POPULATION DENSITY OF MOUNTAIN GOATS IN SOUTHEAST ALASKA

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ABSTRACT

Simultaneous counts by an observer on the ground and one in a fixed-wing aircraft were performed on five occasions during mountain goat (Oreamnos americanus) population surveys in southeast Alaska. The aircraft-based observer's population counts averaged 32 percent lower than those of the ground-based observer. Population counts of mountain goats were made using ground-based surveys in eight sites in southeast Alaska. Year-round goat habitat in each site was distinctly delineated by flat lowlands or bodies of water. Based on the ground counts, densities of goat populations ranged from 0.5 to 4.7 animals per square kilometer, and averaged 1.3 over the total of 219 square kilometers surveyed. These densities are substantially higher than those reported for year-round range in coastal British Columbia and suggest that coastal mountains are more densely populated with goats than previously thought.

INTRODUCTION

Density figures for mountain goat populations have rarely been reported. Problems with both the accuracy of population size determination and difficulty in defining potential goat habitat have prevented widespread calculation of this population statistic. Where density is reported, these factors demand that comparisons between studies be made with caution.

McCrory et al. (1977) reported goat densities ranging from 0.6/km^2 to to a 3.1/km^2 (overall average, 1.5/km^2) in areas of year-round goat habitat in Yoho National Park, British Columbia. Figures calculated from Hjeljord (1971) show densities of about 2.5/km^2 to 6.5/km^2 in "preferred" goat habitat (summer and winter ranges combined) on Alaska's Kenai Peninsula and Kodiak Island, respectively. In areas of "observed distribution" in northern British Columbia, Foster (1982) reported a goat density of approximately 13/km^2. Stevens (1983) reported densities from summer goat habitat in Olympic National Park, Washington as ranging from .6/km^2 to 14/km^2, with the average calculated as about 3.1/km^2. Goat densities in

year-round habitat of coastal British Columbia calculated from Hebert and Turnbull (1977) range from 0.03/km^2 to 0.59/km^2, and average 0.15/km^2. These low figures prompted Hebert and Turnbull (1977) to suggest that coastal goat populations have lower densities than those in interior regions. In another paper in this proceedings, Smith (1984) reports a goat density of 2.3/km^2 in year-round habitat in a site near the southern end of coastal southeast Alaska.

Overall, reported goat densities range from 0.03/km^2 to 14/km^2. With the variety of goat habitat designations used, including year-round range, summer range, observed distribution and preferred habitat, the large variation in densities is to be expected. Furthermore, the different methods for counting goats, from ground-based observations to aerial fixed-wing or helicopter counts, and the use of either actual counts or extrapolated estimates also interject variability into the density estimates. These problems are discussed below in conjunction with determinations of goat densities in southeast Alaska, in an attempt to make some reasonable comparisons of goat density among various regions and studies.

STUDY AREA

The study area was located in the north and central sections of southeast Alaska (Figure 1). Brief descriptions of the locations for each of the eight sites are:

1) Stroller White (58 km^2) - The area between the Mendenhall and Herbert Glaciers, 25 km northeast of Juneau.

2) William Henry (53 km^2) - William Henry Mountain and the connected NW-SE trending ridgeline immediately to its west; in the Chilkat Range, 70 km northwest of Juneau.

3) Wilkes Range (41 km^2) - Just north of the Stikine River delta, 35 km southwest of Petersburg. (The area west of the Twin lakes, i.e. including Wilkes Peak, is not included in this analysis).

The next five sites are located on the outer coast of Glacier Bay National Park, about 150 km west-northwest of Juneau.

4) Torch Bay-east (27 km^2) - From the combined valleys of South Trick Lake and Annoksek Creek to South Deception Lake and a line from there through the pass to the west arm of Torch Bay.

5) Torch Bay-west (16 km^2) - From South Deception Lake and the line to Torch Bay's west arm to Dixon Harbor and River.

6) Thistle Cove (10 km^2) - Northeast of Thistle Cove and bounded by the Dixon River.

7) Astrolabe Peninsula (7 km^2) - West of Dixon Harbor and Thistle Cove.

8) Dixon-Brady (6 km^2) - Between the upper Dixon River and the Brady Glacier, just northwest of the Thistle Cove site.

