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MOUNTAIN GOAT SUBPOPULATIONS IN THE ABSAROKA RANGE, SOUTH-CENTRAL MONTANA

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Abstract: A 3-year field study of mountain goat distribution and abundance was conducted in the Absaroka Range of south-central Montana, 1991-93. Ground surveys produced population counts and composition of goats introduced in the late 1950s and 1960s. Surveys of 4 subpopulations in 4 units of the ~300 km^3 study area took place between May and October. Density estimates ranged from 0.0 goats / km^3 in the least populated unit to 5.1 goats / km^3 in the most populated unit. Group sizes were larger in the high density unit but did not differ in the other 2 units with groups. Mean reproductive success (kids / 100 older goats) seemed greater in the low density units than in the high density unit. Variation in subpopulations was explained in the context of irruptive population growth theory.

Mountain goats were released into the Absaroka Range of south-central Montana in 1956 (5 goats), 1957 (10 goats), and 1958 (8 goats) by the Montana Fish and Game Department (MFG) to provide for recreational opportunities including hunting (MFG 1976). These goats originated from native herds on the Continental Divide in southwest Montana and were released in the northern Absarokas. Between 1942 and 1956, 48 goats were released in the Beartooth Range (MFG 1976) adjacent to the Absarokas (Fig. 1). No significant barriers to movements between the Absaroka and Beartooth ranges exist; therefore, these introductions may have contributed to the Absaroka subpopulations. Since the introduction, the Absaroka population has grown in number and expanded its distribution, primarily to the south and east.

STUDY AREA

The ~300 km^3 study area is located in the northern Absaroka Range of southwest Montana. The study area was divided into 4 units associated with major drainages: Mill Creek, Hellroaring Creek, Pebble Creek, and Cache Creek (Fig. 1). Study units were further divided into smaller subunits of approximately equal size where ground surveys were conducted. The Mill Creek unit consisted of 2 relatively isolated mountain peaks at the headwaters of Mill Creek, Gallatin National Forest. The Hellroaring Creek unit consisted of continuous ridge networks separating Hellroaring Creek from the Boulder River and Mill Creek. Four subunits were surveyed in this unit in the Absaroka-Beartooth Wilderness, Gallatin National Forest. Five subunits consisting of scattered peaks and loosely connected ridgelines in the northeast corner of Yellowstone National Park and surrounding lands comprised the Pebble Creek unit. The 2 subunits of the Cache Creek unit were 2 ridge systems north of Cache Creek in Yellowstone. Mountain goats are legally harvested in the Hellroaring and Mill Creek units but not in the Pebble and Cache Creek units.

METHODS

Ground surveys were conducted to produce a count of goats in the subunits. Subunits were surveyed continuously until the area of the subunit had been searched on foot or glassed with the aid of 7X binoculars and a 20X-60X spotting scope. Care was taken to avoid duplicating located goats in the counts, but it may have occurred in rare instances. Surveys were conducted from mid-May through mid-October, 1991-1993. Most subunits were surveyed more than once, during different months, in a given year. Only the Pebble Creek and Cache Creek units were surveyed in 1991; all units were surveyed in 1992 and 1993.

Density estimates for subunits were derived from the following relationship:

$$SD = SA / SC$$

where SD is the subunit density estimate, SA is the area searched in a subunit in km^3 estimated from U. S. G. S. 7.5" topographical maps, and SC is the largest survey count for the subunit. Density estimates were considered conservative because the largest survey count assumably failed to detect all goats in a subunit; no adjustment was used for sightability due to the difficulty in estimating this bias. Unit densities were the mean density of the subunits.

