Aerial Census and Classification of Mountain Goats in Alaska[1/]

by

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ABSTRACT

Replicate aerial counts were conducted of a herd of approximately 200 goats (*Oreamnos americanus*) using a Piper PA-18-150 Super Cub. Counts were conducted over a 4-year period, in spring, summer and fall, and under variable weather conditions. Results were compared with those from ground counts of portions of the herd, and a helicopter count of the entire herd. When properly done, counts made under good conditions (i.e., overcast skies, soft light, no turbulence), in early to midsummer, included about 90 percent of the goats found from the ground or helicopter. Results were lower and more inconsistent when made on clear, sunny days because of glare and because some goats were hidden. Helicopter and ground counts, thought to include nearly all goats in the areas covered, were equal in accuracy.

1/ A contribution of Federal Aid in Wildlife Restoration, Project A-17-9, 10, 11; Alaska.

Grouping, molting, and physical characteristics by sex and age were studied from the ground over three summers. Sex and age characteristics by which goats can be classified are listed. Although no physical characteristics were found by which to distinguish goats other than kids, yearlings, and "adults" from a fixed-wing aircraft, it was found that numbers of adult males could be estimated by their grouping patterns and stage of molt. Kids, because of their small size, could be classified easily in summer aerial counts. Yearlings, again by size, could be classified in spring counts. By mathematically combining results of spring and summer aerial counts, the numbers of kids, yearlings, adult males, and total goats could be estimated.

To estimate the number of non-breeding 2-year-old animals, and the number of adult females, a second year of aerial counts was found necessary. A significant relationship between overwinter mortality of kids-to-yearlings and yearlings-to-2-year-olds was found to exist, and could be used to estimate the number of 2-year-old goats present in the second year from the number of yearlings present the first year and the observed kid-to-yearling mortality between the first and second years. Thus, with 2 years of spring and summer aerial count data, the important sex and age cohorts can be estimated and population models constructed. These counts could be made by economical fixed-wing aircraft, and without the need for hazardous, close-in flying beyond that needed for "normal" mountain game surveys.

From the estimated population models, sex and age ratios per adult female could be obtained. These ratios permit comparing reproduction, recruitment, survival, etc. between herds or years. Ratios of kids per adult female were found to differ significantly between increasing, stable, and decreasing herds.

Although this method of estimating goat populations appears sound, its absolute accuracy could not be appraised with the data at hand, and further study will be necessary to compare estimated with actual population compositions.

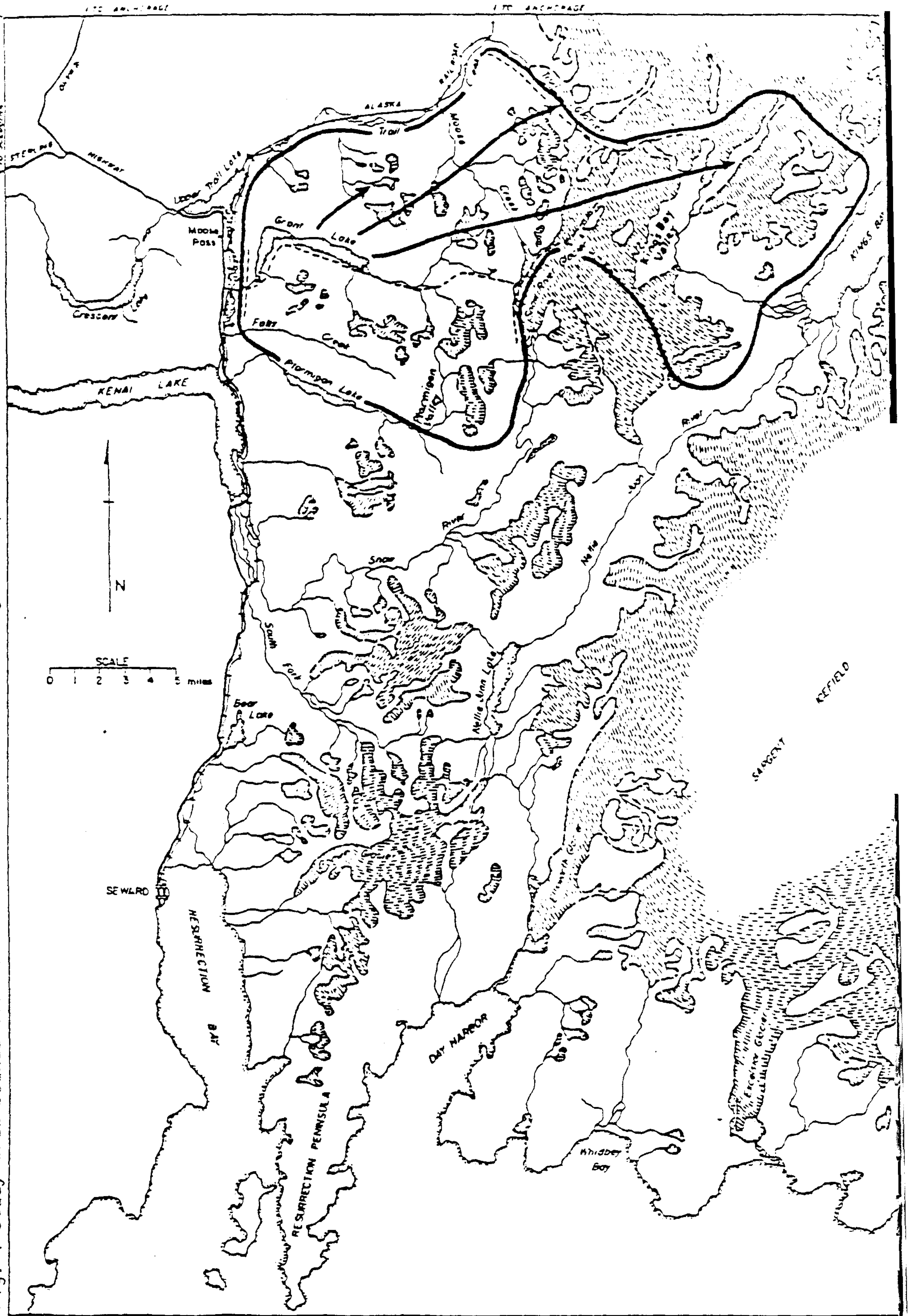
INTRODUCTION

It has long been recognized that one of the greatest immediate goat research needs is to develop methods of inventorying populations (Eastman 1977, Hall and Bibaud 1978, Hebert 1978). A goat herd which occupies heavily glaciated mountains northeast of Moose Pass on the Kenai Peninsula was selected, and it was thought to be confined to the area between Trail Glacier, Snow River Glacier, Ptarmigan Lake, and Trail River. Dall sheep (*Ovis dalli*) share the range with goats south of Grant Lake, but are rarely found north of this drainage. Because the area is relatively distant from the ocean, the herd is considered an "interior" rather than a "coastal" herd.

Investigation during early phases of the present study revealed that some goats in this area were crossing the large icefield at the head of Snow River Glacier and utilizing additional habitat in the headwaters valley of King's Bay on Prince William Sound. The study area was then expanded to include this valley (Fig. 1).

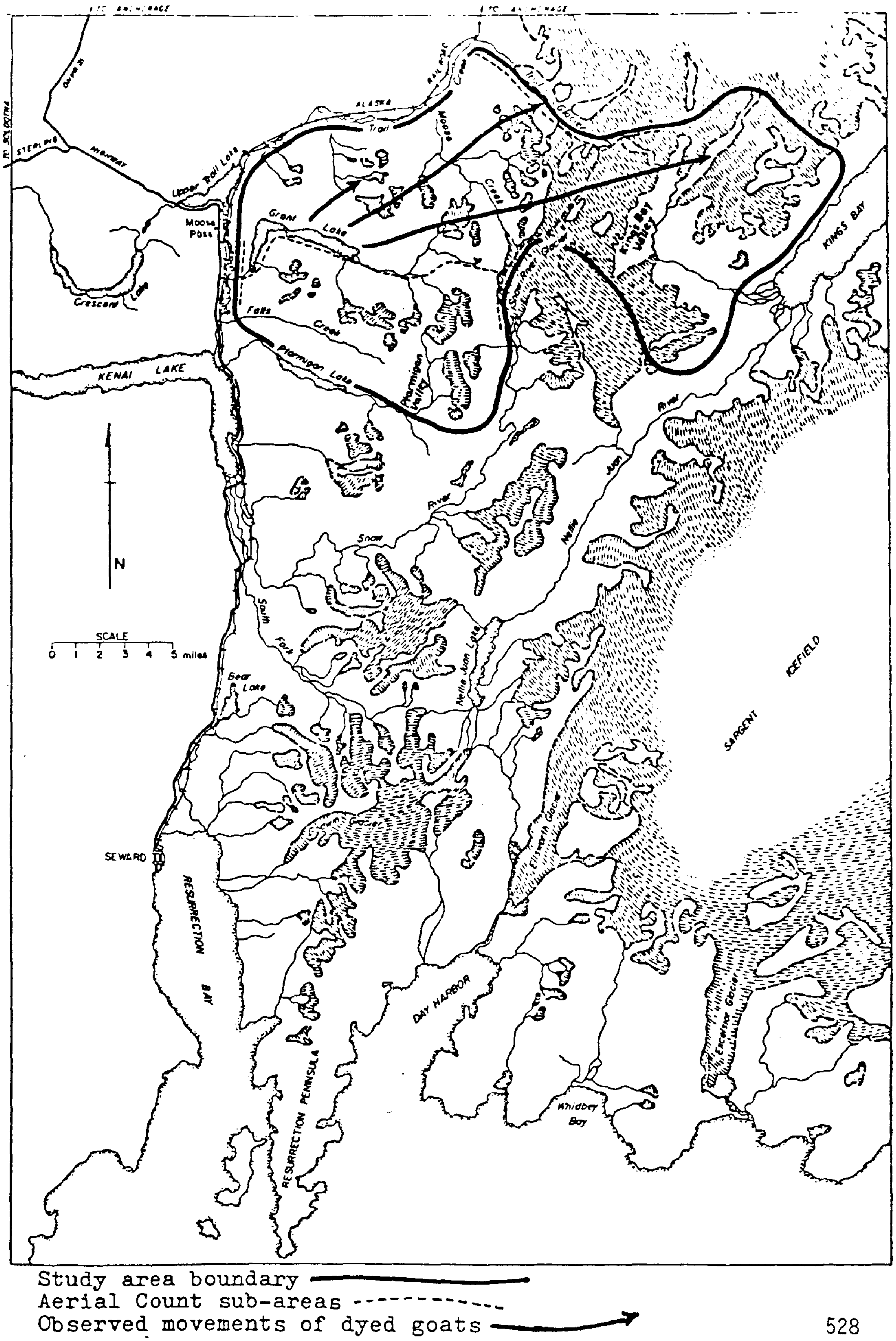
Hebert and Turnbull (1977) found differences in population characteristics between coastal and interior goat herds in British Columbia. Therefore, to compare data between this "interior" herd and a true "coastal" herd, a second study area was established in 1978 at Storm Mountain in what is now Kenai Fiords National Monument (Fig. 2).

Fig. 1 Study area boundaries and observed movements of marked goats, spring 1977.



Study area boundary
Aerial Count sub-areas
Observed movements of dyed goats

Fig. 2. Study area boundaries and observed movements of marked goats, Spring 1977.



Study area boundary
Aerial Count sub-areas
Observed movements of dyed goats

Fig. 3. Goat study sites, summer 1978.

