

AN ABSTRACT OF THE THESIS OF

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California bighorn sheep (Ovis canadensis californiana) were studied on Hart Mountain, Oregon, during the summer and fall of 1976, and the spring of 1977. The population consisted of a minimum of 196 sheep in June, 1977. The high number of lambs observed and high lamb:ewe ratios throughout both years of the study indicated that the population was expanding rapidly. Sheep occupied about 85 percent of the length of the mountain; ewe-lamb groups occupied 25 percent. Both ewes and rams occurred on two distinct ranges during all seasons, and interchange of individuals between the two ranges was minimal during the study. Most rutting activity occurred during November. Lambs were born between mid-April and late May.

Fifteen habitats within the ewe-lamb range were identified and sampled for plant species composition. A habitat preference value (HPV) was calculated for each habitat on Hart Mountain, based on use by ewe groups. Bluebunch wheatgrass (Agropyron spicatum) and big sagebrush

(Artemisia tridentata) were the two most widely distributed plant species in the ewe-lamb range; Idaho fescue (Festuca idahoensis) provided the greatest amount of herbaceous cover. Daily activities of ewe groups centered around four contiguous bedding grounds and three principal feeding areas. Topography, as well as vegetational composition, appeared to influence the preference of ewes for certain locations, particularly for major cliff formations and adjacent feeding areas. Habitat factors unique to the present ewe-lamb range are discussed as possible determinants of its location.

Status and Habitat Use of California Bighorn Sheep
on Hart Mountain, Oregon

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TABLE OF CONTENTS

| <u>Chapter</u> | <u>Page</u> |
|--|-------------|
| I. Introduction. | 1 |
| II. Description of Study Area | 4 |
| III. Methods | 5 |
| Population Characteristics | 5 |
| Use of Habitats. | 5 |
| IV. Bighorn Sheep Habitats. | 8 |
| Hart Mountain. | 8 |
| Poker Jim Ridge. | 11 |
| V. Population Characteristics. | 12 |
| Population Size and Composition. | 12 |
| Mortality. | 12 |
| Group Size and Composition | 13 |
| Location and Use of Ranges | 14 |
| Discussion | 16 |
| VI. Use of Habitats | 20 |
| Activity Pattern | 20 |
| Seasonal Use of Habitats | 21 |
| Use of Forage. | 23 |
| Sources of Water | 24 |
| Availability and Use of Minerals | 24 |

| | <u>Page</u> |
|---|-------------|
| Competition with Other Herbivores | 25 |
| Reaction to Disturbance | 26 |
| Discussion. | 27 |
| Exhibits | 31 |
| Literature Cited | 40 |
| Appendix A | 43 |
| Appendix B | 48 |

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CHAPTER I

INTRODUCTION

The decline of bighorn sheep (Ovis canadensis) populations in the United States coincided with the settlement of the West by European man. The reduction in number and distribution of sheep occurred throughout the ranges of both the California bighorn (Ovis canadensis californiana) and the Rocky Mountain bighorn (Ovis canadensis canadensis). The two subspecies were affected by many of the same decimating factors, including two epidemics of scabies (Bailey 1936; Honess and Frost 1941; Packard 1946; Jones 1950), unrestricted hunting (Gifford 1939; Honess and Frost 1942, Packard 1946; Sugden 1961), and competition with sheep and cattle on winter ranges (Gifford 1939; Packard 1946; Sugden 1961). The California bighorn survived in greatly reduced numbers in British Columbia and California (Spalding and Mitchell 1970).

In Oregon, the California bighorn historically inhabited mountain ranges from the Cascades eastward into the southeastern quarter of the state (Cowan 1940). After two major declines in the state, remnant populations survived on Steens and Hart mountains until about 1915 (Seton 1929).

California bighorns were successfully reintroduced to Hart Mountain in 1954 after an unsuccessful attempt in 1939 (Deming 1961). The present population originated from the 1954 transplant of twenty sheep, removed from the Williams Lake vicinity of British Columbia. The Oregon State Game Commission (Oregon Department of Fish and Wildlife) released the

sheep into a 626-acre (259 ha.) enclosure on the west face of Hart Mountain. By 1961 the herd had increased to more than 70 individuals, including several that had escaped or had been released from the pen (Deming 1961). From 1960 to 1977, 84 sheep were transplanted from the Hart Mountain population to other suitable ranges. Transplants were made initially to Steens Mountain, the Owyhee Reservoir area, the Strawberry Mountains, and Abert Rim in Oregon, and to the Charles Sheldon National Antelope Range in northern Nevada (Masson 1975). During the course of the present study, additional transplants were made to Abert Rim and the Pueblo Mountains in Oregon.

Geist (1967) has stated that prehistorically, bighorn sheep probably demonstrated the adaptive tendency to migrate in groups between isolated patches of mountain habitat. This behavior would have facilitated the extension of seasonal ranges and the colonization of new territories (Geist 1967). In the past fifty years, the activities of man have not only limited the size of sheep ranges, but have blocked potential dispersal routes. Transplanting individuals now appears to be the only practicable means of repopulating former sheep ranges.

Because ancestral sheep ranges have undergone considerable disturbance in the recent past, each reintroduction should be examined periodically to evaluate the quality of the population on its new range. The Hart Mountain population had not been closely examined since its release from the enclosure in the early 1960's, yet it has been the source of all other California bighorn sheep populations in the state. The objectives of this study, therefore, were 1) to estimate the size, composition, and productivity of the population, 2) to locate seasonal

ranges and describe seasonal movements of the sheep during the study period, 3) to locate and describe sheep habitats within the ewe-lamb range, and 4) to assess the use of habitats by ewe-lamb groups.

CHAPTER II

DESCRIPTION OF STUDY AREA

Hart Mountain is located 65 miles (104.6 km.) northeast of Lakeview, in south-central Oregon (Fig. 1). The thirty-mile (48.3 km.)-long, fault-block mountain rises abruptly from the Warner Valley, on its west side, to an elevation of over 8000 feet (2400 m.). The west face is precipitous, composed of extensive cliffs, talus slides, and grass-shrub slopes. The mountain top is a plateau that slopes gently into the Catlow Valley on the east side. The southern half of the mountain is known as Hart Mountain; the northern half is called Poker Jim Ridge (Fig. 1). Vegetation is characteristic of the shrub-steppe communities described by Daubenmire (1970) and by Franklin and Dyrness (1973). Precipitation averages 10.5 inches (26.7 cm.) annually, most as winter and spring snow (Deming 1961). The Hart Mountain National Antelope Refuge was established in 1936 and presently covers approximately 275,000 acres (111,935 ha.) of the mountain and surrounding rangeland, including the current range of the bighorn sheep.

CHAPTER III

METHODS

Population Characteristics

Sheep were observed from late June through September, 1976, November through mid-December, 1976, and mid-April through June, 1977. In order to evaluate lamb survival, observations were concentrated in the ewe-lamb range from April through August. The ram range was surveyed bi-weekly during those months and became the focus of observations in September, during the hunting season. Observations in November and December were concentrated on the rutting ground.

Daily observations of sheep were made from the ground with a 20X spotting scope. The purpose was both to index and to monitor the population, on an equal basis. Indexing procedures included locating, counting, and classifying groups of sheep. Classification was based on the eight class system of Geist (1971): 1) lambs; 2) yearling ewes; 3) adult ewes; 4) yearling rams; 5) class I rams, 2 years of age; 6) class II rams, 3-5 years of age; 7) class III rams, 5-8 years of age; and 8) class IV rams, 8+ years of age. Monitoring sheep involved describing their activities over a period of time. Activities recorded included moving, feeding, standing, and resting.

Use of Habitats

Ten habitats were identified, subjectively, within the ewe-lamb range on Hart Mountain. These were delineated by vegetational and

topographic features of the area that appeared to influence the character or location of sheep activity. Habitats were mapped, and the approximate acreage of each within the ewe-lamb range was calculated.

The ten habitats on Hart Mountain, plus an additional five identified on Poker Jim Ridge, were sampled for plant species composition in June, 1977. Sampling was done within a representative stand of the major plant community defining each habitat. Three 50-meter line transects were placed in each stand. Along each transect the following parameters were measured: 1) herbaceous cover of major species, 2) shrub cover, 3) shrub density, and 4) mean shrub height. Cover of major herbaceous species was obtained by estimating the percent each species covered within 25 x 50 centimeter plots located every 5 meters along the tape. Shrub cover was measured using the line interception method (Canfield 1941). Measurements of shrub density included tabulating all shrubs that were rooted in a belt 1 meter wide along the left side of the 50 meter transect. Mean shrub height was calculated from measurements of the nearest shrub to each 5-meter point.