Group sizes and composition were recorded for goats encountered during surveys. Composition for study units was derived from the yearly totals of classi-

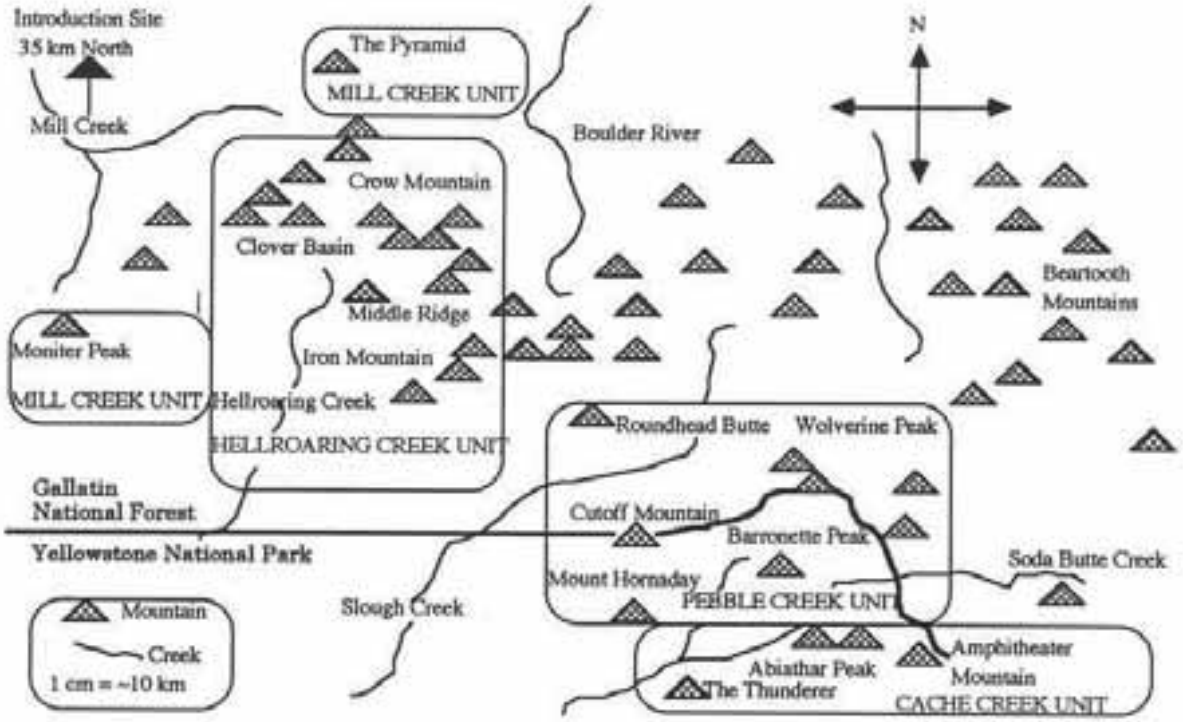

Figure 1. Subunits of the 4 units in the study area in the Absaroka Range south-central Montana.

fied goats located during surveys. Classifications of goat age and gender followed Smith (1988). The number of cases of nannies (adult females) with twins observed was recorded for each unit.

RESULTS

Ground surveys within 14 subunits of the study area produced 96 survey counts. Goats were found in all units with the exception of the Cache Creek unit; no goats were located in The Thunderer (3 surveys) and Amphitheater-Abiathar (2 surveys) subunits of that unit. Density estimates and group sizes in the units varied (Table 1). Density estimates for the 3 units with non-zero counts ranged between 0.2 goats / km^2 in the Pebble Creek unit in 1991 to 5.1 goats / km^2 in the Hellroaring Creek unit in 1993.

The largest counts and group sizes occurred in the subunits of the Hellroaring Creek unit. In 1993, Iron Mountain, where the largest group, 43, was observed, had the highest density estimate, 6.8 goats / km^2, for a subunit. Large groups of 20-40 were consistently found in that subunit as well as the other subunits of the Hellroaring Creek unit. Counts and group sizes for the study (1991-93) were greater in the Hellroaring Creek unit than in the Pebble Creek unit ($t = -3.71$, $p = 0.001$; $t = 39.5$, $p < 0.0001$, respectively) and the Mill Creek unit ($t = -3.54$, $p = 0.002$; $t = -22.6$, $p < 0.0001$, respectivley).

