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HOME RANGES, HABITAT USE AND PRODUCTIVITY OF BIGHORN SHEEP IN THE NEVER SUMMER MOUNTAINS, COLORADO

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Abstract: A study of distribution, movements, habitat use and productivity of bighorn sheep (Ovis canadensis canadensis) in the Never Summer Mountains of north-central Colorado was initiated in 1986. A concern was the continuing use of the herd for transplant stock despite lack of population data. Results from the first 2 field seasons indicated existence of 3 subpopulations in the west-side study area. These subpopulations shared a common mineral lick-lambing-nursery range. Habitat use, movement patterns and home ranges were determined for the south Never Summer subpopulation using radio telemetry. Home ranges were traditional. Plant phenology influenced habitat use. Bighorn preferred subalpine areas in late May and June, and moved to alpine ranges later in a wet than in dry summer. Sheep shifted habitat use from south and west aspects during early summer to north and east aspects in late summer. An extended lambing period (from late May through mid-July) was observed both years and maternal care of yearlings was noted in 1987. Population estimates for the west-side area have doubled since 1976 (120 to 240 bighorn). Observed production and recruitment indicated continued population growth.

Bighorn sheep were originally abundant in the Never Summer Mountains in what is now portions of Rocky Mountain National Park, the Arapaho and Routt National Forests, and the Colorado State Forest. Initial declines were caused by losses if low elevation winter ranges in Middle Park and restriction of bighorn to alpine winter ranges by 1920 (Goodson 1978, 1980). Further declines were attributed to competition with domestic sheep grazed in the Never Summer Range in the 1920's (Goodson 1978, 1980). A major die-off of bighorn was reported in the Never Summer Range from 1925 to 1930. The east slope of the Never Summer Range was included within Rocky Mountain National Park in 1930 and domestic sheep were excluded from the park; however, grazing continued on adjacent lands until the early 1970's. The initial die-off of bighorn was followed by continued decline through the 1960's.

In 1968, Harrington (1978) estimated the bighorn population of the Never Summer Mountains, Mt. Ida; and Specimen Mountain at 96 sheep, approximately 5% of original estimates, (Ratcliff 1941). During 1974-1976, Goodson (1978) reported an increase in abundance (to approximately 120 sheep), and an increasing trend. Trapping operations conducted by the Colorado Division of Wildlife from 1979 to 1984, on Baker Mountain at the southern end of the Never Summer Range, removed 52 bighorn from the

population and provided sheep for reintroduction to vacant historical range in other areas. However, the trapping operations also initiated concern about potential effects on the Never Summer population. Earlier studies, (Goodson 1978 and Harrington 1978), documented range areas used by sheep and gross movement patterns. However, little was known about specific movements or interchange of sheep on winter range areas. A question arose as to what effect the transplants might have on the segment of the population wintering on Baker Mountain.

The effects of the transplanting program on the total population was also in question. The most recent survey of the herd (Goodson 1978) indicated a minimum population of 106 sheep. Although a ground census in 1982 tallied 215 sheep, this total was questionable. Bighorn were counted on Specimen Mountain the day after counts in the Never Summer Range and could have moved between these areas. An aerial count in 1984 found only 69 sheep. A ground count the same year tallied 73.

This study was designed to answer these questions and also provide basic information on the ecology and dynamics of the Never Summer population. Objectives are to determine:

1. Distribution and seasonal habitat use,
2. Distinct herd segments and their fidelity to seasonal ranges,
3. Migration routs and movement patterns of the Baker Mountain herd segment,
4. Sex-age structure and size of population segments.

Support for the study was provided by Rocky Mountain National Park. The Colorado Division of Wildlife cooperated in trapping bighorn and in the 1987 aerial census.

STUDY AREA

The study area was located within Rocky Mountain National Park and the adjacent Arapaho and Routt National Forests and Colorado State Forest. It encompassed the Never Summer Mountain Range from Cascade Mountain on the south to Iron Mountain on the north, and included the Colorado River valley and Specimen Mountain to the east (Fig. 1). Elevations range from 2746 m in the Colorado River valley to 3933 m on Mt. Richthofen. The mountains are formed of precambrian metamorphic shists and gneiss intruded by large masses of granite and pegmatite. Recent volcanic activity in the Lulu Mountain area altered the structure and resulted in an ash flow that formed Specimen Mountain. The present topography is rugged with many rock outcrops and talus slopes.

The vegetation of the study area represents the subalpine forest and the alpine tundra climax regions. The subalpine forest is characterized by an Engelmann spruce (Picea engelmanni)/Subalpine fir (Abies lasiocarpa) forest association interspersed with lodgepole pine (Pinus contorta), limber pine (Pinus flexilis), and aspen (Populus tremuloides) stands. Above 3230 to 3400 m is the alpine tundra, a complex mosaic of low growing plant associations.