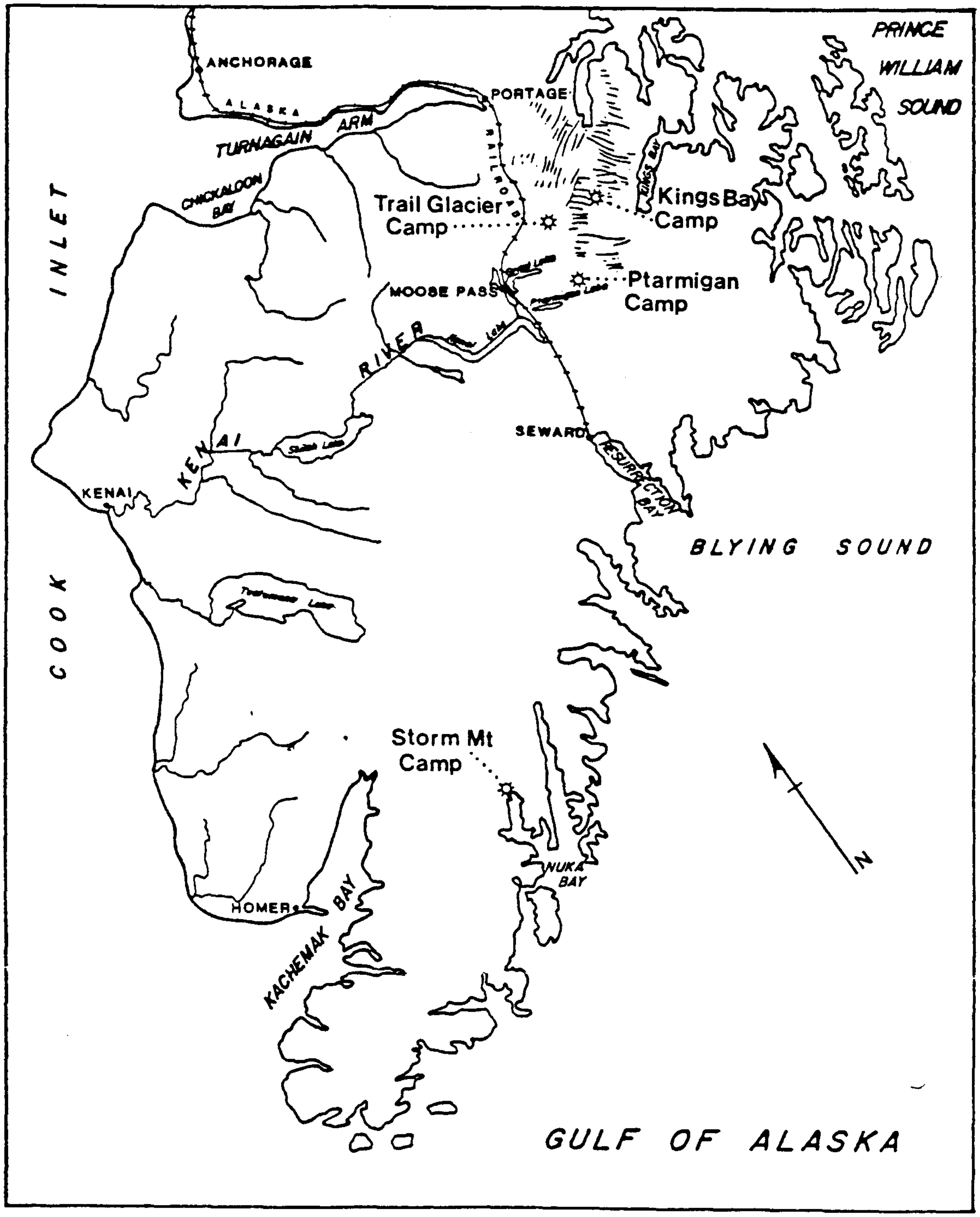
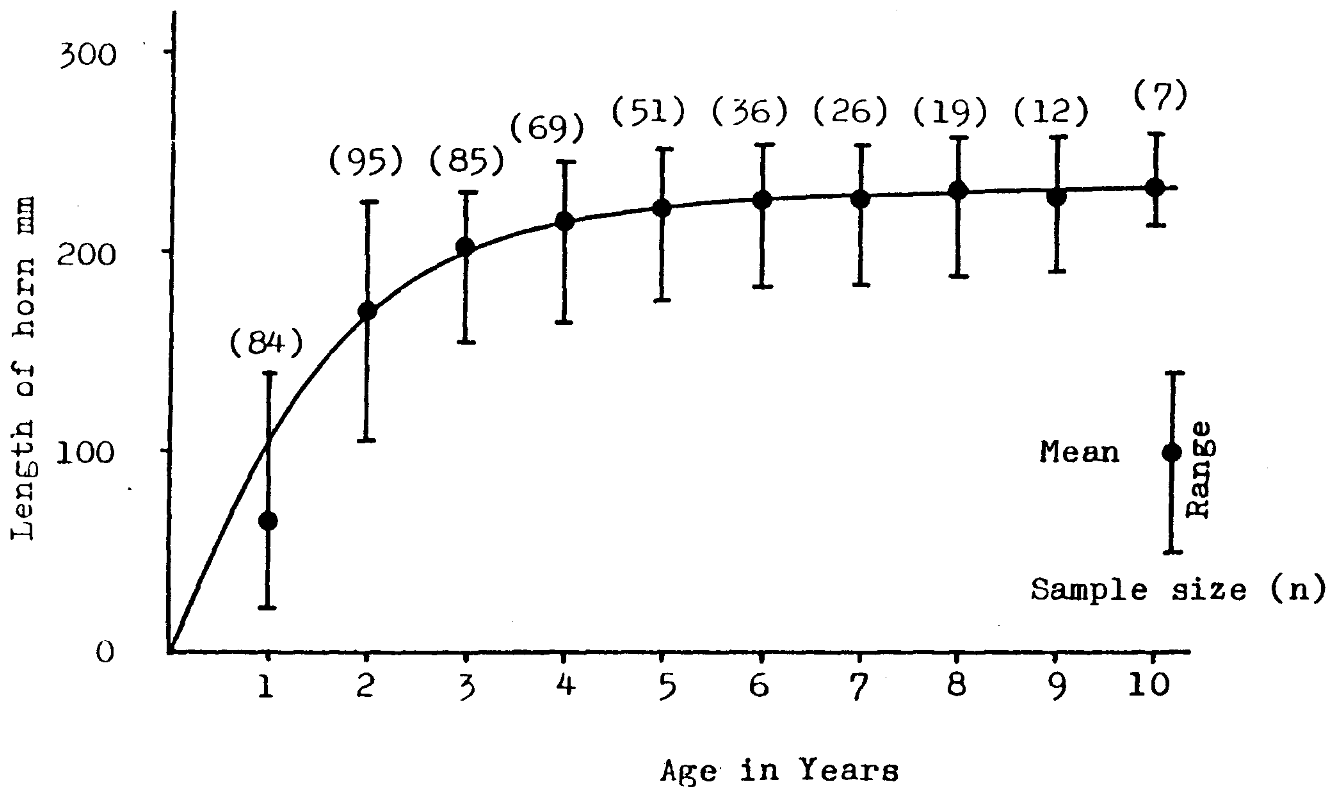


Fig. 2. Goat horn length by age, both sexes combined.



It has been generally accepted that the most practical way to census goats in remote areas is by means of aerial surveys (Couey 1951, Ballard 1975, Hibbs 1966, Lentfer 1955, and others). Ground surveys may provide for more accurate classifications of goats seen, but observers on the ground rarely are able to cover more than small portions of total goat habitat (Ballard 1977, Klein 1953). In addition the problem of duplication with ground counts is greater than for relatively "instantaneous" aerial counts. Although some researchers believe more accurate aerial counts can be obtained from a helicopter (Ballard 1975, 1977; Bone 1978; Hebert and Turnbull 1977; Quaedvlieg et. al. 1973), most concede that a slow-flying, maneuverable, fixed-wing airplane is more practical for general use over large areas because of the lower cost and because goats are less fearful of fixed-wing aircraft (Ballard 1975; Chadwick 1973; Hibbs 1965, 1966).

Although goats are white in color and generally reside in an alpine or subalpine habitat, they are not always easy to see from the air. In bright sunlight, their dingy white coats blend with the many greyish-white boulders, and they often rest in the shade and on, or under, snow banks in warm weather. They also frequently hide under bushes or overhanging ledges at the approach of a plane. Hibbs (1965), who worked extensively with goats in Colorado, considered it "more difficult to obtain accurate air counts for mountain goats than for any of the other big game species observed." Because they live in some of the most rugged and inhospitable mountain terrain in Alaska, surveys are limited in time by frequent periods of bad weather.

Although aerial goat counts traditionally have been conducted traditionally in Alaska and elsewhere, the accuracy of these counts is unknown. Observed population changes may be real or merely the result of counting errors. Lentfer (1955) compared aerial and ground counts, and several aerial counts of the same Montana goat herd, but could not determine the accuracy of either method. In Alaska, Ballard (1975, 1977) attempted to assess the accuracy of aerial counting by comparing results of replicate counts of two herds by helicopter and fixed-wing aircraft. His results were inconclusive.

Previous aerial counts, with the exception of a few conducted at close range by helicopter (Hebert and Turnbull 1977), have provided only numerical data or data reflecting the relative proportions of kids to adults for use as an indicator of productivity. Because data on the proportion of kids do not take into consideration the sex ratio of adults, the survival of previous kid crops, or the numbers of nonbreeding subadults present, they are a poor measure of productivign. Annual production can be assessed accurately only if the proportion of young to breeding age females can be determined, and assessment of population status requires a knowledge of year-to-year survival among sex and age classes. To date, no method has been devised to determine the sex and age of mountain goats from a fixed-wing aircraft.

This study was designed in an attempt to assess the accuracy of aerial counts from a fixed-wing aircraft and to develop, if possible, a method for classifying goats from the air.

METHODS

Replicate aerial surveys of this goat herd were conducted during summer 1976 using a wheel-equipped Piper PA-18-150. I flew all counts and recorded all observations in a tape recorder; two of the counts were flown alone, one with an observer. Locations of all goats seen were recorded.

When it became apparent that extensive, but unknown, movements were taking place in spring as goats left their winter range, I decided to mark a number of animals to ascertain whether the herd was remaining within the arbitrarily established study area and aerial counting boundaries. The method used to mark goats was a modification of that described by Simmons (1971) for aerially marking Dall sheep in Canada, and which I had used successfully on a previous sheep study (Nichols 1973). Red dye (Calcocid Scarlet 2RIL, American Cyanamid Co.) was mixed with water at a concentration of 10 lb. (4.5 kg) of dye per 40 gal. (151.4 l) of water. Up to 60 gal. (227 l) of this mixture were pumped into a modified Sorensen belly tank attached to a Piper PA-18-150 Super Cub. The tank was equipped with an electrically operated dump valve controlled by a trigger switch on the airplane's control stick. The valve opened and shut rapidly, and could be held open as long as desired. In practice, goats were flown over at an altitude of 10-15 ft (3.0-4.6 m), and dye was dumped on them in a drenching spray. Marking flights were conducted in June 1977, and follow-up flights were made to locate marked animals in June and July. Apparent, but unknown movements to and from the King's Bay area in summer dictated further dye-marking attempts in late summer 1978.

Additional replicate aerial surveys were flown during late spring and summer 1977, summer 1978, and spring and summer 1979. Because count results did not indicate there was any advantage in having an observer, most counts were conducted alone. The count area was expanded to include King's Bay and its inland drainage. A thorough helicopter count of the entire area was conducted in midsummer, 1978, using a Bell 206 with pilot and two observers.

