# STATUS OF INTRODUCED MOUNTAIN GOATS IN THE SAWATCH RANGE OF COLORADO

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

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

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

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## STUDY AREA

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

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

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

## METHODS

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

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

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

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

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

## RESULTS

### Habitat and Group Size

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

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

### Minimum Populations

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

### Age Ratios

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

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

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

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

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

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

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

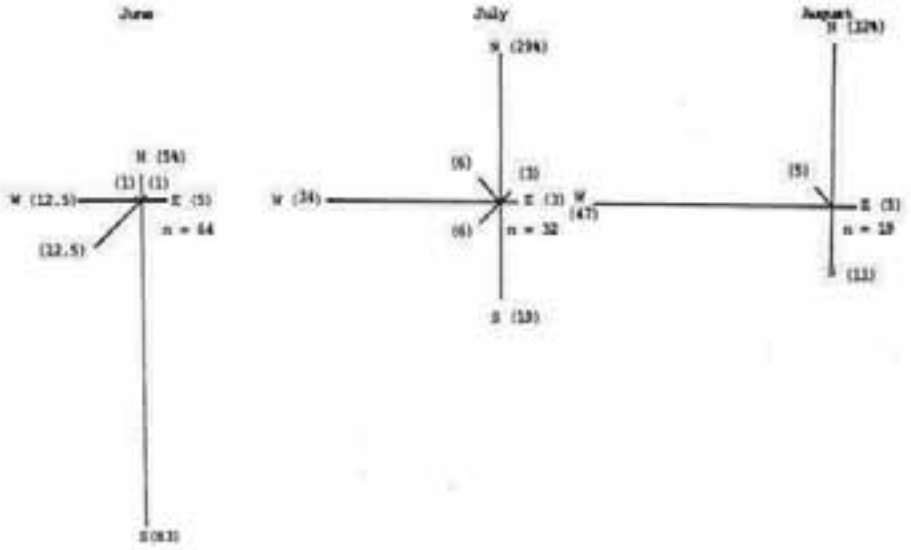


Figure 1. Aspects used by mountain goats on the Sheep Mountain Study area, 16 June - 21 August 1975. Lengths of bars and numbers in parentheses indicate percentages of each month's observations on each aspect; n = number of goat observations each month.

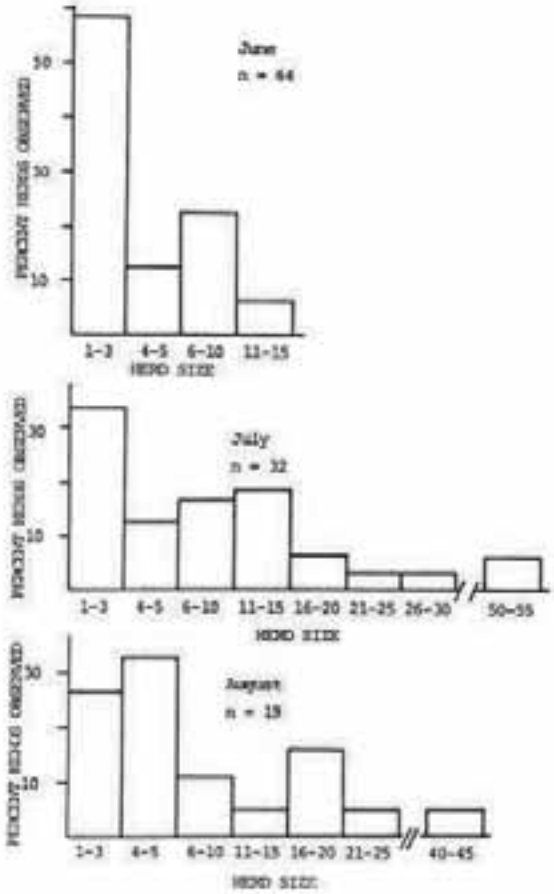


Figure 2. Sizes of goat herds observed on Sheep Mountain study area 16 June - 21 August 1975. (n = number of goat herds observed each month.)