Use of habitats on Hart Mountain by ewe-lamb groups was monitored in two ways. First, the number of sheep performing each activity in each of the ten habitats was recorded at ten-minute intervals. Numerical values indicating sheep preference for each habitat were calculated from the percentage of total use each habitat received, and the percentage of total acreage that each covered. A preference rating of 1.0 indicated that sheep use of a habitat was equivalent to its occurrence over the entire ewe-lamb range.

Simultaneously, more specific interactions of sheep with their environment were noted. These included the use of identifiable plant species, habitat components, water sources, salt licks, and infrequently occupied areas, as well as evidence of competition with other species, and the reaction of sheep to disturbance.

CHAPTER IV

BIGHORN SHEEP HABITATS

Fifteen bighorn habitats were identified on the ewe-lamb range, by prominent physical features and from animal observations; the ten that occurred on Hart Mountain were mapped (Fig. 2). Descriptions of the habitats were based on the results of sampling the vegetation (Table 1; Appendix A). Selection of names was based on dominant vegetation and/or prominent physical features of each area.

Hart MountainThe Moist Draw Habitat

Ten major draws cut the west face of the ewe-lamb range, and a large creek bed (Willow Creek) extended 2.8 miles (4.5 km.) across the high elevation flat. Springs supplied moisture to these draws, resulting in the growth of rushes (Juncus sp.), sedges (Carex sp.), and Kentucky bluegrass (Poa pratensis). Quaking aspen (Populus tremuloides) and Wood's rose (Rosa woodsii) comprised most of the sparse layer of woody vegetation.

The Bunchgrass Habitat

Large patches of Idaho fescue (Festuca idahoensis) appeared in the northern half of the ewe-lamb range, at mid-elevations. These grassy areas were separated by expanses of sagebrush-grass cover. The dominant grass, Idaho fescue, and a variety of forbs were distributed in clumps and covered only 30 percent of the total soil surface.

The Big Sagebrush-Bunchgrass Habitat

This habitat covered approximately 28 percent of the range, and occurred at all except the highest elevations, (Table 2). Tall individuals of big sagebrush (Artemisia tridentata), and bearded bluebunch wheatgrass (Agropyron spicatum) characterized the habitat.

The Sagebrush Basin Habitat

The northern slopes of Hart Mountain formed a protected basin at the juncture with Poker Jim Ridge. Surrounded by talus and rock on three sides, the basin contained the only extensive north and north-northwest facing slopes within the range. Rocky soils supported big sagebrush and low sagebrush (Artemisia arbuscula) at almost equal densities. Herbaceous cover was primarily Thurber needlegrass (Stipa thurberiana), Idaho fescue, and locoweed (Astragalus sp.), contrasting with the bluebunch wheatgrass understory of most other shrubby areas on the mountain.

The Rock Outcrop Habitat

Outcrops were patches of broken rock that surfaced throughout the Big Sagebrush-Bunchgrass Habitat and around the rim of the high plateau. The dominant grass species were Idaho fescue and bluebunch wheatgrass.

The Talus-Shrub Habitat

Talus, or rock slides, occurred at the base of cliffs and were practically void of vegetation. Shrubs that were able to survive in this rocky terrain included rockspirea (Holodiscus dumosus), green rabbitbrush (Chrysothamnus viscidiflorus), and wax current (Ribes cereum).

The Cliff-Shrub Habitat

Cliffs within the ewe-lamb range were vertical rock walls dissected by narrow, horizontal benches. Average height of the cliffs was 350 feet (107 m.). Cliff benches were vegetated with a variety of tall, dense shrubs, dominated by big sagebrush and rockspirea. The sparse herbaceous layer consisted of several forb species and a grass species that occurred only in this habitat, spike fescue (Hesperochloa kingii).

The Grass-Boulder Habitat

Above the cliffs, at elevations higher than 6800 feet (2074 m.), bluebunch wheatgrass was replaced by Idaho fescue, and the slopes were strewn with boulders. Shrubs were low and dense. Herbaceous vegetation, principally Idaho fescue, provided the most complete ground cover of all the habitats.

The Bluegrass Flat Habitat

At about 7100 feet (2165.5 m.) elevation, Hart Mountain leveled to a high flat. Shrub vegetation became sparse and Sandberg's bluegrass (Poa sandbergii) replaced Idaho fescue as the dominant grass. This habitat contained a dense layer of lupine (Lupinus sp.) and Hood's phlox (Phlox hoodii).

The Low Sagebrush Plateau Habitat

A rocky plateau extended half the length of the ewe-lamb range at its highest elevations. It was covered by a dense mat of low sagebrush and green rabbitbrush. Sandberg's bluegrass and a variety of low forbs comprised the sparse herbaceous layer.

Poker Jim Ridge

The Lakebed Margin Habitat

During dry seasons, mudflats occurred at the base of Poker Jim Ridge, as the Warner Lakes receded. Along the margin of the lakebed, these flats supported co-dominant grass species, foxtail barley (Hordeum jubatum) and western wheatgrass (Agropyron smithii).

The Boulder-Big Sagebrush Habitat

Big sagebrush plants averaging 3 feet (97 cm.) in height, and extremely rocky soil characterized this habitat. Herbaceous cover was limited. The most abundant grass species was cheatgrass (Bromus tectorum), an annual species common to disturbed.

The Talus-Big Sagebrush Habitat

Talus habitat on Poker Jim Ridge was similar to that on Hart Mountain, except that the plant composition of the two areas differed. On Poker Jim Ridge, big sagebrush and cheatgrass were virtually the only species growing on talus, probably due to the slightly drier site.

The Cliff-Big Sagebrush Habitat

The diversity of vegetation on the Cliff-Big Sagebrush Habitat was reduced, in comparison to that on the Cliff-Shrub Habitat of Hart Mountain, also a probable consequence of the drier climate on Poker Jim Ridge.

The Rocky Flat Habitat

At its highest elevations, Poker Jim Ridge was a broad rocky flat, sloping gently southeastward. Extremely rocky substrate in this habitat was covered by low sagebrush, similar to the plants occurring on the Bluegrass Flat of Hart Mountain. The major grass species was bluebunch wheatgrass.

CHAPTER V

POPULATION CHARACTERISTICS

Population Size and Composition

The total number of sheep in the Hart Mountain population was estimated to be a minimum of 196 in June, 1977, based on actual counts of 46 lambs, 32 yearlings, and 61 rams (two years of age and older), and an estimate of 57 ewes (Table 3). The ewe estimate was based on an actual count of 36 ewes and on an estimate of a minimum of 21 ewes in a group containing 21 lambs. Classification of the 61 rams was as follows: 8 Class I, 16 Class II, 18 Class III, 11 Class IV, and 8 unclassified (Table 3).

At least 46 lambs were born in the spring of 1977. A minimum of 44 lambs comprised the 1976 cohort, since 32 yearlings were observed the following spring, and 12 lambs were removed in transplant operations during the winter of 1976-77. Lamb:ewe ratios decreased from 91.7:100 to 77.0:100 from July to December, 1976 and from 86.5:100 to 81.3:100 from April to June, 1977 (Fig. 3). The overwinter survival of lambs from 1976 appeared to be excellent, since the yearling cohort nearly equalled the number of new lambs in the spring of 1977. Lambs were born between mid-April and late May, 1977, with the highest number of births occurring the first week of May. There appeared to be no twins in either the 1976 or the 1977 cohorts.

Mortality

No instances of mortality were witnessed during the study. Examination of the lung tissue from three hunter-killed rams revealed nodules of

lungworm (Protostrongylus stilesi) in all three cases. This was consistent with the findings of Kistner et al. (1977). No sheep were observed to exhibit the external symptoms of the lungworm-pneumonia complex described by Woodard, et al. (1974).

Coyotes (Canis latrans) and golden eagles (Aquila chrysaetos), both potential predators of bighorn sheep (Kennedy 1948; Smith 1954), were regularly observed on ewe-lamb ranges, however, no predation on sheep was witnessed. All sightings of coyotes were made in grass-shrub terrain rather than in cliff areas. In most cases sheep appeared to be aware of predators but showed no alarm. Ewes frequently looked up when raptors flew low overhead, and on two occasions they exhibited protective responses toward their lambs, behavior similar to that witnessed by Drewek (1970) in Idaho.

Groups Size and Composition

Ewe-lamb groups were composed of ewes, lambs, yearling ewes, yearling rams, and some two-year-old rams. Average group size for ewe-lamb groups observed during the entire study was 14 individuals. The largest groups occurred in November and June, with mean group sizes of 19.6 and 16.7 respectively; the smallest groups occurred in April and May, with means of 8.1 and 9.7. Ewe-lamb groups varied in size and composition throughout the day and were usually led by a ewe.