Intensive ground observations of goats in portions of the study area were conducted during summers 1976 and 1977. Observers were moved to various locations by Super Cub and helicopter, camps established, and goats at each site repeatedly observed and classified over time using binoculars and telescope. In 1978, semi-permanent camps were established at the head of Ptarmigan Valley and at Storm Mountain. These were manned continually to provide sequential data with the fewest possible gaps. Bad weather forced the abandonment of the Storm Mountain site and that camp was moved in late summer to Trail Glacier.

After it was discovered that goats were concentrated in King's Bay Valley, classification counts were conducted there from the ground in summer 1977, 1978, and 1979, but not on a continuing basis.

At first, conventional spotting scopes were used to classify goats by sex and age. These were later replaced by Questar and Celestron lenses whose superior resolution enabled accurate classification at 1 mile (1.6 km) or more under good conditions. Each goat was identified as to sex and age class and various criteria were recorded on unisort punch cards. Cards were then punched and sorted according to data categories of interest and the resulting data analyzed.

Horns from hunter-killed goats on the Kenai Peninsula were examined and measured by Department personnel in fall 1977 and 1978. Annual growth increments were plotted by sex and age to assess horn growth rates. Other horn measurements were examined for use as possible criteria for sex differentiation.

A method was developed for mathematically constructing population models utilizing data from both ground and aerial counts from consecutive years. Sex and age ratios were estimated from these models.

FINDINGS

Movements

During summer 1976, it became apparent that goats were moving from winter ranges along the north sides of Grant and Ptarmigan Lakes to summer ranges elsewhere. To learn the extent of these movements, aerial dye marking was undertaken in June 1977, before spring migrations began. Dye spraying was conducted on 8, 10 and 19 June along the north side of Grant Lake. In all, four belly tank loads of dye were used, resulting in the marking of at least 33 goats. More may have been marked by rubbing against aerially marked animals which were still wet. All were marked with red dye; marking ranged from almost completely red animals to those with smaller pink splotches.

Marked animals were located during follow-up flights in late June and early July in the drainages north of Grant Lake as far north as Trail Glacier. Tracks were observed crossing the extensive upper Snow River Glacier icefield and subsequent searches revealed a number of marked and unmarked goats in the drainage leading into King's Bay (Fig. 1). This was a distance of over 15 air miles (24 km) from the marking site and completely out of the study area boundary.

Other investigators have recorded similar movements from winter to summer range (Anderson 1940, Chadwick 1973, Lentfer 1955, Smith 1976), while several (Hibbs 1966, Hjeljord 1971) felt that goats were nonmigratory. Brandborg (1955) noted movements as great as 15 mi (24 km), and Stevens and Driver (1978) had one marked 2-year-old male move at least 22 miles (35 km).

Although no dyed goats were observed after 8 July (most were shedding over their backs by then or had completely lost their winter coats which held the dye), both aerial and ground surveys suggested further movements from King's Bay in mid-August. It appeared that at least part of the early summer's "population" had moved elsewhere--possibly back across the ice field into the Trail Glacier area.

In an attempt to learn more about these summer movements, I red dye-marked 20 goats in King's Bay Valley on 15 and 17 August 1978 in two drops. On 18 August, I marked another 10 blue on the north side of Trail Glacier with one drop. Unfortunately, it began raining almost immediately thereafter and apparently washed the dye off. With this method, the dye doesn't "set" in the hair but merely tinctures the surface of the hairs and remains water soluable. Few marked goats were observed afterwards, and no movement data were obtained.

Both Casebeer (1950) and Kuck (1973) noted movements of goats out of early summer range in August. Much remains to be learned about mountain goat movements before it can be assumed that given herds will be found on given areas at any particular time and thus be usable in year-to-year trend counts.

Because of the movements noted, the area counted in replicate aerial surveys was expanded to include the valley of King's Bay in 1977 and thereafter. I believe that most movements were included in the area then counted, so the entire study area population was subjected to repeated aerial census. The possibility exists, however, for further movements out of the area which would certainly affect count results and their interpretation.

Aerial Counts

Problems with weather and aircraft each summer made it impossible to conduct as many replicate surveys as desired. In 1977, and again in 1978, heavy snow pack and late runoff left much of the area snow covered until midsummer. Consequently (in these 2 years), survey flights (except for one preliminary count in late May on winter range) were delayed until late July and early August on the assumption that too many goats would be missed among the remaining snow banks. In 1979, replicate counts were conducted in May, June, and July. Because of funding and weather problems, helicopter surveys were not conducted in 1976, 1977, or 1979, nor were other pilot-observer teams made available to assist in the replicate fixed-wing aerial counts. One detailed helicopter count was made of the entire study area on 2 August 1978. All aerial count results are summarized in Table 1, which lists count results by study area segment.

When the study first began in 1976, nothing was known of the movements to and from King's Bay and I thought the initial study area boundaries from Trail Glacier to Ptarmigan Lake encompassed this entire herd. In fact, I assumed the Trail Glacier to Grant Lake, and Grant Lake to Ptarmigan Lake segments comprised more or less discrete populations and so could be considered separately for counting purposes. Subsequent movement information showed that there was an interchange of goats between the Trail Glacier-Grant Lake segment and King's Bay Valley. If goats crossed freely over the ice field between these two areas, there was no reason to doubt some movement might occur between Ptarmigan and Grant Lakes. Therefore, except in 1976, the study area was considered as a whole for censusing purposes (Area T). However, the sub-areas were maintained for ease in counting (Table 1).

Regressions were calculated for the relationships between number of goats counted on a given count segment and the time spent making the count. No significant relationships were found; i.e., a longer, more intensive count did not necessarily result in more goats observed. All counts included were made with appropriate dilligence. It is probable

Table 1. Summary of aerial goat counts by sub-areas counted, 1976-1979.

Area[1]	Date	Non-kids	Kids	Yearlings	Total	Conditions	CCI[2]
1	7/18/76	65	21	-	86	Poor	
	8/4/76	62	23	-	85	Fair/poor	
	9/5/76	79	27	-	106	Fair/poor	
2	7/24/76	36	15	-	51	Poor	
	8/23/76	35	11	-	46	Poor	
	9/5/76	38	12	-	50	Poor/fair	
T	8/16/77	135	48	-	183	Excellent	1
	9/3/77	-	-	-	120	Poor	4
	9/13/77	124	34	-	158	Excellent	1
	9/24-26/77	-	-	-	126	Fair	3
1	5/21/77	83	-	14	83	Good	
	8/16/77	55	18	-	73	Excellent	
	9/3/77	27	3	-	30	Poor	
	9/13/77	64	14	-	78	Excellent	
	9/24/77	-	-	-	55	Fair	
2	5/28/77	23	-	3	23	Fair	
	7/28/77	37	16	-	53	Poor	
	8/16/77	46	16	-	62	Excellent	
	9/3/77	38	11	-	49	Poor	
	9/13/77	39	13	-	52	Excellent	
	9/26/77	34	14	-	48	Fair	
3	7/18/77	-	-	-	53	Good	
	8/16/77	34	14	-	48	Excellent	
	8/20/77	-	-	-	31	Poor	
	9/3/77	-	-	-	41	Poor	
	9/13/77	21	7	-	28	Excellent	
	9/24/77	-	-	-	23	Good	
T	7/23-25/78	135	43	-	178	Excellent	1
	8/2/78(H)[3]	157	39	-	196	Fair/good	
	8/19-22/78	105	30	-	135	Poor	4
1	5/19-20/78	93	-	13	93	Good	
	7/23/78	45	15	-	60	Excellent	
	8/2/78(H)	59	8	-	67	Fair	
	8/19/78	46	8	-	54	Poor	
	8/24/78	48	4	-	52	Poor	
2	5/19-20/78	44	-	10	44	Excellent	
	7/10/78	27	11	-	38	Poor	
	7/23/78	36	14	-	50	Excellent	
	8/2/78(H)	42	17	-	59	Fair	
	8/19/78	25	9	-	34	Poor	
	8/24/78	-	-	-	33	Poor	

Table 1 (Cont.).

Area[1/]	Date	Non-kids	Kids	Yearlings	Total	Conditions	CCI[2/]
3	7/10/78	40	14	-	54	Fair	
	7/25/78	54	14	-	68	Excellent	
	8/2/78(H)	56	14	-	70	Good	
	8/11/78	40	12	-	52	Fair	
	8/22/78	34	13	-	47	Poor	
T	5/30-6/5/79	158	-	20	158	Fair	3
	6/15/79	172	49	-	221	Excellent	1
	7/27-29/79	94	38	-	132	Fair	3
1	5/30/79	83	-	11	83	Poor	
	6/15/79	74	27	-	101	Excellent	
	7/29/79	42	20	-	62	Fair	
2	5/18/79	29	-	-	29	Poor	
	5/30/79	39	-	5	39	Poor	
	6/15/79	37	10	-	47	Excellent	
	7/29/79	24	9	-	33	Fair	
3	6/5/79	36	-	4	36	Good	
	6/15/79	61	12	-	73	Excellent	
	7/27/79	28	9	-	37	Poor	
	7/30/79	24	8	-	32	Poor	

1/ T King's Bay-Trail Glacier-Grant Lake-Ptarmigan Lake (entire study area)
1 Trail Glacier-Grant Lake segment
2 Grant Lake-Ptarmigan Lake segment
3 King's Bay segment

2/ Counting conditions index; applied only to counts of entire study area:

1 Excellent
2 Good
3 Fair
4 Poor

3/ Helicopter count

that an accuracy-time relationship could be demonstrated by comparing quick, careless counts with longer, more carefully conducted flights.

At first I thought that clear, calm days would be best for aerial surveys, but it soon became evident that goats often were difficult to distinguish from their background in bright sunlight or harsh shadow, and that greater numbers were seen on days with a high overcast, producing a soft, even light. Regardless of light conditions, turbulent air prevented safe flight into downwind cirques or close to slopes and ridges affected by severe downdrafts, further reducing observational effectiveness.

Counting conditions during each aerial survey were grouped into four general classes, and each given a counting condition index (CCI). These indices were: 1. Excellent - high overcast, calm air, even light; 2. Good - good light but some minor turbulence or occasional clouds on the higher peaks; 3. Fair - some bright sun and glare, some areas of moderate turbulence, some low clouds obscuring higher ridges, patches of new snow on higher terrain above normal goat habitat--or a combination of such conditions; 4. Poor - hot with bright sun and harsh light, with or without turbulence. These indices are shown in Table 1 for the surveys conducted on the entire study area.

Using only those counts from fixed-wing aircraft which included the entire study area, and which should have been unaffected by intra-area movements, total goats counted, total adults (non-kids) counted, and total kids counted were compared with the CCI for each count by linear regression. A highly significant relationship ($r = .835$, DF = 6, $P<.01$; $F_{1, 6} = 13.32$, $P<.01$) was found between totals counted in 1977, 1978, and 1979 and the counting conditions of each count, with more goats being counted under better conditions. In 1977, the only year in which enough counts were made for a within-year comparison, a similar, but nonsignificant relationship was found ($P<.08$). Similar trends were noted for the non-kid and kid segments of the population, but the relationships were not statistically significant (probably because sample sizes were smaller; kids were not classified in all counts). However, testing of the regression slopes showed a significant difference between that of the non-kids and B=0 ($F_{1,6} = 10.33$, $P<.025$), but no difference between that of the kids and B=0 ($F_{1,4} = 5.32$). These results indicate that counting conditions do have an effect on the number of non-kids observed, while having little effect on the total number of kids seen.

Mean total numbers of animals counted on the total study are on days having other than calm, high overcast conditions were 68 percent of those found under excellent conditions ($\bar{x} = 67.8\%$, $n = 4$, $s = 6.65$). It was possible to compare results between two counts made under excellent conditions only in 1977. The later of these was made in mid-September and produced a total count of only 86 percent of the earlier, mid-August survey. These results probably are not truly indicative of the variation normally to be obtained under equally good counting conditions because the lower count was obtained so late in the season. Also, during this survey, 92 percent as many non-kids and 71 percent as many kids were found as during the best count. Although this appears to show that more kids than adults were missed, and that relative accuracy of adults counted was high, it was more likely the result of difficulty in classifying kids that late in the year.