Climate is mountain continental with sudden and extreme changes

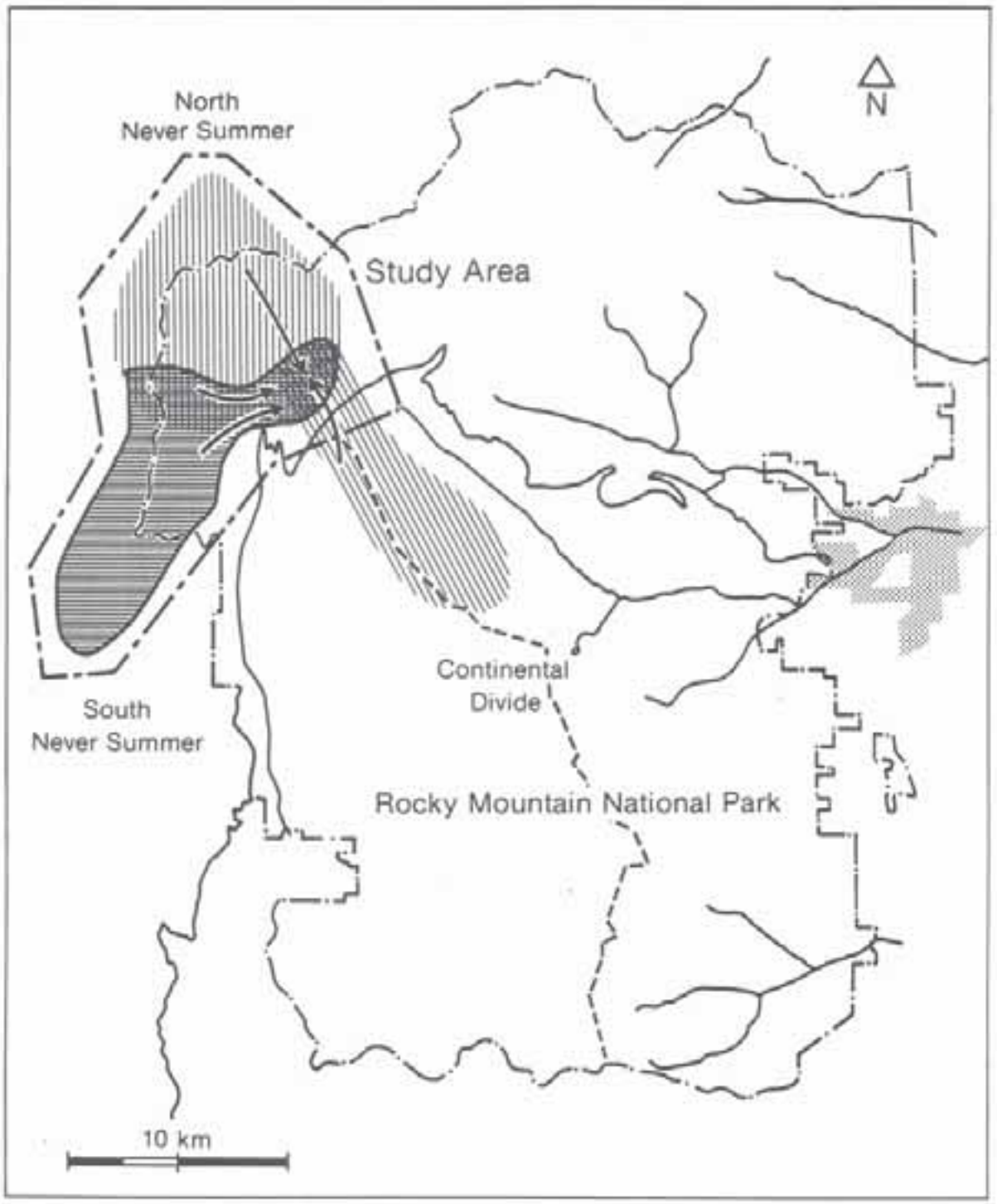

Figure 1. Location of the study area in relation to ranges of bighorn sheep subpopulations on the west side of Rocky Mountain National Park, Colorado.

possible in any season. Above tree line, the mean monthly temperature varies from -14 C in January to 8 C in July. Mean annual precipitation varies from 75 cm in the subalpine zone to 99 cm above tree line. The alpine ridges are generally cleared of snow by the prevailing westerly winds. In the subalpine zone, maximum snowdepths exceed 1.5 m in lee areas most winters.

METHODS

Eight bighorn, seven ewes and one yearling ram were captured and radio-collared in late March 1986. Two ewes (one adult and one yearling), were ear-tagged during the trapping operation. In addition, there were five ewes with old white collars and white eartags in the population in 1986. All of the marked bighorn were tagged on Baker Mountain in the southern part of the Never Summer Range.