Yearling ewes and rams and Class I rams tended to form groups apart from adult ewes and lambs during the spring. While no yearling groups were observed in the summer or fall, 11 such groups, without ewes, were observed from April to early June. During this period, four additional yearling groups were observed with lambless ewes, in which the young ewes

and rams far outnumbered the adult ewes. In late spring, three nursery groups were seen near cliffs, each consisting of 1 ewe with 7, 5, and 13 lambs, respectively.

Ram groups observed in spring and summer were composed of Class I-IV rams, although the majority of Class I rams remained on ewe-lamb ranges. Group sizes ranged from 1 to 20, averaging 7.7 members. During the rutting season, rams became incorporated into ewe-lamb groups, frequently forming ram sub-groups which contained no more than 3 individuals.

Location and Use of Ranges

Bighorns inhabited about 85 percent of the length of Hart Mountain. They occurred in two distinct areas of use, separated by approximately four miles (6.4 km.) of mountain in which sheep were never observed (Fig. 1). The southern area of sheep use, referred to as the Hart Range, extended from the southern end of the mountain to one mile beyond its northern boundary with Poker Jim Ridge. The northern area, the Poker Jim Range, included the northern ten miles (16.1 km.) of Poker Jim Ridge.

Ewe-lamb and ram groups occupied separate ranges except during the rut. The division between home ranges was more distinct on the Hart Range, where rams stayed south of Juniper Canyon during spring and summer months (Fig. 1). With the exception of four sightings south of Juniper Canyon, ewe-lamb groups were always observed north of the ram area. On the Poker Jim Range ram and ewe home ranges appeared to overlap at higher elevations, although rams were usually sighted farther north than ewes.

Seasonal movements of ewe-lamb groups was minimal during the study. On the Hart Range, lambing, summer, and rutting home ranges were not distinct, although there were slight shifts in the center of activity.

Ewe-lamb groups were regularly observed below 5600 feet (1700 m.) elevation during the spring and above 5600 feet (1700 m.) during the summer and fall, when their activity was centered one to two miles (1.6 to 3.2 km.) south. Reliable reports indicated that the Hart Range rams, farther south on Hart Mountain, exhibited a similar shift in elevation between early spring and summer (Carroll Flick, pers. comm.). On the Poker Jim Range the location of sheep varied little throughout the study, with the exception of ram movement onto the ewe-lamb home range during the rut. Seasonal movements in this area did not involve elevational shifts, since sheep were seen to move freely between the base and the top of the ridge throughout the study.

Breeding and lambing took place on both the Hart and Poker Jim Ranges. On the Hart Range, principal rutting grounds were located on the ewe-lamb summer range. Most rutting activity occurred at high elevations, particularly on the top plateau. During fall months, sheep were observed farther east on the mountain top than in other months, up to a mile (1.6 km.) from the west rim. Fewer observations of the rut were made on the Poker Jim Range, however, all classes of sheep were seen at all elevations.

Lambing occurred within the ewe-lamb summer ranges, characteristically in the most protective cliff areas. On the Hart Range, lambs were born on North Point and in the North Cliffs (Fig. 1). On Poker Jim Ridge lambing areas were limited to high cliffs in the southern half of the ewe-lamb home range.

Discussion

The high number of lambs born in both 1976 and 1977, combined with data indicating negligible mortality in the zero age class and high recruitment of lambs into the yearling class showed this to be a rapidly expanding population, according to the characteristics of expansion described by Geist (1971). During the year of the study, growth of the population may have approached or surpassed the theoretical maximum rate of increase for bighorn sheep proposed by Buechner (1960) ($r = 0.258$), since his proposed corresponding lamb:ewe ratio appears to have been exceeded in the Hart Mountain population. In calculating the lamb:ewe ratio, Buechner considered yearling ewes to be in the ewe class, thus, his proposed maximum lamb:ewe ratio was 60:100. In the Hart Mountain population, when half of the 32 observed yearlings were added to the 57 ewes of June, 1977, the estimated lamb:ewe ratio was 63:100.

Growth at a rate greater than that of Buechner's model should occur only in populations which do not exhibit his basic assumptions for the model, particularly one of the following three: 1) one lamb born per ewe per year, 2) birth of first lambs when ewes are three years old, or 3) an equal ratio of rams to ewes. The population on Hart Mountain appeared to meet the first and third assumptions, but may have departed from the model in the age of first breeding of ewes. Yearling ewes were actively courted by adult rams, but were indistinguishable from adult ewes by the following spring. Some may well have produced lambs. Since the population was observed for only one year, it is not known whether this was an isolated year of extremely high productivity, or was one of several years in a trend of expansion.

Twinning was not observed in this study, nor was it encountered in the studies of Smith (1954), Sudgen (1961), Welles and Welles (1961), Woodgerd (1964) or Geist (1971). Twins were considered by Geist (1971) to be rare in all subspecies of bighorn sheep, however, Spalding (1966) provided contradictory evidence from British Columbia, when he examined the reproductive tracts from 11 pregnant ewes and found 4 to be carrying twin fetuses. Most population information has been gathered from Rocky Mountain bighorn studies. The findings of Spalding and Van Dyke (in prep.) suggest that twinning may be more common in the California subspecies.

The extent of interchange between sheep from the two ranges was not established, however, the lack of sightings in the area between the two ranges suggested that mixing was minimal during spring, summer, and fall. Actual counts of sheep in May and June, 1977, indicated that 47.4 percent of the total population inhabited the Hart Range, including 54.3 percent of the lambs, 56.3 percent of the yearlings, 54.4 percent of the ewes, and 31.1 percent of the rams (Table 3). Although the population was almost equally divided between the two ranges in spring, 1977, during the 1976 rutting season 119 sheep, or 68.4 percent of the estimated population at that time, was seen on the Hart Range. This number was reduced when 24 individuals were removed from the Hart Range in December and January. Yet, there still appears to have been a net movement of sheep from the Hart to the Poker Jim Range between November, 1976, and May, 1977. The fact that both rams and ewes were seen on both the ranges during each of the three study periods is evidence that neither area was used only as a seasonal range, by either ram or ewe-lamb groups. The long-term trend of population movement between the two ranges could not be determined within the time span of this study.

The presence of seasonal shifts in elevation in the Hart Range sheep and the apparent absence of such movements in the Poker Jim Range sheep may have been related to distinct differences in the weather and topography of the two ranges. The Hart Range is approximately 800 feet (240 m.) higher in elevation than the Poker Jim Range and received more precipitation. The top one-third of the Hart Range was covered by light snow for ten days in December and May, at which time most sheep were observed to feed below the snow line. The Poker Jim Range was seen under snow cover only twice, for less than a day each time. There also was a difference in the availability of free water on the two ranges. On Hart Mountain, springs, seeps, or ponds existed adjacent to feeding areas on all seasonal home ranges. On Poker Jim Ridge, the principal source of water in dry months appeared to be the lakes at the base of the ridge. Thus, during at least two seasons sheep regularly moved to the base to drink and to higher elevations, including the Rocky Flat, to feed. The location of food and water may have precluded seasonal shifts in elevation.

Bighorn rams are known to occupy as many as six seasonal home ranges in a year; ewes may move among four (Geist 1971). On Hart Mountain it appeared that the number of different seasonal home ranges was reduced to a maximum of four for rams (summer, rut, winter, spring) and three for ewes (summer, winter, spring). These ranges were overlapping or adjacent, so sheep did not migrate between them, but simply shifted the location of their daily activities. Similarly limited seasonal movements were noted in Idaho by Smith (1954) and in Wyoming by Honess and Frost (1942), both of whom found weather to be the major factor determining the onset of

seasonal migration. The unusually mild winter of 1976-77 at Hart Mountain may account for the limited movement of sheep in that year.

Despite the high numbers of sheep on the Hart Range breeding ground, rutting activity involving adult rams during November was minimal. Only three major interactions were witnessed among adult rams. Breeding was not observed. This concurred with observations of California bighorns by Jones (1950) in the Sierra Nevadas and Drewek (1970) in Owyhee County, Idaho. Shackleton (1973) after observing two populations of different sizes near Banff, Alberta, attributed reduced aggression in rams of the smaller population to the greater amount of contact they experienced throughout the year on shared home ranges. Hart Range rams presented a comparable situation. The average size of ram groups on the Hart Range (6.4 members) was high in proportion to the total number of rams observed on that area (14). These rams, then, may have had fewer aggressive encounters during the rut as a result of frequent social contact on their other home ranges. The lack of observed copulations may be related to the estrus cycle of bighorn sheep. Several breeds of domestic sheep tend to mate at night or dawn (Fraser 1968), in synchrony with the nocturnal onset of estrus (Robertson and Rakha 1965). Although bighorns were observed during all daylight hours, breeding may have occurred during hours of limited visibility or darkness.