On other than calm, overcast days, the non-kid and kid portions of the count averaged 67 and 74 percent, respectively, of the numbers found on the best days. This suggests that more adults than kids were missed when conditions were not ideal. Groups of females with kids were usually large enough to be observed despite viewing conditions, while under poor light or turbulence conditions, single adults and small groups would be more difficult to spot. An exception was found during the early season (30 May-5 June 1979) survey, when 92 percent as many adults were seen under poor counting conditions as during the best count later in June.

Fixed-wing counts could be compared with a helicopter survey only in 1978. The helicopter survey was made presumably because it would be almost 100 percent accurate and provide a basis of comparison for other surveys. During the best fixed-wing census, 91, 86, and 110 percent as many goats (non-kids and kids), were observed as during the helicopter flight. That more kids were seen from the Super Cub than the helicopter is most likely due to the much stronger fear reaction caused by the helicopter. Groups of goats tended to bunch up with kids crowding under nannies, thus being more difficult to see. The fixed-wing count on a poor day produced only 69, 67, and 77 percent as many goats (non-kids and kids) as during the helicopter survey.

Counts made from the ground were compared with those made from fixed-wing aircraft and the helicopter on several portions of the herd as well as on goats outside the main study area. Ground classifications were limited to those areas where observers presumably could view all goats using those areas. Ptarmigan Valley and King's Bay Valley goats were readily visible from vantage points. The Ptarmigan Valley goats appeared to remain in the area most of the summer, while those in King's Bay Valley appeared to be relatively stable only for a short period. Therefore, comparisons were made only using aerial counts that were conducted within a short time span of the ground counts in King's Bay Valley. Because of the terrain in Ptarmigan Valley, it was not always possible to see all goats on a given day. Therefore, in 1976 and 1977, population estimates were based on a number of replicate censuses from the ground and on the sex/age classifications made.

The Storm Mountain population was also counted from both ground and air, as was a herd wintering above Tern Lake along the Seward Highway. Results of these ground vs. aerial counts by herd segment, date, method used, aerial counting conditions encountered, and aerial count accuracy relative to the ground counts are presented in Table 2.

The observers felt that the ground surveys produced very nearly 100 percent accuracy; i.e., that all goats in the area under observation were observed and counted. However, it is possible, particularly in Ptarmigan Valley, that a small number were missed.

It is worth mentioning at this point that surveys from the ground are <u>only</u> practical where the observer can cover all the area involved. Many portions of goat habitat in this region cannot be counted from the able 2. Aerial vs. ground counts for selected goat herds and dates.

Area	Date	Type count	Non-kids	A[1]	Kids	A	Total	A	Conditions
tarmigan[2]	7/24/76	Fixed-wing	22	.96	9	1.13	31	1.00	Poor
Valley	8/23/76	Fixed-wing	22	.96	7	.88	29	.94	Fair
"	9/5/76	Fixed-wing	24	1.04	9	1.13	33	1.06	Fair
"	(composit)[3]	Ground	23		8		31		
"	7/28/77	Fixed-wing	21	.66	11	.85	32	.71	Poor
"	8/16/77	Fixed-wing	29	.91	11	.85	40	.89	Excellent
"	9/3/77	Fixed-wing	29	.91	10	.77	39	.87	Poor
"	9/13/77	Fixed-wing	22	.69	8	.62	30	.67	Excellent
"	9/26/77	Fixed-wing	22	.69	11	.85	33	.73	Good
"	(composit)	Ground	32		13		45		
"	7/10/78	Fixed-wing	27	.96	11	1.00	38	.97	Good
"	7/23/78	Fixed-wing	30	1.07	10	.91	40	1.03	Excellent
"	8/2/78	Helicopter	29	1.04	12	1.09	41	1.05	Fair
"	8/17/78	Ground	28		11		39		
"	8/24/78	Fixed-wing	-		-		32	.82	Poor
"	6/15/79	Fixed-wing	30	.94	9	.90	39	.93	Excellent
"	7/19/79	Ground	32		10		42		
"	7/29/79	Fixed-wing	23	.72	9	.90	32	.76	Fair
ngs Bay[4]	7/10/78	Fixed-wing	40	.87	14	1.08	54	.92	Fair
Valley	7/25/78	Fixed-wing	40	.87	12	.92	52	.88	Excellent
"	7/29/78	Ground	46		13		59		
"	8/2/78	Helicopter	44	.96	12	.92	56	.95	Fair
"	7/26/79	Ground	28		9		37		
"	7/27/79	Fixed-wing	22	.79	9	1.00	31	.84	Poor
orm Mt.	6/19/78	Ground	25		15		40		
"	6/28/78	Fixed-wing	24	.96	13	.87	37	.93	Good
rn Lake[5]	5/5/78	Fixed-wing	18	.86	2[6]	1.00	20	.87	Good
"	5/13/78	Fixed-wing	19	.90	2	1.00	21	.91	Excellent
"	5/17/78	Ground	21		2		23		

Accuracy as a percent of the ground count.
Only those areas covered by the ground counts.
Best estimate based on several counts on different dates.
1977 data not used; unable to compare aerial vs. ground area coverages.
Outside regular study area but readily visible from the highway; winter-spring population.
Yearlings; no lambs born by this date.

ground without unknown overlap and missed areas due to the extreme ruggedness of the terrain. Hence, for general population census in this part of Alaska, ground surveys are impractical. They are useful, however, in obtaining accurate counts and classifications of certain accessible sub-populations.

In comparing the accuracy of the Super Cub counts relative to the ground counts, it was found that in these relatively accessible areas counting conditions did not significantly affect results. Therefore, aerial census results were lumped regardless of counting conditions. It was also found that there were no statistically significant differences in accuracy between the four sub-populations counted, nor between cohorts counted (non-kids, kids, total goats). The average composit accuracies of the fixed-wing counts and their 95 percent confidence limits were: non-kids 87.6 $\pm$ 6.0 percent; kids 92.6 $\pm$ 6.3 percent; total goats 88.1 $\pm$ 5.1 percent. Thus, the average accuracy of the Super Cub counts on these sample herds was about 90 percent (89 $\pm$ 3%).

Similar comparisons could be made between ground counts and helicopter counts only on the Kings Bay Valley and Ptarmigan Valley sub-populations in 1978. A strong, but not statistically significant, difference ($P<.06$) was found in accuracy levels attained between the two areas, with relative accuracy being higher in the Ptarmigan Valley count. However, too few samples are available for meaningful analysis. Average relative accuracies of the two areas combined were: non-kids 100.0 percent ($n = 2$, $s = 5.66$); kids 100.5 percent ($n = 2$, $s = 12.02$); total goats 100.0 percent ($n = 2$, $s = 7.07$). In the two areas compared, the average relative accuracy between helicopter and ground counts was 100 percent (CI95 $\bar{x} = 100 \pm 7\%$).

Sexing and Aging Criteria

Most goats observed from the ground were classified by sex, and all by age class. Kids-of-the-year were not sexed, nor were some yearlings. Age classes used were: kid (those animals born during the current summer), yearling (animals born during the previous summer), 2-year-old (animals 24 months old on or about 1 June), and adult (all animals over 36 months of age).

This classification system appears logical from the standpoints of reproductive ability and assessment of population dynamics. Nearly all investigators agree that goats do not breed until approximately age 2 1/2 years (Chadwick 1973, 1979; Foss 1962; Hebert 1978; Holroyd 1967; Lentfer 1955; Peck 1972). Thus, animals older than 36 months can be considered adults.

During summer 1976, we used urination posture (Brandborg 1955, Hibbs and Denney 1965) and direct observations of the genitalia for positive sex identification and to confirm identification based on more readily visible criteria such as horn shape and body size and shape. Others have noted the difference in thickness and shape of the horns between sexes in adults (Brandborg 1955, Casebeer 1950, Cowan and McCrory 1970, Klein 1953, Lentfer 1955, Vaughan 1975). Horns of adult males are more massive, thicker at the base, and follow a smoother curve from base to tip than those of adult females. The latter have horns with smaller bases which, are relatively narrow, and which are somewhat straighter for approximately the lower 2/3 of their length, then curve rearward with a more angular appearance, and usually are more divergent than those of males.

In an attempt to quantify these differences, goat horns taken in the 1976 hunting season were measured by Department personnel and summarized by mean circumference at the base, mean length, sex, and age (Alaska Dept. of Fish and Game files, unpub.). I compared mean base circumferences and mean lengths between sexes by age using the paired t-test. Mean circumference at all age levels was significantly greater in males than in females ($P<.001$), but length was no different. A rough approximation of the mean basal diameter was obtained by assuming the bases to be circular (goat horns are roughly oval in cross section) and dividing each mean circumference by Pi. The mean basal diameter for males was 27 percent greater than for females.

Horns taken in the 1977 and 1978 hunting seasons were measured for length between annuli over the frontal curve to obtain an estimate of growth by year of age. Basal diameters, both front-to-rear and side-to-side, were also measured in 1978, as were the spaces between horn bases.

No significant differences in length were found between 1977 and 1978 data, except in length of the first year's growth, so data from both years were pooled. No distinct annulus occurs at the end of the first growing season so measurements of this segment undoubtedly contained many errors, probably accounting for the noted difference between data years.

No statistically significant differences were found in segment length by age between sexes, again excepting year 1 in which male horns were significantly longer than those of females ($P<.005$). This difference may be real or the result of measurement errors. Foster (1978) also noted problems with first-year measurements for the same reason. He found that horn growth was greater for males than for females during the first 2 years, and that growth varied between sexes in total length, as well as by year. Because I could discern no such differences, and measurements from the first segment and observed differences were questionable, I pooled the length measurements of both sexes. Results of these measurements for both years and sexes are plotted by mean segment length in Fig. 2, ranges and sample sizes are also indicated. Beyond age 10, too few measurements were obtained to be useful. Mean segment lengths by age and sex, including related statistics, are presented in Table 3.

Available data were only sufficient for comparison of horn front-to-rear basal diameters between sexes, by year, through age 7. Basal diameters for males were significantly larger than those of females, with the average diameter being 27 percent greater for males than females.

Basal side-to-side widths were compared by sex through age 7, and found to be 33 percent greater for males than females.

Ratios of horn-base widths to the distance between bases were significantly less in males than in females, with the average space between horn bases on males being approximately 50 percent of the width of the horn base, and that of females being about 75 percent of the basal width.

Table 3. Goat horn segment lengths in mm by age and sex, and related statistics, 1977 and 1978 data pooled.

Horn segment (age)	Sex	Mean total length	Standard deviation	Sample size	DF	t	Significant difference?	Mean total length ♂ and ♀ combined
1	♂	74.7	33.2	56	82	3.41	P<.005	67.2
	♀	52.1	15.6	28				
2	♂	170.9	13.3	61	93	0.21	-	171.2
	♀	171.7	23.5	34				
3	♂	201.8	15.2	57	83	0.45	-	202.3
	♀	203.3	14.7	28				
4	♂	215.2	15.6	43	67	0.19	-	215.4
	♀	215.9	15.0	26				
5	♂	223.3	14.2	31	49	0.32	-	222.7
	♀	221.9	16.9	20				
6	♂	226.1	14.0	22	34	0.15	-	226.4
	♀	226.9	18.5	14				
7	♂	230.4	15.9	16	24	0.41	-	229.3
	♀	227.6	19.3	10				
8	♂	233.3	16.7	12	17	0.72	-	230.9
	♀	226.9	22.5	7				
9	♂	231.8	15.2	8	10	0.67	-	229.0
	♀	223.5	28.5	4				
10	♂	229.4	11.5	5	5	1.53	-	234.3
	♀	246.5	19.1	2				

Thus, horns of male goats were found to be significantly thicker, as viewed from both side and front, than those of females, and the space between horn bases was less in relation to the base widths in males than females. These differences are obvious to the trained eye, and we found that horns, alone, were nearly always an adequate criterion for determining the sex of 2-year-old and older goats. When horns were clearly visible and sex was not in doubt, I later dropped my initial requirement of viewing urination posture or genitals for sex identification.