During the two field seasons, May 28 to September 19, 1986, and May 20 to October 12, 1987, visual locations of individual radio-collared sheep were made 1.5 times per week on average. Numbers of observations of radio-collared individuals varied from 18 to 29 (x=22) in 1986, and 21 to 32 (x=27) in 1987. During each field day, radio signals of sheep which were not sighted were monitored if possible. The direction of the signal, its strength, and the indicated location of the sheep were recorded. During 1986, 279, and during 1987, 334 observations of bighorn groups, including those with and without radio-collared members, were recorded. For each of these observations the following data were recorded, if possible:

1. Identity of marked sheep
2. Location
3. Habitat
4. Behavior
5. Association or lack of association with a lamb or yearling
6. Sex-age classification of group
7. Weather
8. Movements

Aspect, slope, elevation and UTM coordinates of areas used by bighorn groups were estimated from locations mapped on U.S.G.S. 7.5 Minute topographic maps.

The population estimates for the west-side area, (including the north and south Never Summer and Continental Divide subpopulations) were based on coordinated ground counts in 1986 and 1987. In 1987 one helicopter flight by the Colorado Division of Wildlife coordinated with ground counts on Specimen Mountain provided a maximum count of west-side bighorn. A Lincoln Index was used to estimate the total number of ewes in the population. The number of lambs, yearlings, 2-year-olds, and adult rams (over 2 years of age) were estimated by ratios of members of these classes to adult ewes.

For the south Never Summer subpopulation an estimate of the total number of adult ewes utilized observations compiled for each of the four months. For each month, the number of adult ewes was estimated by a

Lincoln Index relating observations of marked non-radioed ewes to total observations of non-radioed ewes. The 7 radio-collared ewes were added to these estimates. The mean of the four monthly estimates was used. The numbers of bighorn in other age and sex categories were estimated by the ratios of members of those classes to adult ewes. However, for this subpopulation, adult rams were estimated by maximum counts per horn curl class.

RESULTS AND DISCUSSION

Distribution and Movements

Differences in weather patterns between the 1986 and 1987 field seasons influenced distribution and movement patterns of bighorn sheep. Snowdepths during the first winter, 1985-1986 were nearly twice normal in the study area. When field work began on May 28, 1986, much of the study area was covered by over 60 cm of snow, and all radio-collared bighorn were still on their winter range on Baker Mountain. Snowdepths during the second winter, 1986-1987, were about one-half normal and by May 20, 1987, when field work commenced, most of the study area was snow free. Four of the eight radio-collared bighorn crossed the Colorado River valley from their winter range on Baker and Bowen Mountains (where they were located in December and March) to Shipler Mountain before May 20, 1987.

The major lambing area in 1986 was Baker Mountain. Five of 6 radio-collared ewes which had lambs in 1986, lambed on Baker Mountain (Fig. 2). One radio-collared ewe lambed in July on Shipler Mountain. In 1987, Shipler Mountain was the major lambing area (Fig. 2). Two of three radio-collared ewes, that had lambs, lambed on Shipler Mountain. No observations of lambs were made on Baker Mountain or an adjacent tundra ridge during June 1987, while 72 observations of lambs were made on Shipler and Specimen Mountains during the same period. One marked ewe lambed on Baker Mountain in July. These data indicate that the Baker ewe-group has alternative lambing areas, use of which possibly depends on snow conditions. Other workers (Geist 1987), Shannon et al. 1975 and Seip 1983) have reported that snowdepth and hardness limit habitat use and movements of mountain sheep.

Summer 1986 was short, cool and wet with extensive snow cover continuing into July, and autumn snows began in late September. Summer 1987 was long, warm and dry with early snowmelt and pleasant weather continuing into October. The distribution of the radio-collared bighorns as a group was essentially the same in 1986 and 1987 (Fig. 2); however, individual sheep moved more and used more areas within the group range in 1987 than in 1986. In 1986, the typical pattern, followed by seven of eight radio-collared bighorn, was a single trip to the Shipler-Specimen area in June, or June and early July, followed by movement back to the Never Summer Mountains. In August and September, use was concentrated in the southern end of the range in the cirques south and north of Bowen Mountain. Only the three radio-collared ewes that lambed early were observed in the Crater of Specimen Mountain.

In 1987, movements were more extensive. Early use of Shipler and Specimen Mountains was followed by movement to the Never Summer Mountains,

