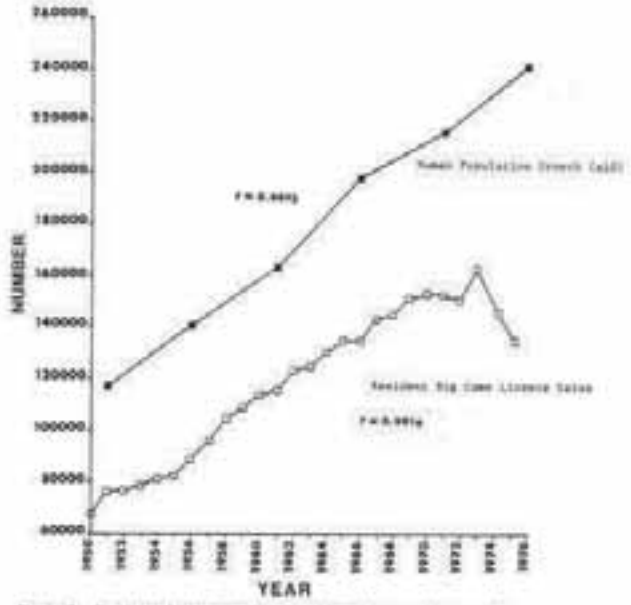

Figure 2. Human population growth and residents big game licence sales.

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

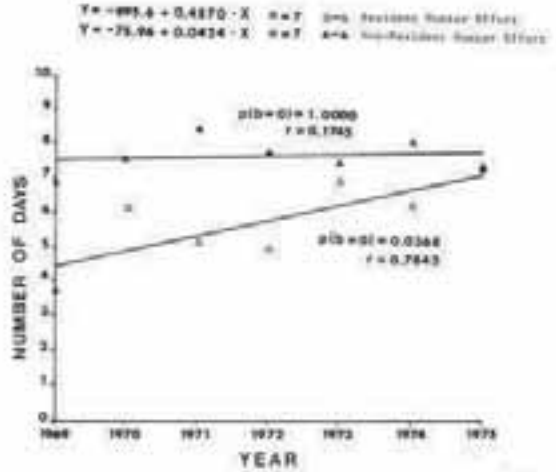

Figure 4. Effort of resident and non-resident hunters expressed in the a mountain goat in British Columbia (1969-1975).

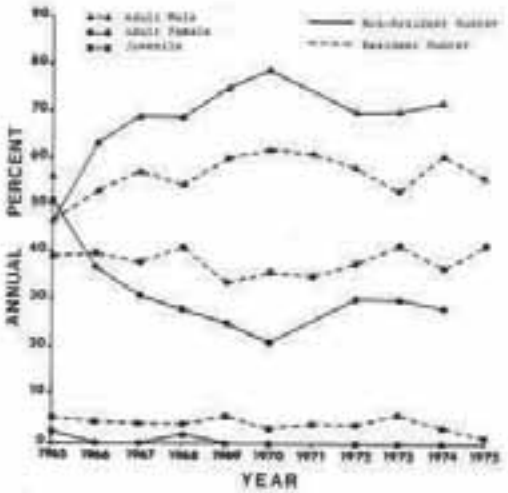

Figure 5. Hunter selectivity of mountain goat harvest in northern British Columbia (1965-1975).

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(h=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 ($r = .0285$, $0.5<\rho<0.2$) (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).

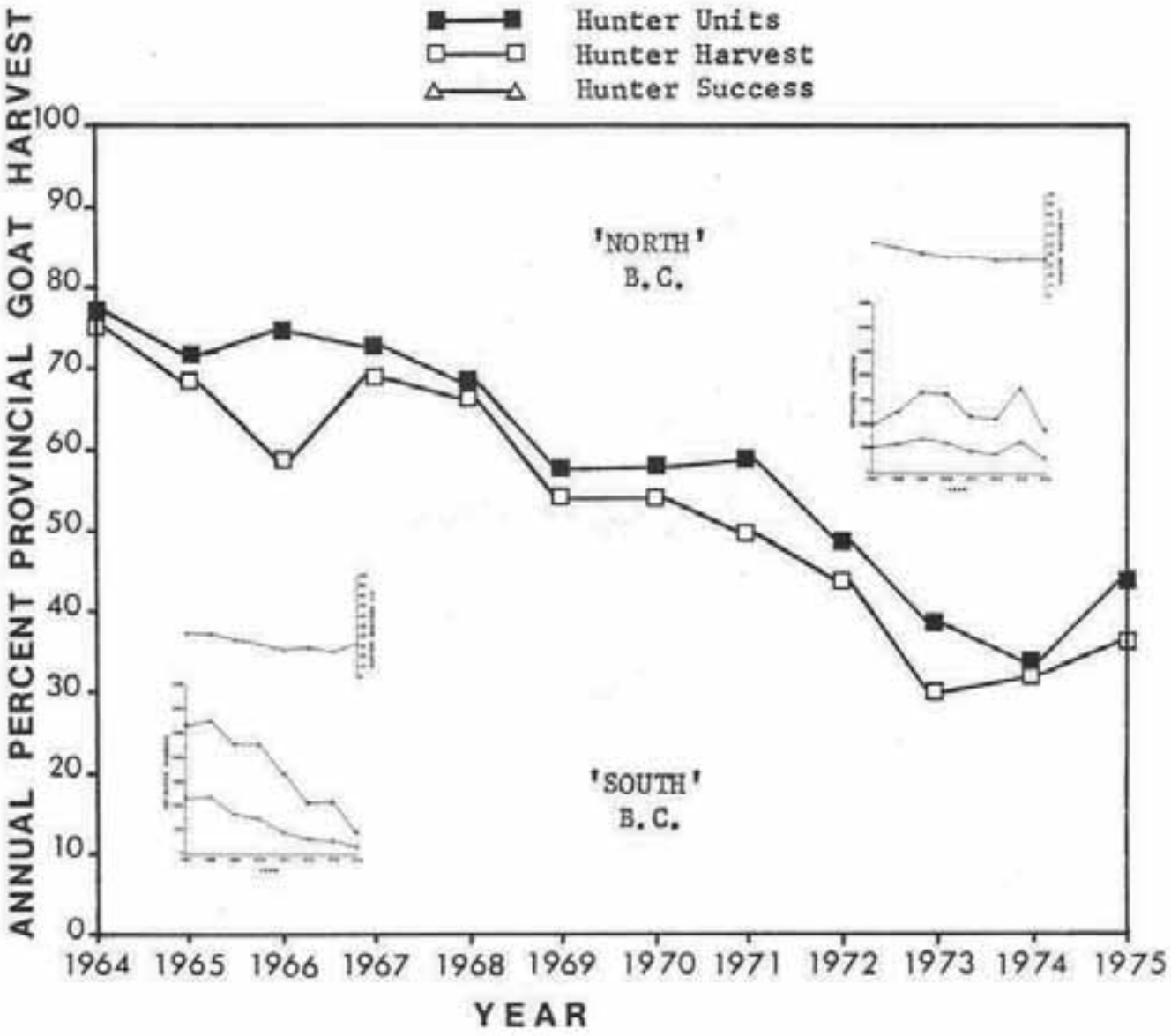

Figure 7. Temporal division of mountain goat hunting pressure, harvest, and success between 'North' and 'South' British Columbia (1964-1974). The areas above the main curves represent proportions of hunter effort and harvest in 'North' British Columbia and the areas below the main curves represent 'South' 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).

	CATCH-PER-UNIT-EFFORT							SUCCESS$_t$ - EFFORT$_{t+1}$		
CMA	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]
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	0.2352	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 contributes 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.

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RESEARCH NEEDS FOR MOUNTAIN GOAT MANAGEMENT

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Abstract: Three aspects of mountain goat research were examined: the amount of information available, research priorities, and the relevance of current research to perceived research needs. Examination of a comprehensive goat bibliography revealed that approximately 60 - 70 scientific papers have been published since 1910. The rate of publication is increasing rapidly so that more information is becoming available to assist wildlife managers. Research priorities were assessed through a questionnaire survey that listed potential topics. Based on a sample of 28 replies, the top three research needs were development of inventory techniques, assessment of the impact of hunting on population dynamics, and development of methods to predict carrying capacity. Studies on economic valuation, and user attitudes and preferences were ranked the lowest. Twelve other topics received intermediate rankings. Statistical analysis showed that the questionnaire respondents applied essentially similar criteria ($P<0.001$) in ranking the research topics. However, this set of ranks was not similar to the priorities assessed from the subject matter of papers presented at this symposium ($P>0.05$). Recommendations for future research included: directing research effort to priority topics, emphasizing experimental versus descriptive projects, improving communications between researchers and managers, holding bi-annual mountain goat workshops, and defining management objectives clearly so that the role of research becomes clarified and more effective.

The concerns of this paper are: 1. How much technical information on mountain goat is available to assist wildlife managers? 2. What are research priorities for mountain goat as seen by researchers and managers? 3. Is present research related to these research priorities? Based on consideration of these concerns, recommendations will be offered that hopefully will aid future research and management.

Mountain goats (Oreamnos americanus) are probably the least understood of all the North American ungulates. Several reasons are responsible for this dearth of knowledge: the species typically inhabits terrain that is precipitous and inaccessible, thus posing logistical problems for researchers and managers; it is widely dispersed, making study difficult; and, other big game species have usually had a higher priority than mountain goats. Consequently, little time or money remained for mountain goats after the needs of higher priority species were met. Also, mountain goats were possibly thought safe from over-hunting due to their inaccessible habitat (Foster 1976).

Given the lack of information on mountain goats, it is not surprising that the species was managed by principles based on experience and knowledge derived from other ungulates. This limited management options prematurely and may prove to be biologically unsound. The following possibilities were largely overlooked: that goats have very low productivity; that they have a social structure that is particularly sensitive to hunting; and that hunting mortality is additive rather than compensatory.

This symposium is a tangible manifestation of growing concern about the adequacy of mountain goat management. It is the first such meeting. (Mountain goats are probably the last of the big game species to have this distinction.) Presumably, the symposium's objective is to encourage better management of mountain goat. It is a laudable target, but the key question about this goal is "better management for what?". Obviously, goals will vary according to geography and organization, but it is my impression that most agencies lack explicit management goals for mountain goat. Lacking these goals, it is difficult to clearly define what research needs to be done for better mountain goat management. Thus in the management process of formulating policies and defining objectives, gaps and problems can be identified that prevent or restrict successful attainment of these objectives. Bridging gaps and solving problems often requires a variety of actions that involves research, administration, public education, etc. The key point is to clearly identify what aspects are best suited to the abilities and skills of research.

Meeting future needs is a difficult challenge. Predicting the future is dodgy at best, but prediction becomes more difficult without a framework of objectives. Without a framework, evaluation is problematic and progress hard to realize. This symposium will probably succeed in identifying research needs for present management but will fare less successfully in identifying future needs.

I wish to acknowledge the assistance of all biologists who answered the questionnaire. Also, appreciation is extended to L. Friis, who prepared Figures 2 and 3, and to Pat Cook who typed the final manuscript.

METHODS

Availability of Information

To be available, information should be published in recognized journals or obtainable as theses from university libraries. To assess the ease-of-access to these types of documents I used a bibliography compiled by Foster (1977) as my data base. From it, I noted the date of publication only of journal articles or theses with the words mountain goat appearing in the title. The numbers of articles were plotted by ten-year intervals to indicate the numbers of articles as well as the rate of publication.

Research Needs for Future Management

My approach to define research needs was through a questionnaire survey. A form letter was mailed to all persons presenting papers in this symposium, to most regional wildlife biologists in Alaska and British Columbia, and to a few other individuals involved in wildlife research, protection and management of mountain goats. The letter requested information regarding affiliation, nature of job responsibility, and asked respondents to priorize 17 research topics that covered a broad range of subject matter (Fig. 1). General remarks and comments were also solicited.

Methods of completing the list of topics varied. In some cases, all were priorized while in other cases only some of the topics were ranked. In some cases, topics were numbered sequentially from 1 - 17 but in other cases, all topics were ranked using an abbreviated scale such as 1 - 7. Many ties resulted. Such a variable data base would be difficult to analyze without some transformation. I made the following alterations for the subsequent analysis. Where all topics were priorized with a scale of less than 1 - 17, and therefore had tied evaluations, each tied score was assigned the average of the ranks they would have been assigned had no ties occurred (Siegal 1956). Where ranking of topics was incomplete, I assumed all unranked subjects were tied at a rank one lower than the lowest one listed. These "tied" ranks were then treated as described above. For example, if only seven topics were ranked from 1 - 7, then I assigned all the unranked topics with a value of $(8 + 9 + \ldots + 16 + 17)/ 10$ or 12.5. Having done this, I was able to examine the concordance of rankings between agencies, between job categories and between organizational levels.

It is important to recognize the limitations of this approach to assessing research priorities. First, most topics were inter-related and thus tied rankings were likely encouraged. I tried to reduce this problem by stressing that the emphasis of the topic should be ranked. Second, my list defined the universe for ranking. Omission of important topics could seriously reduce the value of a ranking exercise. I avoided this difficulty by asking for other topics to be listed, and by emphasizing in the results that they were applicable only to the list circulated. Third, working of the topics may have caused confusion, misunderstanding or both. Semantic problems of this nature are a fact of life. Ideally, such a ranking should be followed up with personal interviews for perception checks but this was impractical.

The Kendall coefficient of concordance (W) was the statistical technique used to assess the degree of association between ranks provided by the respondents. The procedure is summarized briefly by Siegal (1956: 237):

1. Let N = number of topics to be ranked, and let k = number of judges (biologists) assigning ranks. Arrange observed ranks in a k x N table.
2. For each topic, determine the sum of ranks assigned by the k judges (Rj).
3. Determine the mean of Rj. Express each Rj as a deviation from that mean. Square these deviations, and sum them to obtain S.
4. Compute the value of W using the formula: $W = S/ 0.083\ k^2\ (N^3 - N)$
5. To determine if W is significantly different from zero, calculate a value of chi-squared using the formula: $X^2 = k\ (N - 1)\ W$, and test for significance with df = N - 1.

This coefficient tests the degree of agreement amongst biologists in ranking the topics.

1. Work area: University _____ state/province/territory _____
federal _____ private _____ park _____
other (specify) _____

2. Job responsibility is mainly: Research _____ management _____
administration _____ I & E _____ enforcement _____
other (specify) _____

3. Rank the following topic areas in order of your perceived priority for research on goats:

To some extent, some of these topics are inter-related - they represent different emphasis on common phenomena. Thus it is these type of emphases that should be prioritized.

	Topic	Rank
1.	Impact of hunting on population dynamics	_____
2.	Impact of access on goats	_____
3.	Habitat utilization (descriptive)	_____
4.	Social behaviour	_____
5.	Impact of forestry/mining/settlement/hydro	_____
6.	Importance of parasites and disease on productivity	_____
7.	Resource partitioning: niche characterisation	_____
8.	Resource partitioning: habitat selection	_____
9.	Home range (role of tradition), migration, and movements	_____
10.	General ecological studies	_____
11.	Methods for predicting carrying capacity	_____
12.	Economic value (hunting and other uses)	_____
13.	User attitudes and preferences	_____
14.	Nutrition	_____
15.	Significance of mineral licks	_____
16.	Developments of inventory techniques	_____
17.	Development of population/habitat simulation models	_____
18.	Other topics _____	
	Enough research already, application needed _____	

Do you have other remarks related to research needs?

_____

_____

Figure 1. The questionnaire used to assess priorities for mountain goat research.

Once this list of priorities was prepared, I compared it with the frequency of occurrence of topics at this symposium. The most frequent topics were assumed to have the highest rank. The agreement between both tests was examined using the Spearman rank correlation coefficient, r_s, with the null hypothesis that the two sets of ranking were not positively associated (Siegal 1956: 202-213).

RESULTS AND DISCUSSION

Availability of Information

Little published information is available on mountain goats, assuming the data-base was complete (Fig. 2). Since 1910, only 64 papers and theses have been published on mountain goats. This represents approximately 20% of all articles listed by Foster (1977). The number is somewhat inflated as many articles were derived from theses. Both were included in my tally. Conversely, many useful articles did not have the words "mountain goat" in the title and so were omitted in my search of Foster's bibliography. On balance, while the number of publications dealing with goats is probably more than 64, the fact remains that the published literature on mountain goats is scanty.

The rate of publication is increasing rapidly (Fig. 2). During the 1910-1919 decade only one paper was published on goats. By 1960 - 69, this figure was 16, and the projected number for 1980 - 89 is about 45 publications.

Priorities of Research Topics

The data base from the mailed questionnaire was 31 replies. The responses were widely distributed with respect to geographic area, strongly weighted to state and provincial agencies, and evenly divided between researchers and managers (Table 1). To have a better balance of opinions, it would have been desirable to have larger samples from managers in Idaho, Montana and Washington.

Table 1. Source of replies to research questionnaire, by geographic area, job function, and organizational affiliation.

Geographic area	Distribution by function and affiliation						Total by geographic area (%)
	by function			by affiliation			
	mgmt.	res.	admin.	state	fed.	univ.	
Alaska	5	3	2	9	1	-	10 (32%)
Alberta	2	3	-	3	1	1	5 (13%)
British Columbia	7	1	-	7	-	1	8 (26%)
Idaho	-	1	-	1	-	-	1 (3%)
Montana	1	3	-	3	-	1	4 (13%)
Washington	1	3	-	1	1	2	4 (10%)
Yukon	1	-	-	1	-	-	1 (3%)
TOTAL	17	14	2	25	3	5	33 (100%)
	(52%	42%	6%)	(76%	9%	15%)	

Analysis of priorities showed a highly significant ($P<0.001$) degree of concordance (five respondents did not rank topics, so N = 28). This can be interpreted as meaning that the respondents were applying essentially the same set of criteria in ranking the research topics (Siegal 1956). As Siegal (1956: 238) emphasizes, however, this does not mean that the rankings recorded are correct. For example, the biologists could be using the "wrong" set of ordering criteria. In the absence of a "more objective" set of priorities, the rankings based on the sum of individual ranks is probably the best estimate of the "true" order. The test of the correctness of these

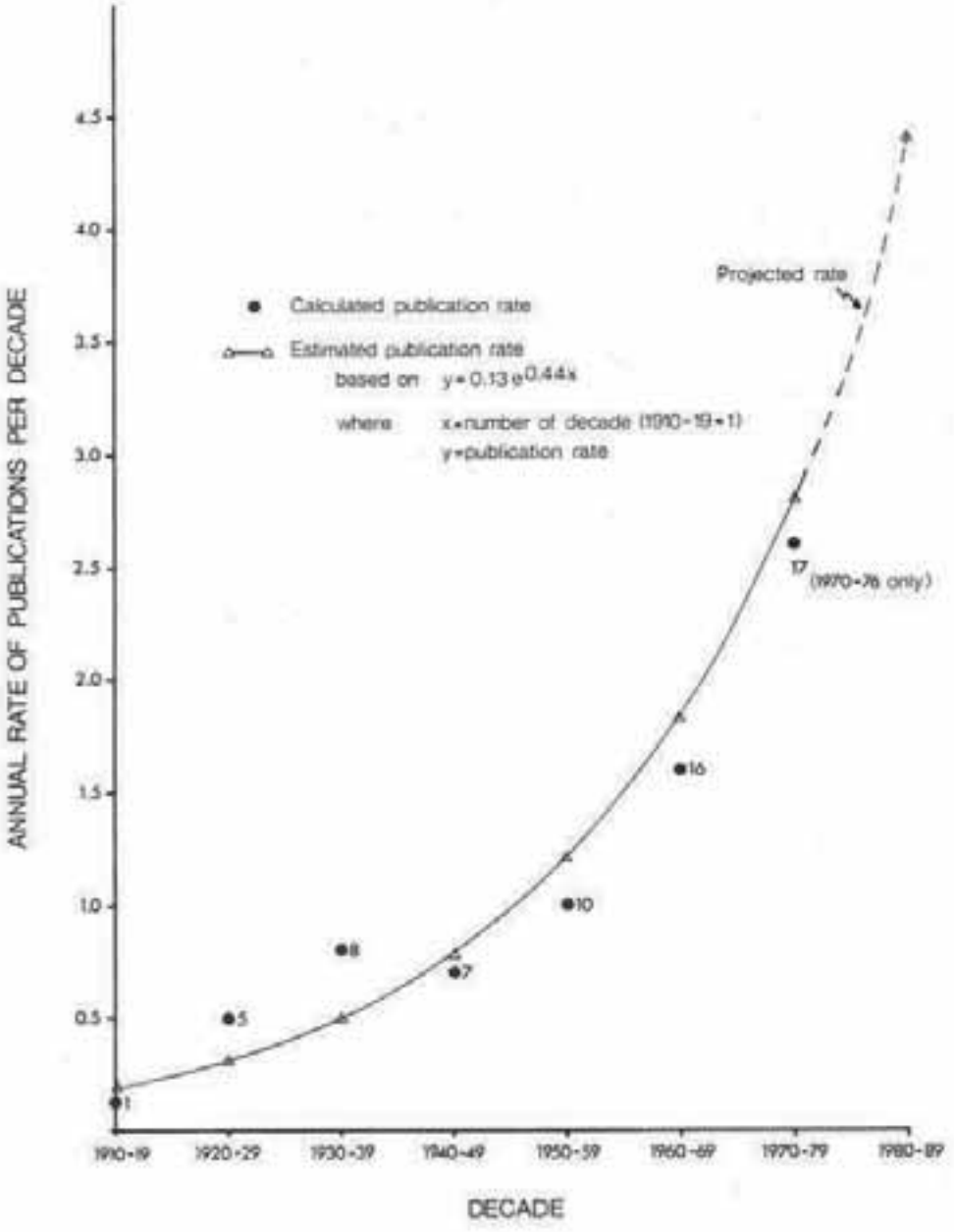

Figure 2. Trend in annual rate of publication of scientific articles on mountain goats, 1910-1989.

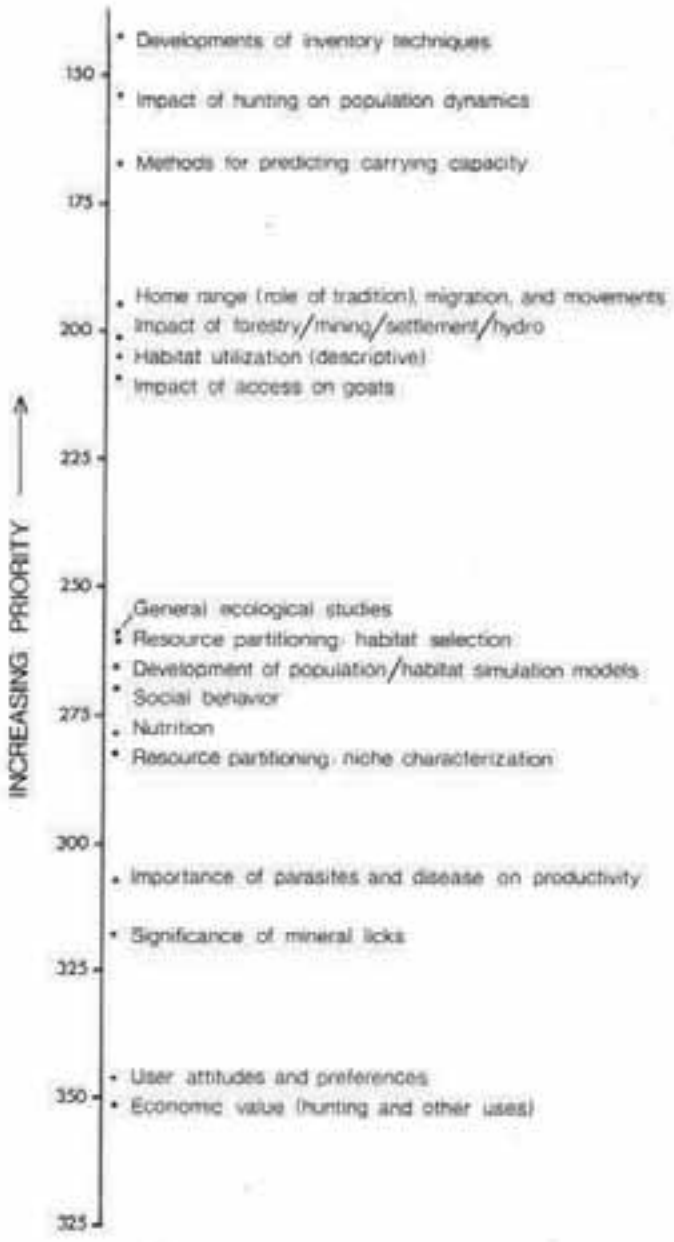

Figure 3. Priorities for mountain goat research as assessed by 28 biologists in northwestern North America.

priorities will be in the thrust of future research and whether or not contemporary management problems are solved. Nevertheless, considering the diverse affiliations and responsibilities of the participating biologists, the degree of agreement is remarkable.

The relative importance of topics is illustrated in Fig. 3. The highest research priority was clearly for inventory techniques (Fig. 3). This need was expressed both by researchers and managers. This a developmental topic that represents a major impediment to further activity, both in research and management. Successful inventories require an appreciation of a species' biology before a suitable sampling scheme can be devised. Also there is a need to establish acceptable criteria for precision and accuracy. These criteria depend upon the objectives stated for management, and upon the types of inventory needed to meet these objectives. For example, are inventories needed most for total herd size, sex ratio or productivity estimates? Is the same intensity of inventory required for all regions of a state or province? These questions are not so much ones requiring research as ones requiring greater support for management programs.

The research topic that ranked second was the impact of hunting on population dynamics. Since managers lacked reliable inventory techniques, changes in mountain goat populations often went undetected. Also inadequate inventories on sex and age ratios were insensitive to changes in goat herds. The research need was well expressed as : "The overwhelming need in goat research must deal with their widespread declines and the controversy over goat's ability to sustain a hunter harvest in many areas." (F. J. Singer, pers. comm.). Sufficient information exists to demonstrate the low productivity of this species. Goats obviously require more careful herd management than do species such as moose and deer. Even more so since it is particularly difficult to regulate harvest of young or females only through specific seasons. Female-only seasons in southeastern British Columbia were of limited success (R. Demarchi, pers. comm.). It seems that the problem is not so much what the sustainable harvest should be (although this does require research), but rather how to manage the distribution and numbers of hunters into specific areas at specific times within the limits of current budgets, and management areas that are too large to be effective. The main solution to the problem is more administrative than investigative.