Horn length in relation to ear length was useful in identifying kids and yearlings. Foster (1978) found that the horn-to-ear ratio (HER) in early summer was about 0.7 for yearlings. In late summer, this ratio reached about 1.4 for yearlings, and 0.7 for kids. Our observations confirmed these relationships.

Body shape and size are also useful criteria for sex differentiation in adult goats. Hibbs (1966) found that adult nannies were generally 10-20 percent smaller than adult billies. Lentfer (1955) was able to group kids, yearlings, 2-year-olds, and adults on the basis of shoulder height, and our observations agreed with his. In addition, we noted that nannies usually had thinner necks and less massive shoulders than billies.

Female goats always exhibit black vulval patches when the tail is raised but no similar dark area is visible on males. In summer, the males' scrotums are readily visible; in winter, long hair generally covers these organs. However, adult males nearly always have a dirt-smeared rump in fall and winter, while females and young goats have relatively clean coats.

Table 4 summarizes external, visible characteristics which may be used to classify goats by sex and age when viewed from the ground. We were able to classify them from a distance of a mile or more using a Questar or Celestron telescope on days with few heat waves.

Grouping by Sex and Age

Male goats are usually solitary in summer, or are found in small groups of one to five (Brandborg 1955, Casebeer 1950, Chadwick 1973, 1977, 1979; Hibbs 1965, Holroyd 1967, Lentfer 1955). They normally remain segregated from the adult females, 2-year-olds, yearlings, and kid groups, although they do occasionally mingle with them for a short time. However, they are not actually a part of these groups when they do so, and go their separate way at the slightest disturbance (Hebert 1967). Young males remain with the female groups until after they reach 2 1/2 years of age when they begin a relatively solitary existence (except during the rut) (Chadwick 1973, Hibbs 1965).

The grouping of all goats classified in summers 1976 through 1978 is listed in Table 5, and plotted graphically in Fig. 3. No significant differences could be detected between data years, so data were pooled. Throughout the summer, about 95 percent of all adult billies were found in male-only groups; the remaining 5 percent were seen in association

Table 4. Useful criteria for distinguishing sex and age of mountain goats during summer.

Age class	Sex	Characteristics
Kid		Small size obvious in early summer, but grow rapidly and require more careful observation from the air by late summer. Horns barely visible early summer to less than approximately 0.75 times the ear length by fall. Face very juvenile in appearance. Nearly always following an adult female.
	Male:	Urination posture: stands in stretched position during urination.
	Female:	Urination posture: squats during urination.
Yearling		Size larger than kid, considerably smaller than adult female in early summer; still obviously smaller in late summer. Horns in early summer less than ear length to up to 1.5 times the ear length by fall. Face still juvenile in appearance. Horns generally with ragged-rough surface texture (later lost, becoming very smooth). Sub-dominant behavior; frequently "picked on" by all older animals. Occasionally solitary in late summer and winter, but most often with female-juvenile groups during summer.

Table 4. (cont.)

	Male:	Urination posture; scrotum visible when hair is short. Horns usually appear heavier than females' and more masculine.
	Female:	Urnination posture; black vulval patch visible when tail raised; horns usually slightly thinner than males'.
<u>2-year-old</u>		Size smaller than adult female in early summer to nearly equal by fall. Horns longer than ears. Face no longer juvenile in appearance but not quite as long and angular in muzzle as adults. Difficult to distinguish from adults in late summer except by careful observation.
	Male:	Urination posture; scrotum visible in summer coat. Horns obviously thicker than females' with less space between bases as seen frontally, smoother curve from base to tip as seen laterally, may look longer in proportion to head length than adult males. Body slightly larger and heavier over neck and shoulders than females. Usually still in company of female-kid groups during summer.
	Female:	Urination posture; black vulval patch visible when tail is raised. Horns thinner and slightly more angular (not always) than males as viewed laterally; more space between bases as viewed frontally. Neck and shoulders not as massive as males. Body obviously smalle

Table 4. (cont.)

		than adult females in spring; still slightly smaller in fall. Difficult to distinguish from adult females-without-kids by late summer.
Adult		Full grown animals; faces long and angular, especially females; horns much longer than ears.
	Male:	Urination posture; scrotum very visible in summer coat. Rump progressively more dirt-smeared in late summer and into winter. Horns more massive than females', tapering and curving smoothly from base to tip as viewed laterally. Horn bases heavy and space between bases as viewed frontally is about 1/2 the width of the base and obviously narrower than females'. Horns may appear proportionally smaller than those of females or 2-year-old males due to larger body and head size. Neck and shoulders massive with crest line forming nearly smooth, convex curve from back of head to lumbar region; body larger than adult female. Usually clean shed by early July and starting to grow winter coat by early August. Only rarely found in association with female-kid groups during summer; often solitary.
	Female:	Urination posture; black vulval patch obvious when tail raised; may have kid at heel. Horns thinner than males and more angular, often diverge in "v" shape as viewed frontally. Space between horn bases is obviously

Table 4. (cont.)

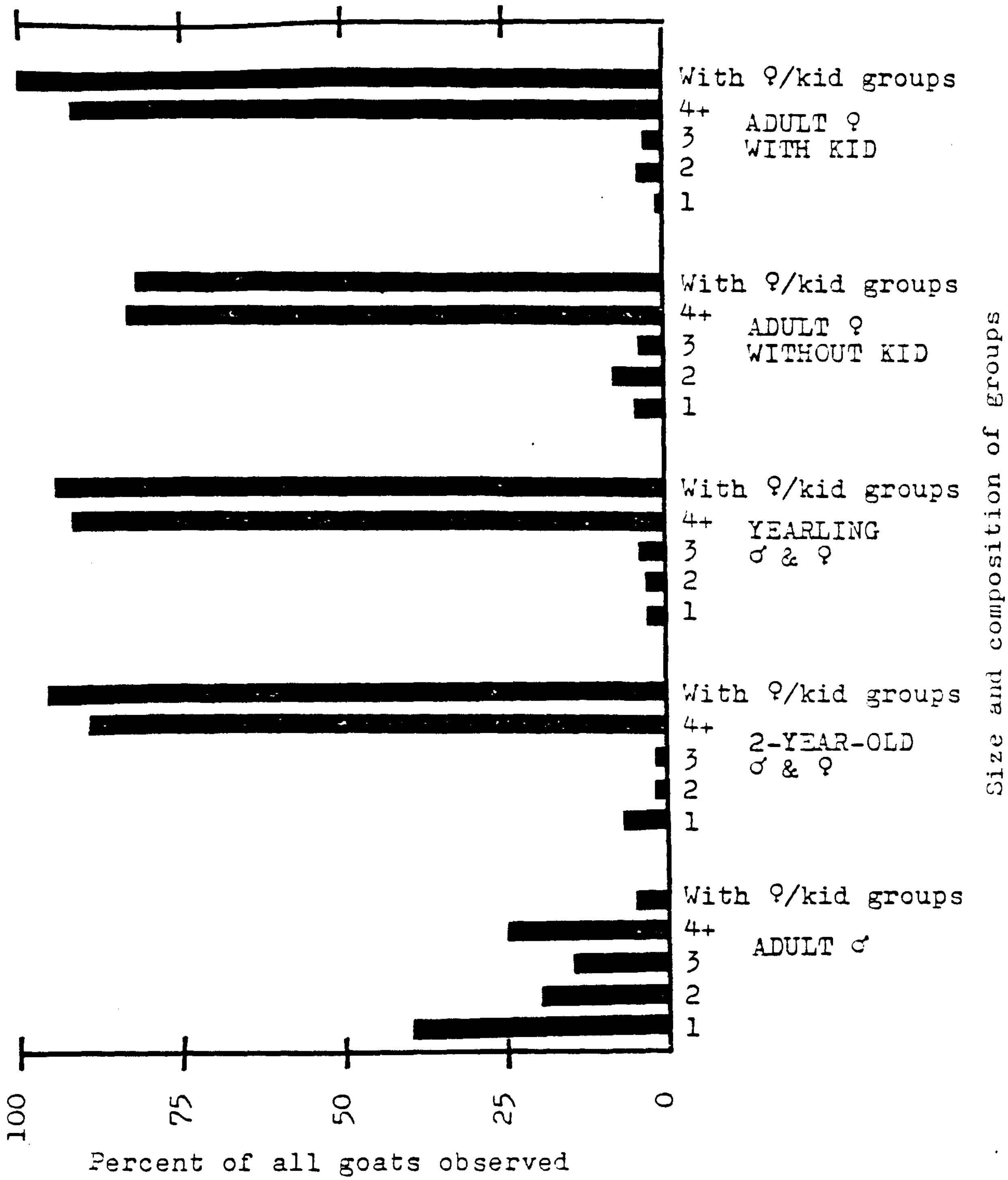
wider than males and is about equal to 3/4 the width of horn base. Appear "ewe-necked" before molt is complete with thin necks and long, angular muzzles. After molt, dorsal crest line appears slightly concave or less convex than males. Shoulders and entire body less massive than adult males. Rump clean in fall and winter. Usually in groups with other females and juveniles.

Table 5. Group size by cohort. Combined data from all study areas and years.

Cohort	Total obs.	1[1/]	%	2	%	3	%	3+	%	With groups including females-with-kids No.	%
Adult ♂	103	41	40	21	20	15	15	26	25	5	5
2-yr. ♂	103	9	9	2	2	3	3	89	86	90	87
2-yr. ♀	51	2	4	1	2	-	-	48	94	48	94
Yrlg.	189	6	3	6	3	7	4	173	92	177	94
Ad.♀ w/o k	133	7	5	10	8	5	4	111	83	109	82
Ad. ♀ w/k	312	1	<1	14	4	10	3	287	92	312	100

1/ Group size when animal first observed.

Fig.3 . Group sizes of mountain goats by sex and age class.



with female groups. However, this association appeared temporary and the adult billies would usually leave the female groups in a short time or when disturbed. Only rarely were adult males found in groups as large as four or five; 75 percent were found in groups containing three or less.

About 90 percent of all 2-year-old male and female goats observed were found in groups of four or more and in groups with adult nannies and kids. Ninety-four percent of yearlings were in groups containing adult females with kids, and 92 percent were in groups larger than three. About 83 percent of adult females without kids were observed in groups larger than three, and in groups containing females with kids. We noted that 2-year-old females and yearlings remained in the female-with-kid groups all summer, but a few of the 2-year-old males and adult females without kids and an occasional yearling, left these groups after early August. The grouping of all cohorts except adult males with the female-with-kid aggregations was most pronounced in late June and July.

In Montana Chadwich (1977) found that adult males were in "mixed groups" 27 percent of the time during July and August, and either solitary or with other males 73 percent of the time. He also found that 2-year-olds were in "mixed groups" 84 percent of the time, and yearlings 94 percent during the same season. His grouping definitions were not exactly the same as mine, so these data are not directly comparable. They do, however, indicate a similar pattern.

Molt by Sex and Age

In early to midsummer, goats molt their heavy winter coats, a process that is very conspicuous because of the contrasting portions of their bodies covered with either thick or very thin pelage. During this molt, patches of loose hair adhere to the animals, flopping in the breeze or during movement. Contrast is very marked between cleanly shed and unmolted animals.