CHAPTER VI

USE OF HABITATS

Activity Pattern

During the summer months, ewe-lamb groups on Hart Mountain followed a pattern of daily activity which can be divided into six phases: 1) pre-dawn until just after dawn - left bedding sites; 2) early morning - moved and fed, with intermittent resting; 3) mid-morning until mid-afternoon - fed, with some movement between feeding areas; 4) late afternoon - fed intensively, with little movement; 5) evening - moved toward bedding grounds; 6) dusk until dark - fed on bedding grounds. The term "resting" refers only to daytime bedding, and "moving" denotes movement to a new location, as opposed to incidental wandering while foraging. Bighorn sheep on Hart Mountain did not exhibit the pattern of morning and afternoon feeding periods separated by a distinct midday rest, as do many bighorn and other ungulate populations (Jones 1950; Smith 1954; Brandenburg 1955; Geist 1971). Honess and Frost (1942) found their Wyoming sheep population to be similarly irregular about the midday rest period. Feeding and moving were the two principal activities of the sheep on Hart Mountain during daylight hours; resting and standing comprised less than 20 percent of all activity throughout the summer days. At dusk, the sheep continued to feed until they were no longer observable.

Seasonal variation in this pattern of activity was evident in the relative amounts of time sheep spent moving and feeding. Sheep moved from bedding grounds to feeding areas more quickly during November and December than during spring and summer months, often reaching feeding areas by the first light of day. This may have been related to the decrease in photoperiod in late fall, or to the general restlessness of sheep during the breeding season. Activity in the spring was characterized by more resting in the first half of the day, and by a sharp increase in movement and a reduction in feeding in late afternoon.

Seasonal Use of Habitats

All four bedding grounds observed on Hart Mountain were located in extensive stands of the Cliff-Shrub Habitat along the benches of cliff formations rising at least 350 feet (107 m.). Less extensive cliff areas did not appear to be used as bedding grounds, nor did cliffs which did not have large talus slides at the base. Sheep bedded most frequently in the cliffs of North Point (Fig. 2), the most isolated and the highest mass of cliffs in the ewe-lamb range. Bedding areas which received markedly less use were located in two concave cliff formations just south of North Point and in the cliffs north of and below North Point. The latter were used primarily in the spring as both bedding and lambing areas, when ewes were at slightly lower elevations.

Early morning activity was centered in and peripheral to bedding grounds, as the sheep began to move onto the adjacent Bunchgrass and Big Sagebrush-Bunchgrass Habitats. Movement during summer months followed three principal routes: over the cliffs to the mountain top

via the Grass-Boulder Habitat, below the cliffs to the Bunchgrass or Big Sagebrush-Bunchgrass slopes, or northeast into the Sagebrush Basin. The first route was used most frequently; 42 percent of the summer-time feeding activity occurred in habitats above the cliffs (Table 4). Sheep moved into the Sagebrush Basin and onto lower slopes less frequently, and these areas received 28 and 20 percent of the feeding activity, respectively (Table 4). The Boulder and Rock Outcrop Habitats were used extensively as standing and resting sites.

Normal daily movement followed a circular pattern. Secondary bedding grounds and a variety of feeding areas allowed the sheep several possible routes of travel, and since the entire herd rarely moved as one group, separate bands travelled different routes to either shared or separate feeding areas. No individual was followed for several consecutive days, but it appeared that the membership of bands was flexible.

In late fall and early spring, sheep use was concentrated in certain areas. During the rut, 81.5 percent of feeding occurred on the top of the mountain, on either the Bluegrass Flat or the Low Sagebrush Plateau. In the weeks following lambing, ewes rarely left the protection of Cliff-Shrub areas and adjacent Bunchgrass and Big Sagebrush-Bunchgrass slopes. Thus, during April and May, no sheep were seen on the Low Sagebrush Plateau, only 21 were seen on the Bluegrass Flat and 8 in the Sagebrush Basin, all without lambs.

Areas receiving a high preference rating were the Cliff-Shrub and the Low Sagebrush Plateau Habitats (Table 4). The preference of sheep for cliffs is reflected in their heavy use of the area during spring lambing season, summer mornings and evenings, and as bedding and escape

terrain all year. Approximately 35 percent of all activity during the rut occurred on the Low Sagebrush Plateau. The Big Sagebrush-Bunchgrass Habitat received relatively little use and a low preference rating (Table 4). This may be a result of its widespread occurrence in the southern half of the ewe range, which received far less use than the northern portion.

Ewes and lambs appeared to avoid wooded areas, which covered 1.44 percent of the range, but received only 0.39 percent of sheep use. Observations of ewe groups among trees were limited to three sightings in quaking aspen groves, two on western juniper (Juniperus occidentalis) slopes, and one in a mountain mahogany (Cercocarpus ledifolius) grove.

Use of Forage

This study did not include an analysis of the food habits of sheep, however, on several occasions it was possible to discern the forage class or the plant species being consumed. During spring, summer, and fall, sheep fed principally on grasses, even when feeding along Cliff-Shrub Habitat. Bluebunch wheatgrass and giant wildrye (Elymus cinereus) were the two grass species observed being taken. Upon closer examination, both species showed evidence of light use. Drewek (1970) found these two species to be the most common foods of sheep in Owyhee County, Idaho, and other studies have concluded bluebunch wheatgrass to be the most important (Blood 1967) or the most nutritious (Demarchi 1965) grass in the bighorn diet. It is one of the most abundant grasses on the sheep range at Hart Mountain (Table 1).

The most common shrub species in the sheep diet appeared to be big sagebrush, as was noted by Sugden (1961) in British Columbia and Drewek

(1970) in Idaho. Sheep were also observed to forage on mountain snow-berry, common chokecherry (Prunus virginiana), rockspirea, Wood's rose, and greasewood (Sarcobatus vermiculatus), a sodium concentrating species.

Sources of Water

Observations of sheep at water sources indicated that they drank from creeks and springs on Hart Mountain and occasionally sought water in patches of snow and puddles in boulders. Willow Creek was the primary source of water on top of the mountain. Sheep on Poker Jim Ridge were never observed at water. However, seeps flowed from the cliffs during months when there was precipitation. Sheep were seen feeding on the dry lakebed of Bluejoint Lake (Fig. 1), and several local ranchers reported having seen them at the edge of the lake.

The frequency with which sheep drank could not be determined since water was available throughout the range. However, 11 of the 20 sightings of sheep at visible water sources were made during November and April. This may have been related to low moisture content of forage during these months or to a higher requirement for water during the stress periods of rutting and lambing (Wilson 1968).

Availability and Use of Minerals

No mineral licks were observed on the ewe range, however, groups of sheep congregated at a cattle salt lick on four occasions during the rut. The use of natural mineral licks by bighorn sheep has been well documented. Packard (1946) and Wilson (1968) have each speculated that certain sheep populations have undergone serious declines as a result of mineral deficiencies. Seton (1929) and Dixon (1940) attributed the

use of licks to the lack of minerals in most non-alkaline sheep ranges. Both men claimed that at low elevations, in the vicinity of alkaline lake beds, sheep would ingest adequate amounts of mineral salts in or with their forage. Soils at Hart Mountain are known to be alkaline, and the sheep on Poker Jim Ridge appeared to feed regularly at low elevations and at the margins of the alkaline Warner Lakes.

Competition With Other Herbivores

Use of the sheep range by mule deer (Odocoileus hemionus hemionus) and cattle was light during the three seasons of this study. Deer were observed in all sheep habitats except the Cliff-Shrub. On the face of the mountain, they were most frequently seen on the Bunchgrass slopes and in Moist Draws, at elevations lower than the sheep. Twenty-six sightings were made of deer within 400 yards (366 m.) of sheep, and ten of these occurred on the sheep rutting grounds during November and December. In only 13 (50 percent) of the 26 instances, did sheep appear to be aware of deer; in 7 (26 percent) instances the sheep reacted noticeably to the presence of deer. Sheep reactions varied; on three occasions the sheep fled and on four they approached and fed among the deer. Sheep appeared to be bolder when adult rams were present, and when the deer were visible from a distance.

Cattle grazed on sheep ranges between late May and December, but did not use areas of steep or rocky terrain. Low numbers of cattle shared portions of the mountain top with sheep between late summer and December, congregating principally along moist meadows at the eastern edge of the sheep range. Vegetation on Hart Mountain appeared to be heavily utilized only at low elevations, below principal areas of sheep

use during spring, summer, and fall. On Poker Jim Ridge, cattle grazed on the Lakebed Margin Habitat, and peripheral groups ranged onto lower elevations of the Boulder-Big Sagebrush Habitat.