A second aspect of hunting impacts is more clearly a research topic: is hunting additive or compensatory mortality? Kuck (1976 and this symposium) believes that it is additive. In a species with characteristically low productivity, assumptions regarding mortality have great significance.

The third most important topic was developing methods to predict carrying capacity. This topic has obvious application to both native and introduced mountain goats. One comment offered was "We totally lack any means of relating populations to habitat capacity -- maybe this approach is not completely practical with mountain goats." The concept of carrying capacity has intrigued and puzzled biologists for decades. For domesticated herbivores, range carrying capacity is defined as: "the maximum numbers which can graze each year on a given area of range, for a specific number of days, without inducing a downward trend in forage production, forage quality or soil." (Stoddart and Smith 1955: 172). This definition and most that are offered for wild animals related to food supply (Edwards and Fowle 1955). That carrying capacity is determined by food supply is an untested assumption for mountain goat. Even if food were limiting, we do not know what aspect of food supply is in shortest supply -- amount, protein, energy, selenium, etc. A combination of controlled laboratory studies and studies of introduced herds offer prospects of gaining insight into limiting factors. Similar to developing inventory techniques, devising methods to assess carrying capacity require a basic understanding of key aspects of the species biology before useful ways can be developed.

The next four topics ranked approximately the same: home range, migration and movements; impacts of forestry, mining, settlement, and hydroelectric developments; habitat utilization; and impact of access (Fig. 3). These topics are inter-related since assessing impacts requires baseline information on habitat use, movements and migrations. For most developments, little "before" type of data exists so that most assessments are made after the fact. In some cases, such as the situation described by Pendergast in this symposium, the changes in goat numbers are so dramatic that even scanty baseline data are sufficient to demonstrate declines. Generally, showing that declines occur is a relatively straightforward matter.

Why they occur is undecided since the possible causes have not been isolated adequately. Three commonly suggested effects of resource developments are: loss of habitat, increased kill through improved access, and desertion through disturbance and psychological stress. This latter factor is important for both non-consumptive and consumptive uses of mountain goats. In unusual cases, losses of habitat may be large enough to reduce range supply significantly. However, this is probably not true in most cases and, in fact, certain limited cases of strip mining may create escape terrain (Pendergast and Bindernagel, this symposium). The latter two effects of impact are more difficult to disentangle and it is only through appropriately designed experiments that the correct answer will be obtained.

The next six topics were ranked as of intermediate importance (Fig. 3). In subject matter they were concerned with resource partitioning, social behaviour, nutrition and development of simulation models.

Four topics ranked low in priority. In decreasing order, they were: importance of parasites and disease in productivity, significance of mineral licks, user attitudes and preferences, and economic value (Fig. 3). The low rank of the latter two subjects is surprising since they continually arise in discussions on management objectives and resource trade-offs. Perhaps these items were considered more in need of application rather than in need of further research. Certainly, user surveys are standard tools of market management, but evaluating a non-market resource continues to pose a research challenge.

The following topics were also suggested by respondents:

1. Parasitology and viral diseases
2. Intra-specific competition with other ungulates
3. Techniques for live-trapping and handling
4. Reproductive potential and survival
5. Effects and level of predation (3 times)
6. Identification of a manageable unit: herd or habitat basis
7. General life history
8. Dynamics of invasions (transplants)
9. Influence of weather on reproduction and survival

These suggestions were not ranked since they were not available to everyone for assessment. They revealed one shortcoming of questionnaire surveys pointed out in the Methods, that is, omitting major subjects in the topics. For example, no titles were listed that related to competition, predation or behaviour of transplants. These omissions reflect my provincial bias since in British Columbia, we appear to have little problems with competition or predation, and are not transplanting mountain goats.

Useful comments were offered on research and its application to management. Some biologists felt that while more research is needed, we should concentrate more on the application of results. Better attempts to publish completed research and other communication methods. One biologist felt that the real problem was people management, and that we should use knowledge gained through research to influence political and public attitudes.

Current Research and Research Needs

Evaluating the agreement in priorities between research needs and papers at this symposium was difficult. Some papers were reviews rather than reports of research projects. Others were comprehensive and dealt with many of the topics listed on the questionnaire. Still others treated the questionnaire topics peripherally rather than as the main theme. For these reasons, I counted some papers for more than one topic if they treated the topics in detail.

Bearing in mind the above qualification, it was nonetheless surprising to find that the null hypothesis of no correlation was not rejected (r_s = 0.33, df = 12, tabulated r_s at 0.05 level = 0.412 in table P of Siegal (1956: 284)). If the symposium topics accurately reflected on-going research and my classification of their topics is representative, then it appears that research is not directed according to the priorities of the questionnaire respondents.

Obviously, redirecting research on the basis of this single, simple test is unwise. Yet it does suggest that fish and wildlife agencies and parks should carefully re-examine their research programs with respect to management needs.

RECOMMENDATIONS

1. Direct research towards priority topics.
2. Direct research away from primarily descriptive projects to experimental approaches.
3. Reduce the lag between research results and management application by improving communication and by publishing results promptly.
4. Researchers should interpret their findings more thoroughly.
5. Hold regular mountain goat workshops at two year intervals, possibly in conjunction with the Northern Wild Sheep Workshop.
6. Define objectives clearly for mountain goat management so that the role of research can be more effective.

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STRATEGY OF RESOURCE USE BY MOUNTAIN GOAT NURSERY GROUPS[1]

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Abstract: Observations of two populations of mountain goats were recorded near Crande Cache in western Alberta in 1974 and 1975 to determine the habitat preferences of nursery groups. Each observation was classified according to the following habitat parameters: cover type elevation, slope, aspect and distance to rock-gravel cover type. They activity of goats during an observation was recorded as feeding, bedded or escape. Over 400 observations were recorded during this investigation and about one half of these were of nursery groups. Foraging activity prevailed on level, high elevation areas most distant from rock-gravel cover types. Bedding and escape activity were associated with steep, rock-gravel areas. There were also pronounced seasonal changes in habitat selection during the period from late spring to early fall. Security and refuge seemed to be critical factors in the selection of habitat parameters by nursery groups. Foraging excursions onto less secure habitat were common only in late summer. Knowledge of the resource strategy of this species is of immediate concern in view of the imminent development of coal deposits in the east slopes of the Rocky Mountains in Alberta.

In recent years more and more studies have examined habitat selection by wild ungulate populations (e.g. Hirst 1975, Peek et al. 1976, Shannon et al. 1975). Saunders (1955) and Hjeljord (1973) have investigated habitat and food selection by mountain goats (Oreamnos americanus). Investigations of habitat use are important in assessing the impact that may accrue to wildlife use by ungulates (including the present one) are not experimental but simply report non-manipulative observation of habitat use. Thus we can only hypothesize about habitat or forage requirements based upon observed preferences.

In this paper I have attempted to assess the habitat use by mountain goat nursery groups and to demonstrate that certain environmental variables may be selected differently by nursery groups at different times of the year and during different activities. I have also attempted to explain variation in habitat selection in terms of varying requirements for security and forage. In Alberta the major threat to mountain goats at the present time is the loss or disturbance of ranges that are occupied by goats through exploration and extraction of coal deposits. By recording the habitat preferences and describing a strategy of resource use by nursery groups I hope that it will be possible to minimize conflict between resource development and mountain goat requirements.

I wish to acknowledge the field assistance of James Stelfox and to thank Jan Murie and Fred Zwickel for helpful discussions about habitat selection by wildlife populations. I also wish to thank those in the Wildlife Services section of the Alberta Fish and Wildlife for logistical support in the field.

STUDY AREA

I recorded observations of mountain goats on three adjacent areas in west central Alberta. Mount Hamell (see Fig. 1, Samuel et al., these Proceedings) the Goat Cliffs and Grande Mountain are situated on the eastern edge of the Rocky Mountaings. The elevation here ranges from 3000 feet (914 meters) at the Smoky River up to 7000 (2134) at the summit of Mount Hamell. The Smoky River flows north between Mount Hamell on the west and Grande Mountain and the Goat Cliffs to the east. It is unlikely that regular movement of goats (particularly nursery groups) occurs across the Smoky River, but I feel that some goats may have moved between Grande Mountain and the Goat Cliffs and that this is possibly a more regular movement route. Table 1 lists the estimated goat populations for each side of the Smoky River in 1974 and 1975 (ie. the estimate for Grande Mountain has been combined with that for the Goat Cliffs). Kerr (1965) reported a decline from 80 to 55 goats on Mount Hamell between 1962 and 1963. That population has declined even further since that time.

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[1]Financial support was provided by the Alberta Fish and Wildlife Division, the University of Alberta and the Canadian Wildlife Service.

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Table 1. Summary of population estimates for two study areas in 1974 and 1975.

	Hamell		Goat Cliffs	
	1974	1975	1974	1975
adult male	8	10-13	8	8-10
adult female	12	13	11	10
two-year-old	7	2	7	3
yearling	3	5	1	2
kid	9	9	3	8
total	32	39-42	23	31-33
Kids/100 nannies	75	69	27	80

These areas are located near the new town of Grande Cache just north of the Willmore Wilderness Park in an area that has recently been developed for rich coal deposits. Several active underground mines and a preparation plant are situated adjacent to these study areas.

METHODS

Field observations were recorded during the summer and fall of 1974 and the summer of 1975. Daily observations were conducted from base camps located on each study area. The location, age and sex were specified when possible for each animal observed or otherwise listed as unclassified. For the purpose of this study a nursery group was defined as any group of goats that included at least one kid. Other individuals in a group may have been of any age or sex cohort, although adult billies were uncommon in nursery groups.

I chose the following habitat parameters as variables that might be relevant to the distribution of mountain goat nursery groups: vegetative cover type, elevation, slope, aspect and distance to the rock-gravel cover type. Each of these variables was plotted on a separate map of the study area. A grid overlay system was established for the maps and each point on the grid was classified for the habitat variables mentioned. Nursery group locations were also identified by coordinates of the grid, allowing a fairly accurate identification of the variables at the point of each nursery group observation.

I identified seven categories of cover type. The deciduous and conifer cover types were situated at lower elevations. The conifer stands (mainly spruce Picea glauca X P. engelmannii) were most often located on north facing slopes while the deciduous forest (mainly poplar Populus balsamifera or dense alder thickets Alnus crispa) were situated on south facing aspects. The grassland was a scarce type on all areas. This too was found at lower elevations of about 3500 to 4500f(1068-1373m). The burn type was situated at higher elevation, usually above 5000f(1525m). These were older burns that have shown very little regeneration of their previous conifer stands but now support a productive grass-herb-shrub vegetation. This cover type was usually characterized by a relatively deep soil layer compared to the other cover types at the same elevation. The subalpine ridge type was another high elevation cover type, usually situated above 4500f (1373 m), and was spatially associated with the rock-gravel type. The species composition of the vegetation on the subalpine ridge was very similar to that of the burn, but the biomass productivity and soil thickness were much less. The alpine tundra type was situated above 6000f(1830 m). Grasses, sedges and small dicot herbs were prevalent on this type. The rock-gravel cover type was characterized by little or no vegetation cover. The slope on this type was usually very steep and the soil unstable.

Elevation was divided into 500 foot (153m) intervals between 3500 and 6500f(1068-1983 m) from the national topographic map series (1:50,000 scale). Slope was estimated for 15^{0} intervals between 15 and 75 degree slopes. I divided the aspect of the study areas into north, south and east facing and a high elevation exposed aspect. The west facing aspect was not represented here. Finally the distance to the closest rock-gravel cover type was considered for each observation. The distance was determined from the grid system used to plot observations and habitat variables. Consequently the category intervals are a function of the distance between grid points (approximately 206 m) and the first category of the distance variable is equivalent to the rock-gravel cover type. The habitat parameters considered here do not vary independently of each other. This must be considered when interpreting the results in the following sections.

RESULTS

Observations of nursery groups on these areas centered around key zones of steep rock-gravel. On Mount Hamell, Hell's Canyon formed the most prominent relief and was the central area used by goats. On the Goat Cliffs, observations of nursery groups centered on two adjacent drainages that converged on the Smoky River. These areas accounted for about 50 percent of all nursery group observations; however, the dependence on the rock-gravel cover type by nursery groups was not consistent throughout the summer period. The predominant activities on this cover type were security oriented (ie. bedded and escape). Use of areas at greater distances from the rock-gravel cover type at higher elevations and on the most gentle slopes were associated with foraging activity. There was a significant association, using and R. x C contingency chi square test ($p < 0.05$ and in most cases $p < 0.005$) between each of the habitat parameters and nursery group activity and the habitats that were used each month.

Resource Use and Activity

I examined the use of each habitat variable to see if there were differences in habitat preferences associated with the activity of nursery groups. Three activity classes accounted for almost all observations recorded. These were feeding, bedded and escape. Fig. 1 show the proportion of observations in each activity category for the vegetative cover type ($p < 0.005$). The smallest proportion of feeding activity occurred on the rock-gravel type. The nominal characteristic of the cover type variable prohibits a sequential interpretation of the categories. That is, the activity of nursery groups on each cover type cannot by ranked according to any value of each cover type.

The activity of nursery groups varied significantly ($p < 0.005$) at different elevations (Fig. 2). The interval characteristic of this variable permits a sequential interpretation, not possible for cover type or other nominal variables. Foraging activity prevailed at higher elevations and bedding decreased. There were no major changes in the proportion of escape activity except at the lowest elevation where the small sample of two observations reduced the significance of this category.

The proportion of observations in each activity on the different slopes is shown in Fig. 3 ($p < 0.005$). Feeding activity was greatest on the most gentle slopes and least on those areas with a slope of greater than 30 degrees. Conversely, bedding activity was least on the more level areas.

The effect of aspect on nursery groups activities should be considered in terms of the effect that aspect has on other factors such as the incidence of radiant energy, vegetation type or snow cover. On the basis that the amount of radiant energy received is greater on south facing that on east facing slopes and greater on east facing than north facing slopes, then it is probable that incident radiation was favoured in the selection of foraging sites by nursery groups (Fig. 4, $p < 0.005$). Minor variation in bedding and escape activity were recorded on each aspect. The small proportion of escape and bedded activity on the exposed slope may reflect the association of this type with high elevation, level areas.

Nursery group activities varied significantly as the distance from rock-gravel cover type increased (Fig. 5, $p < 0.005$). Foraging activity became more prevalent and bedding activity decreased as the distance from rock-gravel cover increased. Escape activity was most frequent on the rock-gravel cover type but remained fairly constant at increasing distances.

Seasonal Patterns of Resource Use

Since observations were only recorded during the summer and fall periods this examination does not extend to the complete annual cycle of habitat use. Observations from all study areas and two years of data are combined to increase sample sizes in this analysis and were divided into monthly intervals.

The most interesting changes in habitat use were associated with cover type, elevation and distance to the rock-gravel cover type. Variation in the seasonal use of cover types occurred on the rock-gravel type, tundra type and the burn cover type (Fig. 6, $p < 0.005$). This variation may have been associated with the selection of other habitat variables such as elevation or distance from the rock-gravel cover, that co-vary with cover type, but may also reflect differences in forage availability or quality on these types as the season progresses.

I observed a significant trend in the seasonal use of different elevation classes by nursery groups (Fig. 7, $p < 0.005$). There was a consistent increase from May to October-November in the proportion of nursery groups observed above 5000f (1525m). Observations in the highest category (ie. above 6000f (1830m) occurred only in July and August. In the previous section I established that the majority of observations at higher elevations were associated with feeding activity.

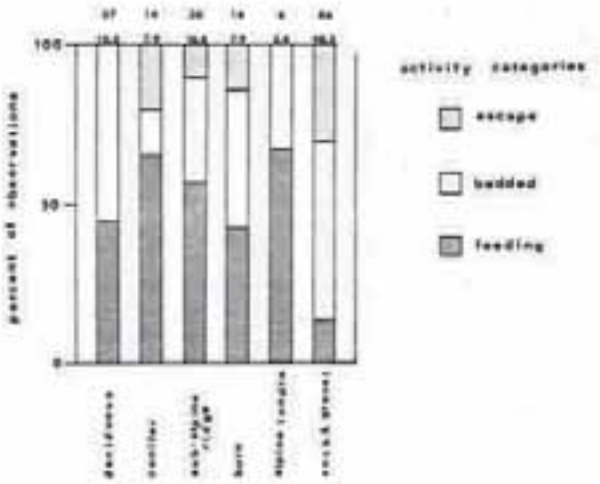

Figure 1. Activity of subunit groups on each forest type.

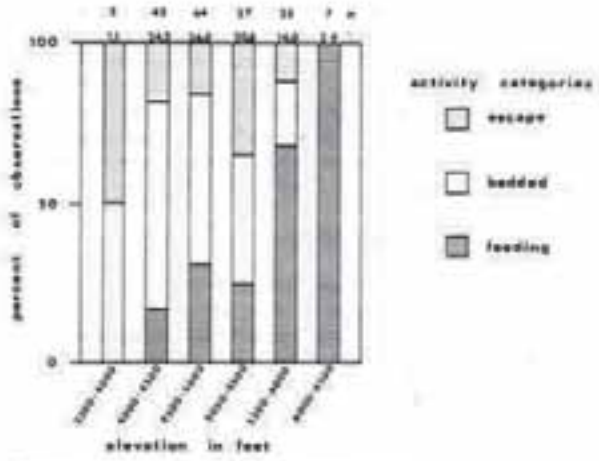

Figure 2. Activity of subunit groups on each elevation category.

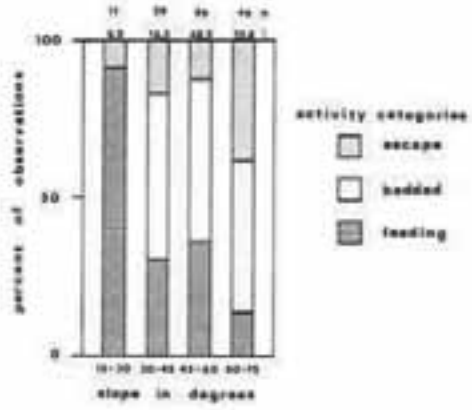

Figure 3. Activity of subunit groups on each slope category.

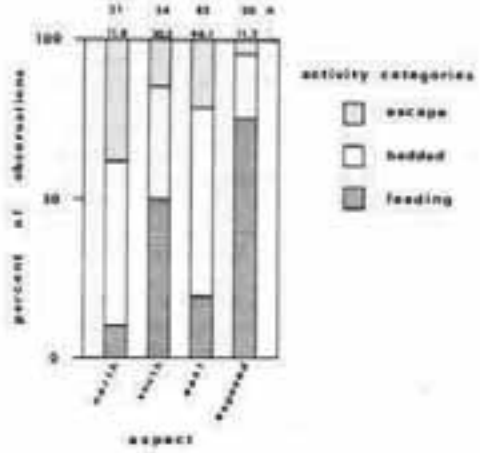

Figure 4. Activity of subunit groups on each aspect.

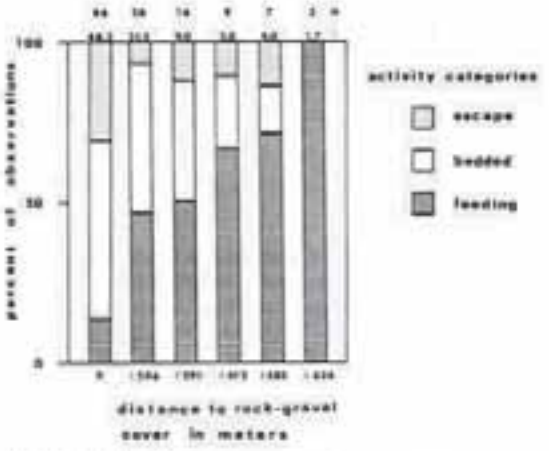

Figure 5. Activity of nursery groups at different distances from the rock-gravel cover type.

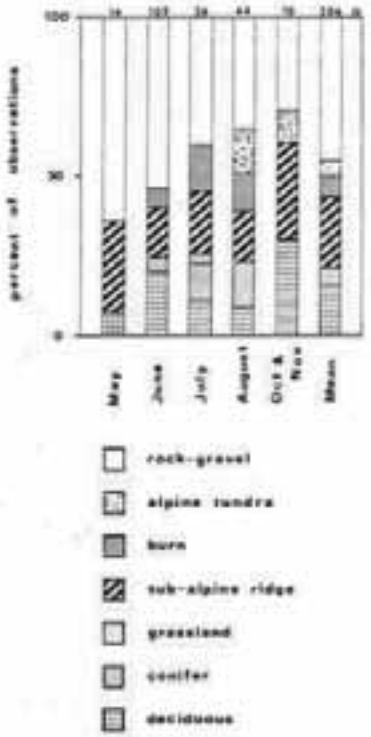

Figure 6. Monthly distribution of nursery groups with respect to cover type.

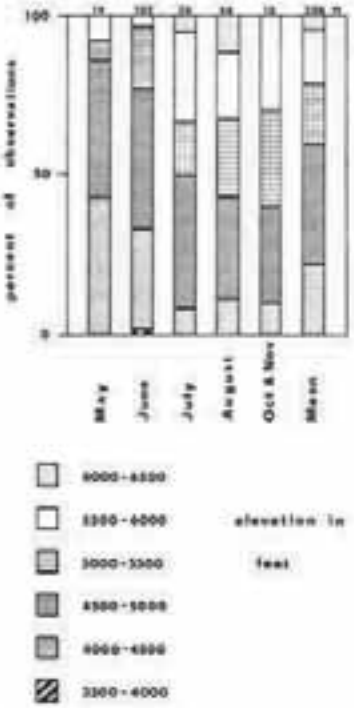

Figure 7. Monthly distribution of nursery groups with respect to elevation.

Figure 4. Model describing the factors influencing habitat preferences of mountain goat nursery groups.

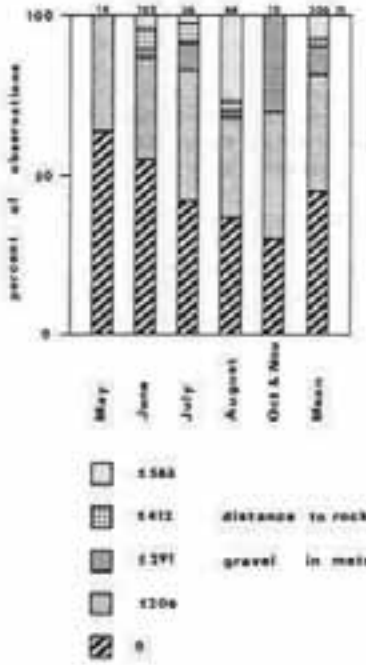

Figure 8. Monthly distribution of nursery groups with respect to distance to the rock-gravel cover type.

There is also a notable seasonal trend towards increasing use of habitat at greater distances to the rock-gravel cover type during the summer (Fig. 8, $p < 0.005$). The greatest proportion of observations in the most distant category occurred in August. I have also indicated in the previous section that feeding activity was the most prevalent activity in the most distant categories.

DISCUSSION

Strategy of Resource Use

The term "strategy of resource use" is used here as a synonym for ecological niche; however, the former term is preferred in this context because it emphasizes the active selection of environmental factors. The idea of a strategy is helpful since it implies a flexible complex niche. This is particularly relevant in a variable and discontinuous habitat such as that occupied by mountain goats. The resource components of the niche have physical, biological and temporal dimensions.

I have prepared a simplified model (Fig. 9) of the strategy of resource use by mountain goat nursery groups that is based on the dichotomy between the need for security and that for forage as factors determining habitat use. It might be argued that the balance between these factors depends upon the existing level of predation. Although several terrestrial predator species (i.e. grizzly bear Ursus arctos, wolf Canis lupus, coyote Canis latrans, and lynx Lynx canadensis) were present no interactions with mountain goats were observed. Golden eagles Aquila chrysaetos were abundant and occasionally made threatening stoops at nursery groups. I would suggest that the requirement for security is reinforced by low levels of predation by terrestrial carnivores and that the refuge strategy of nursery groups is less effective against avian predators as large as eagles.

A major limitation of the resource strategy of nursery groups may be associated with the fact that almost 95 percent of the observations occurred within 412 m of the rock-gravel cover type. Consequently the selection of forage would be restricted to those areas within about 400 m of rock-gravel cover type. This distance may be quite flexible. Murie (1944, p.142) noted that in the presence of heavy wolf predation, Dall sheep (Ovis dalli) range was restricted to the rugged cliff areas, and that in the absence of wolves the sheep moved onto much less secure habitat.

In conjunction with the hypothesis that use of steep rock-gravel areas is associated with the need for security it follows that use of level areas at longer distances from rock-gravel areas are usually associated with highly motivated foraging activity. This is supported by the observation that feeding activity prevailed on those areas.

Seasonal variation in habitat use was possibly due to variation in forage availability and quality on different habitats and differences in security requirements associated with kidding, growth and development of the kids. Nannies typically gave birth to kids on the most rugged portions of the cliff areas and only moved off cliffs after their kids had developed greater physical strength and coordination. As the season progressed the frequency and extent of foraging excursions by nursery groups increased due to the reduction of the need for security. Consequently there was a shift to habitats at greater distances from the rock-gravel type during July and August by nursery groups.

Johnston et al. (1968) showed that the palatability of forage was greater at higher elevations, thus the availability of better forage at higher elevations may encourage feeding activity on these areas. It was apparent that the "green-up" of vegetation in the spring progressed from the lowest deciduous forests in May up to the higher elevations. Consequently the maximum palatability of forage would also progress seasonally up to higher elevations during the summer. This would account for the increased use of tundra and burn types in July and August.

At the present time in Alberta large areas of the eastern slopes of the Rocky Mountains have been leased for extraction of coal deposits. Much of this area corresponds to the areas of major ungulate concentrations and some leases are even situated in alpine zones. There exists a serious potential for conflict between the habitat requirement of mountain goats and other ungulates and the development of non-renewable resources. Detailed knowledge of the habitat use and resource strategy of mountain goats may permit the establishment of spatial and temporal constraints upon future development in order to minimize the impact upon wild populations.