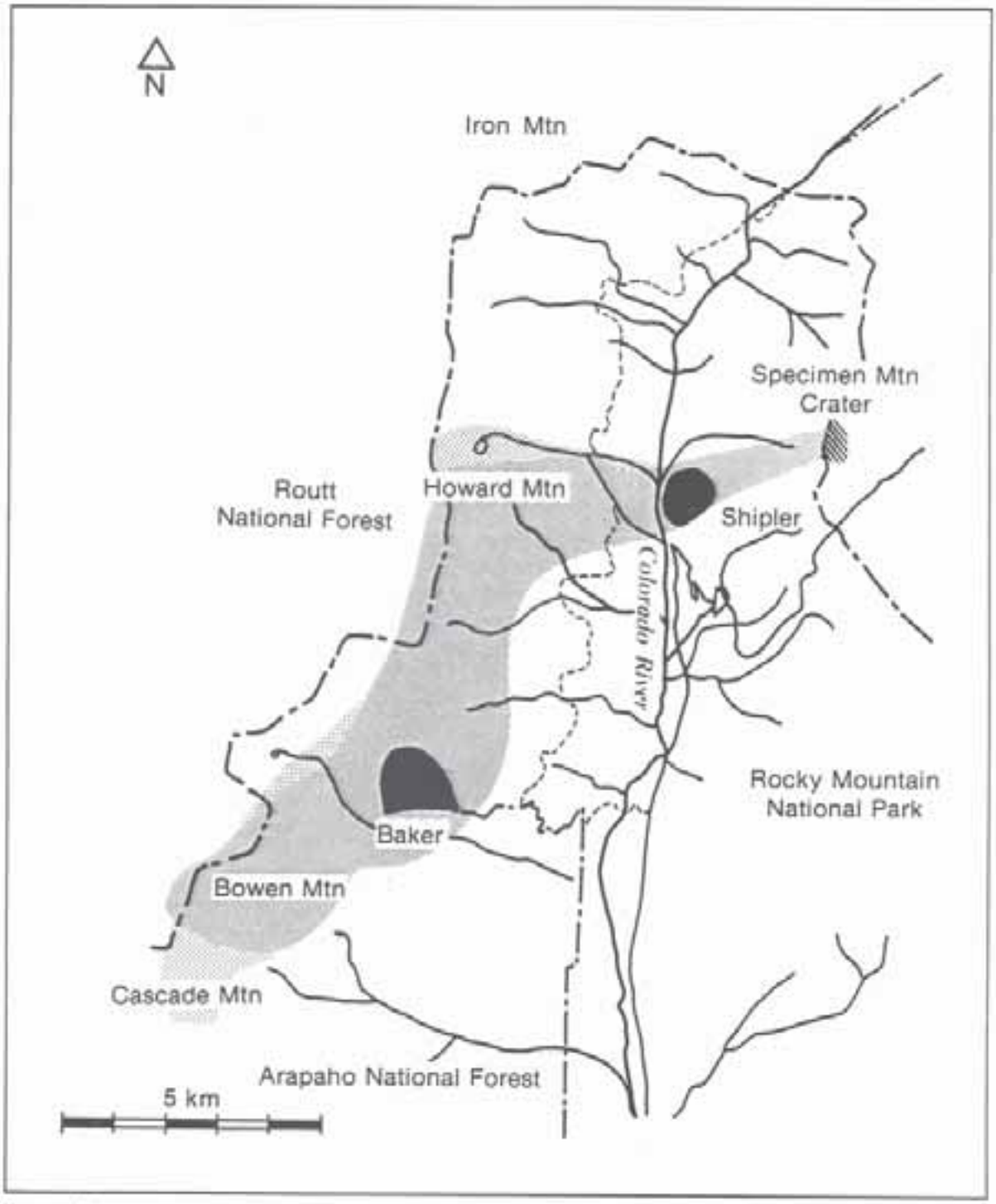

Figure 2. Home ranges of the south Never Summer ewe group during 1986 (medium shading), and 1987 (light shading), as indicated by radio-tracking 7 ewes. Dark shading indicates lambing areas on Baker and Shipler Mountains. Hatched area indicates the Crater of Specimen Mountain.

then return to Specimen and Shipler Mountains in August, and movement back to the Never Summer Mountains. In 1987, all radio-collared bighorn were observed in the Crater of Specimen Mountain during late May-June or June-early July. All but one radio-collared ewe used the Specimen-Shipler Mountain area again for a period in August. In September 1987, bighorn again concentrated use near Bowen Mountain.

Range Fidelity

Range Fidelity of radio-collared ewes was indicated by their use of the same distinct group range both field seasons (Fig. 2). In 1987, a radio-collared ewe was observed once on the mountain crest north of Howard Mountain. However, in 1987, as in 1986, no radio-collared ewes were observed further north on the Never Summer crest. These observations support the preliminary conclusion from 1986 data that the Baker ewe-group has a home range and movement pattern distinct from those of the north Never Summer and Continental Divide ewe-groups. Traditional use of seasonal ranges by bighorn ewe groups has also been observed by Geist (1971) and Festa-Bianchet (1986).

Several radio-collared ewes appear to have individual preferences for certain areas of the group range. Ewe #838 was the only radio-collared ewe which used Mineral Point (the east ridge of Bowen Mountain). She was there from June 10 to June 26, 1986 and from June 10 to July 1, 1987. In 1987, she lambed on Mineral Point. Ewe #863 was one of only two radio-collared ewes observed west of Bowen Mountain in 1986. In 1987, she was the only radio-collared ewe observed west of Bowen Mountain. She used a peak west of Bowen and Cascade Mountains extensively in August and September. Ewe #912 was observed on the steep west slope of Shipler Mountain more than any other marked ewe during both field seasons, and lambed there in 1987.