Although competition for forage between cattle and bighorns appeared to be minimal, sheep tended to avoid cattle when the two species were seen in the same vicinity. On the five occasions that sheep were aware of cattle within 400 yds. (366 m.), they showed no alarm, but moved away. Sheep were never seen mingling with cattle as they did with mule deer. Drewek (1970) found that sheep avoided cattle unless they were accustomed to their presence on the range. Wilson (1968) concluded that sheep would occupy an area only after cattle were removed.

Reaction to Disturbance

Sheep were easily disturbed and exhibited alarm or escape behavior in response to a variety of intrusions. The effects of disturbance by humans can be grouped into two classes -- immediate and longterm. The immediate reaction of sheep was to escape to cliff terrain if it was accessible, or out of sight if it was not. The longterm reaction of large groups (40 or more sheep) was to avoid the vicinity of the disturbance for hours or days. In seven of the nine instances observed, sheep were not seen in the area until at least 36 hours later.

At Hart Mountain, human disturbance to bighorns is minimal except during the sheep hunting season in late September and the muzzle loading deer hunt in early October. During the 1976 sheep hunt, rams showed a net movement of about two miles (3.2 km.) northward, into the lower elevations of the ewe-lamb range.

Discussion

Extensive stands of the Cliff-Shrub Habitat provided critical bedding, lambing, and escape terrain for bighorns at Hart Mountain. One location within the habitat, North Point, was the focal site of most of these activities, and peripheral cliff areas were used less frequently. The location of cliffs on the mountain probably influenced the daily circuit of travel of the sheep. Honess and Frost (1942), in observing bighorn sheep on a larger range, found that the sheep maintained several bedding areas, returning to the closest area each night. The sheep on Hart Mountain were more limited in the distance they could travel each day, and they returned to some point on the same group of cliffs each evening.

Bighorns are not considered to be particularly selective about the plant species in their diet. Instead, they choose plants by phenology, selecting the youngest, tenderest plants and plant structures available as they move over feeding areas (Couey 1950; Sugden 1961; Moser 1962). The tendency of sheep to select greener forage may explain why most sheep fed above the cliffs at Hart Mountain, between mid-summer and December. The age of lambs may also have influenced the seasonal preferences of the sheep for certain feedings areas. Ewes appeared less willing to leave the protection of cliffs when the lambs were young.

The Sagebrush Basin was used heavily as a feeding ground during all seasons except early spring, when ewes fed only on slopes adjacent to cliffs. The location of the Basin near the north end of the mountain afforded protection from the weather and easy access to the cliffs of North Point. The area supported high densities of Thurber needlegrass

and locoweed, each reported to be an important plant species in the California bighorn diet (McCullough and Schneegas 1966; Sugden 1961).

Preference ratings indicated that ewes preferred to feed on Bunchgrass slopes four times as often as on adjacent Big Sagebrush-Bunchgrass slopes. This may have been a result of the location of the Bunchgrass slopes directly below North Point, the plant composition of the area, or a preference for shrubless, grassy terrain.

In 1957, an estimated carrying capacity of 330 sheep was established for Hart Mountain (Rouse 1964). This was calculated from proper use values of the plants for all animals utilizing the area. In 1977, the population was at 59.4 percent of the estimated carrying capacity, and limits to its growth had not yet become apparent. The sheep range appeared to be in excellent condition; use by other species was light.

The greatest amount of contact between sheep and mule deer occurred during the rut. Conversely, Smith (1954) and Sugden (1961) found the two species to be most closely associated on winter and spring ranges. This discrepancy was probably a result of the unusual topography of Hart Mountain. The eastern slopes were far less precipitous than the western and supported greater numbers of deer, even at high elevations. Therefore, during the rut, when sheep were concentrated on the mountain top, the seasonal home ranges of the two species overlapped in the high-elevation habitats. However, competition was reduced in winter months because most deer wintered on the east side of the mountain whereas sheep remained on the west face.

Cattle numbers within sheep ranges during spring, summer, and fall were sufficiently low to cause little direct competition for forage. However, during those seasons, grazing by cattle was concentrated in some

low-elevation areas of both Hart Mountain and Poker Jim Ridge. Sheep probably remain above these grazed areas during mild winters, but in seasons of heavy snowfall they may be forced down to the foothills to feed in areas where cattle have utilized much of the forage.

Disturbance has been found to be a critical limiting factor for bighorn sheep populations throughout the West, although its levels and impacts are difficult to quantify. Dixon (1936), and Jones (1950) attributed the disappearance of certain sheep populations in the Sierra Nevada Range to human disturbance; Welles and Welles (1961) related a brief history of the retreat of sheep in Death Valley in response to human intrusion at water holes; and Geist (1970) noted that rams of hunted populations tended to withdraw to more isolated areas.

Hart Mountain bighorns have had contact with man primarily through hunting and sheep trapping operations, both of which would tend to make the sheep more wary. The reactions of sheep to the occasional presence of hikers and observers showed that they have not become accustomed to man, as they have in some National Parks. At its present level, however, human activity does not appear to constitute a threat to the Hart Mountain population, since the ewe-lamb range is fairly inaccessible.

Since their release on Hart Mountain in 1954, ewes and lambs have established and maintained one range north of the original sheep enclosure in Juniper Canyon and a second on Poker Jim Ridge (Fig. 1). The southern two-thirds of Hart Mountain has remained virtually unused by ewe groups, yet the area has always been accessible to them via the Bluegrass Flat Habitat.

Habitat factors may have been limiting southward expansion of the ewe range. Although the region south of Juniper Canyon was not sampled

for vegetational composition during this study, visual reconnaissance determined that four habitats of the ewe range (Cliff-Shrub, Bunchgrass, Low Sagebrush Plateau, and Sagebrush Basin) were not evident or were greatly reduced in a 3-mile (4.8 km.) area just south of the range. All other habitats continued without interruption, southward from the present ewe range. Three of the four habitats (Cliff-Shrub, Low Sagebrush Plateau, and Sagebrush Basin) received the highest preference ratings, reflecting heavy use relative to their occurrence within the ewe range (Table 4). It is likely that not only the composition of these four habitats but also their proximity to one another within the northern one-third of the mountain, influenced the preference of ewes for this area, and consequently, the location of their range.

Without closer examination, it appears that the southern portion of Hart Mountain offers ample room for expansion of the ewe range. The lack of any southward movement by ewe groups thus far may be a consequence of several factors: 1) Poker Jim Ridge may provide adequate new range for the increasing number of ewes and lambs; 2) the fence of the original sheep enclosure, present in Juniper Canyon until the summer of 1976, may have blocked the passage of ewes southward; and/or 3) areas just south of the present ewe range, lacking three habitats which were found to be preferred by ewes, may act as a barrier to their expansion into potentially suitable range farther south. Undoubtedly, the success of the population of bighorn sheep on Hart Mountain is, in part, a consequence of the suitability of the present ewe-lamb range, which appears to provide both quality forage and protective isolation. Continued increase in the size of the population may depend on the establishment of southern ranges by ewes that traverse the stretches of currently unused habitat.