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INFLUENCE OF SNOW CONDITIONS ON WINTER DISTRIBUTION, HABITAT USE, AND GROUP SIZE OF MOUNTAIN GOATS

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Abstract: Habitat relationships of mountain goats (Oreamnos americanus), native to the Bitterroot Mountains of western Montana, were studied from January 1973 to June 1975. Distribution and habitat use on winter ranges were evaluated in terms of elevation, exposure, slope inclination, terrain types, vegetative associations, and size of winter range used by goats. Observed variations during and between three winters were related to snow conditions. When snow depths were greatest, lower elevations, southern exposures, and cliff terrain were used a greater percentage of the time. Mean group size declined and amount of winter range occupied increased during two severe winters versus a mild winter. Adult females exploited snow-free portions of cliffs while subdominants used less optimum habitat. Successful exploitation of optimum habitat, where energy expenditures are minimized, likely promotes survival of females and their offspring.

Mountain goats have evolved many unique adaptations which permit them to occupy an uncrowded niche. Few other North American mammals can survive in the mountainous environment inhabited year-round by goats. As a result, serious predators upon the species are relatively few and mountain goats experience little competition for food and space from other herbivores. Previous investigators examined the daily and seasonal movements, food habits, behavior, and activity patterns of goats to understand their means of coping with their environment and to determine what constitutes good habitat for goats (Brandborg 1955, Chadwick 1973, Kuck 1973, and Rideout 1974). In these studies, the terrain and vegetational features of goat range were combined into four to eight habitat types used to document habitat use. Such broad classifications could preclude accurate measurement of those habitat characteristics which mountain goats prefer.

During January 1973, I initiated an ecological investigation of mountain goats native to the Bitterroot Mountains of western Montana. Part of that study focused on documentation of winter distribution and habitat use. Data were obtained during three winters to investigate year-to-year climatic influences.

I acknowledge the logistical assistance of Reuel Jansson and John Firebaugh of the Montana Department of Fish and Game. I also thank Dr. B. W. O'Gara for his advice during the study. Financial support for this research came from the Montana Cooperative Wildlife Research Unit (Montana Department of Fish and Game, U. S. Fish and Wildlife Service, University of Montana, and Wildlife Management Institute cooperating) and the Foundation for Environmental Education.

STUDY AREA

This study was conducted 40km south of Missoula, Montana in the Bitterroot Mountains (between 46°16'N and 46°31'N latitude and 114°12'W and 114°28'W longitude), the crest of which forms the Montana-Idaho state line. Seven parallel, steep-walled, glacial canyons, which drain eastward to the Bitterroot River, constituted the study area. The canyons are 10 to 16km in length. Elevations range from 1280 to 2800m (4200 to 9200feet). The eastern half of the south-facing canyon wall in six of the drainages provides winter range for mountain goats. Winter range in each canyon is continuous and characterized by steep, broken terrain in which tiered cliffs, skirted by talus, and dissected by couloirs predominate. Parent material is granite and gneiss. Winter ranges lie within the montane forest zone, where scattered ponderosa pine (Pinus ponderosa) and Douglas-fir (Pseudotsuga menziesii) overstory grows on moderate slopes and cliff ledges. A mixed understory of native grasses, forbs, and shrubs flourishes on ledges, talus, and couloirs where a soil mantle has developed. Common species include: bluebunch wheatgrass (Agropyron spicatum), elk sedge (Carex geyeri), yarrow (Achillea millefolium), stonecrop (Sedum stenopetalum), currant (Ribes spp.), and serviceberry (Amelanchier alnifolia). Forests of lodgepole pine (Pinus contorta), subalpine fir (Abies lasiocarpa), whitebark pine (Pinus albicaulis), and alpine larch (Larix lyallii) grow on the cooler north-facing canyon walls and at higher elevations.

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The climate is typically warm and dry in summer, cold and wet during winter. Precipitation increases from 100cm annually at the canyon mouths to 250cm along the Bitterroot Divide. The majority falls as snow.

METHODS

I censused mountain goats from 1 January 1973 to 10 June 1975. They were spotted and observed from trails in each of the canyon bottoms during fall, winter and spring. Modes of travel used to conduct censuses included hiking, snowshoeing, skiing and, in Fred Burr Canyon (winter 1974-75), snowmobile. Summer censuses were conducted along interfluvial ridgetops. Data from aerial censuses were not included in habitat use analyses as identification of habitat characteristics was difficult from aircraft.

Upon initial observation, habitat characteristics, general behavior, and age and sex composition of each sighting were determined with a 15-60 variable spotting scope and recorded on a datum form. Only one record per day was made of each group. Goats were classified in one of six sex and/or age cohorts: kid (K), yearling (Y), 2-year-old male (2M), 2-year-old female (2F), adult male (AM), and adult female (AF) (Brandborg 1955, Smith 1976).

Throughout the study, each sighting was plotted on U. S. Geological Survey 7.5 minute topographic maps. Elevation, slope inclination, and exposure were recorded. Slope was measured over a 61m (200 f) interval of elevation from 10.2cm:1.6km (4in:1mi) topographic maps. Exposure was determined for an area with a 13.7m (15 yard) radius of each sighting. Furthermore, I devised a dual system for describing the habitats occupied by goats whereby I classified the terrain type and vegetative association separately within a 13.7m radius of each sighting. The final, modified version was used from July 1974 through June 1975. Ten terrain types described the predominate geomorphic features of goat range in the study area. Vegetation was classified in a two-component scheme (understory and overstory) paralleling that developed by Daubenmire and Daubenmire (1968). However, existing plant cover, regardless of successional stage, constituted vegetative associations. Ten overstory and 14 understory types were described. This habitat system was outlined previously (Smith 1976). A dual system was employed to determine whether terrain or vegetation might better predict habitat utilization.

Snow depth was estimated at the location of each goat sighting according to the technique described by Geist (1971:269). Chest height (47cm for adults) and other reference points on goats were used as a measuring stick.

RESULTS

Seasonal Distribution

Mountain goats in the study area occupied different summer and winter ranges. Snow depths limited goat distribution, from mid-November through May, to the eastern 7km of the canyons. Steep slopes, southerly exposures, and the action of westerly winds afforded the eastern south-facing canyon walls with excellent snow shedding properties. Elsewhere, snow accumulated to depths of 1.5-4.5m in winter and remained into spring (Table 1). Six of the seven canyons supported a goat herd during winter.

The fall migration to winter ranges was a gradual process. During mid-Octobers of 1973 and 1974, a few goats began appearing on south-facing canyon walls west of winter ranges. This section of each trunk canyon constituted a transitional range utilized for about one month. The movement to the Fred Burr Canyon winter range was abrupt during 1973, and it followed a storm which produced 75cm of snowfall across the study area on 31 October and 1 November. During the exceptionally mild fall of 1974, the movement of goats onto winter range was less synchronous but also occurred during early November. Mountain goats remained on their respective herd winter ranges until the migrated to high elevational summer ranges along interfluvial ridges and the Bitterroot Divide during mid-June. Movements between winter ranges did not occur.

Habitat Use

During the study, I observed groups of goats 717 times on winter ranges accounting for 1,138 goat observations. "Group" and "sighting" are used interchangeably throughout the text to denote either a single goat or several interacting in close proximity to one another for a period of time. Of these totals, 594 groups accounting for 960 goat-observations were in Fred Burr Canyon, where winter ecology was studied most intensively. These 717 sightings are the basis for analysis of habitat use.

Elevation From 1 January through 27 Mary (which henceforth is referred to as "winter period" while "winter" includes only the months January through March), mountain goats used elevations below 2,225m (7,300f). Over 94 percent were observed on the lower 594m (1,800f) of south-facing canyon walls between 1,366 and 1,981m (4,480 and 6,500f) elevation. A complete altitudinal switch occurred in summer when 98 percent of observed goats were above 2,225m (7,300f) elevation (Fig. 1). The

Table 1. Annual precipitation and snow depths at a USDA Soil Conservation Service collecting station 15 km south of the study area and 1.5 km east of the Bitterroot Divide.[a]

Precipitation in Centimeters													
Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1968-1972 Average	15.49	15.80	24.03	41.17	21.74	16.18	15.04	8.76	11.79	3.07	3.30	11.38	187.76
1973	4.09	8.99	29.18	17.78	7.47	11.89	6.96	6.68	10.03	4.78	1.45	11.91	121.21
1974	12.95	24.33	30.07	40.26	26.62	22.00	18.97	9.55	11.99	9.96	5.00	3.96	215.67
1975	1.75	12.42	2.43	45.64	20.14	17.37	15.44	7.16	11.46	5.82	14.86	2.82	179.22

Snow Depth in Centimeters						
Year	Jan.	Feb.	Mar.	Apr.	May	June
1960-1972[b]	165	196	277	284	277	163
1973	142	--	198	203	183	63
1974	201	--	345	358	338	274
1975	163	--	297	325	333	267

[a]Twin Lakes, Montana, Station No. 14CD8P, 1948m; Sec. 32 T 05 N R 23W (Latitude 46° 09' Longitude 114° 30'); Bitterroot River of Columbia Basin.

[b]January data collected 1968-72, February data in 1968, and June data 1965-72.

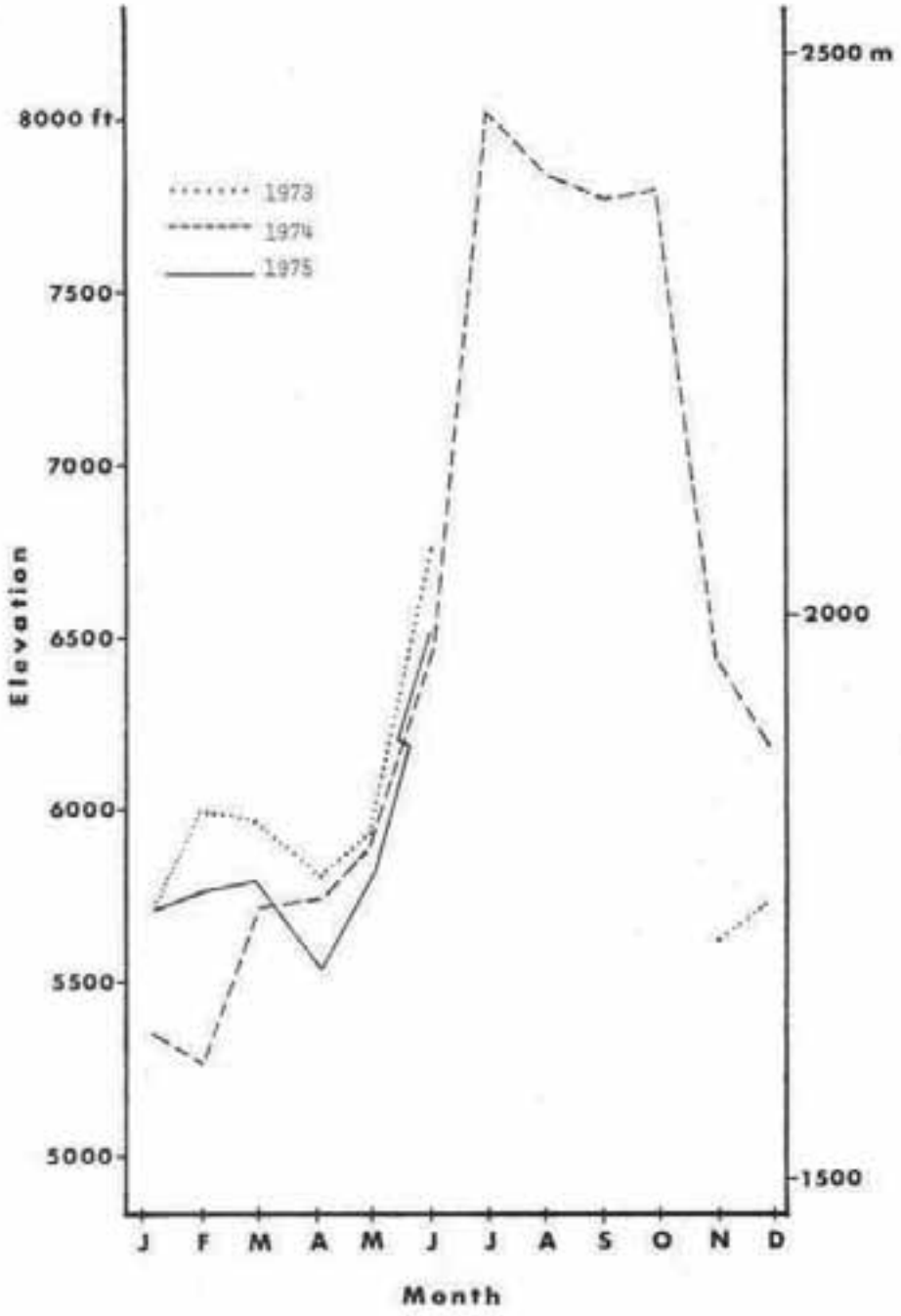


Figure 1. Monthly mean elevation of goat sightings from 1973 to 1975.

alpine cirques used extensively in summer by goats begin at 2,225m (7,300f).

During the winter period of 1974 and 1975, goats utilized mean elevations of 1,735m (5,693f) and 1,741m (5,712f) respectively, compared to 1,786m (5,858f) during winter period of 1973 when snow depths were below normal. The mean elevations used in 1974 and 1975 were significantly less ($p < 0.05$) than in 1973, based on the Student-Newman-Keuls multiple comparison test (Sokal and Rohlf 1969:239). Table 1 shows monthly snow depths recorded at a Soil Conservation Service collecting station 13km south of the study area. Because goat winter ranges lay at lower elevations and farther east of the Bitterroot Divide than the S.C.S. station, they accumulated less snow during winter and retained large patches only on shaded exposures by June. However, the annual trends shown in Table 1 are applicable to goat winter ranges.

The monthly elevations used by goats fluctuated with snow depths (Fig. 1). Deep accumulations of snow during fall 1973 forced goats to lower portions of winter ranges than during the succeeding fall. Below normal daytime temperatures from February through May 1975 delayed spring snowmelt. Consequently, goat sightings were at lower elevations during April and May 1975 than during the preceding two years.

There were no significant differences ($p < 0.05$) between the mean elevations used by feeding and bedding groups (the daily activities at which mountain goats spend 37 and 47 percent of their time, respectively) during each of the three winter periods.

Exposure From the time goats reached transitional ranges in October until the spring migration, all sighting were on E, SE, S, SW, and W exposures. Sixty-three percent were on S exposures which shed snow more readily than others due to favorable sun angle (Table 2). Goats used SE and E exposures more than SW and W, largely because of winter range geomorphology. West exposures of outcrops and cliffs were much steeper, supported less forage, and received full force of prevailing winds, in contrast to E exposures.

From January through April, when snow depths were greater on winter ranges, goat frequented S exposures 56 percent of the time in 1973 compared to 73 and 71 percent of the time in 1974 and 1975. There were no significant differences ($X^2 = 6.52$, 4df, $p < 0.05$) between exposures used by feeding and bedding groups during each of the three winter periods.

As winter snowpack began receding in late May and June, use of S exposures declined and sightings on SE and E exposures increased (Table 2). This shift correlated with the appearance and accessibility of new plant growth on all exposures and rising daytime temperatures. During May and early June, when mountain goats had only partially shed their heavy winter pelage, afternoon temperatures often reached 15.5 to 27 degrees C. Easterly exposures were shaded and cooler during the warm afternoon and evening hours.

Slope From January through June, the average slope used by mountain goats was 47, 49, and 48 degrees respectively in 1973, 1974 and 1975. There was little monthly variation. Although goats displayed no significant ($p < 0.05$) difference in year-to-year preference for slopes, they favored slopes considerably steeper than the average angle (23, 25, 27 and 27 degrees) which Beaty (1962) calculated for the south-facing canyon walls of four representative canyons in the study area. This implied that goats preferred the steepest slopes practical regardless of snow conditions. As specialized rock climbers, goats found snow-free feeding sites and secure bedsites on steep slopes (Fig. 2).

Vegetative Associations From November 1974 through 10 June 1975, goats used the bunchgrass type 62 percent of the time followed by 23 percent in scattered herb. Plant composition was similar in both understory types, but total biomass was greater for the bunchgrass types (Smith 1976). The bunchgrass type covered much of winter ranges and lower transitional ranges on cliff ledges, and parkland and forested colluvial slopes. Scattered herb occurred on sites with thin soils such as cliffs, talus, and broken rock terrain types. Use of vegetative associations was distributed most evenly during November, May and June when snow depths were least (Table 3).

Vegetative associations without overstory were increasingly selected from December through April (0 to 36 percent), then decreased abruptly in importance during May and June. The sites frequented by goats from February through April were wind-swept cliffs capable of supporting only sparse tree growth.

During the winter period of 1975, the observed occurrence of feeding and bedding groups in understory types differed significantly ($X^2 = 16.00$, $df = 5$, $p < 0.01$) from their expected frequencies. Feeding and bedding groups within the bare rock and scattered herb types contributed 32.3 and 36.3 percent, respectively, to the chi-square value. Groups of goats bedded more than they fed in bare rock and fed more than they bedded in scattered herb.

Terrain Types From November 1974 through 10 June 1975, 70 percent of all goat sightings occurred on cliffs (Table 4). Feeding and bedding activities were similarly distributed with 70 percent of feeding and 71 percent of bedding groups observed on cliffs. Herbaceous forage remained available

Table 3. Monthly percent use of exposures by mountain goats on transitional and winter ranges (November to June 1973-1975). Trace (T) amounts are less than 0.5 percent.

Month	No. of Groups	Exposure								
		NE	N	E	NW	SE	W	S	SW	I[a]
Nov.	26					27		69	4	
Dec.	32			6		25		69		
Jan.	57					16		80	4	
Feb.	51			4		33		59	4	
Mar.	100			4		15	1	73	7	
Apr.	225			5		20	2	67	5	T
May	194			9		26	2	53	9	2
June	32			16		44		31	6	3
Total	717									
Averages				6		23	1	63	6	1

[a]I = Indifferent, no exposure.

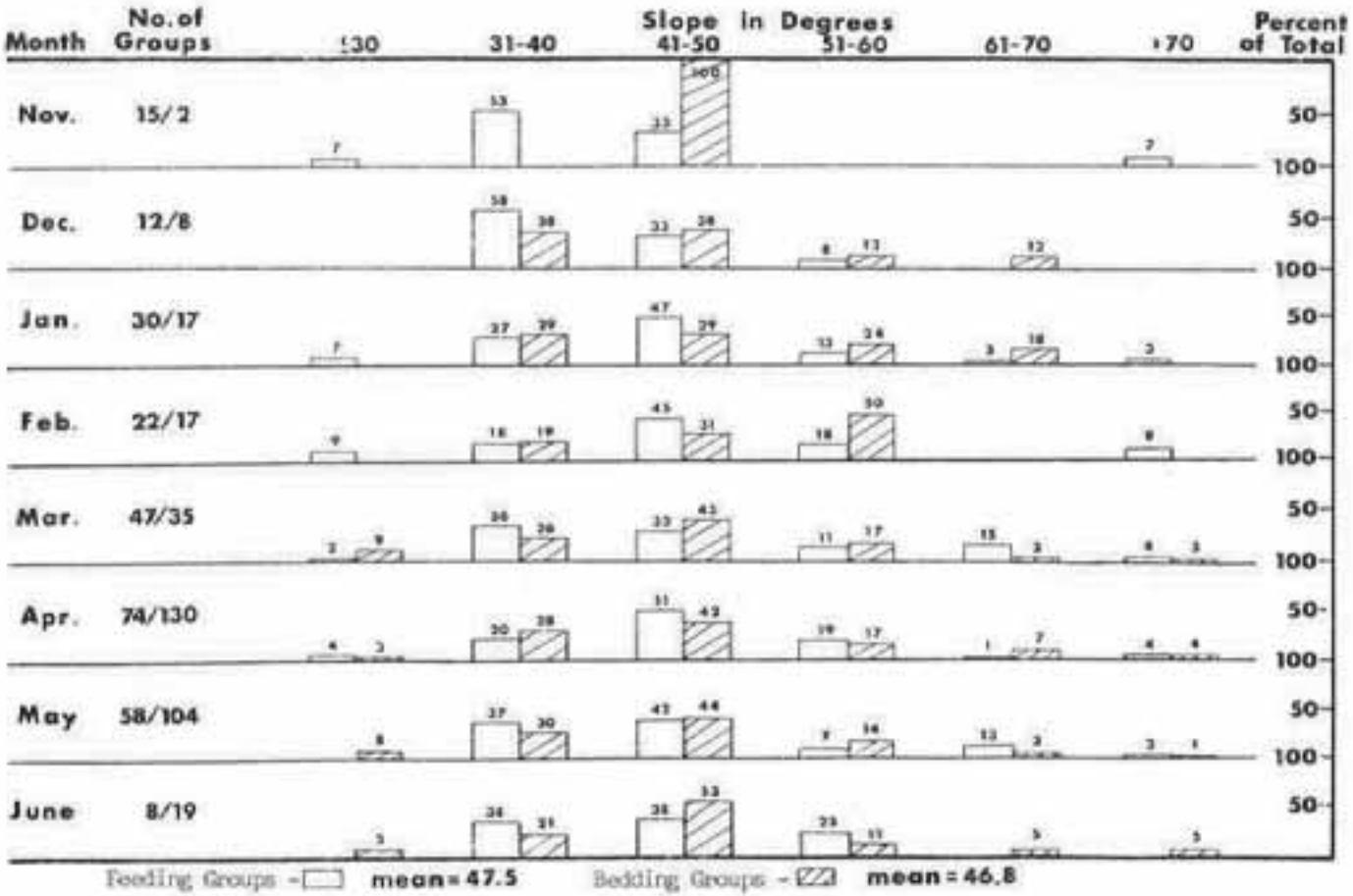


Figure 2. Monthly distribution of feeding/bedding groups on slopes of transitional and winter ranges from January 1973 to June 1975.

Table 3. Monthly percent use of vegetative associations on transitional and winter ranges from November 1974 to June 1975. Trace (T) amounts are less than 0.5 percent.

Month	No. of Groups	Vegetative Associations																													
		Bare rock[a]				Snowfield[b]	Bunchgrass					Beargrass-herb			Deciduous shrub		Scattered herb				Senecio-sedge		
		01	02	03	04	03	01	02	03	04	07	01	03	07	01	04	01	02	03	04	01	03	04
Nov.	17						6		41		6		6	12	6				12		6	6	
Dec.	11			9					55	27									9				
Jan.	22						5	18	18	41			5				5		9				
Feb.	37						11		5	24	41						5		8		5		
Mar.	64	5	2				6		3	27	33		5				9	2	8	2			
Apr.	148	2			2		16		10	10	32		2		1		17	1	5	2			
May	96	7		3	8			8	10	24	1	1				4	5	3	10	13		1	
June	22	14		5	5	5			27	14							5		14			9	5
Means	52	4	T	1	3	T	8	7	18	29	T	T	2	T	T	1	10	1	8	4	1	1	T
Composite Understory Means				9		T			62				3			1			23			2	
Total	417																						

[a]Each written understory type is subtended by the numbers of associated overstory types: 01 - no overstory; 02 - ponderosa pine; 03 - Douglas-fir; 04 - ponderosa pine/Douglas-fir; 07 - subalpine fir.

[b]Pertinent only to May and June.

on cliff ledges in the Bitterroots throughout the winter period due to snow slides and wind action. Mountain goats generally avoided areas of chest-deep snow (approximately 47cm) unless it was sufficiently dense or crusted to support their weight.

During 1975, I estimated the snow depth at each group location. Fig. 3 and Table 4 demonstrate that those terrain types which remained most snow-free also accounted for most sightings. Most parkland colluvial slopes used by goats were essentially very bad ledges. Their use peaked during fall and early winter when snow was fluffy and relatively easy to paw and travel through. The persistence of snow on these shaded, gentle slopes probably reduced their attractiveness to goats in spring. Conversely, cliffs without prominent ledges received no use until February but served as important snow-free feeding sites through spring. As snowbound couloirs and sliderock became snow-free in late spring, their importance increased.

During the winter period of 1975, frequencies of feeding and bedding groups observed in each terrain type did not differ significantly from the expected frequencies ($X^2 = 9.92$, 6 df, $p > 0.05$). Goats were synchronizing their daily activities on the same terrain types.

There were five caves on the Fred Burr winter range and others were located in adjacent drainages. Carpets of pellets, shed hair, and tracks indicated those caves were important to mountain goats. Few goats were seen on days when wind-driven rain or sleet would have soaked their pelage. I believe that caves, overhangs, and the lee side of cliffs provided refuge for goats during such weather.

Size and Distribution of Groups

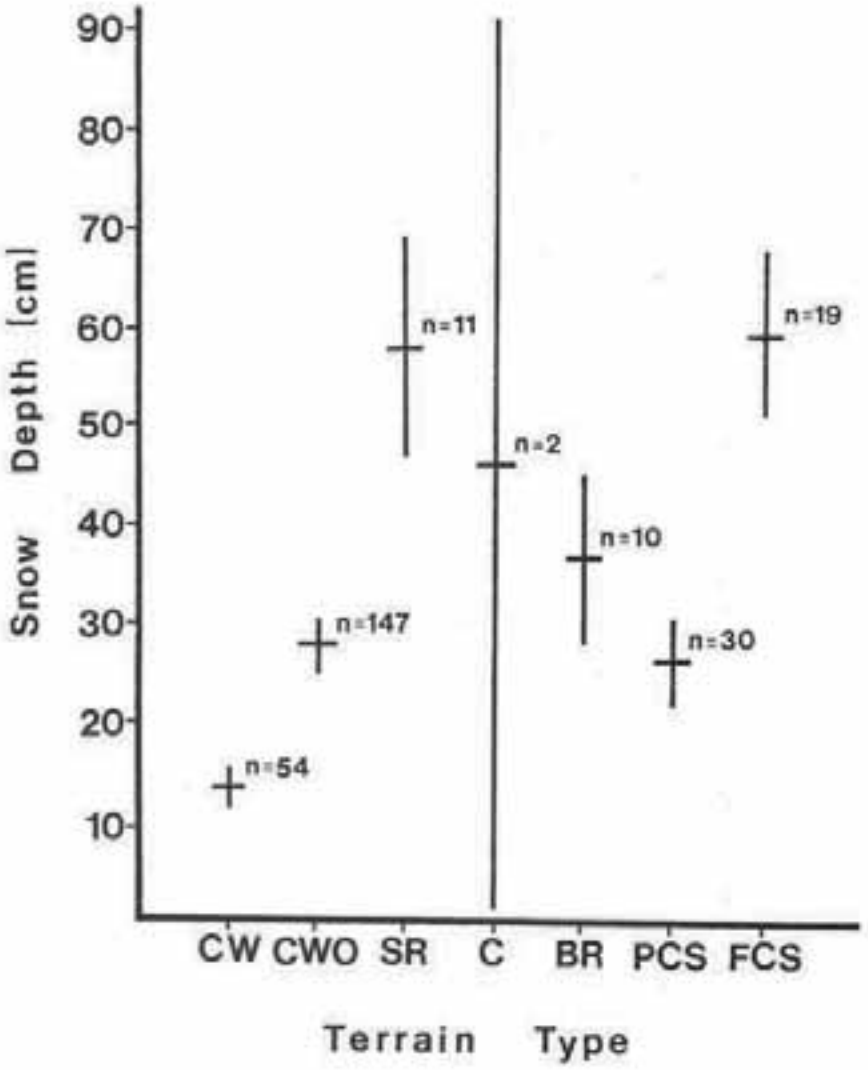
Data from three winter periods indicated that snow conditions affected groups size and distribution of goats on the Fred Burr winter range. During 1973, an estimated herd of 36 goats was distributed across 5km of winter range (Fig. 4 and Table 5). Forty-seven percent of groups were single animals. During the winter period of 1974, snow covered much of the winter range for extended periods. The amount of the south-facing canyon wall occupied by a smaller herd increased to 6.8km. Whereas adult females were distributed similarly to the previous year, 83 percent of adult male sightings were on the western 1.6km of range where snow depths were greater (Fig. 4). Consequently, the mean distances from AM groups (groups containing one or more AMs but no AFs) to their nearest neighbors (closest group regardless of composition) and to the nearest AF groups (groups containing one or more AFs but no AMs) were greater in 1974 than in 1973. This happened despite the fact that the average number of groups on the winter range in 1974 exceeded the average number in 1973 (Table 5).