Counts and group sizes in the Pebble Creek unit did not differ from the Mill Creek unit ($t = 1.2$, $p = 0.2640$; $t = 1.32$, $p = 0.191$). In the Pebble Creek unit, groups seemed to be concentrated in the Wolverine Peak subunit. The largest count for the Wolverine Peak subunit was 49 in 1992. The largest group seen was 11 in 1991. Only small groups (≤ 6) and single individuals were found in 7 surveys of the Cutoff Mountain subunit. Only signs of mountain goat occurrence which included hair and tracks were found on Barronette Peak (2 surveys) and Mount Hornaday (2 surveys).

In the Mill Creek unit, the largest counts in The Pyramid subunit were 10 and 20 and the largest group sizes were 7 and 11 in 1992 and 1993, respectively. Only 2 goats were located in the Monitor Peak subunit during a 1992 survey.

The highest reproductive success ratios (kids /100 older goats) for the study were associated with the Pebble Creek unit where the 3-year mean was 41/100 (Table 2). Approximately one-third of all goats obser-

Table 1. Density, daily unduplicated counts, and group sizes of mountain goats observed during ground surveys of 11 subunits in the Pebble, Hellroaring, and Mill units of the Absaroka study area, 1991-1993.

Year	Subunit and Area (km^2)		Density*	Counts			Group Size		
			Goats / km^2	n	Mean	Range	n	Mean	Range
1991	Wolverine Peak	11.8	0.9	7	3.1	0-11	5	5	1-11
	Cutoff Mountain	6.8	0.0	1	0	0	0	0	0
	Barronette Peak	4.5	0.0	2	0	0	0	0	0
	Mount Hornaday	1.3	0.0	1	0	0	0	0	0
Totals	PEBBLE UNIT	24.4	0.2	11	2.0	0-11	5	5	1-11
1992	Wolverine Peak	11.8	4.1	12	9.9	0-49	25	3.6	1-10
	Cutoff Mountain	6.8	0.7	3	1.7	0-5	1	5.0	5
	Mount Hornaday	1.3	0.0	1	0	0	0	0	0
Totals	PEBBLE UNIT	19.9	1.6	16	8.0	0-49	36	3.5	1-10
	Middle Ridge	8.3	6.0	7	27.5	12-50	26	9.0	1-29
	Crow Mountain	9.7	3.7	4	18.7	2-36	11	7.5	1-33
	Iron Mountain	6.9	2.6	3	8.0	1-18	3	8.0	1-18
Totals	HELLROARING	24.9	4.1	14	20.8	1-50	40	8.5	1-33
	The Pyramid	7.0	1.4	3	4.3	0-10	4	3.3	1-7
	Monitor Peak	5.9	0.3	3	0.7	0-2	1	2	2
Totals	MILL UNIT	12.9	0.8	6	2.5	0-10	5	3.0	1-7
1993	Wolverine Peak	11.8	1.7	22	14.9	0-20	46	3.1	1-10
	Cutoff Mountain	6.8	0.9	3	3.3	2-6	4	2.5	1-6
	Roundhead Butte	4.7	2.3	1	11	11	1	11	11
Totals	PEBBLE UNIT	18.6	1.6	26	13.4	0-20	50	3.0	1-10
	Crow Mountain	9.7	3.9	6	23.7	5-38	10	14.2	1-37
	Iron Mountain	6.9	6.8	3	21.7	0-47	2	32.5	22-43
	Clover Basin	9.3	4.6	9	12.3	0-43	13	6.4	1-24
Totals	HELLROARING	25.9	5.1	18	17.7	0-47	25	11.6	1-43
	The Pyramid	8.0	2.5	6	14.8	6-20	23	3.2	1-11
Totals	MILL UNIT	8.0	2.5	6	14.8	6-20	23	3.2	1-11

*Subunit Density = (Maximum daily unduplicated count) X (area); Unit Density = Mean Subunit Density.

ved in this unit were kids during all years. The proportion was greater in the Pebble unit than in the Hellroaring and Mill units in 1992 and 1993. In 1993, 48/100 was recorded in the Pebble Creek unit, versus 24/100 for the Hellroaring Creek unit and 42/100 for the Mill unit. Eight cases of nannies with twins were observed in the Pebble Creek unit versus 0 cases in the Hellroaring Creek unit and 1 case in the Mill Creek unit during the study.