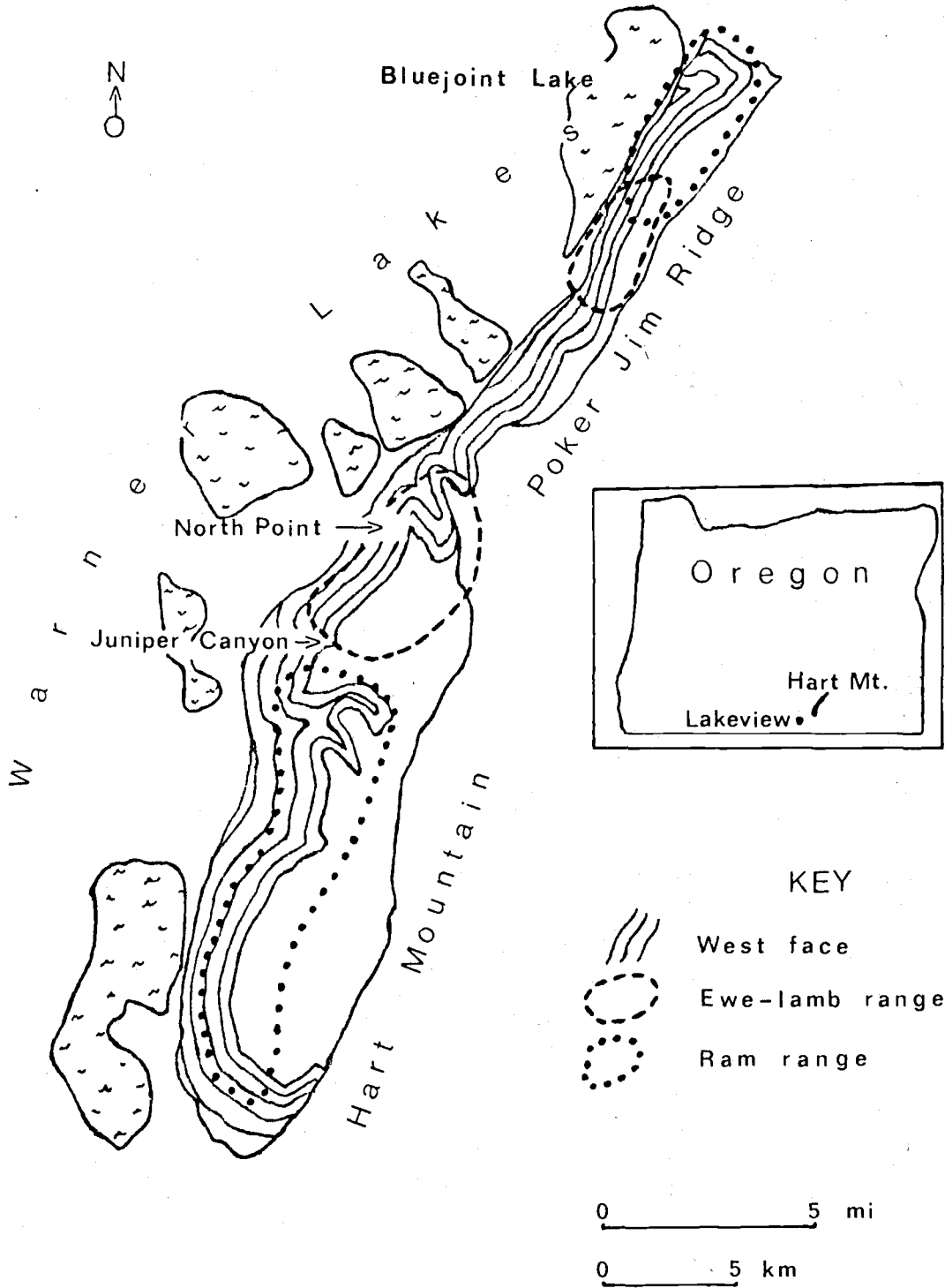


Fig. 1. Location of bighorn sheep ranges on Hart Mountain, Oregon, 1976-77.

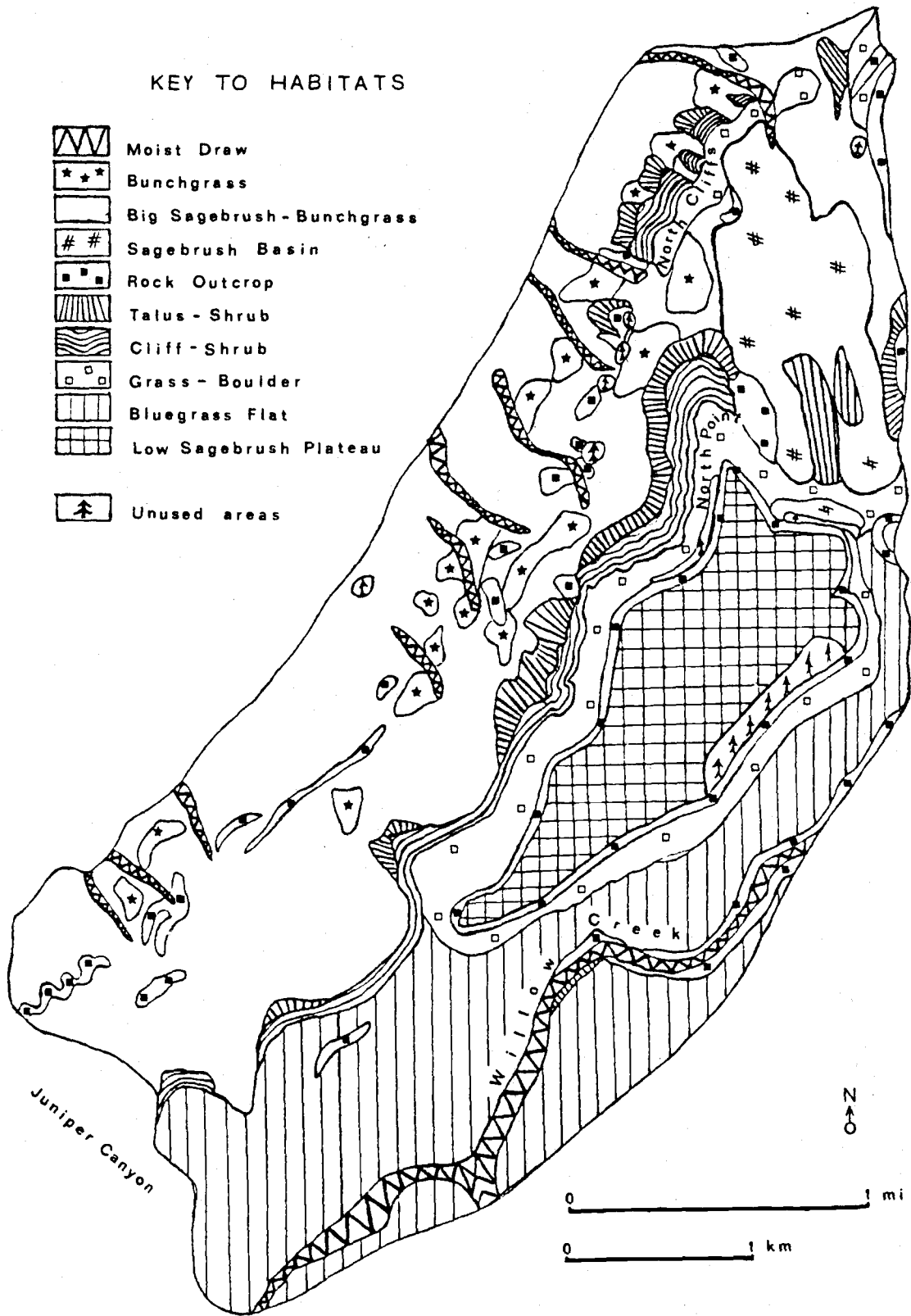


Fig. 2. Location of bighorn sheep habitats within ewe-lamb range on Hart Mountain, 1976-77.

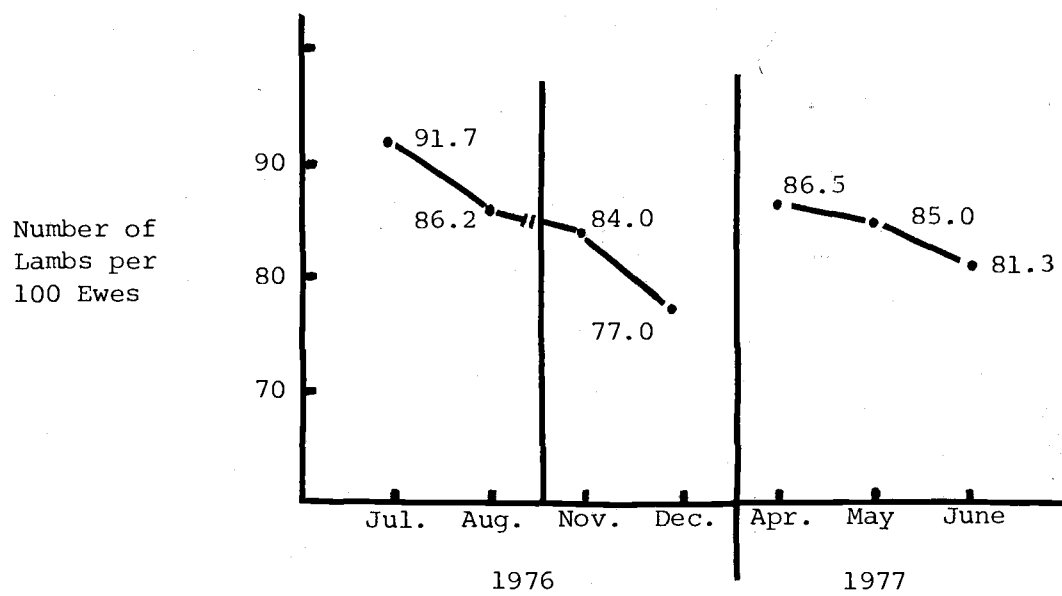


Fig. 3. Lamb:ewe ratios for bighorn sheep on Hart Mountain, Oregon, during summer and fall, 1976 and spring, 1977.