Molting does not occur at the same time for all sex and age classes, a distinction which has been noted by other researchers. Most agree that adult males complete their molt first, and adult females with kids last. However, Holroyd (1967) believed that yearlings were the first to molt in British Columbia, whereas Hibbs (1966) and Casebeer (1950) reported that yearlings were the last to molt in Colorado and Montana, respectively. Chadwick (1973), in Montana, and Hebert (1967), in British Columbia, found that adult males molted first, adult females without kids and young animals (presumably 2-year-olds) next (with young females slightly later than young males) and adult females with kids much later. Hebert (1967) believed that the molt pattern and sequence by sex and age class was a fixed physiological process.

In this study, all animals classified by sex and age class were also classified as to stage of molt to see whether the sequence could be quantified and used as a criterion for determining the sex of goats during aerial surveys. The sequence appeared to be similar in all three summers and between coastal and interior populations, so data were combined (Fig. 4). Both adult and 2-year-old males completed their molt by 20 July. Two-year-old females began molting later and had not completely shed until 9 August. Yearlings of both sexes had not finished until the same date. Adult females without kids followed the same pattern as 2-year-old females. Nannies with kids were the last to shed; none had completed their molt before 20 July, but all had completed it by 8 September.

Population Composition

The populations observed in Ptarmigan Valley and King's Bay during ground observations in 1977, 1978, and 1979 are listed by sex and age class in Table 6. Hunter harvest, as reported by mandatory hunter report cards, is also included in the table so it could be considered when calculating over-winter mortality. Calculated ratios of the various cohorts to adult females are also shown.

Problems encountered in constructing these observed sub-population models included some obvious misclassification (7 yearlings could not increase to 8, 2-year-olds as listed for Ptarmigan Valley between 1978 and 1979), difficulty in observing the entire Ptarmigan Valley population at one time (and so avoiding any possibility of duplication), and early movements of part of the summering population out of King's Bay. In addition, small sample sizes--a problem in almost any Alaskan ground survey for goats--can exaggerate small errors into large differences in proportion. I suspect similar problems are encountered in ground surveys conducted elsewhere.

Fig. 4. Time periods before which no goats of given sex/age class have completely molted, and after which all have molted. Combined 1976-77-78 observations grouped by 10-day periods.

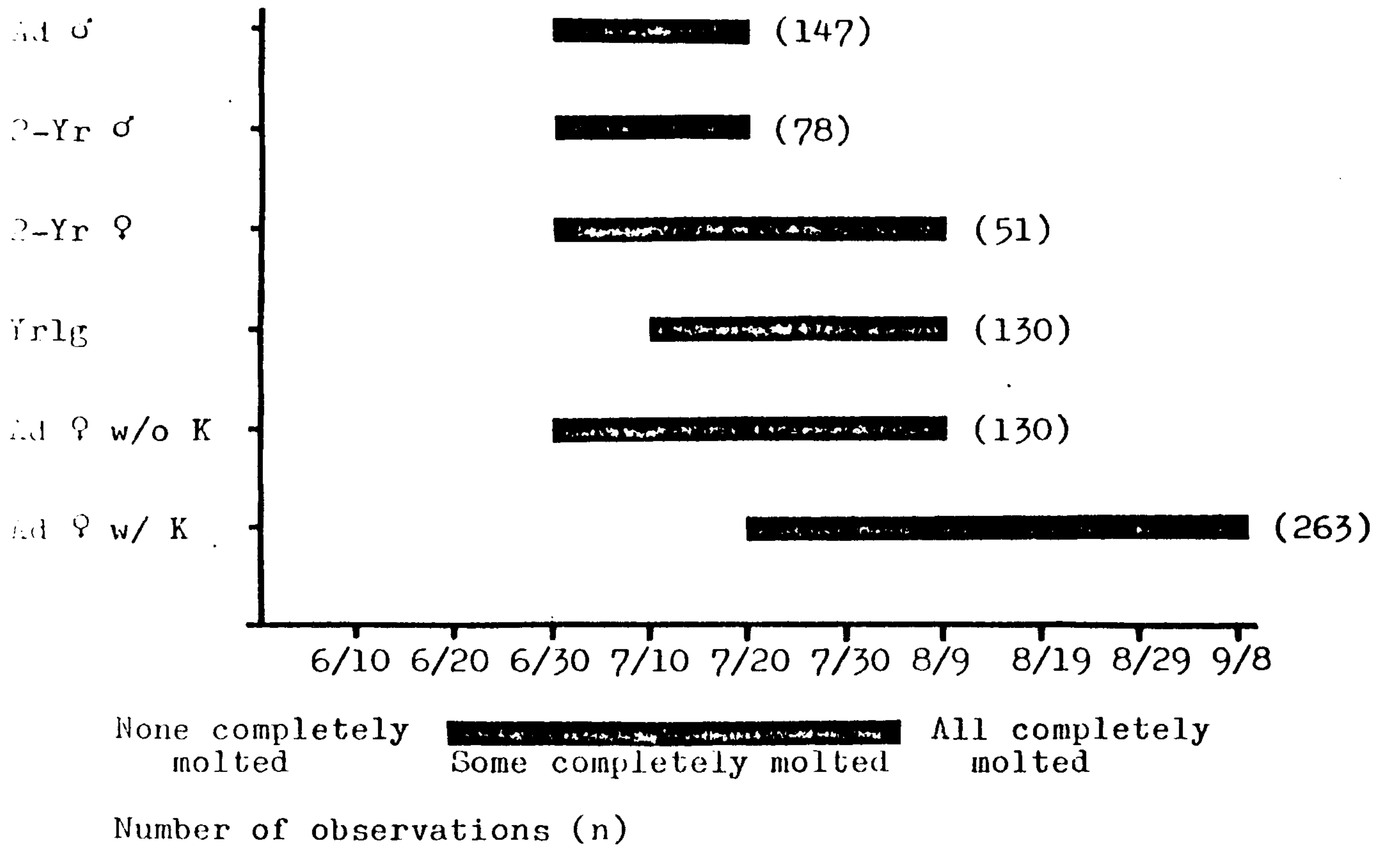


Table 6. Populations observed by sex and age class during observations from the ground in summer.

Area	Year	A♂[1/]	2♂	2♀	2T	Yrl.	A♀	K	TA	T
Ptarmigan	1977	4	4	4	8	8	12	13	32	45
(R:♀)[3/] H[2/]		(.33)			(.67)	(.67)		(1.08)		-1
	1978	3	3	3	6	7	14	11	30	41
(R:♀) H		(.21)			(.43)	(.50)		(.79)		-3
	1979	2	5	3	8	9	13	10	32	42
(R:♀)		(.15)			(.62)	(.69)		(.77)		
King's Bay	1977	8	7	1	8	8	20	14	44	58
(R:♀) H		(.42)			(.42)	(.42)		(.70)		0
	1978	9	3	3	6	9	22	13	46	59
(R:♀) H		(.41)			(.27)	(.41)		(.59)		0
	1979	7	3	1	4	6	11	9	28	37
(R:♀)		(.64)			(.36)	(.55)		(.82)		

1/ A♂ = Adult males
2♂ = 2-year-old males
2♀ = 2-year-old females
2T = Combined 2-year-olds
Yrl. = Yearling
A♀ = Adult female
K = Kid
TA = Total non-kids
T = Total

2/ H = Reported harvest by hunters.

3/ (R:♀) = Ratio : Adult female, in parenthesis.

Nevertheless, I believe the populations, as listed, are close to their actual sizes in the areas at the times they were censused. The 1979 King's Bay population had begun leaving this valley before the count was made and, when classified, was obviously smaller than the "normal" summering herd. Whether the proportions of sex and age cohorts were altered by the movement is unknown.

Study Area Aize and Population Density

Because mountain goat populations appear to be limited in number by the size and quality of their winter range (Brandborg 1955, Chadwick 1979, Hibbs 1965, Vaughan 1975), population density on winter ranges possibly a useful criterion for judging population status. However, until true extent of winter range can be accurately delineated by ongoing studies of radio-collared animals, density cannot be determined for the population under study. Therefore, I have merely estimated the density over the entire range known to be used by this herd by planimetering the area, less all glaciers and lakes, on 1:63,360 topographic maps, and dividing by the estimated herd size. Using this rough method, the approximate total area of usable habitat is 139 mi^2 (360 km^2), the estimated herd size in 1979 was 246 animals, and the estimated density was 1.8 goats/mi^2 (0.7/km^2). This compares with densities of 3.1/mi^2 (1.2/km^2) found by Chadwick (1979) in Glacier National Park, Montana and 1.4/mi^2 (0.6/km^2) found by Moorhead (1977 unpub. ms) on the Olympic Peninsula, Washington.

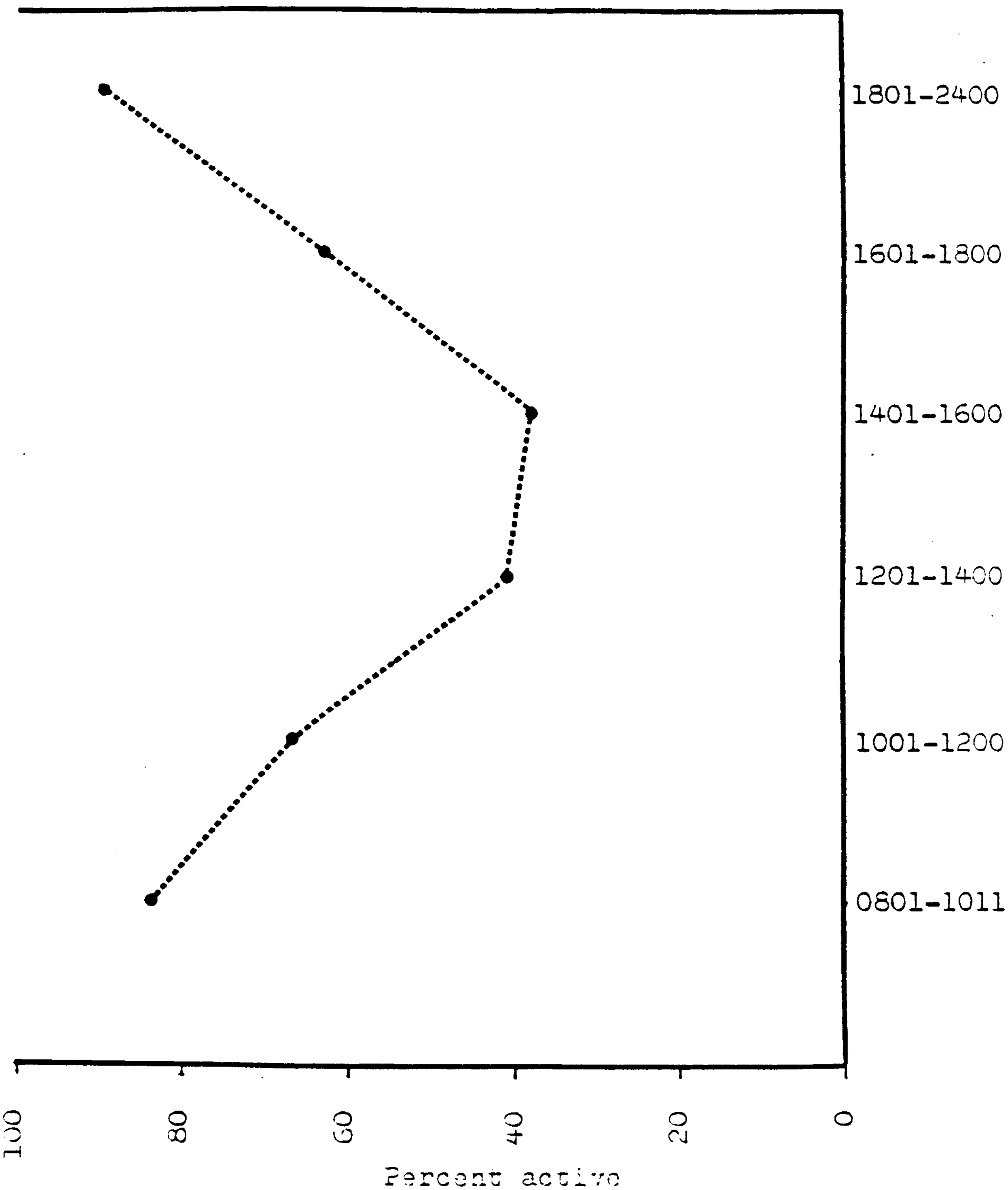
Activity by Time of Day and Weather

Reportedly, mountain goats are active early in the morning and late in the afternoon. During mid-day, most may be found bedded and resting or ruminating (Anderson 1940, Brandborg 1955, Chadwick 1973, Lentfer 1955, Rideout 1974). The observed activity pattern in this study agreed with those findings (Fig. 5). No differences could be discerned between daily activity patterns in 1976, 1977, or 1978. Most morning activity occurred before 1000 hours, and most afternoon activity after 1800 hours.