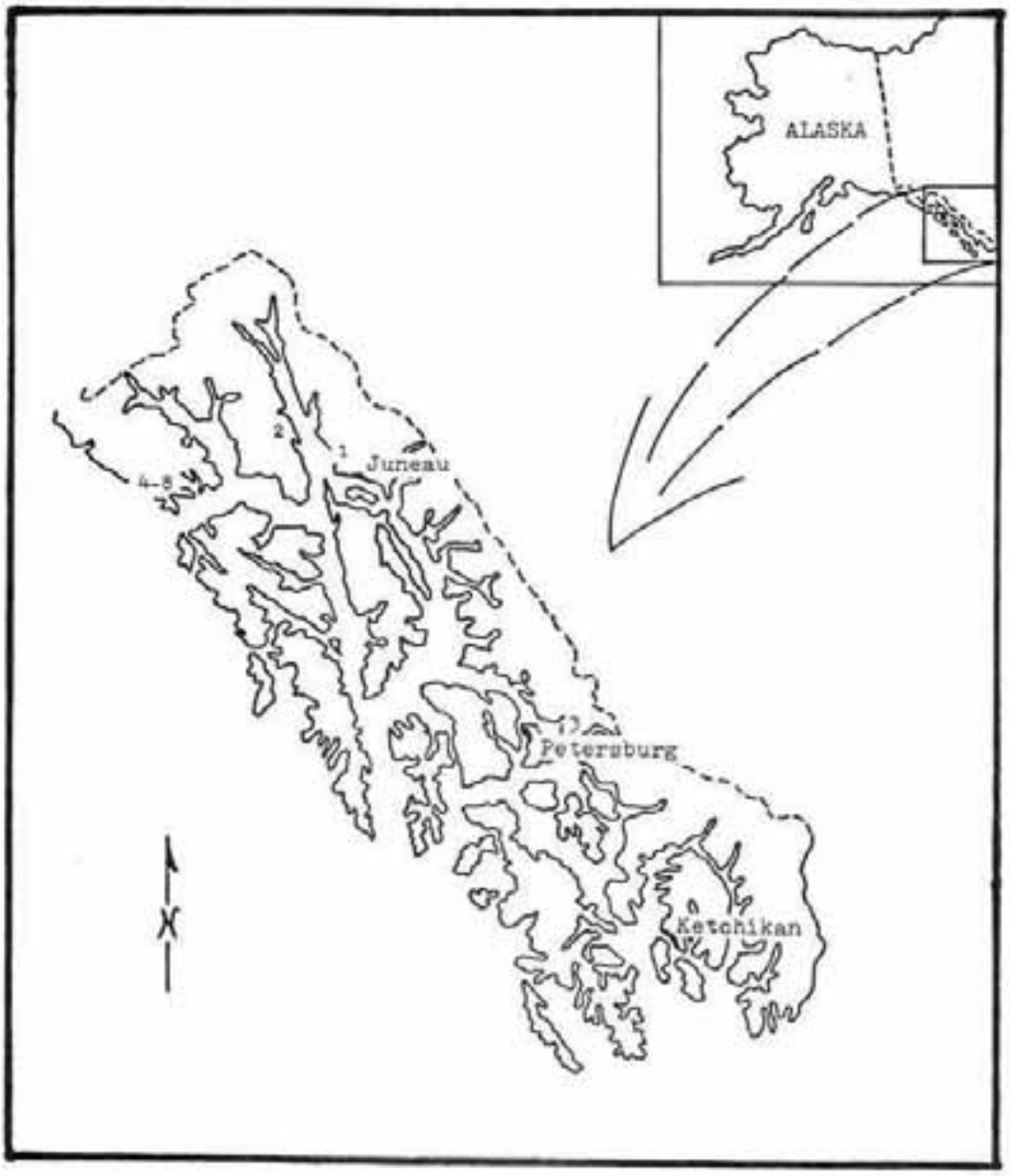

Figure 1. Study sites in southeast Alaska: 1. Stroller White, 2. William Henry, 3. Wilkes Range, 4-8. outer coast of Glacier Bay National Park.

Elevations in the study sites range from sea-level to 1750 m, with most sites being less than 1,200 m. Vegetation includes dense hemlock (Tsuga heterophylla) and spruce (Picea sitchensis) forests at low elevations, with lush subalpine and alpine meadows higher up, and sparsely vegetated rock at the highest elevations. Treeline varies from about 800 to 900 m. More detailed descriptions of plant communities typical of the study sites can be found in Alaback (1980) and Fox (1983). Mountain goats in southeast Alaska are known to utilize all elevations from sea-level to the highest points encountered within the study sites (Fox 1978, 1983).

METHODS

GOAT HABITAT

The sites used were selected primarily because they represent distinct areas of year-round mountain goat habitat. Each site was an isolated mountain block separated from other mountains by glaciers or flat lowlands. Goat habitat was defined as all terrain within the mountain block above a boundary where the mountain slopes decrease to less than 30° as they grade into relatively level lowlands or icefields and glaciers. There is no implication that the sites hold discrete goat populations, only that they represent easily delineated goat habitat.

The area of goat habitat within each site was calculated using a digital image analyzer. Overlays traced from United States Geological Survey 1:63,360 topographic maps were used to create darkened areas encompassing the identified goat habitat at each site. Once the analyzer was calibrated to the map scale it automatically measured the area of the darkened portions. These measures of goat habitat area were used in the density calculations.