Tabel 5. Distribution-related data for mountain goats on the Fred Burr range from January to 27 May 1973-75. Distances (m) from AM groups to nearest-neighbors (N-N) and to nearest AF groups were measured on a census by census basis, then averaged for all censuses during a winter period. Distances were measured from topographic maps and not adjusted for elevational change.

Year	1973	1974	1975
Herd Size	36	32	27
Mean Group Size	2.18	1.45	1.47
Largest Group	8	5	6
Average Number of Groups on Winter Range[a]	16.4	22.0	18.4
Linear Area of Winter Range Used	5 km	6.8	6.8
Mean Dist. to N-N of AM Groups	347	411	517
Mean Dist. to Nearest AF Group from AM Groups	621	1263	1083

[a]Herd size=mean group size; the herd sizes were calculated by Smith (1976).

The winter period of 1975 was another with persistent snow cover. A herd of 27 goats occupied 6.8 km of Fred Burr Canyon. Groups were homogeneously distributed with a clump of AF sightings on the eastern 1.6 km of winter range and a clump of AM sightings on the western end. The distinct east-west segregation of 1974 disappeared. Nevertheless, mean distance from AM groups to their nearest neighbors increased over the previous two years. Group size remained small.



CW = cliffs with prominent ledges; CWO = cliffs without prominent ledges; SR = slide rock; C = couloirs; BR = broken rock; PCS = parkland colluvial slopes; FCS = forested colluvial slopes; and N = 273.

Figure 3. Mean ± standard error of snow depths estimated at the locations of goat sighting within each terrain type on winter ranges.

Table 4. Monthly percent use of terrain types on transitional and winter ranges (November 1974 to June 1975).

Month	No. of groups	Terrain Types						
		Cliff w/o prominent ledges	Cliff w/ prominent ledges	Slide rock	Couloir	Broken rock	Parkland colluvial slope	Forested colluvial slope
Nov.	17		47		12	6	29	6
Dec.	11		45	9		9	36	
Jan.	22	5	55	5	5		23	9
Feb.	37	11	54	3		5	16	11
Mar.	64	19	53	5		2	14	8
Apr.	148	23	55	4	1	5	7	5
May	96	24	43	11	3	6	3	9
June	22	18	50	9	14	5	5	
Means		19	51	6	2	5	10	7
Total	417							

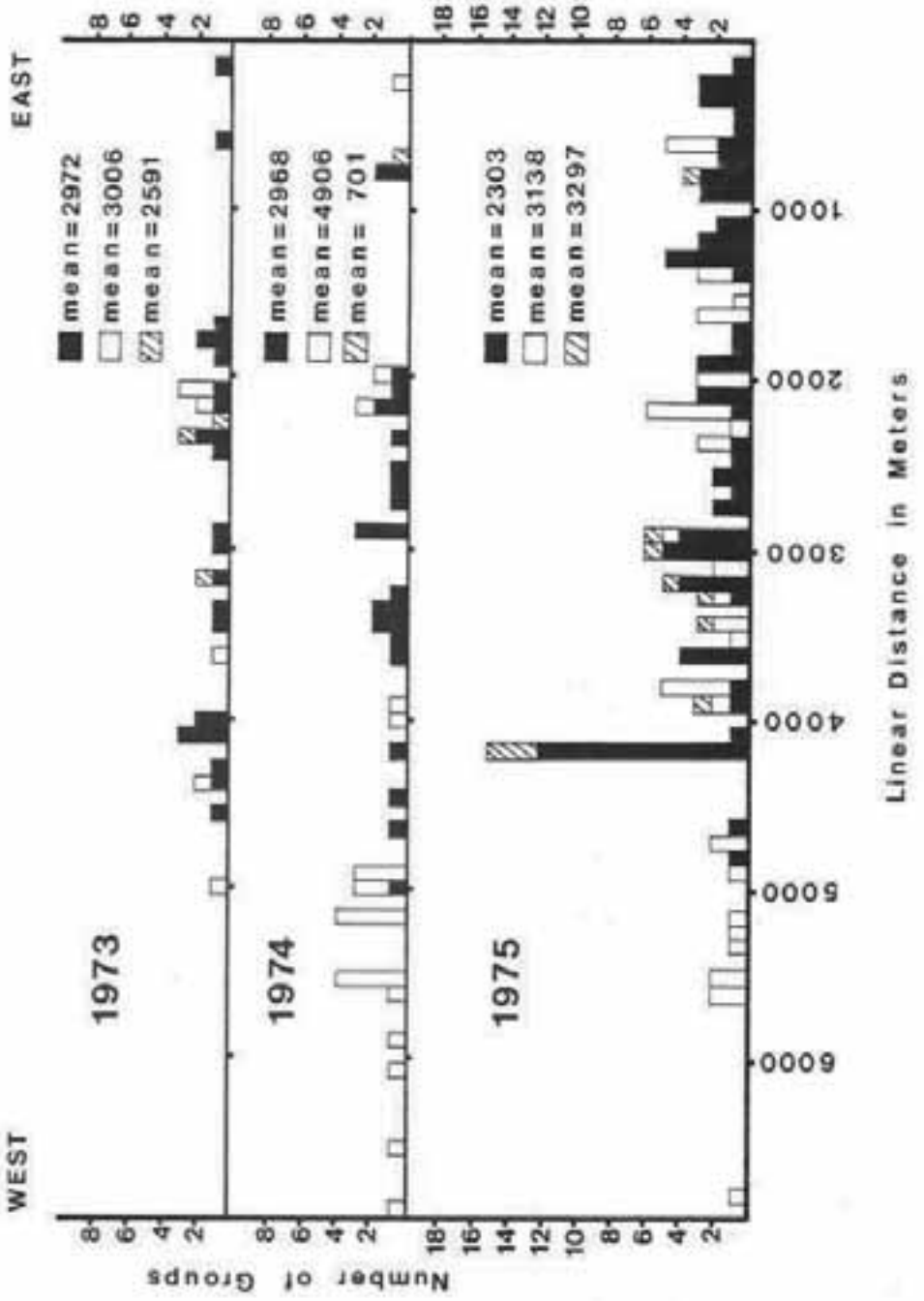


Figure 4. Linear distribution of goat sightings across the Fred Burr winter range from January through May 1973 - 1975. The 0 meter reference point coincides with the eastern most location at which any goat was seen.

A chi-square test revealed that observed groups of goats, categorized as AM, AF, and subadult (groups containing one or more Ks, Ys, 2Ms, and 2Fs but no AMs or AFs) groups, differed significantly from their expected occurrence in various snow depths ($N = 246$, $X^2 = 19.34$, 4df, $p < 0.05$). A Bonferonni multicomparison test (Neu et al.1974) demonstrated that AF groups used areas with 0-16cm snow depths significantly more than expected ($p < 0.05$) as compared with AM and subadult groups (Table 6).

Table 6. Occurrence of AM, AF, and subadult groups of mountain goats by snow depth in the Bitterroot Mountains, Montana, January through April 1975.

Hierarchical groups	Snow depth category in centimeters	Observed proportion (number) of groups $\hat{p}$	Expected proportion (number) of groups E(p)[a]	Confidence interval on proportion of occurrence (95%)[b]
AF				
	0-16	0-635 (73)	0.508 (58.4)	0.526 E(p) 0.744
	17-47	0.226 (26)	0.280 (32.3)	0.132 E(p) 0.320
	48+	0.139 (16)	0.211 (24.3)	0.060 E(p) 0.218
TOTAL		(115)	(115.0)	
AM				
	0-16	0.379 (25)	0.508 (33.5)	0.233 E(p) 0.525
	17-47	0.273 (18)	0.280 (18.5)	0.203 E(p) 0.343
	48+	0.348 (23)	0.211 (14.0)	0.203 E(p) 0.493
TOTAL		(66)	(66)	
Subadult				
	0-16	0.415 (27)	0.508 (33.0)	0.264 E(p) 0.566
	17-47	0.385 (25)	0.280 (18.2)	0.236 E(p) 0.534
	48+	0.200 (13)	0.211 (13.7)	0.077 E(p) 0.323
TOTAL		(65)	(64.9)	
GRAND TOTAL		(246)	(245.9)	

[a] $.508 = \frac{73+25+27}{246}$ The null hypothesis states that hierarchical groups of mountain goats occur in the three categories of snow depths in equal proportions.

[b] $\hat{p} \pm t\sqrt{\hat{p}\,(1-\hat{p})/n}$

AF groups accounted for 66 percent of all sightings on cliffs without prominent ledges--the most snow-free terrain type. (Cliffs without prominent ledge, which provided adequate forage and were navigable by goats, were not abundant on the study area). No significant differences were found at depths exceeding 16cm.

DISCUSSION

Winters of above normal snowfall probably increase intraspecific competition for food and space, in comparison to mild winters, and alter habitat use of mountain goats. Goats in the study area utilized lower elevations and more southerly exposures, which were generally more snow-free, during 1974 and 1975 than during 1973 when snow depths were below average. Goats in the Sapphire Mountains, 25km east of the Bitterroots, likewise sought lower elevations during the severe winter of 1972 than during 1973 (Rideout 1974). Similarly, Hjeljord (1973) found that goats in Alaska wintered above timberline on windswept ridges, when their subalpine winter range of the following mild winter became laden with 60 - 90cm of crusted snow.

Within their 1975 winter range, goats generally avoided areas of chest-deep snow unless it supported their weight. Kelsall (1969) and Gilbert et al. (1970) found that movements of moose (Alces alces), and white-tailed (Odocoileus virginianus) and mule deer (Odocoileus hemionus) were severely restricted by snow which exceeded two thirds of chest height. In deep snow, energy expenditures are high during travel and feeding because movements are cumbersome and animals must paw for herbaceous forage. Geist (1971:266-268) felt that pawing frequencies of Stone's sheep (Ovis dalli stonei) and mountain goats reflected the relative effort being expended. He observed

that both pawing frequency and number of scratches per bout increased with snow depth. Either one or both of the two most frequented vegetative understory types, bunchgrass and scattered herb, grew on all seven terrain types on winter ranges. Yet two of those terrain types, cliffs with prominent ledges and cliffs without prominent ledges, received over 70 percent of all goat use. In the Bitterroot Mountains, cliff ledges supported considerable forage, provided secure bedsites, and shed snow more readily than other terrain types. Parkland colluvial slopes received heavy use only in fall and early winter when snow was fluffy, and easily blown off that terrain type. Thus, winter habitat use was concentrated on terrain types with shallow snow and accessible forage. During winters of below normal snow accumulations, vegetation composition, biomass, and/or palatability may play a larger role in habitat use.

The similarity in elevations, slopes, exposures, and terrain types chosen for both feeding and bedding, suggests that these activities were synchronized on the same topographic locations to conserve energy. In many cases during the winter period of 1974 and 1975, feeding bouts ceased as goats reached prime bedding sites. Vaughan (1975) hypothesized that the low reproductive success of nannies in the Wallowa Mountains resulted from the inadequacy of winter range. He observed that goats travelled twice daily between removed feeding and bedding sites and that those travels adversely affected gravid females.

The variable effects of hardness and density as well as depth of snow on habitat use were reported for moose (Peek 1971) and various mammals of Russia (Formozov 1946). Snow which is dense and/or crusted, but incapable of supporting an animal's foot load, poses obvious feeding and locomotional difficulties for ungulates. Measurements of these snow characteristics were not obtained during this study. However, Gilbert et al. (1970) demonstrated the effectiveness of snow depth in altering the monthly and annual distribution of mule deer on mountainous winter range. Annual snow depths affected distribution and size of winter range occupied by mountain goats in the Bitterroot Mountains. During the winter period of 1973, the Fred Burr herd exploited a variety of habitats. Of the 77 groups recorded from January through May, no two were at the same location. During the succeeding two years, the herd occupied 25 percent more linear winter range. Sightings were clumped on more snow-free cliff areas.

The explanation to this relates to the social interactions of goats in the study area. On winter ranges, small groups appeared to be selectively adaptive since:

1) The broken nature of winter habitat and dispersed food base favored small foraging groups. Evenly distributed small groups maximized use of available food while reducing intraspecific competition and the potential for degradation of small areas.

2) Lower rates of agression in small groups promoted individual conservation of energy under adverse conditions.

3) Large groups would likely increase the potential for accidents resulting from crowding on narrow cliff ledges.

During winters with deep and persistent snow, as in 1974 and 1975, heightened intraspecific competition for feeding sites probably reduced group stability. Mean group size declined. With less snow-free habitat available on the eastern 5 km, groups typically comprised of one to three animals exploited all relatively snow-free patches along a greater length of winter range.

Apparently different social strategies have evolved in other goat populations. Casebeer et al. (1950) reported that goats in the Red Butte area of Montana ranged in large groups during winter. He felt this was advantageous in deep snow as the goats developed well-trodden trails between scattered open areas of available feed. Chadwick (1973) reported group sizes averaging three to six animals in the Little Creek drainage of Montana. There, 3.5 ha of windblown ridgetops constituted the primary winter range for 17 mountain goats. Groups averaging six to seven animals in January and February occupied the Mt. Wardle winter range in Kootenay National Park (Holroyd 1967). DeBock (1970) found that from January to May in Kootenay Park, AM groups averaged about three goats, and female-young groups averaged over nine. Reporting on an introduced population of goats in the Crazy Mountains of Montana, Lentfer (1955) noted that group sizes were larger during winter than summer or fall, but gave no figures. Foss (1962) reported group sizes averaging 2.0 for June, August, and September, and 4.5 for July in the Crazy Mountains. Saunders (1955) regarded windswept ridgetops and slopes as important winter habitat for goats in the Crazy Mountains. All four of these goat populations inhabit winter ranges less broken than those in the Bitterroot Mountains. Windblown slopes or ridgetops provide relatively large patches of habitat over which groups of five or six goats can easily feed without directly competing with one another. Intragroup agonistic behavior does not jeopardize the lives of group members as it may on steep cliffs. Such cliffs characterized goat winter ranges in the Bitterroots, and along the Salmon River (Brandborg 1955) and Lemhi Range (Kuck 1973) of Idaho where group sizes averaged 3.5 and 2.0, respectively. The nature of available habitat apparently dictates winter social strategies.

Winters with deep and persistent snow would further encourage grouping on ranges characterized by windblown slopes and ridgetops as goats become aggregated on less range. Goats in Banff National Park formed larger groups during period of deep winter snow (Petocz 1973).

The distribution of AMs was more variable between years than that of AFs. My observations concur with those of Geist (1964) and Chadwick (1973) that outside the rut, AFs are socially dominant to other classes and that AMs are subordinate to all others. In Fred Burr Canyon, AFs successfully exploited optimal winter habitat. In particular, AFs monopolized favorable cliffs without prominent ledges. AMs generally avoided those areas occupied by other goats, especially AFs. Geist (1971:257-260) observed that Stone's sheep rams were more solitary in winter than other seasons, and reduced social activity then. He felt this reduced energy expenditures. During winter 1974, AF and AM groups were segregated east-west on winter range, but in 1975, linear segregation was not apparent. Instead, AMs used suboptimal habitat on the eastern 4 km of winter range. Lower herd density and reduced likelihood of confrontations with other groups may have permitted the changed distribution of AMs in 1975. DeBock (1970), Chadwick (1973), and Rideout (1974) observed AMs occupying winter areas peripheral to AFs and subadults.

This distribution of hierarchical groups may be evolutionarily selective in maintaining herd numbers. If AFs survive the winter period and are healthy in spring, their changes of producing viable offspring increase. Edward (1956) linked declines in Canadian goat populations during the mid-1940's to harsh winters with excessive snowfall. The reproductive rate of the Fred Burr herd during 1973 exceeded the rate following the winters of 1974 and 1975 (Smith 1976). In addition, it seems reasonable that Ks, which follow their nannies for the first ten or eleven months of life, would experience higher winter survival in relatively snow-free habitat. Avoidance of AFs by AMs limits forage competition between those classes and diminishes nonessential energy expenditures in the form of agonistic behavior. Although AMs generally respond submissively to AFs, their reluctance to associate with AFs neutralizes the potential for injurious encounters between AMs and AFs and their offspring.

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SUMMER MOUNTAIN GOAT ACTIVITY AND HABITAT PREFERENCE IN COASTAL ALASKA AS A BASIS FOR THE ASSESSMENT OF SURVEY TECHNIQUES

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Abstract: Weather conditions in coastal south-central and south-east Alaska greatly limit the amount of time available for mountain goat censusing. The large area occupied by goats necessitates use of aerial surveys in determining population indices but such surveys have been extremely variable in their results. Goat activity and location within available habitat will influence the ease with which they can be located and counted; in particular, movements and activity change related to the onset and duration of clear weather are an important concern. Results of this study indicate that on clear days goats tend to congregate in larger groups, move higher in their range, closer to ridgelines and farther from trees, use more smooth habitat including snowbanks and exhibit a synchronized activity period in the late afternoon. Surveys conducted in late afternoon on clear days and timed sufficiently after the cessation of cloudy and rainy weather should provide close to optimum results.

Mountain goat distribution in Alaska is restricted predominantly to the south-central and south-east coastal ranges with northern termini extending inland into the Wrangell and Talkeetna Mountains at just over 62°N latitude. The main concentrations are in the wet, rugged coastal ranges which has necessitated a reliance on aerial reconnaissance for obtaining population indices over much of the region. Although aerial goat counts have been conducted by the Alaska Department of Fish and Game since 1959, results have shown great variation in total numbers and adult-kid ratios for specific areas both within and between years, and comparison of results is questionable. Summer aerial goat surveys carried out by Fish and Game personnel in a coastal south-east region with fixed wing aircraft provided seven counts which ranged from 30 percent to 97 percent of the total number observed from a helicopter (Ballard 1975). Since current management is based on such surveys a more detailed determination of their reliability is essential. This should involve knowledge of expected goat location and activity under various weather conditions and provide a measure of comparison with simultaneous ground surveys. This paper addresses the relation of goat group size, activity and habitat preference to weather condition.

Past observations on goats have produced comments on typical daily morning and evening feeding periods and suggesting these as the best times for conducting survey counts (Casebeer et al. 1950, Merriam 1965). Chadwick (1973) suggested that late afternoon-evening was the best time for censusing since feeding activities were more synchonous at that time. With respect to weather, it has been observed that goats tend to increase activity and emerge onto open slopes for feeding immediately following a storm which had caused them to seek shelter (Casebeer et al. 1950, Brandborg 1955, Chadwick 1973). Prolonged warm, sunny weather is characterized by a retreat to shaded areas (forest) or to snowbanks (Brandborg 1955), both habitats which tend to conceal goats. Inclement weather induces irregularities in the timing of normal activity patterns (Brandborg 1955) and may result in significant movements. For example, although Klein (1953) states that summer movements are little affected by weather he qualifies this with the case of severe storms which precipitate moves to leeward slopes and often to the upper fringes of forest.

Coastal south-east Alaska presents a somewhat different situation than encountered in most of the studies cited above because the region has typically inclement weather. Hence, irregularities in goat activity patterns might best describe those changes induced by the short clear spells. Thus movements, activity and habitat changes related to the onset of clear weather and acceptable survey conditions are an important concern in the south-east.

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STUDY AREA

The study area is located in south-east Alaska, 58° 30'N, 134°35'W, 25 km northwest of Juneau. Coastal ranges in the vicinity vary in height from 2500 m mountains within the huge ice-fields bordering British Columbia to more common 1500 m to 2100 m peaks nearer the coast. Tree-line in the region, characterized by spruce (Picea sitchensis) and hemlock (Tsuga Mertensiana) forest interspersed with thickets of alder (Alnus crispa), is generally about 800 m. Scrub and krummoltz occasionally approach 900 m and precipituous cliffs virtually devoid of tree growth sometimes span the drop from alpine to sea-level. The study area is a relatively discrete alpine zone of approximately 40 km^2 dominated by Stroller White Mountain (1570 m). Bounded to the north and east by glaciers and ice-fields, the study area slopes west and south into forested lowlands along the inland waterways of lower Lynn Canal (Fig. 1).

METHODS

The study took place during the months June through August, 1976. Data consist of 2,021 point-in-time observations on goat groups taken at 15 min. intervals and catagorized as to elevation, topography, slope exposure, slope angle, snow cover in vicinity, basic vegetation type, group composition and individual activity. An estimate of distance from nearest ridgeline and that to treeline was recorded for each group. Weather information was recorded at least every two hours while animals were under observation and included air temperature, wind speed and direction, humidity, cloud cover and precipitation type and rate. Major weather changes (defined below) were also recorded as time since last such change in conjunction with the 15 min. observations.

About nine km^2 of the study area included terrain which could be observed easily given good visibility. Family groups comprised primarily of adult females, kids and juveniles were the predominant subjects of observation. These totalled between 30 and 35 animals of the approximately 70 goats inhabitating the entire study area.

A group was defined as an individual or aggregation of goats 100 m or more from the nearest other individual or aggregation. The term group observation refers to one point-in-time recording of data on a particular group; individual observations refer to records on each individual made during a group observation. Graphical presentations below are ordinated in terms of these individual or group observations. Major weather types were separated as: clear, 0-50 percent cloud cover; partly-cloudy, 51-95 percent cloud cover; and cloudy, 96-100 percent cloud cover, fog and rain included. Weather types were divided into two periods: less than or equal to 5 hr and greater than 5 hr from the initiation of a particular type. Unless otherwise specified, observations during the transition period of 5 hr are not included in calculations pertaining to a particular weather type.

RESULTS

Weather types and the percent of observations made within them were distributed as shown in Table 1. Note the relatively small percentage of clear weather over the summer. Partly cloudy conditions are even less frequent indicating their existence as a rather short transition stage. Convectional afternoon cloudiness and thunder storms characteristic of continental mountains are generally lacking here where the controlling influences are cyclonic weather patterns from the ocean with rather abrupt changes between clear and stormy conditions.

Table 1. Percent distribution of weather types over the study period and within the time sampled.

Weather Type	Study time Span 15 June-21 Aug.	Observation Time Span	Number of "Group Observations"
Clear	29	39	42
Partly Cloudy	13	32	32
Cloudy	58	29	26

Diurnal activity patterns are somewhat different under the various weather types. These patterns are displayed in Fig. 2 where activity is reflected in a running average of active animals summed for hour intervals. Active animals are on their feet and may be feeding, standing, walking, nursing or playing. The graphs include all individual observations in each weather type assuming that the animals react more rapidly to weather change in their activity than, say in their group size, habitat or elevation locus.

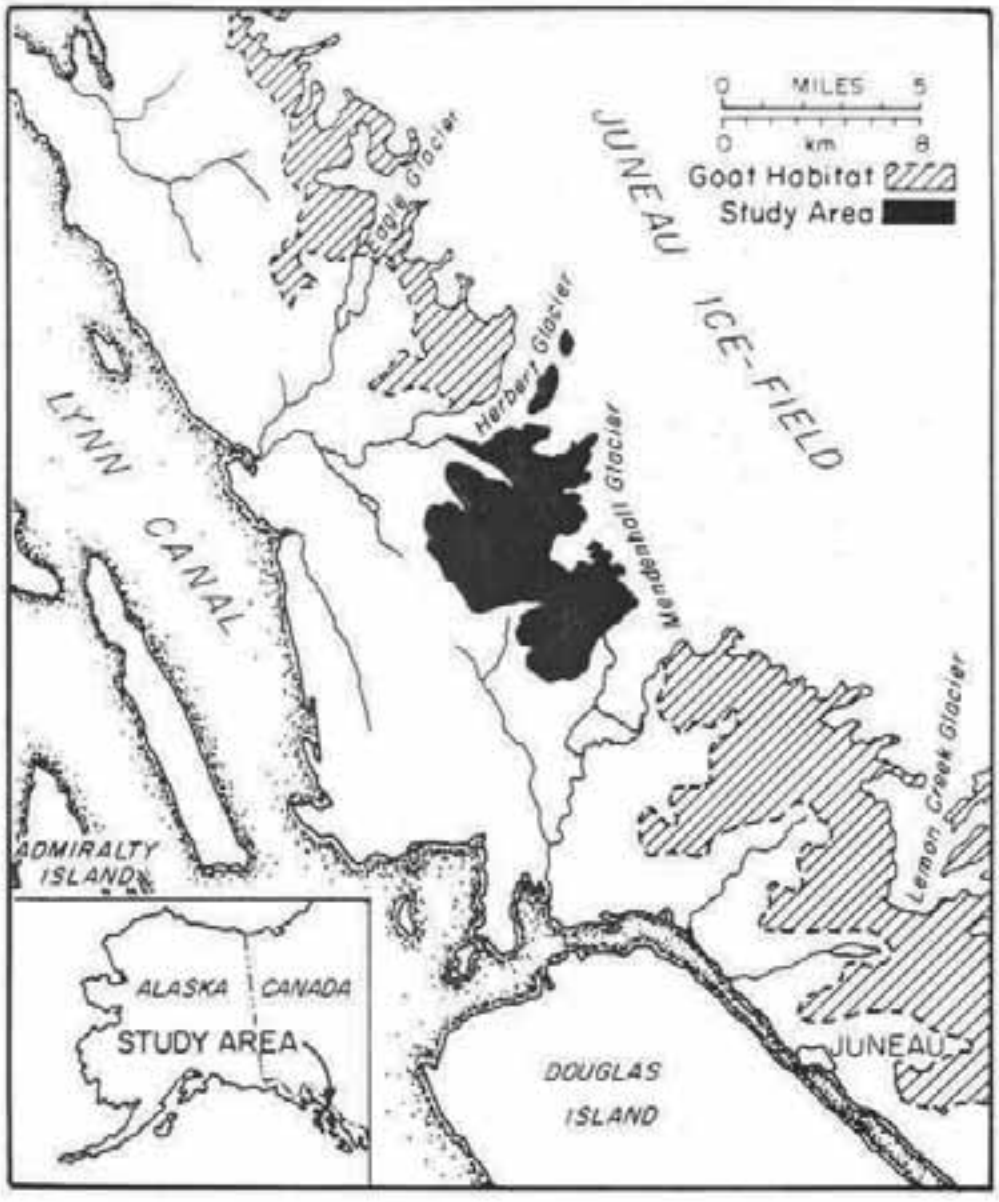

Figure 1. Location of study area.