An interesting phenomenon I observed, and which was also mentioned by Casebeer (1950), was what he called the "evening get-together." This did not occur every day, nor can I say what triggered it except that it appeared most frequently after very warm, sunny days during which activity was minimal. Just about sundown, nearly every goat on the slope under observation would begin to move toward some choice feeding area. Scattered animals and small groups would form one large band, all moving purposefully toward their goal. The most accurate classification counts could be made during such gatherings, and these "get togethers" were usually worth waiting several days to observe.

Others have found goats to be more active following storms or rainy periods than on clear, hot days (Casebeer 1950, Fox 1977, Richardson 1971, Saunders 1955). Goats observed in this study during 1976, 1977, and 1978 were classified as active (feeding, moving) or inactive (bedded, standing). No differences could be found when comparing activity by

Fig. 5. Percent of goats active by time of day.



weather either between years or between the interior and coastal study areas. No differences are apparent that would be of use in determining the best conditions for conducting surveys. These results are not necessarily comparable with those of the previously mentioned authors since we did not note weather preceding the observation periods.

During August, when most goats were beginning to grow a heavier coat following the molt and were thus unable to lose heat readily, Chadwick (1973) and Peck (1972) found that they preferred shade for all activities, and were more prone to use cooler, north facing slopes. I did not attempt to quantify activity as to use of shaded or open habitat, and the terrain involved did not permit ground observers to obtain sufficient observations to quantify goat use by direction of slope. During aerial surveys, it was apparent that goats were more difficult to find on hot, clear days in August, and many of those seen were in the shade of rocks, cliffs, overhanging snow banks, or glacial crevasses. Many were observed lying on snow banks or glaciers. While tracking radio-collared goats during an ongoing study, I found that 35 percent of my collared goats were out of sight under overhanging snow banks or under glacier caverns on a hot day in late August. On cooler, overcast days goats were more conspicuous and appeared to be more in the open.

DISCUSSION

Observed and inferred intra-range movements during summer showed that the study herd could not be broken down into sub herds for accurate census comparisons, at least until further knowledge of movements is obtained. I suspect that similar situations occur in other goat ranges in Alaska. Thus, biologists attempting to establish trend-count areas should be cautious in interpreting year-to-year results until they are aware of the entire ranges used by their herds and count each as a whole.

Once the overall spring-summer range of a herd is known, it appears possible to obtain reasonably accurate population data by use of slow-flying, fixed-wing aircraft under suitable weather conditions. Ballard (1975) felt that a Cessna 180 was an appropriate aircraft for goat censusing. I disagree strongly, as did Hibbs (1965). Such an aircraft, while certainly more comfortable than a Piper Super Cub, is too fast for adequate viewing, and is not maneuverable enough to get into the small canyons occupied by many goats. A slow, highly maneuverable plane with good visibility and an ample power margin for safety is required to operate in the very rugged habitat utilized by mountain goats. The Super Cub 150 is the most commonly available aircraft to meeting the required performance characteristics.

In conducting aerial counts in summer, it was found that, in this area at least, visibility conditions were all-important. Goats have been found by many investigators to be more active in early morning and late afternoon on warm summer days, and some have suggested those periods as the best times for aerial census (Chadwick 1973, Fox 1977, Hibbs 1965, Vaughan 1975). Fox (1977) also found that goats were more active, and hence more visible, on warm, clear days following periods of bad weather, and suggested such days as the best for surveys. In this study, however, I found that many goats were not seen because of sun glare despite the probability of greater animal movement on such clear days. Goats certainly were more visible just before sunrise and just after sunset, but the time spans involved were too short to be very useful for census purposes.

Furthermore, on warm, sunny days from about mid-July until the first snowfall, I found that many goats were not visible at all during the main part of the day because they sought relief from the heat under snowbanks and glaciers, and in rock crevices. Others have also noted similar behavior in late summer on hot days (Chadwick 1973, Peck 1972, Smith 1976).

Ballard (1977) noted in his study that more goats were counted when cloud cover exceeded 20 percent. Broken clouds might provide some heat relief to goats, but contrasting light conditions would still preclude satsifactory viewing. He believed, and I agree, that variability in count results is closely related to observability of goats.

Throughout this study, summer aerial surveys counducted on overcast days produced the highest total counts and most consistent results. An overcast results in soft, even light without glare or strong contrast. Under such conditions, goats were found to be very visible against all backgrounds, whether up and feeding or bedded. Furthermore, they appeared more active and remained more in the open, behavior which was also noted by Chadwick (1973) and Saunders (1955). This factor was found to be particularly important as summer progressed, days became warmer, and new pelage thicker. Results of replicate summer aerial surveys on clear, sunny days were found to be low and generally inconsistent and unpredictable.

The ideal conditions for summer aerial surveys thus consist of overcast conditions which still allow enough light for good visibility, and air calm enough for safe, low-altitude flying. I believe that summer counts conducted under other than good viewing conditions produce inconsistent results and are therefore, not worth doing for census purposes.

Various seasons have been recommended as best for aerial goat surveys. Some investigators recommend winter for total counts because goats are generally concentrated, the sexes are more or less mixed, and the goats can be located by tracks in the snow (Brandborg 1955, Hibbs 1965, Hibbs and Denney 1965, Vaughan 1975). However, under conditions prevailing in this part of Alaska, goats are simply too hard to see in winter. They blend with the broken pattern of snow and rock, and many utilize heavy timber or brush where they are hidden beneath the canopy.

Spring has also been proposed for total counts (Bone 1978, Smith 1976). I have found that good results could be obtained on warm days in late April to mid-May when most goats move onto open slopes seeking newly emerged vegetation, and so become very visible. Since they are usually found on open, snow-free southern exposures, they are readily seen despite sunlight which is not yet bright enough this far north to produce bad glare on south-facing slopes. At this time, all ages and sexes are still more or less together, not yet having scattered onto summer ranges. Furthermore, this is the only time after winter is over when yearlings are still easy to recognize from the air. Spring counts should be conducted before parturition begins because gravid females seek the solitude of rugged terrain, and are, again, difficult to locate.

Some investigators have suggested early summer (late June to mid July) as best for estimating total numbers (Lentfer 1955), or for obtaining kid/adult ratios (Hall and Bibaud 1978, Hibbs 1965, Vaughan 1975), while Klein (1953) thought that in Alaska late summer would be best because of lack of snow banks. I believe that the best total counts can be obtained in early to midsummer, from mid-June through July. Additionally, kids are easiest to recognize from the air during this period; by late summer, they are often confused with yearlings or adults when in large groups. Group size also is greatest during this period (Chadwick 1973, Hebert 1967, Hibbs 1965), suggesting that fewer of the more solitary adult males would be confused with small groups of other cohorts.

By late summer, despite reduced snow cover, goats are more difficult to locate except on cool days (for example, I found one radio-collared adult male to be out of sight under a snowbank on a sunny day in late summer despite an air temperature of 0 degrees centigrade at that elevation). By late summer kids are becoming difficult to recognize.

Thus, to obtain the most accurate estimate of the total number of goats present in a given herd, and the number of kids-of-the-year present, aerial census by slow-flying, fixed-wing aircraft should be conducted during the early to midsummer period when light and wind conditions are optimal; i.e. overcast and reasonably calm. Under these conditions, and with due diligence in searching all habitat, an accuracy level of approximately 90 percent can be expected.

In addition to accurate and comparable yearly estimates of total herd size, which can be obtained by summer aerial surveys under good visibility conditions, the game manager needs to know the condition of the herds as indicated by reproduction, survival, and sex-ratio data. The usual kid:adult ratio obtained from aerial surveys provides little useful information. As with other species, reproductive success can best be evaluated by determining ratios of young to breeding age females. Recruitment into a herd depends on survival of young to breeding age; hence the need to learn survival rates. Successful reproduction depends in part, on the relative abundance of breeding-age males, so sex ratios must be monitored.

Because it is generally recognized that goats do not first breed until age 2.5 years, and bear young until their third year, adult goats can be considered as those 3 years old and older. Recruitment into a breeding herd is the number of animals surviving to breeding age or, for practical purposes, the number of 2-year-old goats present in the summer population. Initial reproduction is indicated by the number of viable kids produced per adult female, while survival to breeding age is shown by the numbers of yearlings and 2-year-olds present in relation to kids and yearlings of the previous year. Thus, to correctly understand population status, the number of kids, yearlings, 2-year-olds, adult females, and adult males must be determined. The ratios of the various cohorts to adult females are useful in comparing years and herds. This information can be estimated from aerial surveys, but not from one survey or on the basis of one year only.

To begin compiling data by which to estimate herd composition, an initial aerial count must be conducted in spring, preferably in early May, to obtain the percentage of yearlings in the herd. A "total" count of the herd is unnecessary, but the larger the sample size, the better. Yearlings are relatively easy to recognize from the air at this time, being much smaller than adults and generally still following their dams. If the count is conducted in late May or early June, yearlings are rarely with their mothers, but are still recognizable by their size. However, they are easier to identify and count before parturition begins in late May. Also, pregnant nannies have not isolated themselves yet and so are more apt to be seen and included in the total tallied.

A second aerial count is needed in late June (after parturition) or July to obtain the best estimate of total herd size and the number of viable kids present. By early to mid July, goats seem to be more or less established on their summer range, and aggregations have become relatively stable. I believe the first 2 or 3 weeks in July are best for this count.

During this survey, the number of goats in each group counted must be noted, as well as whether the groups contain any kids or obvious yearlings. This survey should produce the following information: 1) the herd size; 2) the number of kids present; 3) the composition of groups; (i.e. whether the groups contain kids or yearling, or only adult animals); and 4) the size of each group. In examining groups without kids or yearlings, it should also be noted whether the animals are molting or clean shed (or nearly so).

At this time of year, nearly all adult males have been found to be completely, or almost completely molted. Furthermore, nearly all large, single goats, or large goats in groups of up to three with no kids or yearlings present, will be adult males. If such goats are only partly molted, they might be considered as adult females or 2-year-olds; however, I have seen few goats fitting this category which were other than adult males during this time period.

Since it has been shown that the average accuracy level of an aerial count conducted under good viewing conditions in early summer is approximately 90 percent, a correction factor should be applied to the observed totals counted to obtain an estimate of the "true" population size. This may be accomplished by dividing the total number counted, the total number of kids counted, and the total number of "adult males" (all adult, clean, or nearly clean, shed animals in groups of three or less) by 0.9.