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

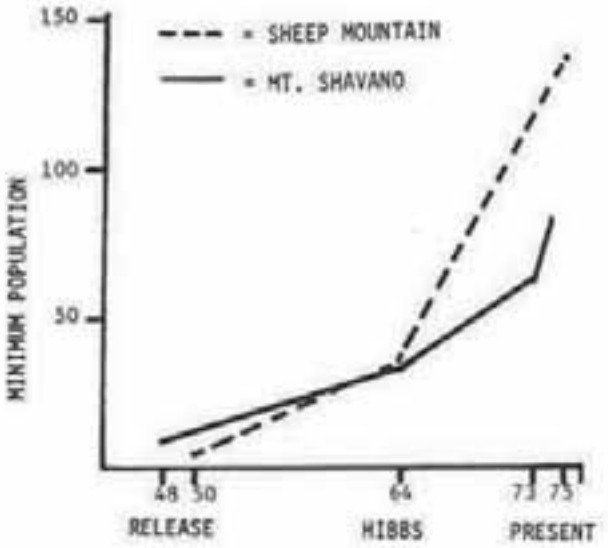


Figure 3. Minimum populations of mountain goats on two Sawatch Range study areas, 1948 - 76. The data from 1964 are from Hibbs (1965).

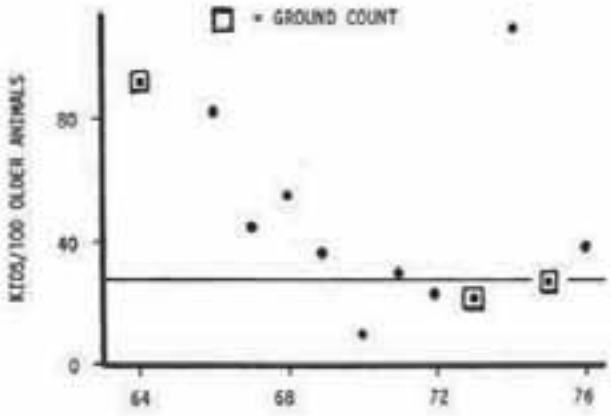


Figure 4. Observed age ratios of mountain goats on Mt. Shavano, 1964 - 76. The line at 28 kids per 100 older goats is the average reported for native and "established" herds.

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

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

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

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

## FOOD HABITS

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

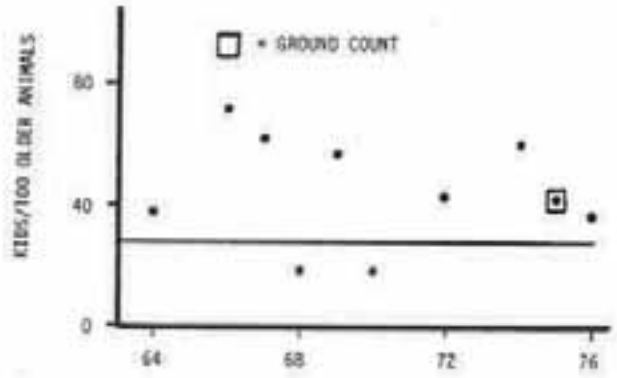


Figure 5. Observed age ratios of mountain goats on Sheep Mountain and vicinity, 1964 - 76. The line at 28 kids per 100 older goats is the average for native and "established" herds.

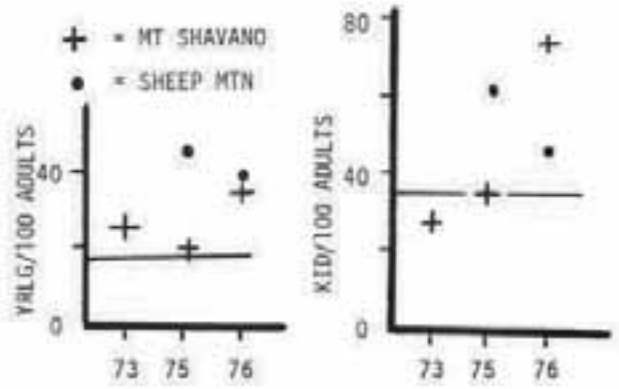


Figure 6. Observed age ratios of mountain goats on two Sawatch Range study areas, 1973 - 76. Lines at 17 yearlings and 34 kids per 100 adults are averages for native and "established" herds.