Confidence limits (P=.05) have been established for at least two points on the graph (Fig. 2) in each weather type to provide a sample of variation within the data. Because of group synchrony in the activity of goats serial correlations between the activity observations exist and direct point to point comparisons between weather types would not be extremely meaningful. The confidence limits provide an approximation of the range in variance for all hours of the day and permits some comparison. The most significant differences between weather types in daily activity pattern are in the peaks during mid to late morning and late afternoon. A late afternoon (1900-2000 hr) activity peak in clear weather is evident as in an earlier (1700-1800 hr) but less pronounced peak during cloudy weather. A mid to late morning active period is demonstrable, though appearing successively later in partly cloudy and cloudy than in clear weather.

There may be differences in total daily active time under the various weather conditions. Through the hours 0800-2400 animals were overall less active in cloudy and rainy weather (53 percent active) and clear weather (56 percent active) with activity during partly cloudy conditions being greatest (61 percent active).

Groups ranged in number from 1 to 30 individuals. Group size, as exhibited by the mean of all group observations was 7.0; Table 2 outlines means, sample sizes and standard errors for group size relative to the weather types. The mean for partly cloudy conditions is intermediate and not significantly different from clear or cloudy weather respectively ($t=1.35$, $P > .1$; $t=52$, $P > .5$). However, a difference in means between clear and cloudy conditions is evident ($t=2.11$, $P < .05$) indicating that groups are larger on clear days.

Table 2. Group size under the different weather types

	Clear	Partly Cloudy	Cloudy
Mean Group Size	7.4	6.8	6.6
Sample Size (Groups)	n=781	n=276	n=289
Standard Error	.21	.39	.34

Use of different elevation zones during the various weather types is displayed in Fig. 3; percent of group observations is that within a specific weather type. Differential use or selection of elevation is very evident under the different weather regimes ($X^2=348$, $P < .005$). General elevation use was between 750 m and 1200 m with virtually no use below 750 m recorded here. Under partly cloudy conditions (>5 hr) goats are relatively high on the slopes, more closely approximating the distribution under clear weather. The indication is that a notable movement to higher elevations occurs following clearing weather.

Knowledge of distributional changes in elevation use under different weather regimes is important for planning and assessing surveys but general applicability may be somewhat limited due to effects of other habitat parameters on elevation range even at the same latitude. The recording of group distances from treeline and ridgeline was initiated in an attempt to provide a more common basis for comparing or combining altitudinally related information with other areas. Differences in goat distribution relative to ridgeline are evident under the various weather conditions ($X^2=137$, $P < .005$) as are use distribution differences relative to treeline ($X^2=280$, $P < .005$). Use of elevations above 1200 m (Fig. 3) virtually all of which is within 130 m of ridgeline in the study area, indicates increased use of ridgetop areas on clear days. Distance from ridgelines (Fig. 4) also indicates use of ridgetop zones on clear days, although the ridgeline data does not reflect as strongly the elevation changes related to weather as does the distance from treeline data (Fig. 4). This variation was probably effected by lateral movement of the goats toward the lower end of a watershed, thus bringing them in cloudy weather somewhat closer to the descending ridgeline without greatly changing the distance to treeline. Ridgeline elevation is generally more variable than treeline. Distance from ridgeline information would probably provide a rather equivocal comparison between areas of very different topography. Still it is evident that there is a significant movement bringing goats close to ridgeline and farther from treeline in clear weather.

Physical habitat selection is evident ($X^2=85$, $P < .005$) under the various weather conditions recorded (Fig. 5). Goats use smooth slopes and snowbanks more during clear weather than during cloudy weather. Use distribution of slope exposure was different ($X^2=243$, $P < .005$) according to weather type. Westerly aspects were preferred over southerly aspects in clearer weather. The overall use of slope exposure during this summer study period is shown in Fig. 6. In general it reflects the lay of the land, sloping to the west and south with peaks in the other directions abutting high icefields and glaciers, thus limiting available terrain to the east and north.

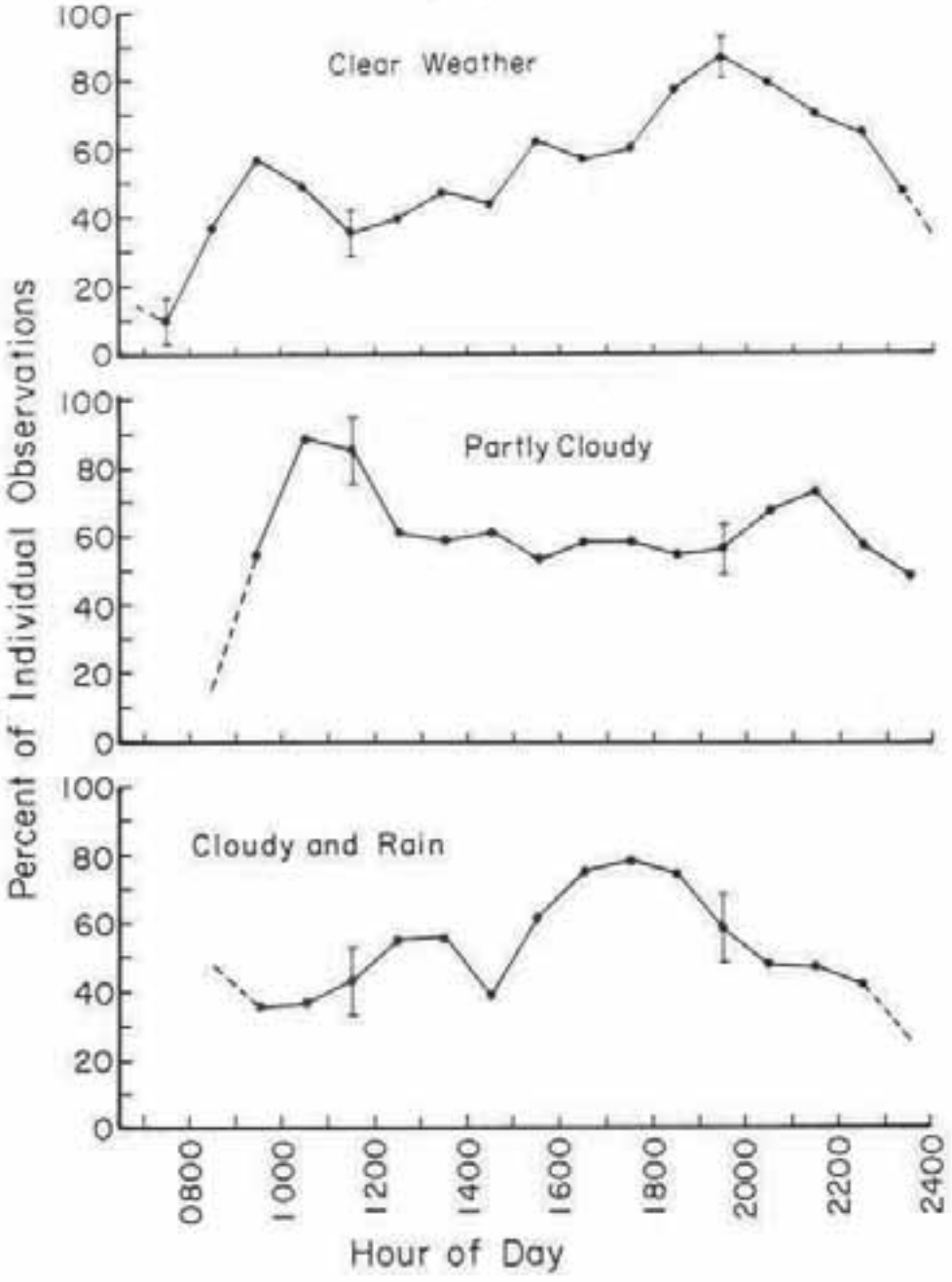

Figure 2. Daily activity pattern reflected in percent of active individuals.

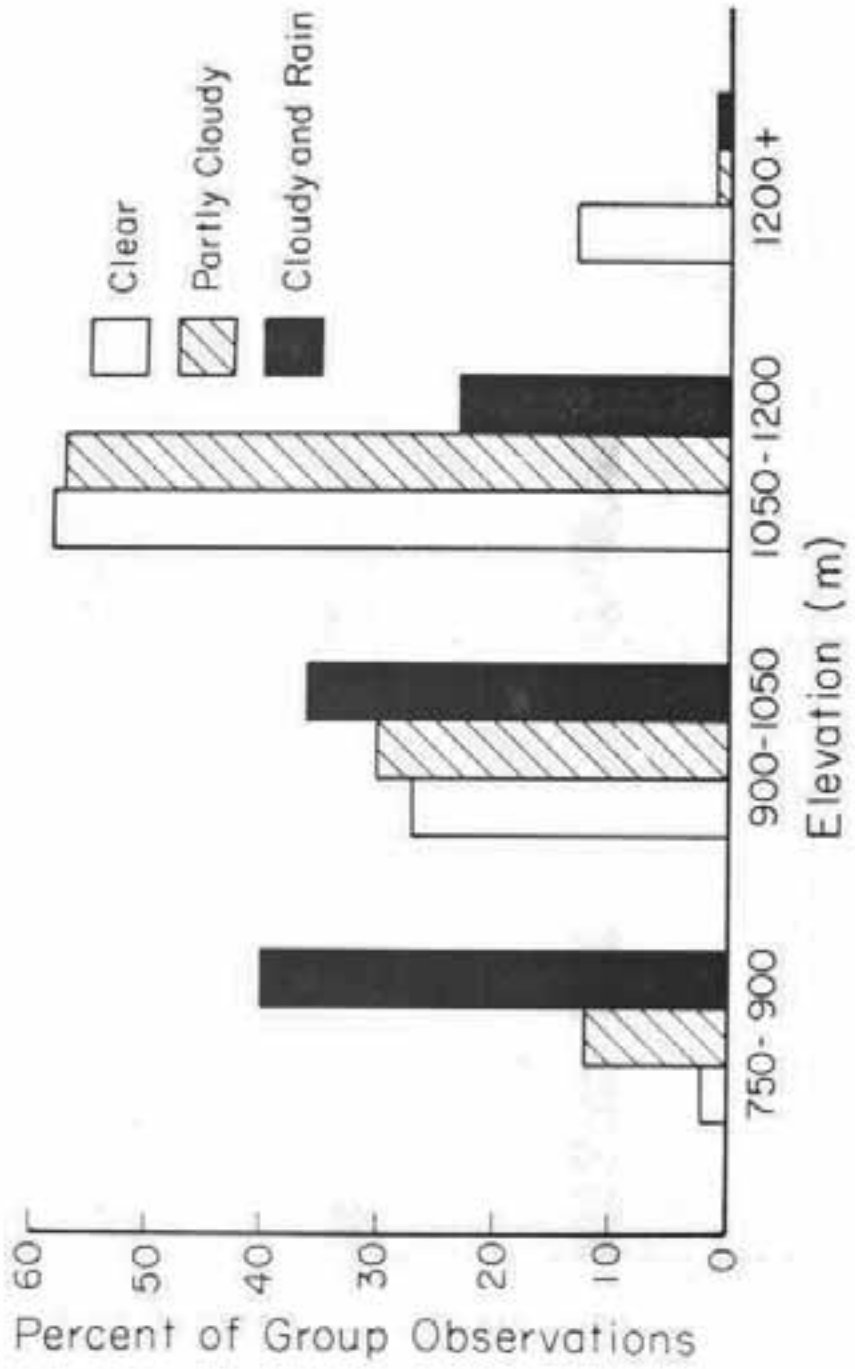

Figure 3. Differential use of elevation according to weather type.

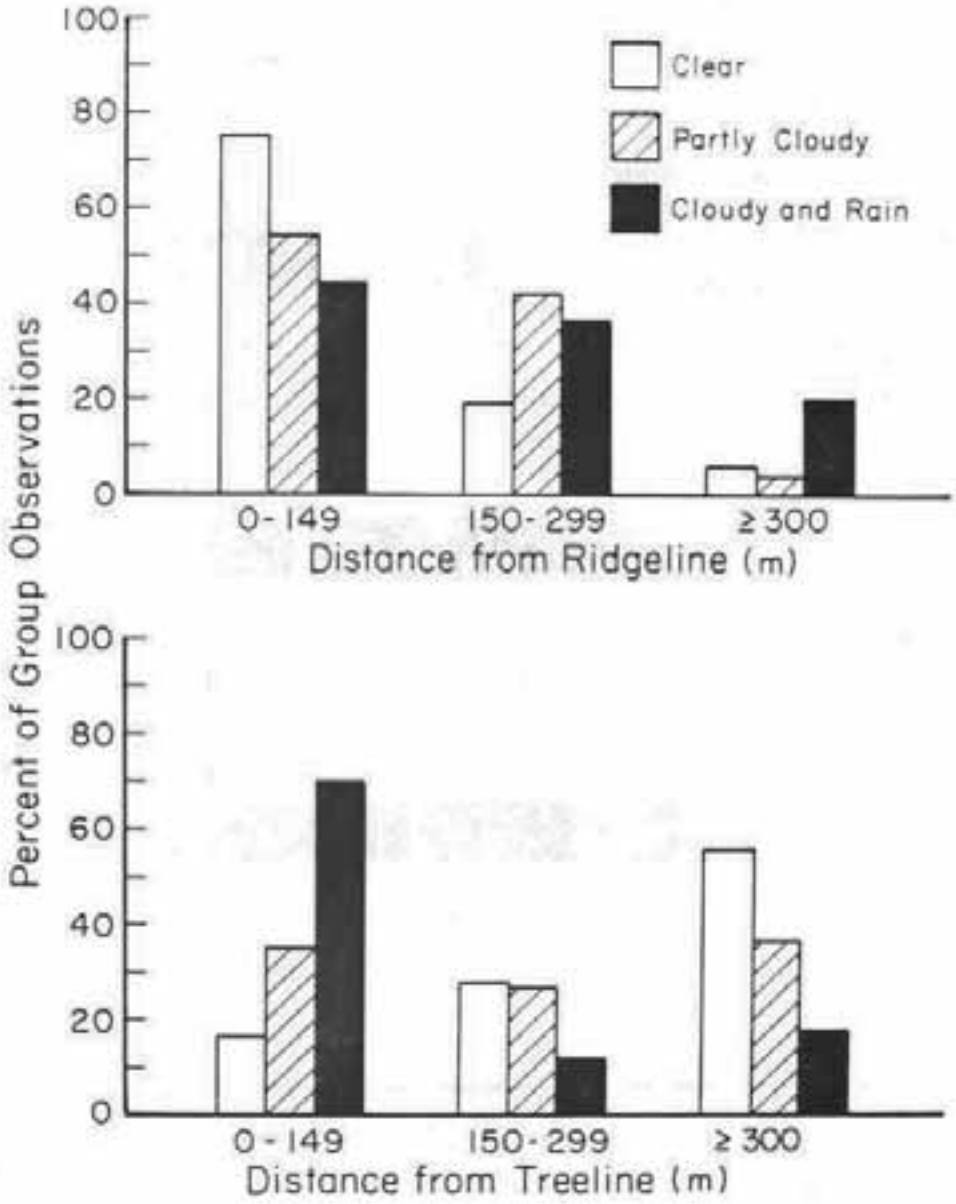

Figure 4. Differential use with respect to ridgeline (top) and treeline (bottom) according to weather type.

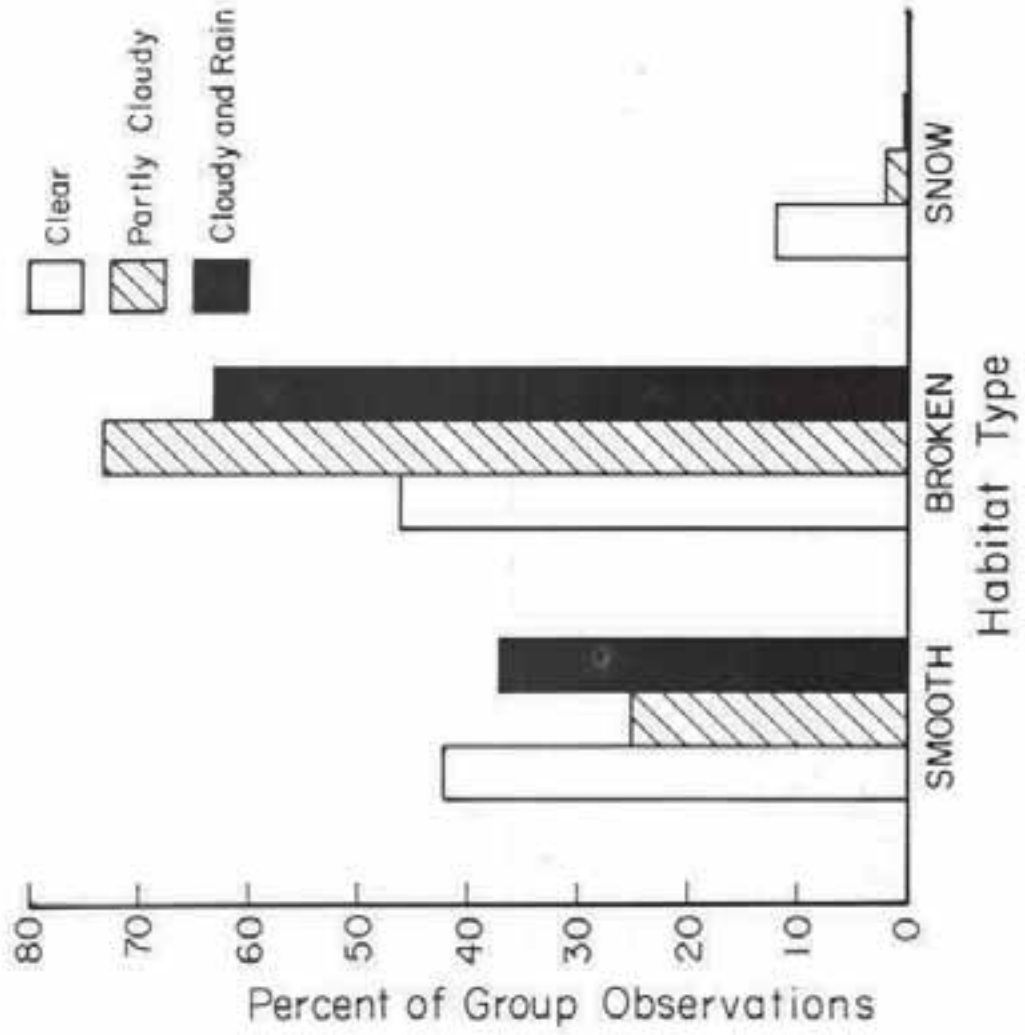

Figure 5. Physical habitat selection according to weather type.

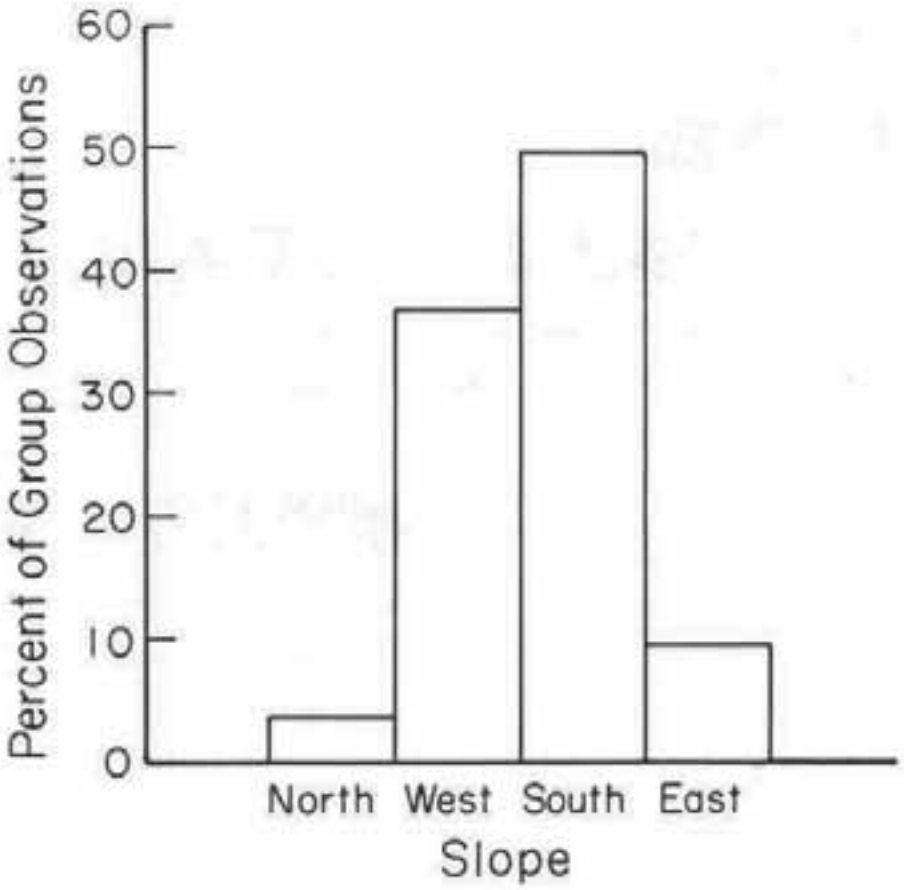

Figure 6. Overall use of slope exposure.

DISCUSSION

The results are somewhat site restrictive and will require a test of their applicability to other areas of goat habitat in the region. They suggest that in clear weather goats of coastal Alaska congregate in larger groups, use less rugged terrain and move higher, away from trees and nearer to ridgelines. Goats are also more active in the late afternoon during clear weather than under any other weather conditions or at any other time. Surveys conducted during late afternoon in clear weather should provide optimum results. Before surveying, at least 5-10 hours should follow the initiation of clearing weather to allow for goat movements to habitat typical of clear weather.

There are drawbacks to air surveying on sunny days in goat habitat. The strong light contrast between sunny and shaded slopes in late afternoon is difficult to adjust to in searching for goats. Mid-day conditions provide more even light but there is strong glare from the snowfields and goats will be less active. There have been suggestions that partly cloudy or cloudy weather with the clouds high and not obstructing visibility may provide good conditions for locating goats in a survey (Ballard 1975). Such a possibility deserves further investigation in light of evidence that goats are more active through the day under partly cloudy conditions and with close to full cloud cover light contrast would not be a problem in searching for goats. There should still, though, be a substantial (5-10 hr) wait following cessation of prolonged cloudy and especially rain or storm conditions before surveying is begun. The availability of such high cloud conditions will determine its usefulness.

Finally, in determining survey accuracy it is desirable and should be feasible to derive, through comparative simultaneous ground and aerial counts, a statistically acceptable accuracy for aerial surveys under a particular range of conditions such that a few yearly replicate counts would provide a good estimate of numbers and adult-kid ratios in selected trend determination areas.

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INTERRELATIONSHIPS OF INTRODUCED MOUNTAIN GOATS

AND

SUBALPINE HABITAT IN OLYMPIC NATIONAL PARK[1]

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Abstract: The alpine/subalpine vegetation of the geologically complex Klahhane Ridge in Olympic National Park was mapped and is being studied with regard to the influences of non-native mountain goats. Klahhane Ridge is a west-east trending, mostly volcanic mountain in the northeastern portion of the Olympic Mountains. Steep topography and precipitous rock formations are basic habitat factors which have influenced the varied subalpine/alpine plant communities and experience accelerated erosion under mountain goat influence. A vegetation map of the ridge will be presented. This ridge is unique in the park in that there is no similar confined ridge to which mountain goats have dispersed.

Mountain goats (Oreamnos americanus), introduced in the late 1920's, have reached a population size that has affected the vegetation. The mountain goats have established themselves on Klahhane Ridge in greater number than anywhere else in the Park. Various types of influences from feeding to trampling to bedding and dust-bathing have been measured. Ratios of vegetated/unvegetated goat-used areas have been determined and will be compared to similar vegetation types that are little or not at all used by goats. Cover and density measurements were made of most plant species used by the mountain goats. Permanent plots have been established for monitoring changes and succession.

Summer food habits of the goats will be reported. Soil bulk densities were determined for all habitat types used by goats and compared to those not used by them. Five endemic plant species of Olympic National Park grow on Klahhane Ridge. Their status and condition will be reported.

Park management is confronted with keeping mountain goats and vegetation healthy. Therefore a look at management for the whole ecological goat-plant relationship is necessary.

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[1] This is a first-year report of an on-going study. Pre-publication copies are available from Dr. Ingrid Olmsted, College of Forest Resources, University of Washington, Seattle, WA 98195 or 805 W. Seventh St., Port Angeles, WA 19362.