A futher correction factor should be applied to the estimated total of adult males since it was found that approximately 75 percent were found in groups of three or less. By dividing the estimated number of males by 0.75, a better estimate of the actual number of adult males present is obtained.

An estimate of the number of yearlings present may be obtained by multiplying the total number of non-kids seen by the percentage of yearlings observed to be present in the spring count.

Thus, an estimate will have been obtained of the total herd size, and the number of adult males, yearlings, and kids present. Remaining unclassified will be the adult females and sub-adult 2 year old animals. No way was found to differentiate between these two classes from the air with any degree of success, and a second year of data must be obtained before this can be done mathematically.

Both of the above described surveys are relatively simple to conduct; neither requires dangerous, low flying since the cohorts, as defined, can be recognized from a relatively safe distance.

The problem of estimating the number of 2-year-old animals can be solved mathematically from data obtained in this first year's survey combined with that from successive years of similar surveys. By comparing the numbers of kids, yearling, and 2-year-olds over a 2 year period in the Ptarmigan Valley and King's Bay herd segments (as classified from the ground), estimates of overwinter mortality were obtained. Similar mortality data were obtained from other studies and are listed in Table 7.

Analysis of these data showed that although the mortality rates were significantly different ($P<.01$) between kid-to-yearling and yearling-to-2-year-old classes, there was a statistically significant relationship between that of kids-to-yearlings and yearlings-to-2-year-olds over the same winter ($r=.737$, 13DF, $P<.01$). The average overwinter mortality of kids-to-yearlings was 41.9 percent, and that of yearlings-to-2-year-olds was 26.6 percent.

By using the method described by Sokal and Rohlf (1969) to determine the confidence limits of the difference between means, I found the average mortality of yearlings-to-2-year-olds equalled approximately 64 percent of the mortality of kids-to-yearlings that same winter, with 95 percent ± 23 percent confidence limits. Thus, if the numbers of kids and yearlings are known for 2 consecutive years, the number of 2-year-old animals can be estimated for the second year based upon the kid-to-yearling mortality rate as observed, and the number of yearlings present the first year.

The formula for the estimated number of 2-year-olds, and its minimum and maximum confidence limits are:

Let: Mky = observed kid-to-yearling mortality in percent

Y1 = observed number of yearlings during first summer

E2 = estimated number of 2-year-olds during second summer.

Table 7. Observed mortalities between years by cohort.

Source	Area	Years	Kid-Yrl.	Yrl-2-yr-old
Dane 1977	B.C.	1967-68	- 45%	- 0
		1968-69	-100%	-67%
		1970-71	- 14%	-25%
		1971-72	- 29%	-17%
		1974-75	--	-25%
		1975-76	- 50%	--
Chadwick 1979	Montana	1974-75	- 38%	-42%
		1975-76	- 43%	-36%
Nichols 1980	Ptarmigan	1977-78	- 46%	-25%
		1978-79	- 18%	+14%
	Kings' Bay	1977-78	- 36%	-25%
		1978-79	- 54%	-56%
Smith 1976	Montana	1973-74	- 33%	- 0
		1974-75	- 29%	-33%
Rideout 1974	Montana	1971-72	- 73%	-59%
		1972-73	- 28%	- 2%

$$E2 = (1-.87\ Mky)(Y1) < (1-.64\ Mky)(Y1) < (1-.41\ Mky)(Y1)$$

This method was applied to the observed populations in the combined King's Bay and Ptarmigan Valley areas to compare calculated and observed numbers of 2-year-old goats in this sample (Table 8). The estimated numbers of 2-year-olds agreed closely with those actually counted.

Using results of the best aerial counts flown closest in time to the ground counts of the combined King's Bay and Ptarmigan Valley herds, population models were constructed utilizing the estimation methods described. These models are compared with ground survey results in Table 9. Only those portions of the aerial surveys which overlapped the areas covered by the ground surveys were used. Discrepancies between the observed population cohorts and those estimated from aerial counts are obvious.

Major sources of error include: yearling percentages were estimated from aerial surveys of a larger portion of the study herd in which the sex-age cohorts were presumably homogenous while on early spring range (and, therefore, not be applicable to the largely female subadult groups in the sample areas); the aerial and ground counts were not conducted close enough in time and unknown movements may have occurred into or out of the areas between counts. Unfortunately, it is not possible, with the available data, to determine where errors may lie. My feeling is that the estimation methods are sound, and the problem is in attempting to compare aerial and ground counts of sub-herds which may

Table 8. Observed numbers of kid, yearling, and 2-year-old goats, observed mortality rates, and calculated numbers of 2-year-old goats in combined Ptarmigan Valley and King's Bay populations based upon ground classifications.

Year	2-year-old	Yearling	Kid
1977			
observed	16	16	27
		-25% ↙	-41% ↙
1978			
Observed	12	16	24
Calculated 1/	12±2		
		-25% ↙	-38% ↙
1979			
Observed	12	15	19
Calculated	12±2		

1/ Mortality of yearlings to 2-year-olds calculated as 64±23% of observed kid to yearling mortlaity (95% confidence limits).

Table 9. Combined King's Bay and Ptarmigan Valley goat populations as observed from the ground and as estimated from aerial counts[1/].

Year	Method	A♂[3/]	2 yr	Yr1	K	A♀	TA	T
1977	Ground	12	16	16	27	32	76	103
	(ratios)[2/]	(.38)	(.50)	(.50)	(.84)			
	Air	3	--	12[4/]	28	--	70	98
	(ratios)	--	--	--	--			
1978	Ground	12	12	16	24	36	76	100
	(ratios)	(.33)	(.33)	(.44)	(.67)			
	Air	1	8±1	13	24	56±1	78	102
	(ratios)	(.02±0)	(.14±.02)	(.23±0)	(.43±.01)			
1979	Ground	9	12	15	19	24	60	79
	(ratios)	(.38)	(.50)	(.63)	(.79)			
	Air	10	7±2	7	20	26±2	50	70
	(ratios)	(.39±.03)	(.28±.10)	(.26±.02)	(.77±.06)			

1/ Includes only areas covered by both ground and aerial counts, except yearling percentages obtained from aerial count of entire study area.

2/ Ratios per adult female.

3/ A♂ = adult male; 2 yr = 2-year-old; Yr1 = yearling; K = kid; A♀ - adult female; TA = total adults (non-kids); T = total.

4/ Estimated from percentages of TA as observed in spring aerial counts.

not be comparable due to differences in counting times and to unknown movements.

The estimation methods have been applied to the aerial surveys of the whole study area to construct population models of the entire herd. A partial model for 1977, 1978 and 1979 was first constructed for each year to obtain estimates of herd size, number of adult males, yearlings, kids, combined adult females and 2-year-olds, and kid-to-yearling mortalities (Table 10). The kid-to-yearling mortality (Mky) between 1977 and 1978 is close to that observed in the King's Bay-Ptarmigan Valley sub-samples, but that between 1978 and 1979 is considerably smaller. This is probably because the entire herd was included in the models under discussion, eliminating--as far as is known--inter-area movements, and increasing the sample size.

After the preliminary models were constructed, numbers of yearlings estimated, and mortality rates determined, complete population models could be calculated for 1978 and 1979 by the methods described. These models, with estimated confidence limits and ratios of the various cohorts per adult female, are shown in Table 11. These ratios, in addition to total herd size as an indicator of trend, are the ultimate goals of herd classification counts. They provide the manager with a basis for assessing reproduction, recruitment, survival and sex ratios. They also give him means for comparing herds and years which are more meaningful than numbers alone.

Table 10. Partial population models of entire study herd as observed during spring and summer aerial surveys with correction factors applied, and observed kid-to-yearling mortalities.

Date	A♂	2 yr	A♀	Yrl	K	TA	T
8/16/77	52	----(60)----		26	53	150	203
				-51%			
7/23-25/78	39	----(85)----		26	48	150	198
				-48%			
6/15/79	59	----(107)----		25	55	191	246

Table 11. Population models of entire study herd based on spring and summer aerial counts, applied correction factors, and 2-year-old goats calculated from kid-to-yearling mortalities.

Year	A♂	2 yr	A♀	Yrl	K	TA	T
1978	39	17±3	68+3	26	48	150	198
(ratios)1/	(.57±.03)	(.25±.05)		(.38±.02)	(.71±.03)		
1979	59	18±3	89±3	25	55	191	246
(ratios)	(.66+.03)	(.20±.04)		(.28±.01)	(.62±.02)		

1/ Ratios per adult female, including 95% confidence limits.

For example, the status of this herd, as expressed as ratios of cohorts to the adult female constant, can be compared with other herds in other areas where similar ratios can be calculated. Chadwick (1973) obtained usable population data on an increasing herd in the Swan Mountains of Montana, and on a stable or slowly decreasing herd in Glacier National Park (Chadwick 1979). Dane (1977) studied a rapidly declining goat herd in British Columbia. From their data, I calculated mean sex and age ratios comparable to mine (Table 12), then compared means statistically. I have assumed, from the 3-year trend in total numbers, that my population is increasing.

No statistically significant differences could be detected between any of the ratios (Ao:A♀ ; 2 yr:A♀ ; yrl:A♀ ; k:A♀) from Chadwick's increasing herd and my herd. The ratios of Ao:A♀ and k:A♀ were significantly higher ($P<.05$) in my population than in Dane's rapidly decreasing herd, while the k:A♀ ratio was significantly higher in my herd than in Chadwick's stable or slowly decreasing herd. All ratios except yrl:A♀ were significantly higher in Chadwick's increasing herd than in Dane's decreasing herd, while the Ao:A♀ and k:A♀ ratios were significantly higher in Chadwick's stable or slowly decreasing herd than in Dane's population. Chadwick's increasing and stable or decreasing herds showed no differences except that the Ao:A♀ ratio was lower in his increasing herd.

Thus, it appears that the ratio of k:A♀ can be used as an indicator of population trend, and I suspect that, with another year or 2 of data to work with, the 2 yr:A♀ and yrl:A♀ ratios would also have proven

Table 12. Means and associated statistics of ratios between sex and age cohorts and adult females of two increasing and two decreasing herds.

Source		Ao:♀	2 yr:♀	Yrl:♀	K:♀	Population status
This study	$\bar{x}$	.62	.23	.33	.67	Apparently increasing
	S	.0636	.0354	.0707	.0636	
	n	2	2	2	2	
Chadwick 1973	$\bar{x}$	.39	.38	.50	.69	Increasing
	S	.1531	.1709	.2597	.2281	
	n	3	3	3	3	
Dane 1977	$\bar{x}$	.14	.17	.23	.28	Strongly decreasing
	S	.0404	.0800	.1746	.1867	
	n	7	7	7	7	
Chadwick 1979	$\bar{x}$	.73	.28	.36	.56	Moderately decreasing
	S	.1464	.0800	.0351	.0100	
	n	3	3	3	3	

$\bar{x}$ = mean

S = standard deviation

n = number of years of data

significant as indicators. The 2 yr:A♀ ratio should be of particular interest as an indicator of recruitment since it shows the rate of breeding-age animals entering the herd.

No way has been found to check the accurancy of my composition estimates against the actual population. Although the methods appear to be usable, their true accuracy is as yet unknown, and could only be inferred by comparing the aerially estimated and ground censused King's Bay-Ptarmigan Valley sub-herds, including their associated problems as mentioned. I believe the estimated classifications of the total herd to be more accurate than those for the sub-herds since the problem of unknown intra herd movements was largely eliminated as far as is known. Further work is necessary to corroborate these findings. Current studies of radio-collared goats should provide considerable information on the seasonal and within-season movements of this herd, while further comparisons between ground and aerial counts should help clarify the accuracy of the method of estimating sex and age cohorts.

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