Seasonal Habitat Use

Bighorn moved through all vegetation types present on the study area, from riparian meadow and shrub types on the Colorado River through lodge-pole pine and aspen association, to the spruce-fir forest and alpine tundra. The sheep foraged and rested below tree line in openings created by avalanche paths or associated with rockslides, boulderfields, or cliffs. Both above and below tree line use was restricted to areas close to steep and/or rock-covered escape terrain.

In 1986 and 1987, bighorn shifted use of aspects and elevations from early to late summer (Figs. 3 and 4). From late May through July 14, most observations of groups of bighorn including radio-collared sheep were on south, southwest or west aspects. From July 15 through September, use by bighorn shifted to north, northeast, east, and southeast aspects (Fig. 3). In 1986, groups including radio-collared bighorn used lower elevations more during June and July than during August and September (Fig. 4). In 1987, a warmer and drier year, bighorn moved to higher elevations earlier than in 1986 (Fig. 4). The mean elevation of observations was below tree-line during July in 1986, but was above treeline during July 1987 (Fig. 4). Shifts in use of elevations and aspect suggest plant phenology was an important factor in determining gross patterns of habitat use. Smith

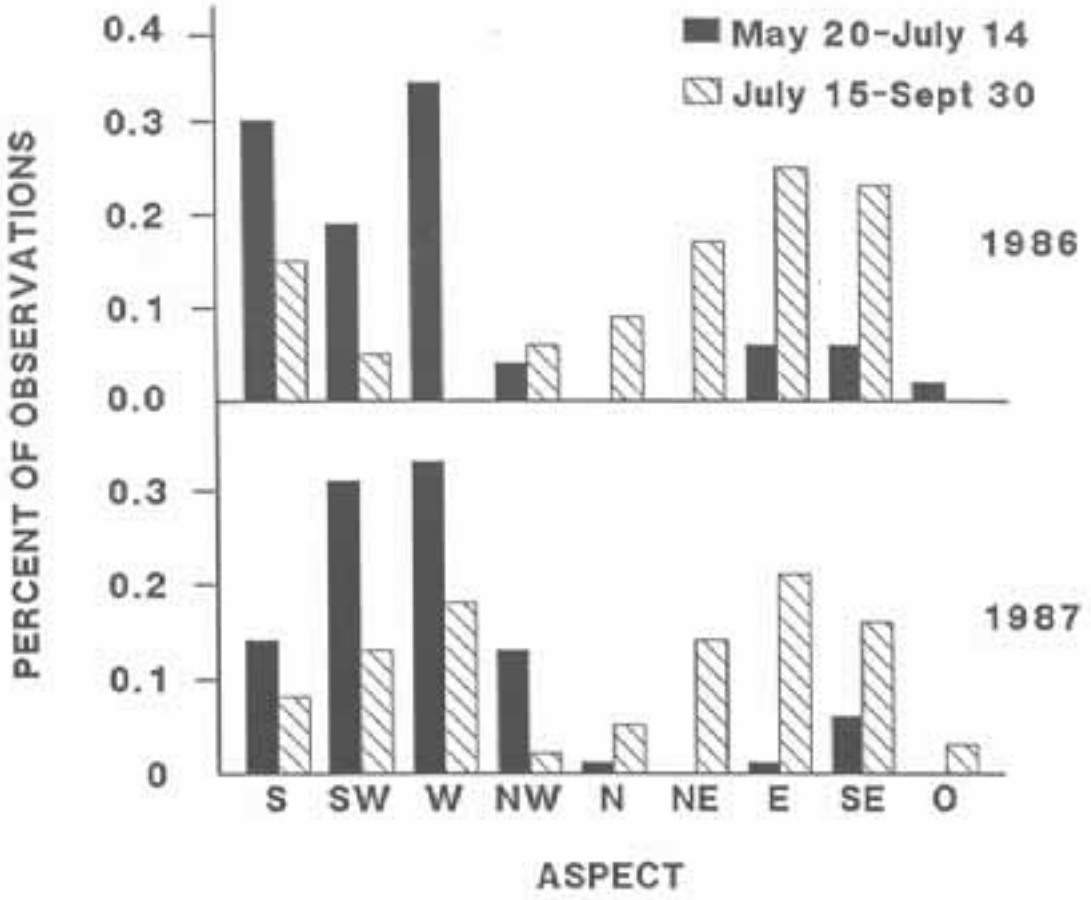

Figure 3. Changes in use of aspects by bighorn groups (including one or more radio-collared sheep) from early to late summer, 1986 and 1987, Rocky Mountain National Park and adjacent areas. N (number of groups of bighorn observed) = 53 early summer, 65, late summer, 1986; 70 early summer, 62 late summer, 1987.