MOUNTAIN GOAT HOME RANGES IN THE SAPPHIRE MOUNTAINS OF MONTANA

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Abstract: Twenty-eight mountain goats (Oreamnos americanus) were captured in the Sapphire Mountains of Montana from 1971 to 1973; 16 were equipped with radio collars. Mean yearly home ranges (convex polygon estimates) calculated from radio locations were 48.3km^2 for yearlings, 31.1km^2 for two-year-olds, 24.0km^2 for adult females, and 21.5km^2 for adult males. The size of monthly ranges of four goats decreased from August to November of 1972 as snow accumulated at high elevations. Females were traditional in their use of summer ranges, whereas males were not seen in the study area during consecutive summers. Mean winter migration distances (measured between summer and winter activity centers) ranged from 9.2km for the severe 1971-72 winter to only 2.9km during the mild winter of 1972-73. Goats with radio collars occupied south-facing cliffs at approximately 1,700m altitude during the winter of 1971-72, but they ranged at much higher elevations (2,100 to 2,500m) in the winter of 1972-73.

The mountain goat, because of its low populations and the remoteness of its native ranges, has been the subject of few ecological studies. Because of the broken terrain they occupy, and because of the problems involved in their capture (Rideout 1974a), still fewer of these studies have involved the marking and long term observations of individual animals. This paper on mountain goat home ranges presents a portion of a movements and ecology study of a native herd of mountain goats in western Montana (Rideout 1974b). Information obtained in this study has been utilized in land planning in the Bitterroot National Forest, and hopefully will be useful in improving the management of the species.

I thank Robert S. Hoffmann, University of Kansas, for his help and encouragement throughout this study. Hampton W. Shirer, University of Kansas, helped with electronics design and provided equipment for the project, and George Sogatie and Charles Duvier, University of Kansas, assisted in construction of the transmitters. Bart W. O'Gara, Montana Cooperative Wildlife Unit, provided helpful advice, and Joel Varney, also from the Montana Cooperative Wildlife Unit, help maintain the receiving equipment. Reuel Jansson and Claude Smith of the Montana Fish and Game Department provided housing, equipment, and advice, and Timothy "Stu" Burns, Bitterroot National Forest, helped with habitat mapping. I thank Gordon and George Maclean, Peter Smith, and Tom Watkins for their help with field work.

This study was supported by the National Rifle Association, the Watkins Fund of the University of Kansas, The National Science Foundation, the National Aeronautics and Space Administration, the Montana Fish and Game Department, and the American Forest Institute. Two snowmobiles were provided for this study by the Polaris Snowmobile Company.

STUDY AREA

Dome Shaped Mountain (2,640m), which served as our center of operations, is located on the divide ridge of the Sapphire Mountains (Fig. 1). Much of this top ridge is forested with whitebark pine (Pinus albicaulis), subalpine fir (Picea englemannii) and alping larch (Larix lyallii). Unlike most goat ranges there is no true alpine zone in the Sapphires, and no Krummholz stands exist. Large snowbanks form along ridges, and they do not melt completely until July or August. Lodgepole pine (Pinus contorta) is common between altitudes of 1,500 and 2,400m, and douglas fir (Pseudotsuga menziesii) reaches a maximum altitude of 1,830m. For detailed information on habitats in the Sapphires see Rideout (1974b).

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MATERIAL AND METHODS

We captured 27 mountain goats during this study in a woven-wire pen trap on a natural salt lick on a ridge top at 2,585m (Rideout 1974a). They were marked with sheep marking paint, numbered plastic eartags, and colored marking collars; 16 were equipped with radio collars having radio frequencies ranging from 27.570 to 27.680mHz (Rideout 1974c). Signals were received with loop antennas, a two element hand-held Yagi antenna, and two three element Yagi antennas attached to 9m masts on two mountain tops. The masts rested on swivel bases, and declination circles aligned with compass directions were used in determining directions of signals. An airplane with loop antennas attached was used to locate goats during the winter. A total of 749 goat locations was obtained by telemetry, and they were recorded in 16.2 ha (40 acre) grid squares. Home ranges were estimated by drawing lines between grid square centers and measuring the area of convex polygons (Jennrich and Turner 1969:228) with a compensating polar planimeter. Although convex polygons were always used in computing home range size, minimum polygons were used in some figures to indicate the areas of use more accurately (Figs. 2-5). This study involved 241 days in the field during a four-year period.

RESULTS AND DISCUSSION

Home Ranges

Home ranges were determined for 13 of the 16 goats equipped with radio collars. This included six adult females, two adult males, one females and two male two-year-olds, and two female yearlings. The average transmitter life was 144 days, and an average of 67 telemetry fixes per animal were used to determine home ranges (Table 1). Movements to lower elevations occurred in early or mid-November, and the movement back to summer ranges occurred in late May or June. Summer-fall home ranges (SFHR) were measured over the 16 May to 15 November period (the earliest actual summer-fall radio location in this study occurred on 25 June), and yearly home ranges (YHR) also included locations from the 16 November to 15 May period.

Adult Females

Six adult females were equipped with radio collars; home ranges were calculated for five, omitting goat 36, a female captured in October and providing only 21 locations (Fig. 2). The mean SFHR for the five females was 19.8km^2, and the mean YHR value was 24.0km^2 (Table 1). Females 23 and 21 were observed during the two years following their capture; 23 was always seen within her 1971 SFHR, but goat 21 was observed two km east of her 1971 SFHR in September of 1972.

Adult Males

Three adult males had radio collars, but only two (27 and 31) provided enough locations for home range calculation. Male 33 was captured on 14 November 1972, two weeks before we left the study area, and only five locations were obtained. The mean AFHR values fro males 27 and 31 was 17.6km^2; the mean yearly home range was 21.5km^3 (Fig.3, Table 1). Male 31's SFHR was probably much larger than indicated since we were frequently unable to locate him by triangulation.

Goat 27 was a six-year-old male of unusually small size (54.9kg). Like male 31, he was often found in suboptimal habitat (less escape terrain, more forest) during summer. His body was found on 20 May 1973 in river bottom habitat at 1,648m below the confluence of Stony and Little Stonly Creeks; the cause of death was not determined. Males 31 and 33 were not seen during the years following their capture.

Two-Year-Olds

Three two-year-olds were radio-collared in 1971, two males (24 and 25) and a female (22) (Fig. 4). All three of them were captured on 22 July 1971; winter locations were obtained for 22 and 24, but we only received signals from goat 25 for 27 days. The mean SFHR for 22 and 24 was 15.9km^2, and the mean YHR 31.1km^2 (Table 1). Males 24 and 25 were not seen in later years, whereas 22 was seen frequently during the summer and fall of 1972 and 1973, always within her 1971 SFHR. Goat 22 was shot on 15 September 1974 at the head of Little Stony Creek, again within her 1971 SFHR.

Yearlings

Two female yearlings, 29 and 30, were trapped and radio-collared on 7 August 1972, and yearlings 34 (female) and 34 (male) were equipped with radio collars on 31 July 1973. Home ranges were not determined for 34 and 35 due to the small number of locations, but the mean SFHR (41.2km^2) and YHR (48.3km^2) values for female yearlings 29 and 30 were much larger than any other age group (Fig. 5).

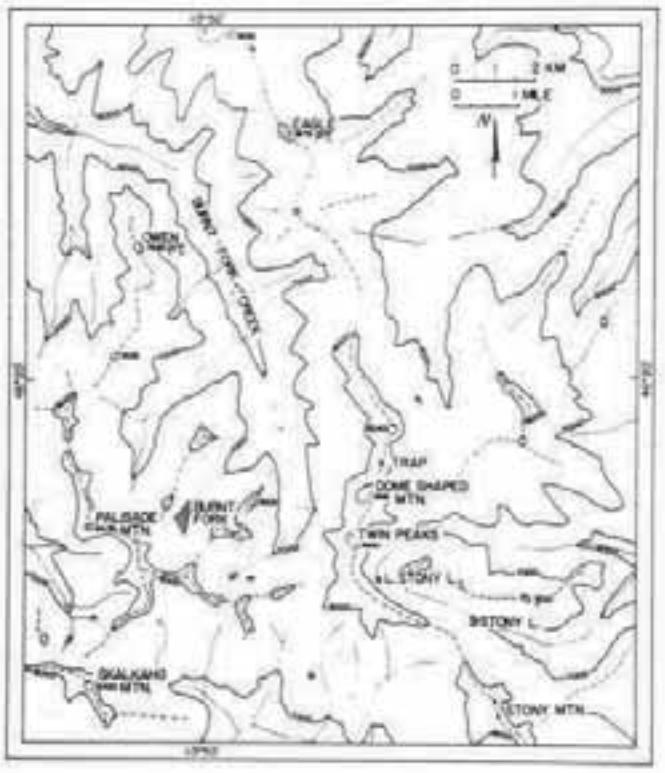

Figure 1. Habitat map of the study area in the Sapphire Mountains. Map prepared from Sapphire Quadrangle Map. U.S.G.S.

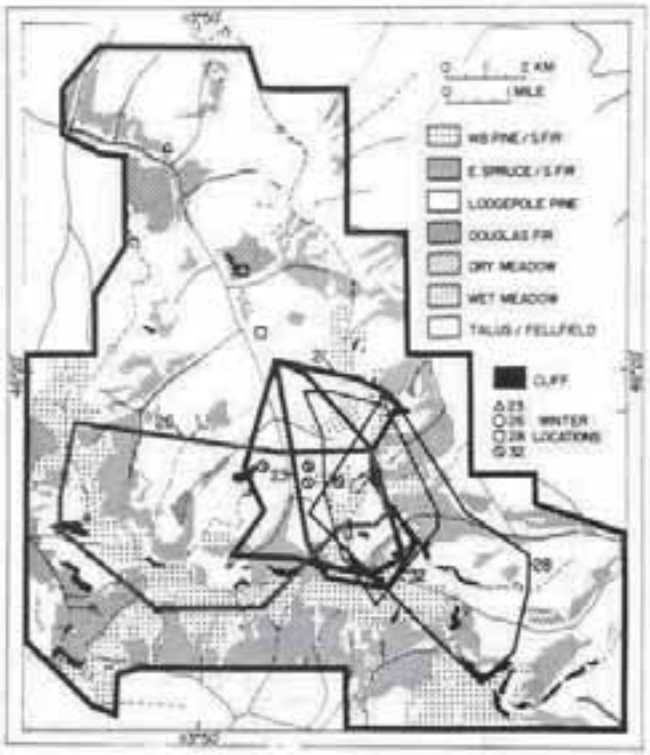

Figure 2. Summer-fall home ranges and winter locations for five adult female mountain goats.

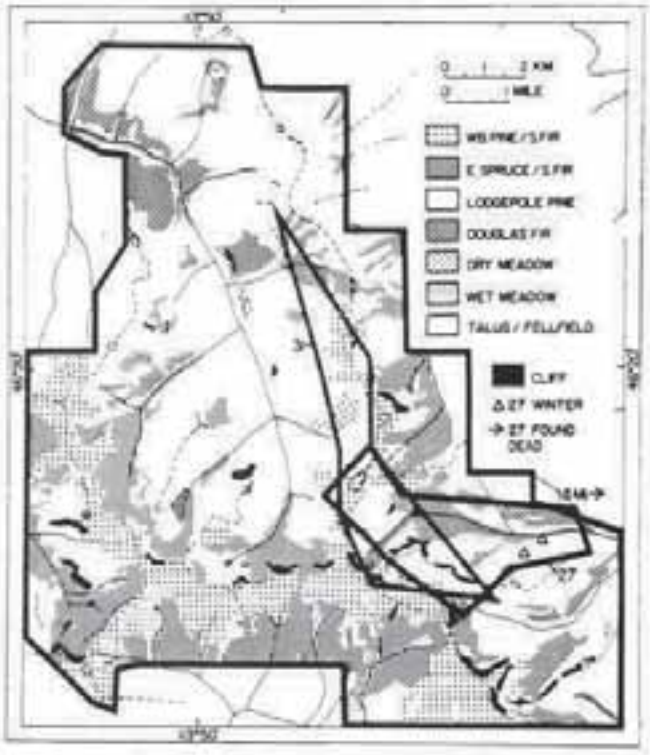

Figure 3. Summer-fall home ranges and winter locations of two adult male mountain goats. Male 27 found dead 2.4km (1.5 mi) east of arrow.

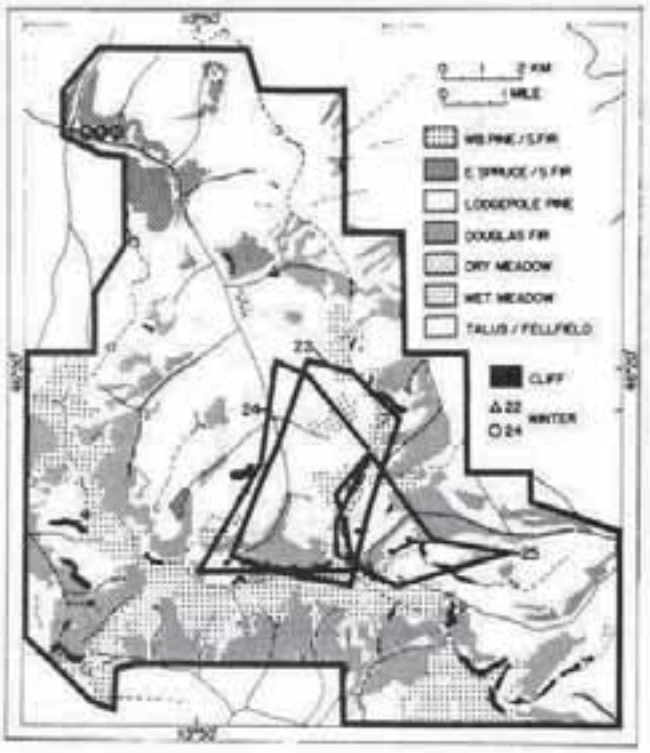

Figure 4. Summer-fall home ranges and winter locations of three 2-year-olds; males 24,25 and female 22.

Table 1. Home ranges of radio-collared goats (in km^2) from maximum polygon estimates. Dates of collar operation refer to time from capture to reception of last signal. Summer-fall home ranges (SFHR) is the area used from the time of capture until 25 November; yearly home range (YHR) is the area used during the entire period of collar operation.

Age Group	Sex	#	SF Fixes	Winter Fixes	Date of Capture	Collar Operation	SFHR	YHR
YEARLINGS								
	F	29	36	41	7 Aug. 72	226 days	38.7	38.7
	F	30	58	62	7 Aug. 72	226 days	43.8	57.9
	F	34	3	3	31 July 73		- *	- *
	M	35	3	3	31 July 73		- *	- *
Mean Home Range Values:							41.2	48.3
TWO-YEAR-OLDS								
	F	22	51	52	22 July 71	164 days	15.6	21.9
	M	24	30	34	22 July 71	287 days	16.2	40.3
	M	25	41	41	22 July 71	27 days	8.1*	8.1*
Mean Home Range Values:							15.9	31.1
ADULT								
	F	21	40	40	7 July 71	39 days	20.1	20.1
	F	23	49	50	25 July 71	193 days	11.1	18.5
	F	26	63	69	16 July 72	248 days	31.0	31.0
	F	28	117	124	27 July 72	175 days	25.6	34.8
	F	32	68	74	4 Sept. 72	85 days	11.2	15.7
	F	36	16	21	23 Oct. 72	149 days	5.6*	7.1*
Mean Home Range Values:							19.8	24.0
ADULT								
	M	27	72	76	1 Aug. 72	117 days	16.3	24.1
	M	31	41	41	25 June 72	56 days	18.9	18.9
	M	33	4	5	14 Nov. 72	24 days	- *	- *
Mean Home Range Values:							17.6	21.5

*Not included in calculation of mean values.

Yearlings of other ungulate species tend to have large home ranges as well. Houston (1968) reported large home ranges in yearling moose (Alces alces) in Jackson Hole; Bayless (1969) found that yearling pronghorns (Antilocapra americana) have the largest winter home ranges of 16 marked animals; and Martinka (1969) found that radio collared male yearling elk (Cervus canadensis) have the largest summer home ranges, followed by adults and female yearlings. Adult female mountain goats frequently threaten yearlings; the greater mobility of yearlings may be due in part to their forced movement from one female-kid group to another.

Monthly Ranges

The monthly ranges of five goats were determined from the time of capture (July or August,

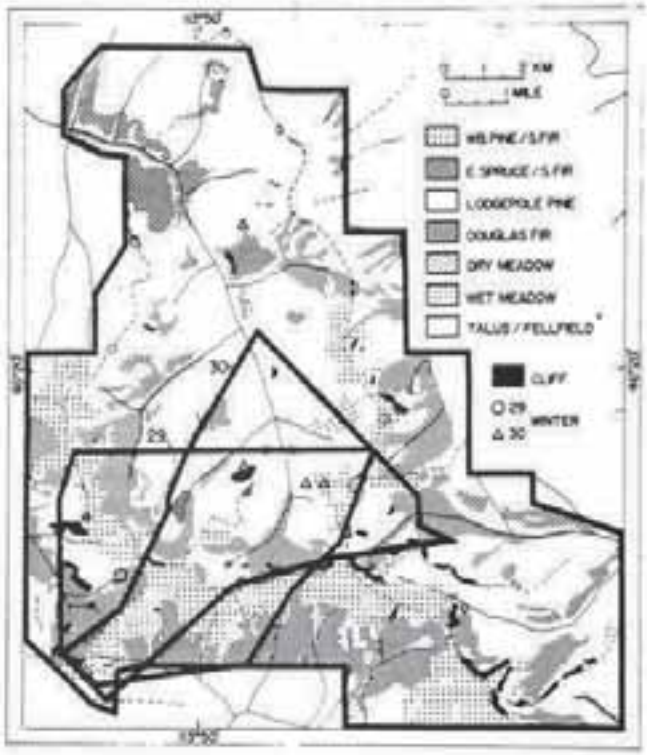

Figure 5. Summer-fall home ranges and winter locations of yearling females; 29 and 30.

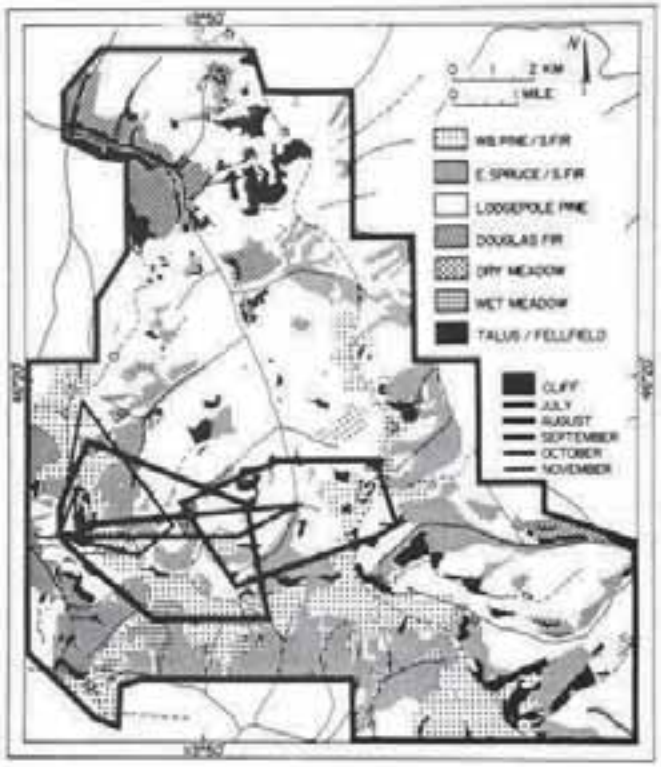

Figure 6. Monthly ranges for adult female 26.

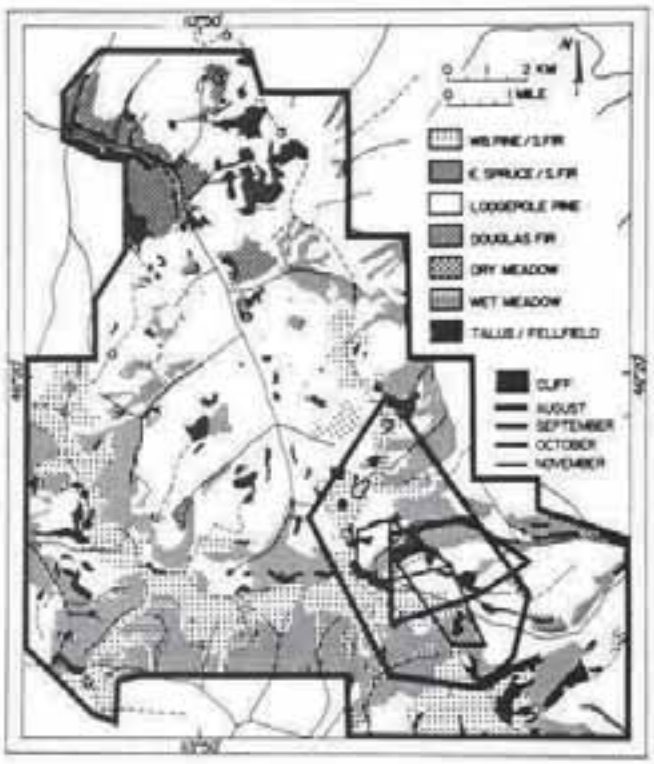

Figure 7. Monthly ranges for adult female 26.

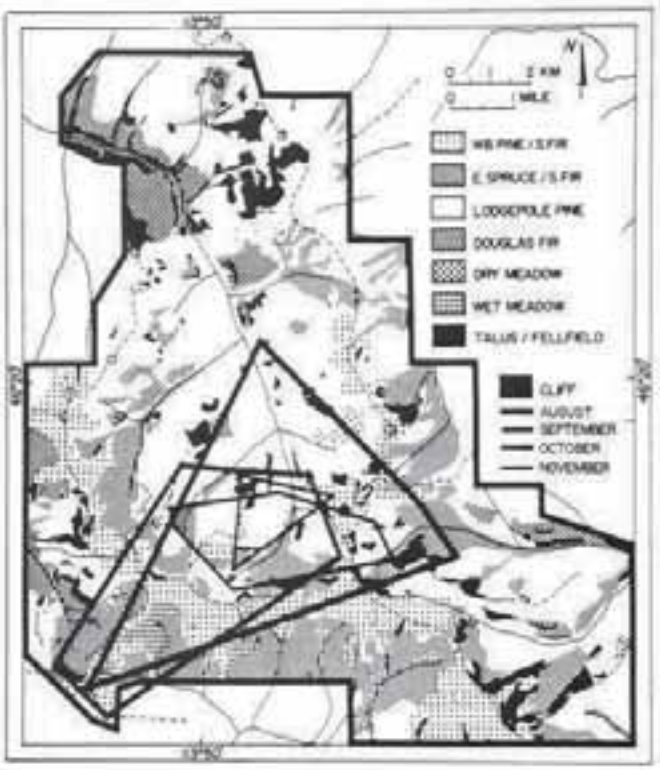

Figure 8. Monthly ranges for yearling female 30.

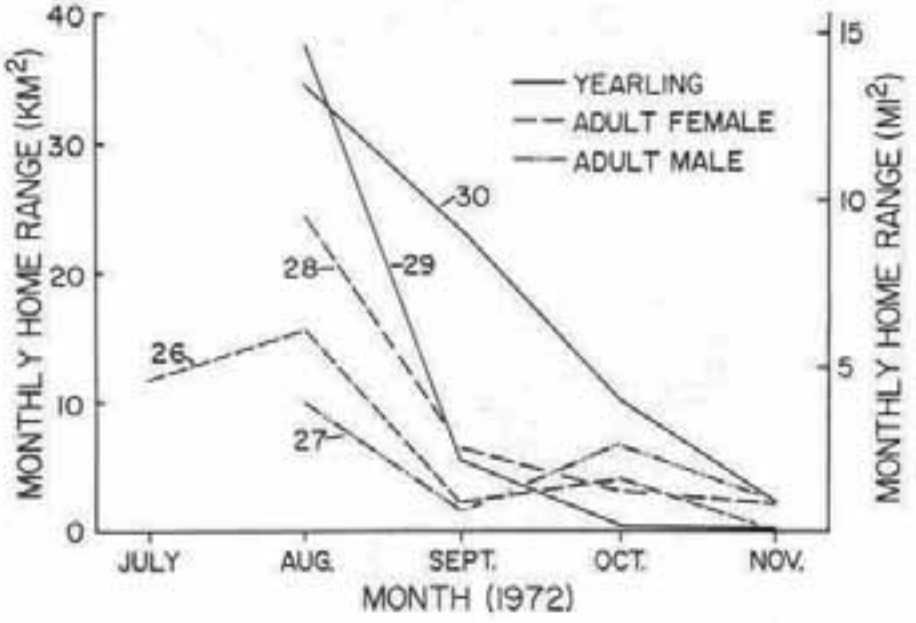

Figure 9. Monthly range size for five goats during 1972.

1972) until November 1972. These included adult male 27, adult females 26 and 28 (Figs. 6 and 7), and female yearlings 30 (Fig. 8) and 29. Goat 25 was captured on 16 July 1972, so the July value refers to only half of the month; the other goats were captured in late July or early August. In all cases, the largest monthly ranges occurred in August, and the smallest in November (Fig. 9). Male 27 and female 26 had greater monthly ranges in October than in September, possibly due to greater movement during the pre-rut.

Large monthly ranges in August are probably due to one or more of the following factors:

1) There is a greater ease of movement due to the lack of snow.
2) August is the warmest month; snowbanks and north-facing cliffs, which are popular during warm periods, are widely separated.
3) Flies are most common during August, and cause the goats considerable irritation; they may stimulate movements to areas having more snow or greater exposure to wind.
4) The Sapphire salt lick is used primarily during July and August, and goats captured in August (27, 29, and 30) have the travel to the licks included in their August monthly range.

As snow levels increase during fall, goat mobility decreases. November monthly ranges varied from 16 to 251 ha. Smith (1976) showed similar results in the Bitterroot Mountains of Montana from January through May; he reported a seasonal home range value for adult females for this period of 42 ha. Petocz (1973) noted that winter storms are extremely common in January and February in Alberta, and both he and Chadwick (1973) reported minimum daily movements during those months.

Winter Ranges

The total area occupied by radio-collared goats during the summer-fall period (summer-fall composite home range) is shown in Fig. 10. Locations for the severe winter of 1971-72 (six locations) are more widely separated from the summer-fall composite home range than are those of the mild winter of 1972-72 (15 locations). The seasonal movement of nine mountain goats was determined by calculating the distance from the summer-fall activity center of each goat $\frac{(\bar{X}, \bar{Y})}{n}$ to its corresponding winter activity centers for three goats during the severe winter of 1971-72 was 9.2km (six winter locations), whereas the mean distance between activity centers for six goats in the mild winter of 1972-73 was only 2.9km (15 winter locations).