Adult females comprised the largest proportion (41.3%) of the mountain goats observed in the study area (Table 2). They often occurred in groups with yearlings and kids of both sexes in the units where goats were encountered. Adult males (11.5%) were encountered singly or in smaller groups (2-5).

DISCUSSION

Analysis of density and reproduction in subpopulations within the 4 study units suggests the demographics of subpopulations can vary widely so that information on any one subpopulation can be misleading if extrapolated to the entire population. Density, reproductive success, and cases of twins varied among 4 subpopulations within the Absaroka study area (Fig. 2). While not producing accurate population estimates, the ground survey method seemed reliable to detect relative differences in abundance among the 4 units which will be discussed in the context of irruptive population growth.

Table 2. Population composition of mountain goats observed in three units of the Absaroka study area, 1991-1993.

Year	Study Unit	n = goats	Classifications[a]					Age ratio[b]		Twins[c]
			Billy	Nanny	Yearling	Kid	Uncl.	Yearlings	Kids	
1991	Cache	0	0	0	0	0	0	0	0	0
	Pebble	25	3 (12)[d]	12 (48)	2 (8)	8 (32)	0 (0)	9	47	3
	Totals	25	3 (12)	12 (48)	2 (8)	8 (32)	0 (0)	9	47	3
1992	Cache	0	0	0	0	0	0	0	0	0
	Pebble	179	14 (8)	68 (38)	45 (25)	40 (22)	12 (7)	33	29	0
	Mill	15	1 (7)	4 (27)	5 (33)	3 (20)	2 (13)	50	25	0
	Hellroaring	252	24 (12)	111 (44)	35 (14)	47 (19)	29 (11)	16	23	0
	Totals	446	42 (10)	183 (41)	85 (19)	90 (20)	43 (10)	24	25	0
1993	Cache	0	0	0	0	0	0	0	0	0
	Pebble	157	24 (15)	53 (34)	13 (8)	51 (32)	16 (10)	9	48	5
	Mill	74	13 (18)	30 (40)	9 (12)	22 (30)	0 (0)	14	42	1
	Hellroaring	323	38 (12)	143 (44)	27 (8)	62 (19)	53 (16)	9	24	0
	Totals	554	75 (14)	226 (41)	49 (9)	135 (24)	69 (12)	10	32	6
91-93	Totals	1025	117 (12)	421 (41)	136 (13)	233 (23)	112 (11)			

[a] Classifications include Billy (male, 2+ years), Nanny (female 2+ years), yearlings (1-2 years), kids (0-1 year), and unclassified.
[b] Number per 100 other classification.
[c] Number of cases of females with twins observed.
[d] Number observed, (percent of total).

The irruptive population growth curve described by Riney (1955) and Caughley (1970) suggests population growth varies with duration of subpopulation establishment after introduction (Fig. 3). The growth rate is slow following the initial introduction until the population becomes established, followed by an initial increase phase characterized by a low-density population responding to abundant resources with high reproductive rates. Growth following the inital increase phase levels off above the long-term carrying capacity (K) of the range in the initial stabilization phase characterized by high density and moderate or declining reproduction. Resources become scarce and the population subsequently drops below K in the decline phase that follows the initial stabilization phase. Population growth fluctuates near the long-term K thereafter in the post-decline phase.

The Pebble Creek unit subpopulation is likely in an initial increase phase of population growth. Low density and high reproductive success are indications of a productive subpopulation which may be responsing to abundant resources occurring in this newly exploited area. Cases of twins indicate high productivity which is common in recently established populations (Lentfer 1955, Hayden 1984, Festa-Bianchet et al. 1994). On June 29, 1966, an adult mountain goat sighted on Meridian Peak represented the first known sighting of a mountain goat in the Pebble Creek unit (Varley 1996). In the same year, the first goats were harvested from an established and growing population in the Hellroaring Creek and Mill Creek units (Swenson 1985). Occasional sightings continued in the Pebble Creek unit through the 1970s and 1980s while the subpopulations in the Hellroaring and Mill Creek units grew. Current distribution and abundance data indicate a viable subpopulation is now established in the Pebble Creek unit, 35-40 years after the initial introductions took place.