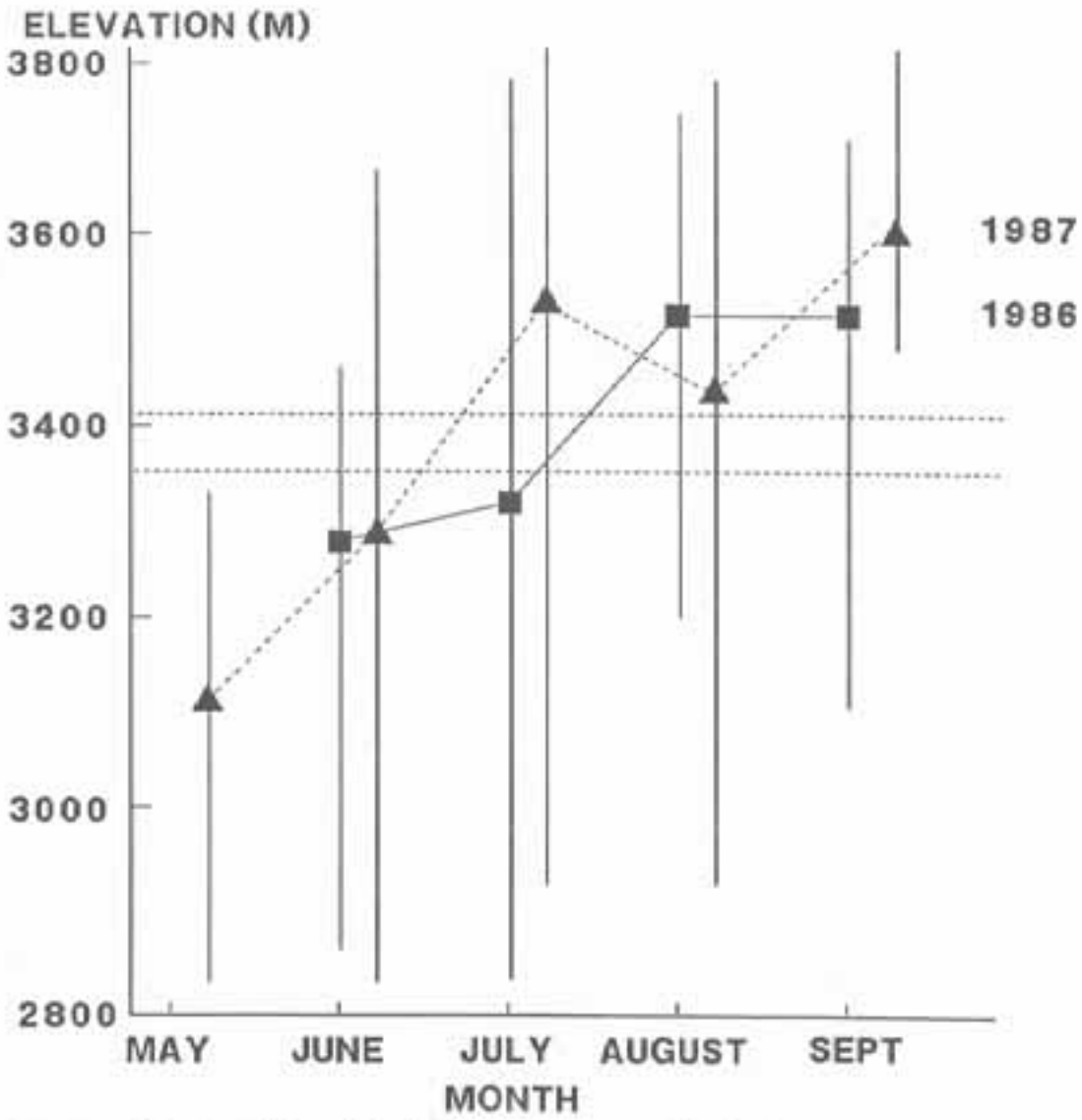

Figure 4. Changes in use of elevations by bighorn groups (including one or more radio-collared sheep) during late May through September, 1986 and 1987, Rocky Mountain National Park and adjacent areas. N (number of bighorn groups observed) = 118, 1986; 132, 1987. Solid vertical lines indicate ranges of observations. Dashed horizontal lines indicate the zone of treeline.

(1954), Shannon et al. (1975), Johnson and Smith (1980), and Seip (1983) also found plant phenology influenced habitat selection by bighorn sheep. Hebert (1973) documented the nutritional advantage to bighorn of foraging on early phenological stages of plants.

Lamb Production and Yearling Recruitment

Lamb production by marked ewes was lower in 1987 (L:E = .46) than in 1986 (L:E = .75). Despite the fewer lambs observed,the extended lambing period during 1986 was repeated in 1987. Estimated birth dates of the three lambs born to marked ewes for which dates could be closely estimated were May 23, June 28, and July 9. Combining data from 1986 and 1987, twelve lambs were born from May 23 to July 9 (Fig. 5). Festa-Bianchet (1988) observed a similar extended lambing period in Alberta bighorn ewes. He reported poor condition in autumn and low survival of lambs born after June 10. In this study, both early and late-born lambs of marked ewes were in good condition when fieldwork ended in mid-September (1986) or early October (1987). Assuming that association of a ewe with a yearling indicates survival of her lamb of the previous year, at least one of three late-born lambs of radio-collared ewes survived its second summer. Using the same assumption, at least two of three early-born lambs of radio-collared ewes survived for the same period.