TABLE 1. Plant species composition of bighorn sheep habitats on Hart Mountain, Oregon, June 1977.

| <u>Habitats</u> | <u>Herbaceous Cover</u> | | | <u>Shrub Cover</u> | | | | |
|----------------------------|-------------------------|--|-----------------------|--------------------|--|----------------------|--------------------------|---------------------------------------|
| | <u>Total %</u> | <u>Major Species</u> | <u>Ground Cover %</u> | <u>Total %</u> | <u>Major Species</u> | <u>Crown Cover %</u> | <u>Shrub Height (cm)</u> | <u>Shrub Density (/m²)</u> |
| Moist Draw | 46.5 | Kentucky bluegrass (<u>Poa pratensis</u>) | 10.5 | 4.1 | Mountain snowberry (<u>Symphoricarpos oreophilus</u>) | 2.8 | 89.8 | 0.2 |
| | | Sedge (<u>Carex</u> sp.) | 7.3 | | Wood's rose (<u>Rosa woodsii</u>) | 1.0 | | |
| Bunchgrass | 30.3 | Idaho fescue (<u>Festuca idahoensis</u>) | 19.0 | 1.9 | Green rabbitbrush (<u>Chrysothamnus viscidiflorus</u>) | 1.9 | 25.0 | 0.8 |
| | | Bearded bluebunch wheatgrass (<u>Agropyron spicatum</u>) | 6.7 | | | | | |
| Big Sagebrush - Bunchgrass | 25.0 | Bearded bluebunch wheatgrass | 11.8 | 19.7 | Big sagebrush (<u>Artemisia tridentata</u>) | 16.6 | 48.8 | 1.4 |
| | | Locoweed (<u>Astragalus</u> sp.) | 4.5 | | Low sagebrush (<u>Artemisia arbuscula</u>) | 1.7 | | |
| Sagebrush Basin | 19.8 | Thurber needlegrass (<u>Stipa thurberiana</u>) | 5.7 | 21.1 | Big sagebrush | 11.5 | 47.8 | 1.6 |
| | | Curvepod locoweed (<u>Astragalus curvicaopus</u>) | 4.8 | | Low sagebrush | 9.8 | | |

| <u>Habitats</u> | <u>Herbaceous Cover</u> | | | <u>Shrub Cover</u> | | | | |
|-----------------------|-------------------------|---|-----------------------|--------------------|---|----------------------|--------------------------|---------------------------------------|
| | <u>Total %</u> | <u>Major Species</u> | <u>Ground Cover %</u> | <u>Total %</u> | <u>Major Species</u> | <u>Crown Cover %</u> | <u>Shrub Height (cm)</u> | <u>Shrub Density (/m²)</u> |
| Rock Outcrop | 13.5 | Idahoe fescue | 6.8 | 12.0 | Mountain snowberry | 4.5 | 30.3 | 1.4 |
| | | Bearded bluebunch wheatgrass | 6.3 | | Big sagebrush | 3.8 | | |
| Talus-Shrub | 4.5 | Giant wildrye (<u>Elymus cinereus</u>) | 3.8 | 27.7 | Rockspirea (<u>Holodiscus dumosus</u>) | 11.7 | 77.8 | 1.4 |
| | | | | | Rubber rabbitbrush (<u>Chrysothamnus nauseosus</u>) | 7.5 | | |
| Cliff-Shrub | 3.0 | Spike fescue (<u>Hesperochloa kingii</u>) | 3.0 | 42.5 | Big sagebrush | 15.7 | 44.0 | 4.6 |
| | | | | | Rockspirea | 14.7 | | |
| Grass-Boulder | 49.5 | Idahoe fescue | 29.0 | 18.2 | Big sagebrush | 14.2 | 25.5 | 4.7 |
| | | Cusick bluegrass (<u>Poa cusickii</u>) | 2.5 | | Green rabbitbrush | 2.0 | | |
| Bluegrass Flat | 37.0 | Sandberg's bluegrass (<u>Poa sandbergii</u>) | 18.3 | 4.1 | Low sagebrush | 1.8 | 17.4 | 2.0 |
| | | | | | Green rabbitbrush | 1.4 | | |
| Low Sagebrush Plateau | 13.8 | Sandberg's bluegrass | 2.8 | 26.6 | Low sagebrush | 21.8 | 11.0 | 8.3 |
| | | | | | Green rabbitbrush | 4.8 | | |
| Lakebed Margin | 28.0 | Foxtail barley (<u>Hordeum jubatum</u>) | 13.3 | | | ... | | ... |
| | | Western wheatgrass (<u>Agropyron smithii</u>) | 9.0 | | | | | |

| <u>Habitats</u> | <u>Herbaceous Cover</u> | | <u>Ground Cover %</u> | <u>Total %</u> | <u>Shrub Cover</u> | | | |
|---------------------------|-------------------------|--|-------------------------------|----------------|----------------------|------------------------------|----------------------------------|---|
| | <u>Total %</u> | <u>Major Species</u> | | | <u>Major Species</u> | <u>Crown Cover %</u> | <u>Shrub Height (cm)</u> | <u>Shrub Density (/m²)</u> |
| Boulder- Big Sagebrush | 8.8 | Cheatgrass (<u>Bromus tectorum</u>) | 5.5 | 10.7 | Big Sagebrush | 10.4 | 97.0 | 0.3 |
| Talus-Big Sagebrush | 5.7 | Cheatgrass | 3.5 | 9.8 | Big Sagebrush | 9.8 | 66.2 | 0.5 |
| Cliff-Big Sagebrush | 11.3 | Bearded bluebunch wheatgrass | 4.0 | 19.8 | Big Sagebrush | 16.2 | 65.0 | 1.0 |
| Rocky Flat | 13.0 | Hood's phlox (<u>Phlox hoodii</u>) | 5.0 | 4.8 | Low sagebrush | 4.0 | 16.5 | 1.2 |
| | | Bearded bluebunch wheatgrass | 4.5 | | | | | |

TABLE 2. Occurrence of bighorn sheep habitats on Hart Mountain, Oregon, 1977.

| <u>Habitat</u> | <u>Elevation</u> | | <u>Slope</u> (%) | <u>Size*</u> (ha) | <u>Occurrence</u> (%) |
|------------------------------|-------------------|--------------------|---------------------|----------------------|--------------------------|
| | <u>Low</u> (m) | <u>High</u> (m) | | | |
| Moist Draw | 1380 | 2130 | 20.6 | 91.8 | 4.8 |
| Bunchgrass | 1470 | 1920 | 21.5 | 97.0 | 5.1 |
| Big Sagebrush- Bunchgrass | 1380 | 2130 | 21.5 | 528.7 | 27.8 |
| Sagebrush Basin | 1680 | 2055 | 9.1 | 123.8 | 6.5 |
| Rock Outcrop | 1590 | 2190 | 23.9 | 145.4 | 7.7 |
| Talus-Shrub | 1440 | 2070 | 35.1 | 94.6 | 5.0 |
| Cliff-Shrub | 1530 | 2130 | 33.9 | 75.7 | 4.0 |
| Grass-Boulder | 2040 | 2175 | 16.9 | 142.6 | 7.5 |
| Bluegrass Flat | 2040 | 2166 | 7.6 | 397.8 | 20.9 |
| Low Sagebrush Plateau | 2100 | 2202 | 2.2 | 176.6 | 9.3 |
| Unused areas | 1608 | 2148 | 11.8 | 27.3 | <u>1.4</u> |
| | | | | | 100.0 |

*Habitat size was calculated by multiplying the flat area of each by a correction factor for average slope.

TABLE 3. Classification and distribution of observed bighorn sheep on two ranges on Hart Mountain, Oregon, during June, 1977.

| | Hart Mountain | | Poker Jim Ridge | | <u>Total</u> |
|-----------|----------------------------------|----------|----------------------------------|----------|--------------|
| | <u>Number of Individuals</u> | <u>%</u> | <u>Number of Individuals</u> | <u>%</u> | |
| Ewes | 31 | 54.4 | 26 | 45.6 | 57 |
| Yearlings | 17 | 53.1 | 15 | 46.9 | 32 |
| Lambs | 25 | 54.3 | 21 | 45.7 | 46 |
| Rams I | 2 | 25.0 | 6 | 75.0 | |
| II | 6 | 37.5 | 10 | 62.5 | 61 |
| III | 4 | 22.2 | 14 | 77.8 | |
| IV | 2 | 18.2 | 9 | 81.8 | |
| Unclass. | .. | | 8 | ... | 8 |
| Total | 87 | 47.4 | 109 | 52.6 | 196 |

TABLE 4. Use of habitats by ewes and lambs on Hart Mountain, Oregon during summer and fall, 1976, and spring, 1977. Habitat preference values (HPV) are marked (+) where the percentage of sheep use exceeds the percentage of occurrence of the habitat on the ewe-lamb range.