GOAT COUNTS

The number of goats within each site was determined from ground-based counts, using binoculars and a 35X spotting scope. Counts were made on clear days and were conducted by travelling along ridgelines within each mountain block to observe as much habitat as possible. Goats were searched for intensively from dawn to dusk (about 18 hours) along predetermined ridgeline routes. The ridgelines used were above timberline, generally rounded and easily traversible, and afforded widespread views of the goat habitat being surveyed. Goats were monitored as best as possible throughout the day. All counts were made between June and August of 1976 and 1977.

In the Stroller White study site several replicate counts on different days were performed. Also, in the Stroller White and William Henry sites five pairs of simultaneous ground-based and aerial count were conducted. These simultaneous counts consisted of a typical aerial mountain goat population survey conducted by the Alaska Department of Fish and Game, which was performed during a ground-based count. During each aerial count, the observer spent approximately one hour searching for and counting goats from a small fixed-wing aircraft (Helio-Courier).

RESULTS AND DISCUSSION

COMPARISON OF COUNTING METHODS

Two replicate ground-based counts of mountain goats were conducted within the entire Stroller White study site during each of the summers of 1976 and 1977. The total counts were within eight percent of each other in each year (Table 1). Within a portion of this same study site, four replicate counts in 1976 and two replicate counts in 1977 were within five percent of one another (Table 2). The accuracy of ground-based counts depends on techniques used and the terrain and vegetation characteristics present, and has not been evaluated in any detail. The count totals show a high degree of consistency, and suggest confidence in their reflection of the actual goat population size. However, the number of counts was few and their consistency must be viewed with some skepticism, especially considering previous reports on the low and variable observability of goats (Ballard 1975, Foster 1982, Hebert and Langin 1982).

In the five pairs of simultaneous ground-based and aerial counts performed in the Stroller White and William Henry sites, the aerial count totals were consistently less ($p < 0.05$), by an average of 32 percent, than the ground-based counts (Table 3). Even acknowledging a probable greater variation in the results of ground-based surveys than was found here, this method was apparently more productive than aerial counts under the conditions present. The aerial counts were generally made in the afternoons of bright, sunny days and may have been adversely affected by the glare conditions present in such circumstances. Goats within or near the forest edge and those at lower elevations, even in open areas, were most often missed by the aerial observer. In one case a group of 25 goats in an area of alder and rock scree near the floor of a steep-walled valley was overlooked during the aerial count.

Although totals for the ground-based counts were substantially greater than the aerial ones, the aerial counts did include some animals not found during the ground-based search. In all cases, these animals were in limited areas which were not visible from the ground observation routes. During the full day of intensive searching from the ground, the chances of observing goats in hard-to-see locations (e.g., timberline forest patches) are certainly greater than those in an hour-long aerial search. The ground-based counts were made from easily traversible ridgelines, allowing observation of much of the potential goat habitat. Thus, the higher totals of the ground counts here are to be expected.

In contrast, Foster (1982) reported ground-based counts of mountain goats in a northern British Columbia study area to average only about 50 percent of aerial (helicopter) counts. His ground-based counts were made along forest roads, thus viewing the goats from below, and were made during all seasons and under a variety of weather conditions. These methods are not directly comparable to those used in the present study. In fact, neither set of ground-based methods could be easily applied to the other area due to various terrain or road availability restrictions. Such problems only serve to highlight the difficulties in comparing results of ground-based goat counts, or in applying methods to new regions.

Most counts of goats have been made from the air, either from a fixed-wing plane or helicopter. Small, slow flying planes and similarly maneuverable

Table 1. Ground-based counts of mountain goats in the Stroller White study site.

Date	Composition		Total
	Adults	Kids	
25 July 1977	56	22	78
15 August 1977	54	25	79
19 July 1976	51	15	66
28 July 1976	49	15	64

Table 2. Ground-based counts of mountain goats within a portion of the Stroller White study site.

Date	Composition		Total
	Adults	Kids	
25 July 1977	26	12	38
15 August 1977	28	13	41
28 June 1976	33	10	43
19 July 1976	31	10	41
28 July 1976	31	10	41
14 August 1976	31	10	41

helicopters are considered the best aircraft for finding goats (Nichols 1982). No conclusive tests have been made to determine the relative effectiveness of these types of aircraft in surveying mountain goats.

McCrory et al. (1977), Foster (1982), Stevens (1983) and Smith (1984) each used correction factors to estimate actual population sizes from their survey counts. McCrory et al. (1977) and Foster (1982) used subjective assumptions about the percent of goats missed in aerial counts, applying correction factors of between 10 and 30 percent to estimate real population size. In a limited test with marked individuals, Smith (1984) found aerial surveys (2 fixed-wing and 1 helicopter) to account for about 50 percent of the known population.