The three radio-collared ewes which did not have lambs in 1987 but which had lambs in 1986, were observed in close association with yearlings during part or all of the 1987 field season (Table 1). These observations are supplemented by occasional observations of unmarked ewes suckling yearlings on the study area each summer. The maternal care of yearlings observed in 1987 may indicate an adaptation to the short growing season experienced by bighorn living at high elevations.

Table 1. Observations of three radio-collared bighorn ewes associated with yearlings in 1987.

Collar #	Lambing date 1986	Size of yearling	Period of association	Suckling observed # times
737	7/9	Small	5/26-9/22	2
784	5/31	Large	7/01-7/21	0
863	5/31	Large	6/02,7/01-7/15	1

No definite reproductive pattern was evident from the first 2 field seasons. Of the marked ewes, 3 raised lambs both years, 2 raised lambs neither year, and 5 raised a lamb in either 1986 or 1987.

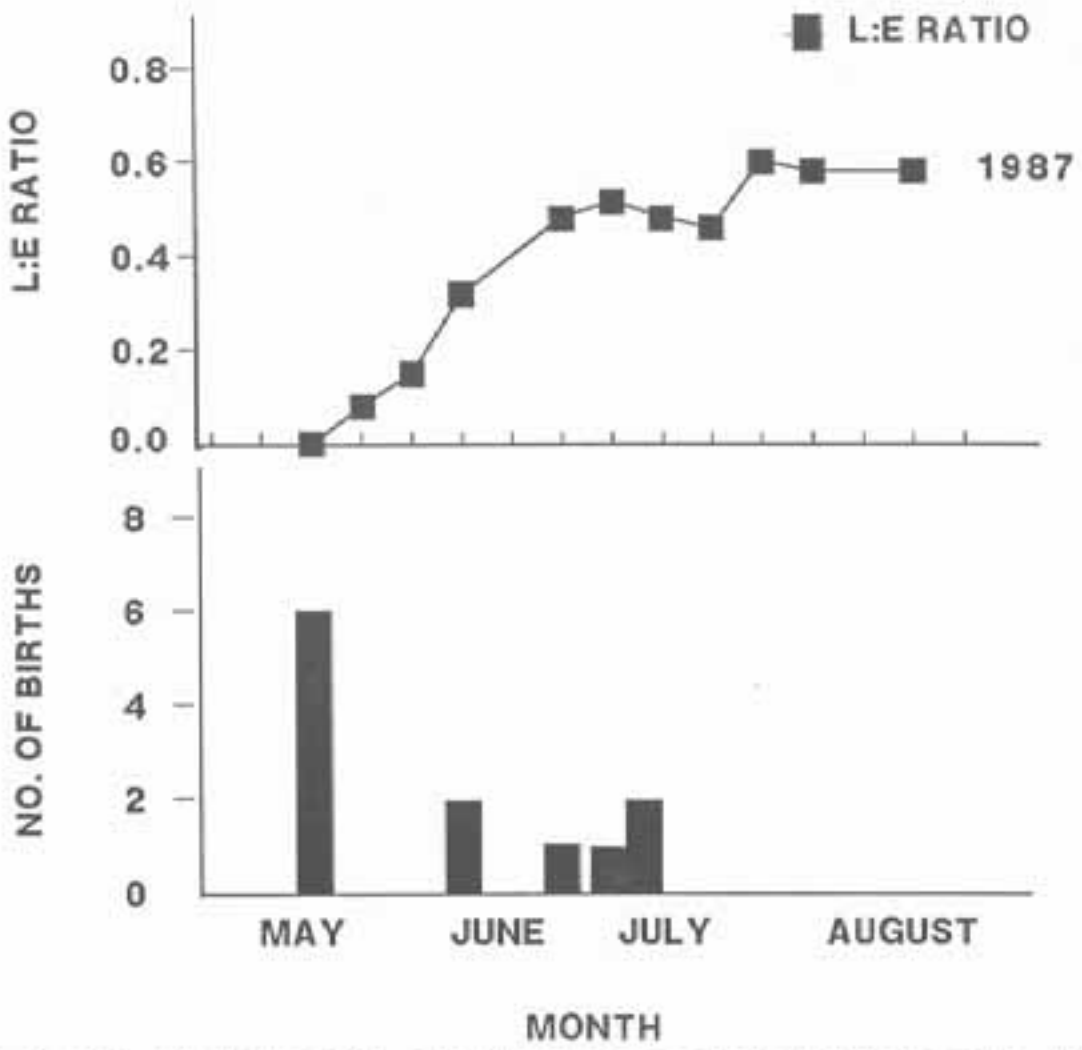

Figure 5. Distribution of birth dates of lambs born to marked bighorn ewes, (data from 1986 and 1987 combined), and weekly lamb:ewe ratios for groups containing marked ewes, 1987, Rocky Mountain National Park and adjacent areas, Colorado.