Some areas used during the winter by the goats of the Sapphires were probably not located by radio telemetry. A female and her kid were observed on a west-facing rock outcrop near the confluence of Stony and Rocky Creeks, 14.8km east of Dome Shaped Mountain in February 1974 (D. McCleerey, pers. comm.). The goats were not marked, but they were probably from my study area since it is the closest goat range.

Table 2. Distance from summer-fall activity center to winter activity center for nine mountain goats (see text).

WINTER 1971 - 72				WINTER 1972 - 73			
Sex	#	Age	Distance	Sex	#	Age	Distance
F	22	2	6.1km	F	29	1	3.0km
F	23	3	10.4km	F	30	1	3.0km
F	24	2	11.1km	F	28	5	4.0km
Mean:			9.2km	F	32	5	2.4km
				F	26	6	3.1km
				F	27	6	1.7km
				Mean:			2.9km

McCleerey also saw a male two-year-old from my study area, which was marked with radio collar as a yearling (35) in July of 1974, near the head of Little Hogback Creek at 2,347m elevation. This location is 19.3km NNE of Dome Shaped Mountain on the other side of Rock Creek, and 35 was accompanied at the time by four other goats.

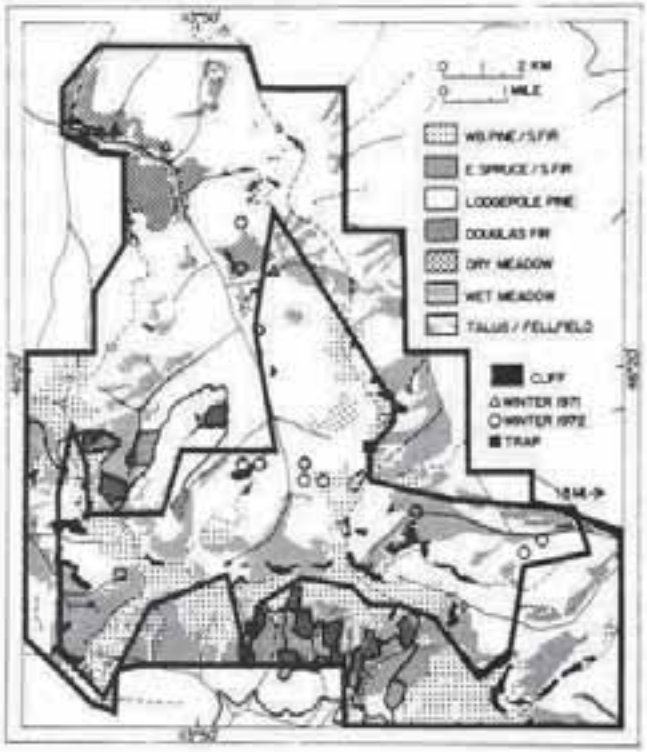

Figure 10. The summer-fall composite home range for all radio collared goats. Clear-cut logging indicated by cross hatch.

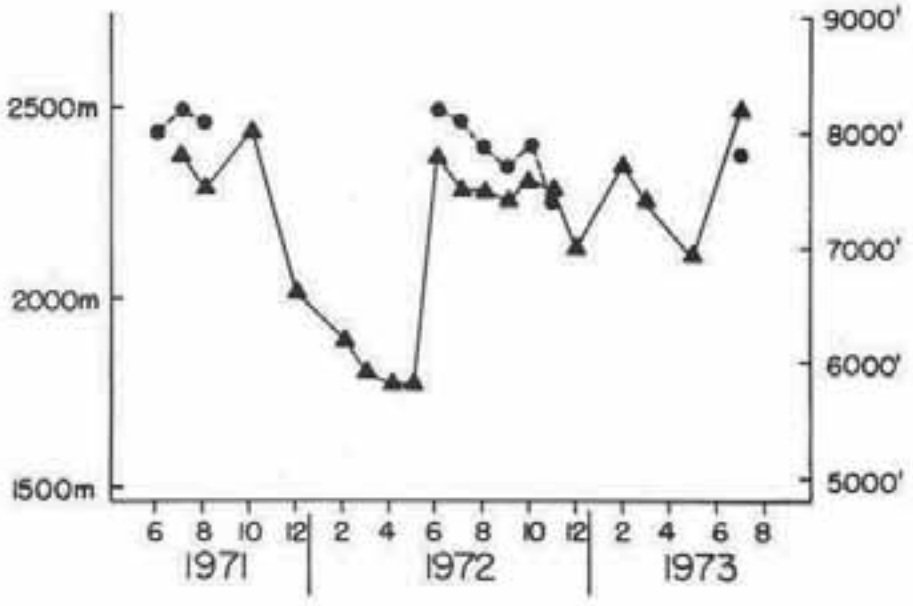

Figure 11. Altitude by month in the Sapphire Mountains. Triangels indicate mean altitudes determined by radio tracking; circles indicate mean altitudes determined by observation.

Altitude

During summer months radio collared goats were found at altitudes greater than 2,250m. During the severe winter of 1971-72 goats sought lower altitudes than in the mild winter of 1972-73; this information is, however, based on a total of 21 winter locations obtained by air tracking. Summer-fall altitude estimates from observational data are slightly higher than radio-tracking estimates in 1971 and 1972; we established our camp on Dome Shaped Mountain and did our hiking along the top ridge of the Sapphires, so goats at higher altitudes were more easily seen (Fig. 11).

Home Range Use and Seasonal Movements in the Sapphires and their Significance

Mountain goats migrate to low altitudes in the Sapphires during severe winters, but like mountain goat habitat in other areas, good summer range is extensive whereas good winter range (south-facing cliffs at low elevations) is rare (Smith 1976). As a result, during mild winters in the Sapphires goats stay at high elevations within or near their SFHR.

Female goats in the Sapphires were traditional in their use of their home range; goats 21, 22 and 23 used the same areas in successive summers. Males were never seen in the study area the year following their capture, and one male (yearling 35) was located in another goat range. Male mountain goats have been known to move to new mountain ranges, whereas females use the same summer and (in some areas) the same winter ranges year after year (Chadwick 1973, Smith 1976). Geist (1971) observed bighorn rams (Ovis canadensis) moving between widely separated female groups during the rut, and he suggested that the chance of breeding success in distant herds due to hybrid vigor would result in selection for this behavior. Preobrazhenskii (1961) has shown that reindeer cows (Rangifer tarandus) bred by closely related bulls have lower fertility and smaller calves that do those bred by bulls of distant ancestry. The home range use exhibited by males and females of the Dome Shaped Mountain goat herd suggest a pattern of home range constancy by females and emigration by males; such behavioral differences between the sexes would help guard against inbreeding in small isolated mountain goat herds.

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PARASITES OF MOUNTAIN GOAT, OREAMNOS AMERICANUS (BLAINVILLE), OF WEST CENTRAL ALBERTA WITH A COMPARISON OF THE HELMINTHS OF MOUNTAIN GOAT AND ROCKY MOUNTAIN BIGHORN SHEEP, OVIS C. CANADENSIS SHAW.

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Abstract: Fifty-three mountain goat from in and near Willmore Wilderness Park were examined for parasites between 1970 and 1974. Seventeen species of helminths (12 nematodes, 5 cestodes) and 1 species of tick were recovered. Twenty-five bighorn sheep from various parts of Alberta, and 3 goat from British Columbia also were examined for helminths. Three helminths, Trichuris schumakovitschi, Avitellina sp. and Nematodirus davtiani, are new host records for goat. Several measures were used to compare results of the present study to those of other studies of mountain goat and bighorn sheep where overall helminth fauna information was recorded. Generally mountain goat and bighorn sheep have: 1) similar numbers of helminth species, 2) many helminth species in common, and 3) are accidental hosts of a few others. Several host populations such as bighorn sheep of the National Bison Range, Montana, and the introduced mountain goat of the Black Hills, South Dakota, have unique helminth faunas, some of which were probably acquired from ungulates already established there. The role parasites may play in goat-sheep interaction is discussed.

The mountain goat, Oreamnos americanus (Blainville), and Rocky Mountain bighorn sheep, Ovis canadensis canadensis Shaw, share range in much of mountainous Alberta. Data dealing with specific aspects of this sympatry such as direct competition are non-existent for Alberta and scant for other areas. Nonetheless, the fact that goat and sheep are seen together commonly in the mountains of Alberta raises some interesting questions for parasitologists, the most obvious of which is whether or not these hosts "share" parasites.

The cross-infection capabilities of parasites in sympatric hosts are based, firstly, on the assumption that the hosts have parasites in common. Unfortunately the data base for helminths of both mountain goat and sheep is small: only a handful of studies have dealt with overall parasite faunas of either host. Kerr and Holmes (1966) and Boddicker et al. (1971) presented percent prevalence data for helminths and ectoparasites of 7 and 28 adult goat from west central Alberta and the Black Hills of South Dakota, respectively. Others such as Cowan (1951) and Brandborg (1955) presented a checklist of the parasites of goat from various areas.

Parasite studies of Ovis c. canadensis have emphasized lungworms (Uhazy et al. 1973, Hibler et al. 1974, Forrester and Littell 1976), but several surveys for helminths (Becklund and Senger 1967, Uhazy and Holmes 1971) have been conducted. The literature on parasites of sheep and goat has been reviewed by Post (1971) and Cooley (1976).

Between 1970 and 1974 the University of Alberta and Alberta Fish and Wildlife Division cooperated in a study of the helminth and tick parasites of 53 mountain goat in and near Willmore Wilderness Park west central Alberta. The study was undertaken to determine the prevalence and intensity of parasites of mountain goat from this region. This report summarizes the findings and adds comparative data from 26 bighorn sheep of several National Parks and Willmore Park of Alberta and three goat from Kootenay National Park, British Columbia.

MATERIALS AND METHODS

Willmore Wilderness Park comprises 4600km^2 and is located on the Alberta-British Columbia border north of Jasper National Park (Fig. 1). Approximately 250 goat were present in and near the Park when the study began (unpubl. records of the Alberta Fish and Wildlife Division). The climate, topography and vegetative associations of the region have been described by Kerr (1965) and McFetridge (1977).

Initially 15 goat were collected in the Park between April, 1970 and December, 1970 by personnel of the Fish and Wildlife Division. Four others were collected in the Syncline Hills which are located just outside the Park, near the new town of Grande Cache, and approximately 8km east of Mount Hamell (Fig. 1) in June, 1971 and January, 1972. Samples were taken from 34 other goat killed by hunters in Willmore in October 1972, 1973 and 1974. Goat were examined for ectoparasites in the field, but internal organs were frozen until they could be examined in the laboratory. Age of goat varied from ½ to 12+ years, but only three goat were less than two years of age.

Three goat kids with severe contagious ecthyma (= soremouth) (see Samuel et al. 1975) were collected from Mount Wardle, Kootenay National Park (Fig. 1) and frozen in July 1967, February and April 1972, and examined in 1972.

Complete viscera, or parts thereof, from 26 bighorn sheep of western Alberta were examined for helminths between May 1968 and May 1971. Twelve came from Jasper National Park, three from Banff National Park, six from Waterton Lakes National Park, three from Willmore Wilderness Park, and two from unknown locations in Alberta. Ages varied from 1 to 10 years of age.

Gastrointestinal tracts and lungs of goat and sheep were examined for helminths (and those helminths handled) following the procedures of Pillmore (1961), Uhazy and Holmes (1971), and Uhazy et al. (1973).

Various measures were used to summarize results and to compare the helminth faunas in goat and sheep of Alberta with results of other published surveys. These measures are:

1) the prevalence (percent of the sample infected) of the parasite;
2) the median intensity (median number of individuals per infected host) of the parasite;
3) species richness (the absolute number of species in a collection (Peet 1974));
4) an index of similarity (percent similarity) of species composition between pairs of samples (= studies), calculated by converting the prevalence of each species of helminth recovered from a sample to a percentage of the total prevalences of all species, making a similar conversion for the other sample, and summing the smaller of each value for helminths common to both samples;
5) the size of the population of a parasite expressed as the product of prevalence and median intensity;
6) the relative abundance (i.e., the percentage that each species contributed to the total number of helminths of a sample) expressed as parasite profiles (Uhazy and Holmes, 1971), and
7) Simpson's (1949) index of diversity, calculated as:

$$SI = (Y/_N)^2$$

where Y = the number of worms of each species of helminth recovered from a sample, and N = the total number of worms of all species in a sample.

For convenience of discussion hosts have been categorized according to Dogiel (1966: 437) as "main", "secondary", or "accidental". However, usage here is not confined to the strict definitions of Dogiel. We consider the "main host" as one where the parasite is most "abundant" (see number 5 above), the "secondary host" as one where the parasite is less abundant, and the "accidental host" as one rarely infected. We are not implying, as Dogiel does, that normal growth of the parasite is inhibited in the secondary host or that the secondary host is an "abnormal" host.

RESULTS

Number and Prevalence of Goat Parasites

Seventeen species of helminths (12 nematodes, 5 cestodes) and one species of tick were

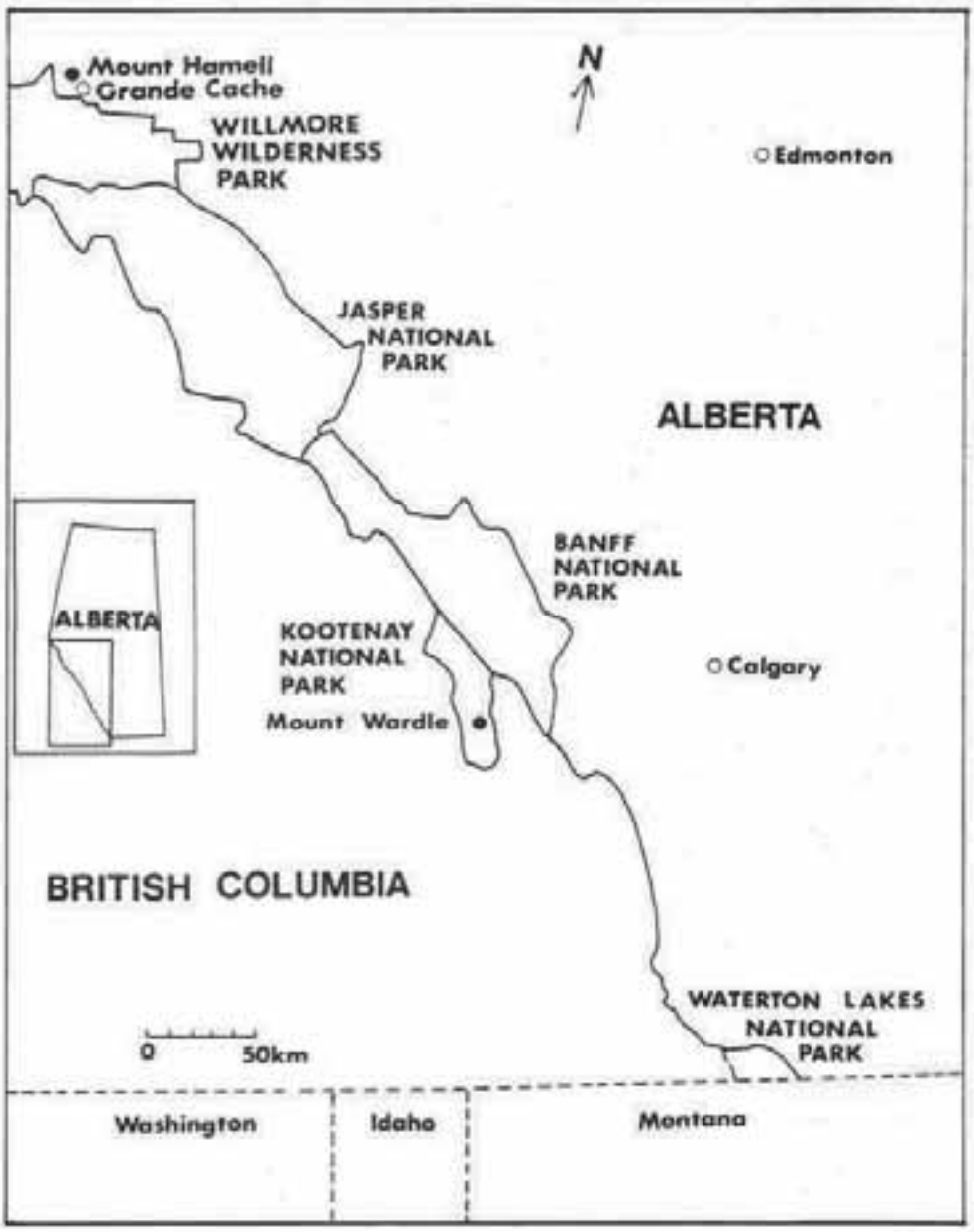

Figure 1. Location of the study area, Willmore Wilderness Park, showing other collection areas for mountain goat and bighorn sheep.

recovered during examination of 53 mountain goat in or near Willmore Wilderness Park (Table 1). Six species of helminths including one, Trichuris oreammos, not found in goat of Willmore Park, were identified from three young goat (two, nine and nine months old) of Mount Wardle, Kootenay National Park, British Columbia. Complete taxonomic citations for each parasite are presented in Table 1. Only Trichuris schumakovitschi, Nematodirus davtiani, and Avitellina sp. are new hosts for goat although T. oreammos was described (Knight 1974) from specimens of this study.

Table 1. Prevalence and intensity of infection with helminths and ticks of mountain goat.

Parasite	-- Willmore Park Area -- Prevalence	Number of parasites	------ Mount Wardle ------- Prevalence	Number of parasites
Nematoda:				
Protostrongylus rushi Dikmans, 1937	46(78)[a]	10(1-35)[a]	3(33)	3
P. stilesi Dikmans, 1931	41(63)	--	3(0)	--
Marshallagia marshalli (Ransom, 1907)	30(87)	36(2-128)	3(67)	423(202,644)
Ostertagia circumcincti (Stadelmann, 1894)	30(97)	184(8-2054)	3(67)	269(94,444)
O. occidentalis Ransom, 1907	30(80)	7(1-29)	3(0)	--
O. trifurcata Ransom, 1907	30(77)	10(1-132)	3(0)	--
Teladorsagia davtiani Andreeva and Satubaldin, 1954	30(67)	4(1-72)	3(0)	--
Marshallagia, Ostertagia and Teladorsagia spp. (females)	30(100)	327(3-2516)	3(67)	875(490,1261)
Nematodirus davtiani Grigoryan, 1949	32(3)	1	3(0)	--
N. helvetianus May, 1920	32(3)	3	3(0)	--
N. maculosus Becklund, 1965	33(82)	53(1-846)	3(100)	4(2-496)
Nematodirus spp. (females)	33(85)	62(1-1062)	3(67)	225(2,449)
Skrjabinema ovis (Skrjabin, 1915)	28(4)	17	3(0)	--
Trichuris sp.	28(1)	3	3(0)	--
T. oreammos Knight, 1974	28(0)	--	3(67)	78(34,123)
T. schumakovitschi (Savinkova, 1967)	28(7)	6(1,11)	3(0)	--
Cestoda:				
Avitellina sp. Gough, 1911	31(19)	6(1-23)	3(0)	--
Moniezia benedini (Moniez, 1879)	31(19)	1(1-17)	3(0)	--
Unidentified Anoplocephalidae	31(10)	--	3(33)	--
Thysanosoma actinioides Diesing, 1834	29(14)	2(1-16)	3(67)	11
Taenia hydatigena Pallas, 1766	39(13)	1(1)	3(0)	--
Anthropoda:				
Dermacentor andersoni Stiles, 1908	18(17)	1(1-2)	3(0)	--

[a]Prevalence = Number goat examined (% infected); median intensity and (range).

Twenty-eight of the 53 goat were examined in their entirety. (For example, only the lungs and/or liver were available for 20 goat.) Where complete examination of goat from Willmore was possible, a mean of seven species (range 1-11) of parasites was present. The youngest goat examined (from Mount Wardle, see above) had only four Nematodirus maculosus while the goat with 11 species was a three year old male in good condition. The total helminth burden in goat of Willmore ranged from 33 to 5314 (median 720) per goat.

Thirty-six goat had Protostrongylus rushi; 26 had P. stilesi (Table 1). No attempt was made to count P. stilesi directly because of their parenchymal location, but a general assessment of the extent of infection was made following the semiquantitative method of Pillmore (1961) which is based on the surface area of the lung with lungworm lesions. Following this technique 25 goat had "light" infections and one had a "heavy" infection. Twenty-two goat had both parasites.

Five species of abomasal nematodes (see Marshallagia, Ostertagia and Teladorsagia of Table 1), three small intestinal nematodes (Nematodirus) and three caecal and large intestinal nematodes (Skrjabinema and Trichuris) were found. Adult males of Ostertagia circumcincta (female nematodes in the abomasum and small intestine were not identifiable at the species level) comprised 85 percent of the abomasal fauna, while adult male N. maculosus dominated (99.8%) the nematodes of the small intestine.

Comparison with Other Studies of Goat and Bighorn Sheep Parasites

Parasite findings for goat of the Willmore Park area were compared to other goat studies in Alberta (Kerr and Holmes 1966) and South Dakota (Boddicker et al. 1971) and sheep studies in Alberta (this study, Uhazy and Holmes 1971) and Montana (Forester and Senger 1964, Becklund and Senger 1967). Data for sheep of Alberta and goat of west central Alberta (Kerr and Holmes op. cit.) are summarized in Table 2.

Table 2. Prevalence and intensities of helminths of adult mountain goat and bighorn sheep of Alberta based on present and previous studies.

Parasite	-Mtn. goat- Kerr and Holmes 1966	Bighorn Sheep			
		Uhazy and Holmes 1971		This Study	
		Prevalence	Number of parasites[b]	Prevalence	Number of parasites[b]
P. rushi)	7(14)[a]	33(30)[a]	7(1-20)	26(48)[a]	5(1-14)
P. stilesi)		33(94)	--	26(92)	--
M. marshalli	7(43)	24(100)	145(1-1270)	16(100)	149(20-985)
O. circumcincta	7(100)	24(13)	19(10-60)	16(25)	144(3-279)
O. occidentalis	7(71)	24(88)	25(2-240)	16(87)	20(2-310)
O. trifurcata	7(71)	24(0)	--	16(0)	--
T. davtiani	7(28)	24(13)	4(2-40)	16(0)	--
Marshallagia, Ostertagia and Teladorsagia spp. (females)	--	24(100)	263(3-1990)	16(100)	269(43-2526)
Capillaria sp.	7(0)	25(4)	2	17(0)	--
Nematodirus archari Sokolova, 1948	7(0)	25(84)	156(1-1318)	17(76)	40(1-269)
N. davtiani	7(0)	25(52)	18(5-398)	17(53)	10(1-106)
N. maculosus	7(86)	25(4)	24	17(0)	--
N. oiratianus Raevskaia, 1929	7(0)	25(64)	47(1-1490)	17(76)	15(1-370)
N. spathiger (Railliet, 1896)	7(0)	25(12)	29(1-32)	17(18)	3(2-30)
Nematodirus spp. (females)	--	25(84)	352(6-2850)	17(94)	82(1-1231)
S. ovis	7(28)	25(8)	1	15(27)	197(2-1000)
Trichuris sp.	7(14)	25(0)	--	15(0)	--
T. schumakovitschi	--	25(68)[c]	20(1-371)	15(47)	18(7-57)
Moniezia expansa Rudolphi, 1810	7(0)	25(12)	3(1-40)	17(12)	2(1-3)
T. actinioides	7(28)	25(0)	--	17(0)	--
Wyominia tetoni Scott, 1941	7(0)	25(4)	1	17(0)	--
T. hydatigena	7(14)	25(20)	2(1-5)	15(7)	4

[a] Number animals examined (percent infected).
[b] Median intensity and (range).
[c] Originally identified by Uhazy and Holmes (1971) as "T. ovis", but recognized as T. schumakovitschi by Knight and Uhazy (1973).

Five helminths of goat (Tables 1 and 2), Ostertagia trifurcata, Nematodirus helvetianus, Moniezia benedeni, Avitellina sp., and Thysanosoma actinioides, were not found in sheep, while six species of helminths in sheep, Capillaria sp., Nematodirus archari, N. oiratianus, N. spathiger, Moniezia expansa, and Wyominia tetoni, were not found in goat. Ten species were common to both hosts.

Prevalence data (Tables 1 and 2) and parasite profiles (Fig. 2) for goat and sheep in the Willmore Park region show that O. circumcincta was the most prevalent and relatively abundant parasite of goat and Marshallagia marshalli of similar position in sheep. Adult males of M. marshalli comprised 49 percent of the small intestinal nematodes. Few other parasites were abundant although N. maculosus comprised nine percent of the goat fauna. Ostertagia occidentalis was prevalent in both hosts, but contributed little to the relative abundance.

Indexes of similarity, which compare helminths common to a pair of samples (= studies), were determined for the three and four known goat and sheep studies and are presented in a "trellis diagram" (Fig. 3) following Holmes and Podesta (1968). High values which indicate similar faunas were found between the two Alberta studies on goat (85%) and the two on sheep (89%), and, unexpectedly, between goat of the Black Hills and the sheep of Wildhorse Island, Montana (91%). Sheep from the National Bison Range, Montana, showed relatively low percent similarities to all other populations and were most similar (67%) to the sheep at Wildhorse Island, only 65km away. Bighorn sheep of this study (termed J_1 on Fig. 3), collected in ranges either shared with goat of Alberta studies or near them, showed higher percent similarities (75 and 70%) with goat of Alberta than did sheep from more distant locations (J_2) (61 and 58%).

Lungworms, particularly P. stilesi, were prevalent in sheep and goat of Alberta and elsewhere (Table 3). There were few similarities between studies when the subjective semiquantification technique of Pillmore (1961) was used. The technique of Forrester and Senger (1964) of multiplying the length of each lesion by its width in order to determine the total area of the lesion, is probably a more appropriate way of assessing infections of P. stilesi.

Table 3. Prevalence, intensity, and estimation of the extent of infection of Protostrongylus spp. for several populations of mountain goat and sheep.