Methods for counting goats may necessarily vary from one region to another, due to specific terrain or logistic constraints. However, the reliability of the methods used should be tested. This is most easily accomplished through the use of repeated censuses with marked animals in the population. Since more investigations are being conducted using marked animals, especially radio-collared goats, these studies should be producing more such tests of census reliability.

DENSITY ESTIMATES

Goat population densities in the eight sites surveyed ranged from 0.5/km^2 to 4.7/km^2 (Table 4), with a combined average of 1.3/km^2. These figures represent a relatively wide range in population density, but reflect differences among small areas. Factors such as forage availability and amount of "escape" terrain may be important in determining the overall quality (hence, carrying capacity) of habitat within a mountain block. In addition, natural fluctuations in population size will also have an influence. At the William Henry site, for example, in 1974 Ballard (1975) counted a total of 55 goats. That was a density of 1.0/km^2, double the density reported here. The overall terrain in the William Henry mountain block is relatively gentle compared to that on the Astrolabe Peninsula, for example, and may help to explain the low goat density it supports. Using the combined average density (1.3/km^2) over the entire 219 square kilometers surveyed should smooth over these differences in comparison with other regions.

Let us assume, as Smith (1984) indicates, that aerial counts represent about half the actual population size. Considering the average 30 percent higher numbers seen in ground-based counts compared with aerial counts in the present study, an inflation of the ground counts by 10 to 20 percent may better reflect actual totals and densities. This would give an average density of about 1.5/km^2 in the present study.

Such goat density is consistent with the 1.5/km^2 reported by McCrory et al. (1977) for year-round range in interior British Columbia. Smith's (1984) reported goat density of 2.3/km^2 for year-round range in southeast Alaska is also comparable to that reported here. If the area of potential winter range substantially increases the amount of goat habitat in the Olympic Mountains of Washington, then the average year-round goat density from Steven's (1983) work could approach 2/km^2, and is similar to the above figures.

Using the roughly doubled population estimates relative to aerial counts shown by Smith (1984), we can recalculate Hebert and Turnbull's (1977) density

Table 3. Comparison of simultaneous counts of mountain goats made from the ground and from a fixed-wing aircraft.

Date	Study site	Ground Total	Aerial Total	Aerial total as a percent of ground total
15 Aug. 1977	Stroller White	79	31	39
25 July 1977	Stroller White	78	46	59
28 June 1976	Stroller White (partial area)	43	39	91
28 July 1977	William Henry	16	10	63
30 July 1976	William Henry	25	22	88

Table 4. Density of mountain goat populations at eight sites in southeast Alaska.

Site	Area (km2)	Number of goats	Density
Stroller White	57.8	83	1.4
William Henry	53.4	26	.5
Wilkes Range	41.4	38	.9
Torch Bay (east)	27.3	57	1.6
Torch Bay (west)	15.8	26	2.1
Thistle Cove	10.4	15	1.4
Astrolabe Peninsula	6.8	32	4.7
Dixon-Brady	5.7	12	2.1
TOTAL	218.6	289	1.3

estimates. Even with this increase, however, the resulting density range of 0.1/km^2 to 1.2/km^2 (average, 0.2/km^2) is still quite low. Differences in definitions of goat habitat, very low count accuracy, or actual low densities due to recent population crashes or unexplained poor quality habitat are all possible explanations for these low density figures.

In cases where density is measured within year-round goat range, one or two goats per square kilometer appears to be a fairly consistent average. The low densities reported by Hebert and Turnbull (1977) in southern British Columbia are the exception. Considering the results of this study and Smith's (1984), there is no reason to continue assuming that coastal goat populations are any less productive or of lower density than those elsewhere.

Densities based on preferred habitat or area of observed distribution are difficult to compare with those from year-round range. These designations are more restrictive than year-round range, which includes areas between often-used habitat, and therefore produce higher goat density estimates. Since goats may use habitats in other seasons or years than those when observed use was tabulated, it is possible that some areas of habitat important to goats may be overlooked, thus inflating density estimates in these more restrictive evaluations. However, the use of year-round range has its own drawbacks, especially with uncertainty concerning the proportions of good versus poor goat habitat within the boundaries delineated. Some consistent definition of important goat habitat will be essential to more detailed comparison of goat densities.

Thus, in the future, identification of habitats critical to mountain goat survival may provide the most realistic comparisons of goat density from one area to another. This will involve the development of a model for depicting goat habitat. For example, a definition of potential goat habitat which is restricted to certain types of vegetation (or amounts of forage), and specific terrain characteristics (e.g., slope steepness and distance from escape terrain) may allow more meaningful measures and comparisons of goat population densities along large latitudinal or longitudinal gradients.

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