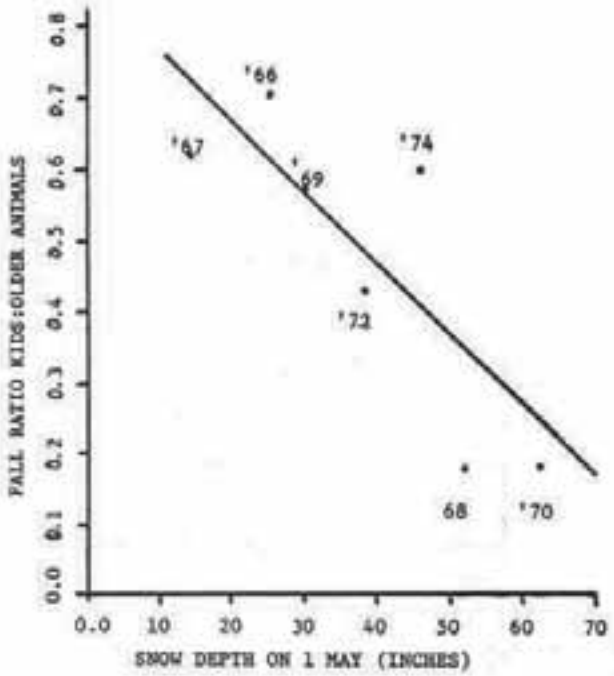


Figure 7. Relationship between 1 May snow depth from the previous winter at Monarch Pass and kid:older animal ratios from fall aerial surveys of mountain goats on Sheep Mountain and vicinity.

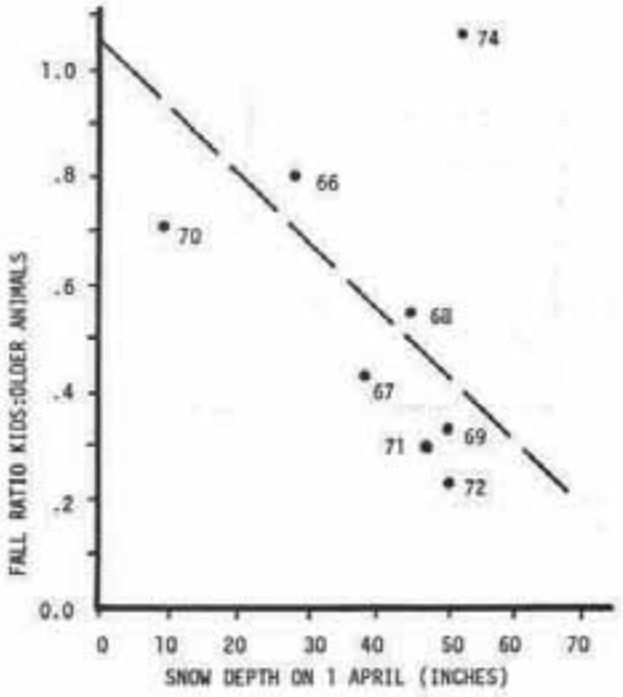


Figure 8. Relationship between 1 April snow depth from the previous winter at Monarch Pass and kid:older animal ratios from fall aerial surveys of mountain goats on Mt. Shavano.

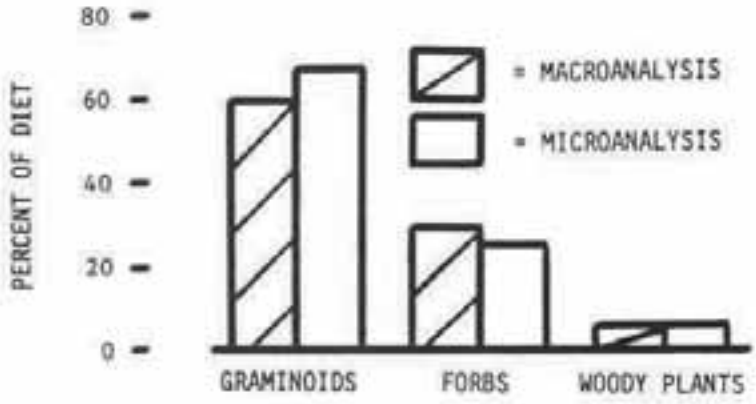


Figure 9. Summer forages of mountain goats in the Sawatch Range, Colorado.

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

## DISCUSSION

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

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

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

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