	Prevalence (%)		Intensity of P. rushi		% P. stilesi infections termed		
	P. stilesi	P. rushi	Md.	Mn[a]	Light	Moderate	Heavy
Goat:							
Mt. Hamell, Alberta[b]		14[c]					
Willmore, Alberta[d]	63	78	10		96	0	4
Black Hills, South Dakota[e]	100	38			50	23	27
Bighorn Sheep:							
Alberta[d]	92	48	5		65	35	0
Alberta and British Columbia[f]	91	38	7		55	24	21
Montana[g]	93	40		10			
Colorado[h]	98	16			36	52	12

[a]Md = median, Mn = mean
[b]Kerr and Holmes (1966)
[c]Kerr and Holmes (1966) identified lungworms only as "Protostrongylus spp."
[d]This study
[e]Boddicker et al. (1971)
[f]Uhazy et al. (1973)
[g]Forrester and Senger (1964)
[h]Pillmore (1961)

The abomasal and intestinal fauna (nematodes and cestodes) varied markedly in presence and prevalence between populations. No species of helminth from the abomasum or small intestine was common to all populations. These differences are easily visualized by comparison of the percent prevalences of helminths in goat of Willmore Park and the Black Hills (Fig. 4). Fourteen species were found in the abomasum or small intestine of these goat, but they only had six in common.

The measure of the size of the population of parasites of Alberta sheep and goat was determined by the product of prevalence and the median intensity (Table 4). Parasites were then categorized by host using: 1) this "measure"; 2) prevalences of P. stilesi and T. oreamnos; and 3) prevalence

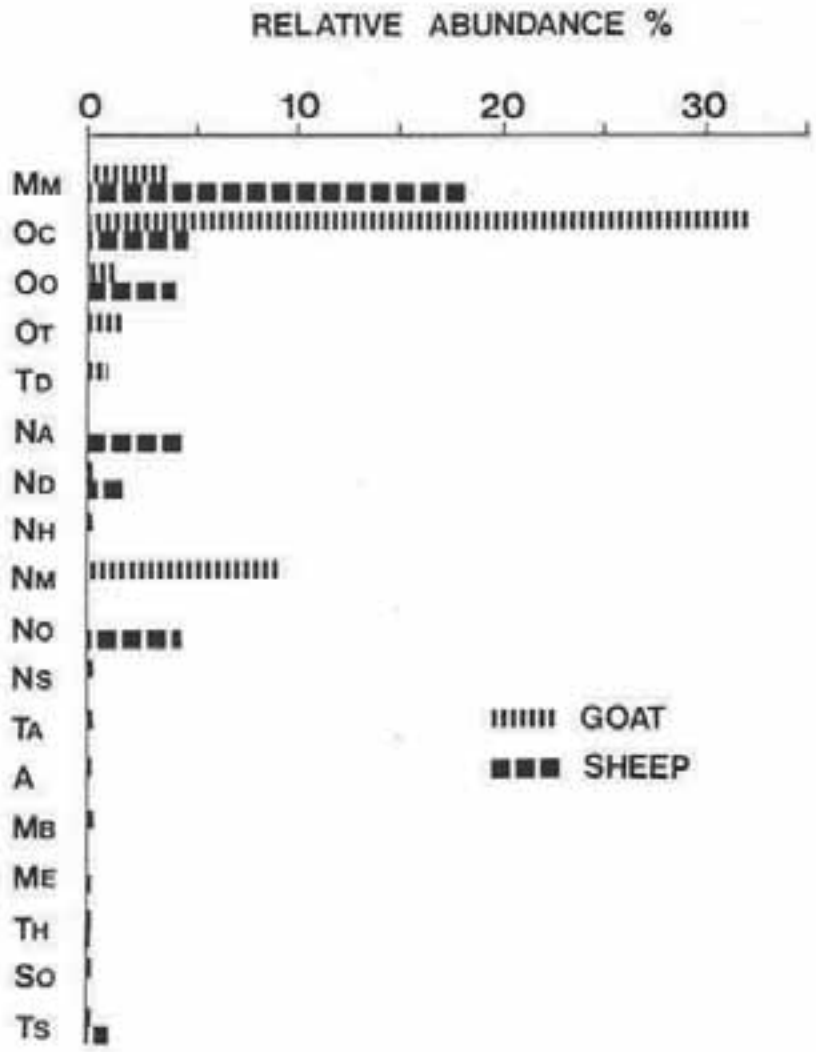

Figure 2.

Parasite profiles for mountain goat of Willmore Wilderness Park and 15 bighorn sheep of Willmore and Jasper National Parks based on total number of worms = 100%. Data for female nematodes of the abomasum and small intestine are not displayed. Mm = Marshallagia marshalli; Oc = Ostertagia circumcincta; Oo = O. occidentalis; Ot = O. triforcata; Td = Teladorsagia davtiani; Na = Nematodirus archari; Nd = N. davtiani; Nh = N. helvetianus; Nm = N. maculosus; No = N. oiratianus; Ns = N. spathiger; Ta = Thysanosoma actinioides; A = Avitellina sp.; Mb = Moniezia benedeni; Me = M. expansa; Th = Taenia hydatigena; So = Skrjabinema ovis; Ts = Trichuris schumakovitschi.

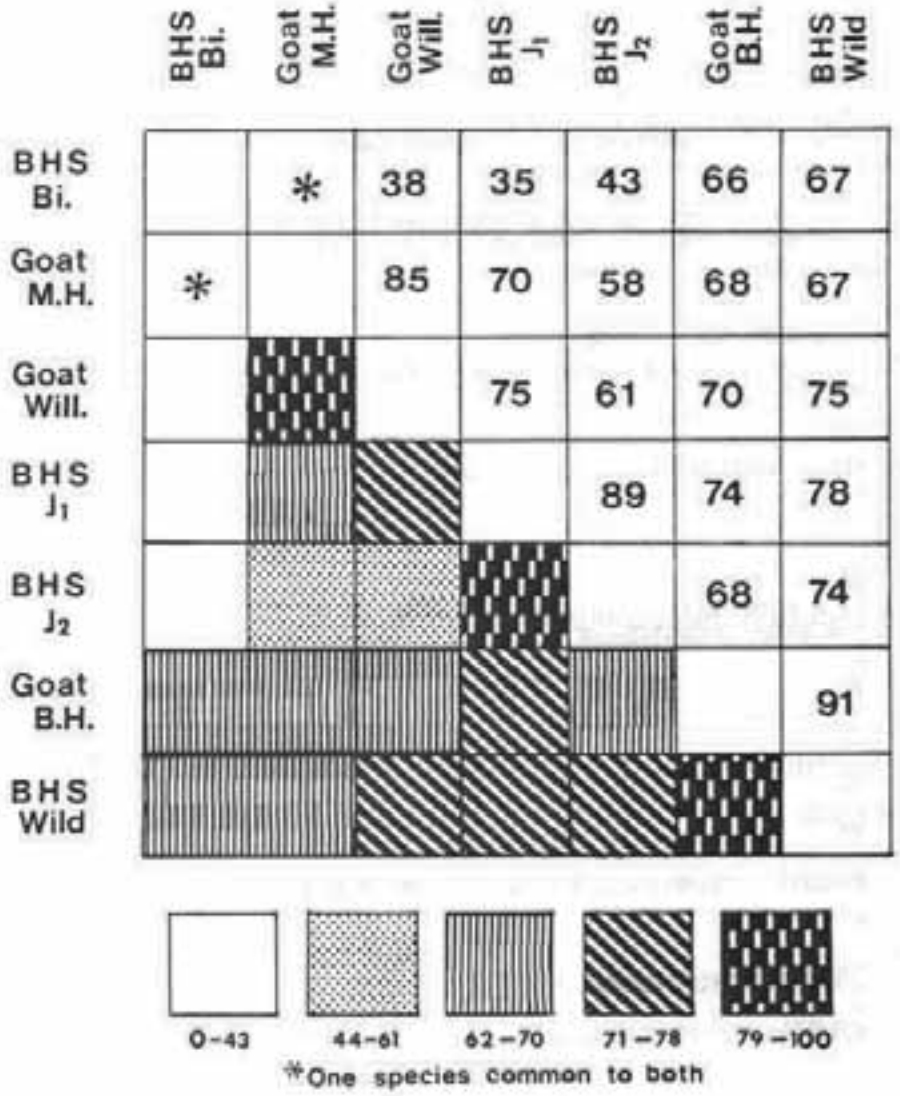

Figure 3.

Trellis diagram showing indexes of similarity between the helminths of mountain goat and bighorn sheep. Bi = National Bison Range, Montana; MH = Mount Hamell, Alberta; Will. = Willmore Wilderness Park, Alberta; J_1 = Jasper and Willmore Parks - this study; J_2 = Jasper National Park and vicinity (Uhazy and Homes 1971); BH = Black Hills, South Dakota; Wild. = Wildhorse Island, Montana.

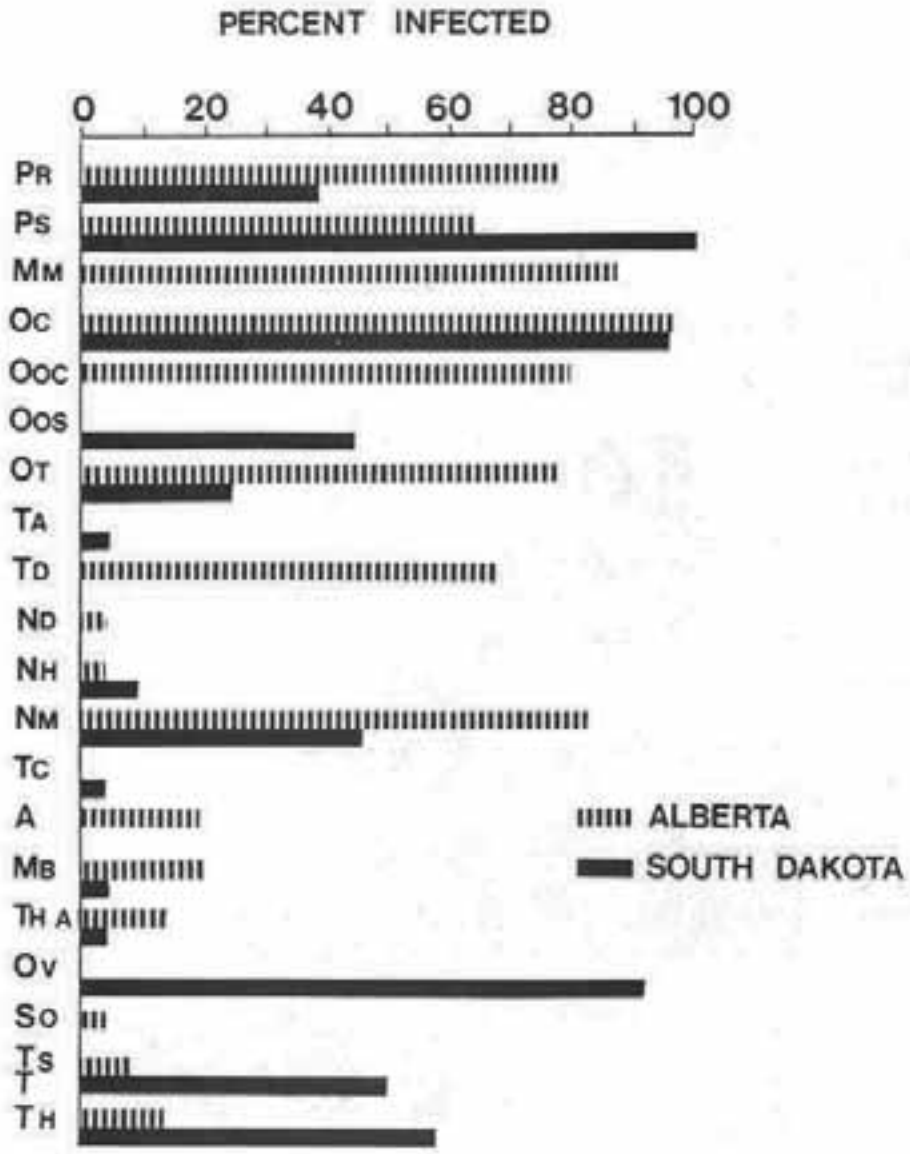

Figure 4.

Percent prevalence of helminths in mountain goat of Willmore Wilderness Park, Alberta, and the Black Hills, South Dakota (Boddicker et al. 1971). Pr = Protostrongylus rushi; Ps = P. stilesi; Oos = Ostertagia ostertagia; Ta = Trichostrongylus axei; Tc = T. colubriformis; Tha = Thysanosoma actinioides; Ov = Oesophagostomum venulosum; T = Trichuris sp. All other abbreviations are explained on Fig. 2.

data for other ungulates available in the literature or from our unpublished files. Five species, O. circumcincta, O. trifurcata, Teladorsagia davtiani, N. maculosus, and T. oreamnos (not shown on Table 5), were clearly parasites of goat and likely are not abundant in other mountain ungulates not examined during this study. Three tapeworms, Avitellina sp., M. benedeni, and T. actinioides, were found only in goat, but have been reported from hosts of other areas or close relations that are present in Willmore Park (Soddicker and Hugghins 1969, Flook and Stenton 1969, Allen 1973).

Table 4. The size of the parasite populations in goat of Willmore Wilderness Park and bighorn sheep of Alberta.

Parasite	Prevalence x Median Intensity			Host Category		
	Goat	BHS[a]	BHS[b]	Main	Secondary	Accidental
P. rushi	7.8	2.3	2.1	G	S	
M. marshalli	31.3	149	145	S	G	
O. circumcincta	178	36	2.5	G	S	
O. occidentalis	5.6	10.7	22	S	G	
O. trifurcata	7.7	0	0	G		
T. davtiani	2.7	0	0.5	G		S
Capillaria sp.	0	0	0.1	?		S
N. archari	0	30	131	S		
N. davtiani	0.03	5.3	9.4	S		G
N. helvetianus	0.03	0	0	?		G
N. maculosus	43.5	0	1	G		S
N. oiratianus	0	11.4	30.1	S		
N. spathiger	0	.5	3.5	S		
S. ovis	0.7	53.2	0.1	S		G
T. schumakovitschi	0.4	8.5	13.6	S		G
Avitellina sp.	1.1	0	0	G		
M. benedeni	0.2	0	0	G		
M. expansa	0	0.2	0.4	S		
T. actinioides	0.3	0	0	G		
W. tetoni	0	0	0.05	S		
T. hydatigena	0.1	0.3	0.4	G-S		

[a] This study
[b] Uhazy and Holmes 1971.

Helminths clearly of bighorn sheep were M. marshalli, O. occidentalis, N. archari, N. davtiani, N. oiratianus, T. schumakovitschi, and W. tetoni. Two, N. spathiger and M. expansa, were found only in sheep, but the small size of their populations and known host distributions suggest that they may be abundant in other ungulates. Categorization of P. stilesi, N. helvetianus, Capillaria sp., Skrjabinema ovis, and Taenia hydatigena was difficult because of similarities between sheep and goat, abundance in only one of the sheep studies (S. ovis), or extremely low values suggesting acquisition from hosts other than sheep and goat. Cysticerci of Taenia hydatigena were prevalent in sheep and goat and probably occur in all species of ungulates of Alberta (Stelfox 1962, and unpub. data of W. M. Samuel).

The diversity of parasites of goat and sheep was determined using species richness (Feet 1974) and Simpson's (1949) index (Table 5). Simpson's index can be used to test the hypothesis that the species in a sample from one area are more equitably distributed than are those in other samples (Holmes and Podesta 1968). Low indexes indicate that the parasites are equitably distributed in the parasite community and high indexes suggest that a few helminth species dominate the community.

Table 5. Species richness (S = number of species) and Simpson's index (SI) for several populations of mountain goat and bighorn sheep.

Study Area	Reference	S	SI	Number hosts Examined
Goat:				
Willmore Park	This study	17	.46	53
Mt. Hamell	Kerr and Holmes 1966	13	--	10
Black Hills	Boddicker et al. 1971	16	--	28
Mt. Wardle, British Columbia	This study	7	--	3
Banff-Jasper Nat'l. Parks, Alberta	Cowan 1951	14	--	10
Idaho-Montana	Brandborg 1955	15	--	--
Sheep:				
Alberta	This study	13	.25	26
Alberta-British Columbia	Uhazy and Holmes 1971	17	.31[a]	36
Nat'l. Bison Range, Montana	Forrester and Senger 1964[b]	1	.40	13
	Becklund and Senger 1967	7 }8		12
Wildhorse Island, Montana	Forrester and Senger 1964	1	.46	9
	Becklund and Senger 1967	7 }8		5
Sun River, Montana	Forrester and Senger 1964	2	--	55
	Becklund and Senger 1967	7 }9		1

[a]Only computed for 11 sheep from in and near Jasper National Park (Uhazy 1969).
[b]Forrester and Senger examined lungs only. Becklund and Senger examined gastrointestinal tracts excluding the caecum and large intestine.

Species richness was 13 or higher for all but one population of sheep or goat in which 10 or more animals were examined (Table 5). Simpson's index was high for the helminths of goat from Willmore Park, and sheep from Wildhorse Island and the National Bison Range, Montana, and low for sheep of Alberta. The goat fauna was dominated by O. circumcincta (Fig. 2), while N. oiratianus and N. spathiger dominated the faunas of the two areas of Montana (Becklund and Senger 1967).

DISCUSSION

This is the third report that presents information on prevalence and/or numbers of helminths of the Rocky Mountain goat. Twenty-two species of helminths have been identified from goat if identifications based on eggs and larvae (Brandborg 1955) are deleted, while thirty species of helminths have been identified from the Rocky Mountain bighorn sheep, if records from sheep in zoological parks and possible errors (Dictyocaulus viviparus and Protostrongylus frosti) are deleted (Becklund and Senger 1967, Uhazy and Holmes 1971). We found four species, Nematodirus davtiani, N. helvetianus, Moniezia benedeni, and Avitellina sp., not found by Kerr and Holmes 1966, even though their study area (= Mount Hamell) is less than 8km from locations where some of our goat were collected (see Fig. 1). However, they only collected seven adult goat: five from Mount Hamell and two from an isolated band at Pinto Creek, 56km east of Mount Hamell. We have assumed that the Protostrongylus sp. and Trichuris sp. of Kerr and Holmes (1966) included the P. stilesi, P. rushi and T. schumakovitschi of our study.

This is the first report of N. davtiani (only 1 male was recovered), T. schumakovitschi, and Avitellina sp. from mountain goat. The Trichuris oreamnos found in two goat of Mount Wardle (Table 1) were described as a new species by Knight (1974). The trichurids reported by Uhazy and Holmes (1971) from bighorn sheep as T. ovis proved to be T. schumakovitschi (Knight and Uhazy 1973), previously known only from domestic sheep of eastern U.S.S.R. (Savinkova 1967). Similarly, this is only the fourth report of N. davtiani in North America but it is a common parasite of domestic sheep and goat of the U.S.S.R. (Becklund and Senger 1967). The Avitellina sp. of this study is very similar to and may be A. arctica (Kolmakov 1938), previously reported from reindeer (Rangifer tarandus) and Siberian roe deer (Capreolus pygargus) in the Soviet Union (Spasskii 1951). Woodland

caribou (R. t. caribou) are sympatric with goat of our study, but Avitellina has not been reported from them (Cowan 1951, Low 1976). The only previous North American record of the genus Avitellina is from the barren-ground caribou (Gibbs 1960).

It is clear "that P. stilesi and P. rushi are fairly host-specific and occur only in native sheep and goats of North America" (Forrester 1971). These lungworms, particularly P. stilesi, "are important in producing the lungworm-pneumonia complex and in the history of the North American bighorn sheep" (Uhazy et al. 1973). The "Discussion" of the Uhazy et al. (op. cit.) paper is worth consulting; it presents an interesting, somewhat hypothetical picture of the role of lungworm in this complex.

Although mountain goat have burdens of lungworms similar to those of sheep (Tables 1-3) and, therefore, may be involved in the same disease syndrome, no die-offs of goat similar to those of sheep have been reported. Boddicker et al. (1971) found "massive" infections of P. stilesi in the lungs of two goat of South Dakota and we found a "heavy" infection in one 12 year old female in very poor condition collected in April, 1970, suggesting that lungworms may contribute to mortality of individual goat.

It was not surprising that the results of the two Alberta studies on goat were similar, particularly since many animals came from adjacent mountain ranges. However, not all adjacent populations of the same host have similar faunas: the helminth faunas of bighorn populations at the National Bison Range and Wildhorse Island (only 64km apart) were remarkably different and had only P. stilesi, P. rushi and cysticerci of Taenia hydatigena in common (Forrester and Senger 1964, Becklund and Senger 1967).

Banff National Park was the origin of the "Blackhills goats" (Boddicker et al. 1971) and the bighorn sheep of the National Bison Range (Becklund and Senger op. cit.). Although the latter authors thought that the unique fauna of the N.B.R. population "may be" related to the herd's origin, it is probably an unimportant factor (Uhazy and Holmes 1971).

Boddicker et al. (op. cit.) found five species, Trichuris sp. ("probably T. ovis"), Ostertagia ostertagia, Oesophagostomum venulosum, Trichostrongylus axei, and T. colubriformis, that have not been reported from goat in Alberta. The opinion of Boddicker et al. (op. cit.) and Uhazy and Holmes (op. cit.) was that some parasites were probably acquired from wild and domestic ungulates already established on the Bison Range and the Black Hills. Ostertagia ostertagia is a common parasite of pronghorn, Antilocapra americana, mule deer, Odocoileus h. hemionus and cattle of South Dakota or Montana (Boddicker and Hugghins 1969, Worley et al. 1970 and Worley and Eustace 1972).

Oesophagostomum venulosum is a well known parasite of domestic animals and was prevalent in wapiti (Cervus canadensis) from the Black Hills (Boddicker and Hugghins 1969). Both T. colubriformis and T. axei were rare in Black Hills goat, but are well known parasites of domestic livestock (Becklund 1964) and mule deer (Worley and Eustace 1972).

We are assuming that transplanted goat take some parasites with them that will become established on new range (example, N. maculosus), acquire new parasites from ungulates established there, and lose some. If the trichurid of South Dakota goat is "probably T. ovis" and not T. oreamnos or T. schumakovitschi of our study, five (see above) parasites of goat of the Black Hills were probably acquired from established ungulates. Species prevalent in goat of Alberta and likely transplanted with their host, but which are now absent in goat of the Black Hills, include N. marshalli, O. occidentalis and T. davtiani. We would have expected that N. marshalli and O. occidentalis would have been reacquired from bighorn sheep of the area (Boddicker and Hugghins 1969) but since goat only share range with mule deer, wapiti and a few whitetail in the Black Hills (Richardson 1971), this has not happened.

Cowan and Brink (1949) attributed the high prevalence of nematodes in mountain goat to their habit of frequenting natural mineral licks with other mountain ungulates such as the bighorn sheep. This assumption implies that species of helminths are exchanged between the two hosts. Bighorn sheep and mountain goat of Alberta have 11 of 22 species of helminths in common, but whether or not any actual sharing occurs remains unknown. Results of Presidente and Knapp (1973) for Dictyocaulus viviparus of black-tailed deer and cattle, and Baker et al. (1957) for trichostrongyles of black-tails and domestic sheep suggest that exchanges are limited. These and most studies of cross-transmission are concerned with the wild ruminant as a contributory factor in the epizootiology of helminthic infection of domestic livestock or vice versa (Dunn 1968). If Dunn's "truism" that "the greatest risk to a domesticated sheep or bovine is not a wild ruminant, but another sheep or bovine" is acceptable, then perhaps a similar truism exists between wild ruminants.

Barbehenn (1969), in a paper largely ignored by parasitologists, "argued convincingly that coexistence between two mammal species is possible if one harbors parasites that are more destructive to the other than to itself, and if the habitat is patchy with respect to parasite distribution" (Cornell 1974). If applied to sympatric populations of goat and sheep one or several of their respective parasites, to which each host would be relatively immune, would adversely affect

its competitor. Cornell (op. cit.) elaborated on how this might happen and concluded that distributional gaps between the hosts may result. Whether such a mechanism is operating between sheep and goat is, perhaps, wild premature speculation, since data on competition or any interaction between these hosts are scant (Klein 1953, Cooley 1976). The ideas of Barbehenn (op. cit.) are introduced here because, as Cornell has stated for comparison of two chickadees (Parus spp.), they "provide some compelling arguments to look beyond conventional competition theory for the answers" to host distributional patterns. Perhaps we should take a different view of Protostrongylus spp. of both sheep and goat and their pathogenic properties when self- and cross-transmitted. Such experiments should be preceded by morphological studies of the lungworms to guarantee that goat and sheep have the same species. If lungworms and/or other parasites are not influential for sheep or goat on native range, perhaps these interactions will be important in areas where goat and sheep transplant programs are underway.

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BIBLIOGRAPHY OF NORTH AMERICA'S MOUNTAIN GOAT

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This bibliography hopefully encompasses all of the published literature on mountain goat for the period 1900 to 1976 inclusive. References vary from critical scientific studies to those making casual reference to the species. Species lists referring to mountain goat and books on wildlife of the newest edition only are included. Reference to typescript, multilith and mimeograph reports of government and professional agencies is undoubtedly incomplete, however many of those citations presented may lead one to discover other such report forms by the said author if further enquiries are made. Some articles are incompletely cited but are included in hope that their source may be known or discovered by some interested reader. A plea is made to all readers for submission of corrections to the author regarding incorrect, incomplete or deleted citations. Notification of 1977 articles on mountain goat will also be appreciated for inclusion in a future revised edition of this bibliography.

The largest single sources of information utilized in compiling the present bibliography were the works of F. J. Singer and myself, Castle (1965), and Hibbs (1966). The approach in acquiring information was often unorthodox and time-consuming, but seemed essential if the bibliography was to be as current as possible. From the lists of Castle (1965) and Hibbs (1966) a preliminary list of references was compiled and checked with the card catalogue at the University of British Columbia's Main Library. A search of "Literature Cited" was then performed with new references added to the main list. Biological Abstracts were employed for the period 1960-76, and the CAN SDI search profile of P. L. Bunnell has included 'Oreamnos' since August, 1974. Singer utilized CAIN, the Denver Public Library - Fish and Wildlife Reference Service, the American Society of Mammalogists Special Bibliograph Search, and the United States Department of the Interior Computerized Search Services. Current publications on mountain goat from 1974 were updated by checking all articles in the Pre-bind section of U.B.C.'s Woodward Library. This procedure was necessary because computer-based searches may lag by 18 months or more. Alberta and British Columbia Provincial game agency personnel and Alaska, Idaho, Montana, Oregon, Utah and Wyoming State game service employees provided recent reports from their respective Departments. In particular, references from D. M. Hebert and L. Kuck were very useful.

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