Estimates of lamb:ewe, and 2-year-old:ewe ratios for groups including marked ewes were lower in 1987 (L:E = .52, 2-yr-old:3 = .20), than in 1986 (L:E = .62, 2-yr-old:E = .36). Yearling-ewe ratios were similar for both years (.27, 1987 and .28, 1986). For groups of unmarked ewes observed on Specimen in 1987, including both north Never Summer and Divide ewes, ratios were L:E = .66, Y:E = .26, and 2-year-old:E = .22.

Reasons for lower production in the Baker ewe-group in 1987 may include the short, cool growing season in 1986, a high proportion of first breeding 3-year-old ewes in the population, (indicated by the 2-year-old to ewe ratio in 1986), or good lamb production in 1986. Lamb production in the marked subsample of ewes was greater than average for the Baker group in 1986 and less in 1987. This fact and the alternate year reproduction of half of the marked ewes suggest that a tendency toward alternate year reproduction may influence annual lamb production.

Population Estimates

South Never Summer group.--The total number of adult ewes in the subpopulation was 38 (C.L. 34-42) in 1986, and 33 (C.L. 29-38) in 1987 based on the Lincoln Index (Table 2). In 1986 the sex-age ratios observed during June and July, and in 1987 those observed June 29 - July 4, when groups including marked ewes were concentrated, were used to estimate size of lamb and yearling classes (Table 2). The results indicated a decline in the total population based on the lower number of adult ewes. Since the confidence limits do not confirm a decline, it may reflect sampling error. A decline would not be expected since production and recruitment in 1986 were excellent and the following winter was mild. The rams in this subpopulation were all young (1/2 curl or less) and traveling with ewe groups. At this time of year older rams were concentrated in the northern Never Summer area and were therefore not included in this subpopulation.

Total west-side area.--Fifty-one adult females were counted on the coordinated ground and helicopter count on June 25-26, 1987. The count included 9 of the 13 marked ewes. These marked ewes provided an estimate of the ewe population, using the Lincoln Index, of 74 adult ewes. Using observed sex-age ratios based on the total classified sheep and the estimate of total ewes, a total population of 238 bighorn was estimated (Table 2). This estimate may be low because only one of 3 subpopulations of ewes and juveniles contained an adequate marked sample.

In 1986, the estimate for the west-side population, using the same methods with the ground counts, was 200. The difference, between the 1986 and 1987 estimates, is due to a 21% increase in the estimate of total ewes (61 to 74) (Table 2). an increase in the total number of ewes was expected since production and recruitment were excellent the first year. However, part of the estimated increase in adult females may have been due to a greater number of ewes moving into the Specimen Mountain area where they were more easily counted. Radio-collared ewes used the Specimen Mountain area more in 1987 than in 1986.

The number of adult rams (3-years or older) was estimated to be 61

and 74 in 1986 and 1987 respectively, based on a 1:1 ratio to adult ewes. This 1:1 ratio was observed in 1986. In 1987 the observed ratio was 1.3:1; however, this total included marked rams from the east-side populations. Therefore, the ratio from 1986 was used.

The west-side bighorn population, including the north and south Never Summer and Continental Divide subpopulations, has approximately doubled in size (from 120 to 240 sheep) since 1976. Possible reasons for the increase include removal of domestic sheep from bighorn ranges outside of Rocky Mountain National Park during the early 1970's and restrictions on visitor use on Specimen Mountain (Stevens 1982).

Table 2. Population estimates for the south Never Summer subpopulation of bighorn sheep and for the total west-side population (including the north and south Never Summer and Continental Divide herds) in 1986 and 1987.

Herd	Year	Ewes	90% C.L.	Lambs[a]	Yearlings	Female 2-yr-olds	Male 2-yr-olds	Rams	Total
South Never Summer	1986	38	(34-42)	24	11	6	8	5	92
South Never Summer	1987	33	(29-38)	17	9	5	2	4	70
West-Side	1986	61		38	18	22		61[b]	200
West-Side	1987	74		39	30	21		74[b]	238

[a] The number of lambs, yearlings, 2-year-olds and rams are estimated by ratios of members of these classes to adult ewes, except for rams of the south Never Summer herd. These were all young rams (one-half curl or less) and were estimated by maximum counts per horn curl class.

[b] The observed ram:ewe ratio was 1:1 in 1986. The observed ram:ewe ratio in 1987 was 1.3:1; however, the ram total included marked rams from east-side populations of bighorn, so the 1:1 ratio was used in estimating the 1987 ram population.

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