Goats in the Hellroaring unit have been established 20-30 years longer than in the Pebble Creek unit, and density and group sizes are high relative to the other units. No cases of twins were observed, a sign of high density (Houston and Stevens 1988). Swenson (1985) suggested the subpopulation was in an initial increase phase in the 1970s. Although reproduction estimates have not reached a critically low level, the indicators suggest the subpopulation may now be nearing the peak of irruptive growth, and may forewarn a density-dependent decline similar to cases reported in Montana (Foss 1962) and Colorado (Adams and Bailey 1982, Bailey 1991).

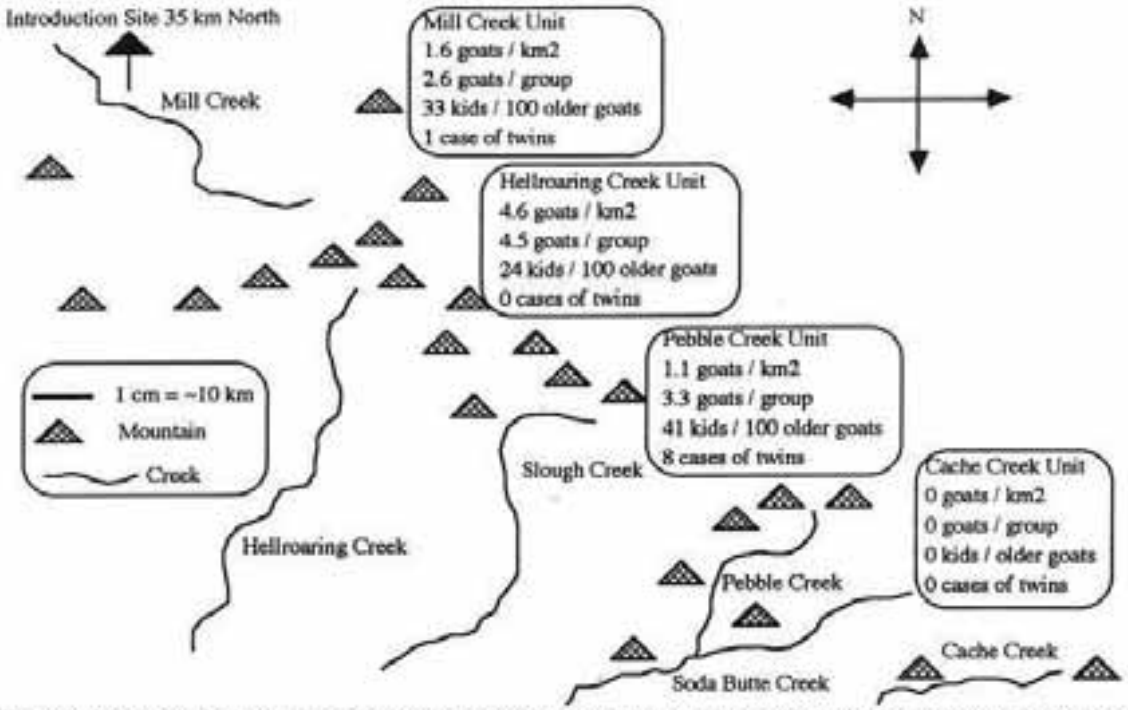

Figure 2. Mean density, mean group size, mean reproductive success, and cases of twins in the 4 units of the Absaroka study areas.

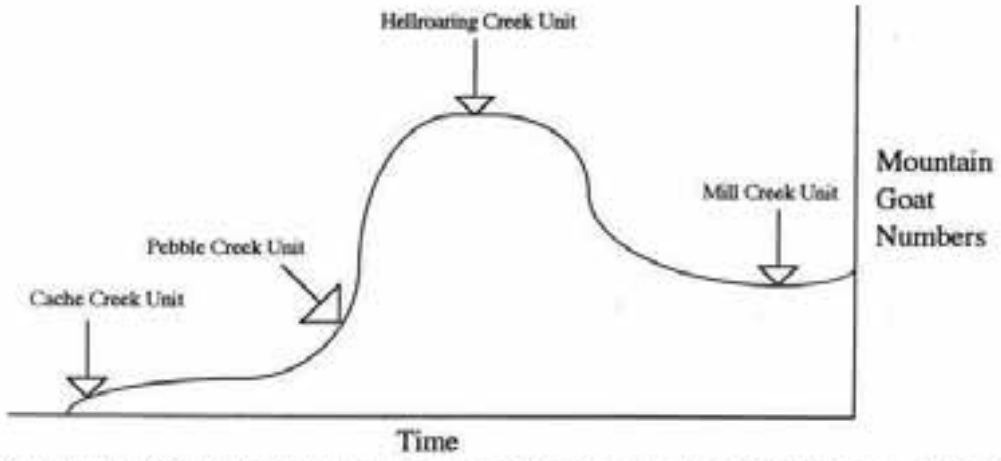

Figure 3. Irruptive population growth curve with placement of the 4 Absaroka Range study area units along the curve.

The Mill Creek unit subpopulation may be in the post-decline stage of population growth; however, there is no evidence to confirm that ecological carrying capacity was reached. Density and reproduction in this unit did not vary significantly from that of the Pebble Creek unit so it may be that this subpopulation is in a similar state. Lack of habitat linking goat-use areas may limit use of suitable, but isolated, areas (Hayden 1989), such as the subunits of the Mill Creek unit. These subunits were essentialy island-like, and although movements between islands of habitat occur, lack of alpine connectivity may have limited colonization to the extent that it slowed subpopulation growth. The Pyramid and Monitor Peak subunits had suitable goat habitat, but were geographically isolated from large, continuous mountain chains by 10-20 km of forested and/or patchy habitats.

Similarly, the Barronette Peak and Mount Hornaday subunits of the Pebble Creek unit may be isolated to the extent of having a low colonization and establishment rate. In contrast, the habitat of the Hellroaring Creek unit and the Wolverine Peak subunit were continuous mountain ridges with high continuity, and were likely areas for initial herd establishment and growth to occur in the colonization process.

No evidence of subpopulation establishment was found in the Cache Creek unit. Whether this is due to insufficient colonization or resource deficiency is unclear. Considering the close proximity (5 km) of the Amphitheater-Abiathar subunit to the populous Wolverine Peak subunit, an explanation for the subunit's low counts may be resource deficiency. The Amphitheater-Abiathar subunit was characterized by multiple near-vertical slopes and little ledge habitat as found in more populous subunits (Varley 1996). The Thunderer subunit appeared to have suitable goat habitat; however, its distance from established subpopulations and isolation from other alpine habitats may be the more proximal factor limiting growth.

Mountain goats are considered to be relatively poor dispersers (Stevens 1983), and the time required to establish herds in currently unoccupied but suitable areas is difficult to estimate. Goats colonizing the Olympic Range progressed at an estimated rate of 3-6 km/year (Houston et al. 1994). Goats may have reached the Pebble Creek unit within 10 years of their introduction to the region, but took 3 times longer to establish a resident subpopulation. This supports the supposition that goats are slow to establish herds in vacant ranges, but that individuals will travel great distances from established herds (Chadwick 1974). The Pebble Creek unit is ~100 km south and ~85 km west of the Absaroka and Beartooth introduction sites, respectively, resulting in a rate of ~2.5 km/year. Goats seem to respond to habitat factors during colonization by establishing subpopulations in the highest quality, most continuous portions of their range first and filling in the more isolated portions subsequently so that this rate is non-uniform and would apply to a broad spatial scale such as the entire Absaroka range.

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