| Habitat | | Use | | HPV | |
|------------------------------|----|-----------|------------|-------|--------|
| | | Feed % | Total % | Feed | Total |
| Moist Draw | Su | 1.2 | 1.2 | 0.25 | 0.24 |
| | Fa | 4.5 | 6.8 | 0.94 | 1.40+ |
| | Sp | 0.7 | 0.9 | 0.15 | 0.19 |
| Bunchgrass | Su | 6.3 | 5.0 | 1.24+ | 0.97 |
| | Fa | 3.0 | 2.0 | 0.59 | 0.39 |
| | Sp | 14.3 | 10.1 | 2.80+ | 1.98+ |
| Big Sagebrush- Bunchgrass | Su | 13.8 | 8.1 | 0.50 | 0.29 |
| | Fa | 0.9 | 0.7 | 0.03 | 0.03 |
| | Sp | 21.4 | 9.7 | 0.77 | 0.35 |
| Sagebrush Basin | Su | 28.4 | 23.0 | 4.37+ | 3.53+ |
| | Fa | 5.0 | 3.3 | 0.77 | 0.50 |
| | Sp | 8.5 | 3.7 | 1.31+ | 0.57 |
| Rock Outcrop | Su | 2.1 | 6.9 | 0.27 | 0.90 |
| | Fa | 0.7 | 4.4 | 0.09 | 0.58 |
| | Sp | 1.2 | 4.1 | 0.16 | 0.54 |
| Talus-Shrub | Su | 4.4 | 4.1 | 0.88 | 0.82 |
| | Fa | 0.6 | 0.5 | 0.12 | 0.10 |
| | Sp | 9.7 | 10.2 | 1.94+ | 2.05+ |
| Cliff-Shrub | Su | 1.6 | 14.9 | 0.40 | 3.74+ |
| | Fa | ... | 1.0 | | 0.25 |
| | Sp | 26.8 | 49.0 | 6.70+ | 12.32+ |
| Grass-Boulder | Su | 7.9 | 11.6 | 1.05+ | 1.55+ |
| | Fa | 3.9 | 3.9 | 0.52 | 0.52 |
| | Sp | 17.4 | 11.5 | 0.99 | 1.54+ |
| Bluegrass Flat | Su | 21.5 | 12.1 | 1.03+ | 0.58 |
| | Fa | 42.5 | 42.8 | 2.03+ | 2.05+ |
| | Sp | ... | 0.2 | | 0.01 |
| Low Sagebrush Plateau | Su | 12.6 | 13.2 | 1.35+ | 1.42+ |
| | Fa | 39.0 | 34.7 | 4.19+ | 3.73+ |
| | Sp | ... | 0.5 | | 0.06 |

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APPENDICES

Appendix A. Presence of plant species within bighorn sheep habitats on Hart Mountain, Oregon, July, 1977. Species listed are those encountered along 50-meter transects, during vegetational sampling*

| Species | Moist Draw | Bunchgrass | Big sagebrush-Bunchgrass | Sagebrush Basin | Rock Outcrop | Talus-Shrub | Cliff-Shrub | Grass-Boulder | Bluegrass Flat | Low Sagebrush Plateau | Lakebed Margin | Boulder-Big Sagebrush | Talus-Big Sagebrush | Cliff-Big Sagebrush | Rocky Flat |
|--|------------|------------|--------------------------|-----------------|--------------|-------------|-------------|---------------|----------------|-----------------------|----------------|-----------------------|---------------------|---------------------|------------|
| Grasses: | | | | | | | | | | | | | | | |
| Barley, foxtail (<u>Hordeum jubatum</u>) | | | | | | | | | | | + | | | | |
| Bluegrass (<u>Poa sandbergii</u>) | | | | | | | | | + | + | | | | | + |
| Bluegrass, alkali (<u>Poa juncifolia</u>) | | | + | | | | | | | | | | | | |
| Bluegrass, Cusick (<u>Poa cusickii</u>) | | | | | | | | + | | | | | | + | |
| Bluegrass, Kentucky (<u>Poa pretensis</u>) | + | | | | | | | | | | | | | | |
| Bluegrass sp. (<u>Poa</u> sp.) | | | | | + | | | | | | | | | | |
| Brome, cheatgrass (<u>Bromus tectorum</u>) | + | | | + | | + | | | | | | + | + | + | |
| Fescue, Idaho (<u>Festuca idahoensis</u>) | | + | + | + | + | | | + | | + | | | | | |
| Junegrass, prairie (<u>Koeleria cristata</u>) | | | | + | | | | | + | | | | | | |

| Species | Moist Draw | Bunchgrass | Big Sagebrush- Bunchgrass | Sagebrush Basin | Rock Outcrop | Talus-Shrub | Cliff-Shrub | Grass-Boulder | Bluegrass Flat | Low Sagebrush Plateau | Lakebed Margin | Boulder-Big Sagebrush | Talus-Big Sagebrush | Cliff-Big Sagebrush | Rocky Flat |
|--|------------|------------|------------------------------|-----------------|--------------|-------------|-------------|---------------|----------------|-----------------------|----------------|-----------------------|---------------------|---------------------|------------|
| Needlegrass, Thurber's (<u>Stipa thurberiana</u>) | | | | + | | | | | | | + | | | | |
| Rush (<u>Juncus</u> sp.) | + | | | | | | | | | | | | | | |
| Sedge (<u>Carex</u> sp.) | + | | | | | | | | | | | | | | |
| Spike fescue (<u>Hesperochloa kingii</u>) | | | | | | | + | | | | | | | | |
| Squirreltail, bottlebrush (<u>Sitanion hystrix</u>) | | | | | | | | | + | | | | | | |
| Wheatgrass, bearded bluebunch (<u>Agropyron spicatum</u>) | | + | + | + | + | | | | | | | + | + | + | + |
| Wheatgrass, western (<u>Agropyron smithii</u>) | | | | | | | | | | | + | | | | |
| Wildrye, giant (<u>Elymus cinereus</u>) | + | | + | + | | + | | | | | | | + | | |
| Forbs: | | | | | | | | | | | | | | | |
| Alumroot (<u>Heuchera parvifolia</u>) | | | | | | | + | | | | | | | | |
| Avens, prairesmoke (<u>Geum triflorum</u>) | | | | | | | | | | + | | | | | |
| Balsamroot, arrowleaf (<u>Balsamorhiza sagittata</u>) | | + | | | | | | | | | | | | | |

| Species | Moist Draw | Bunchgrass | Big Sagebrush- Bunchgrass | Sagebrush Basin | Rock Outcrop | Talus-Shrub | Cliff-Shrub | Grass-Boulder | Bluegrass Flat | Low Sagebrush Plateau | Lakebed Margin | Boulder-Big Sagebrush | Talus-Big Sagebrush | Cliff-Big Sagebrush | Rocky Flat |
|--|------------|------------|------------------------------|-----------------|--------------|-------------|-------------|---------------|----------------|-----------------------|----------------|-----------------------|---------------------|---------------------|------------|
| Bluebells, small (<u>Mertensia longiflora</u>) | | | | | | | + | + | | + | | | | | |
| Columbine, sitka (<u>Aquilegia formosa</u>) | | | | | | | + | | | | | | | | |
| Eriogonum, mat (<u>Eriogonum caespitosum</u>) | | | | | | | | | | + | | | | | + |
| Eriogonum (<u>Eriogonum sp.</u>) | | | + | | | | | | | | | | | | |
| Hawksbeard, tapertip (<u>Crepis acuminata</u>) | | | | + | | | + | | | | | | | + | |
| Locoweed, curvepod (<u>Astragalus curvicarpus</u>) | | | | + | | | | | | | | | | | |
| Locoweed, specklepod (<u>Astragalus lentiginosus</u>) | | | | | | | | | | | + | | | | |
| Locoweed (<u>Astragalus sp.</u>) | | + | + | | | | | | | | | | | | |
| Lupine (<u>Lupinus sp.</u>) | | + | + | + | | | | + | + | | | | | | |
| Nettle (<u>Urtica sp.</u>) | + | | | | | | | | | | | | | | |
| Paintbrush (<u>Castilleja sp.</u>) | | + | | | | | | | | | | | | | |
| Penstemon (<u>Penstemon sp.</u>) | | + | | | | | | | | | | | | | |

| Species | Moist Draw | Bunchgrass | Big Sagebrush- Bunchgrass | Sagebrush Basin | Rock Outcrop | Talus-Shrub | Cliff-Shrub | Grass-Boulder | Bluegrass Flat | Low Sagebrush Plateau | Lakebed Margin | Boulder-Big Sagebrush | Talus-Big Sagebrush | Cliff-Big Sagebrush | Rocky Flat |
|---|------------|------------|------------------------------|-----------------|--------------|-------------|-------------|---------------|----------------|-----------------------|----------------|-----------------------|---------------------|---------------------|------------|
| Phlox, Hood's (<u>Phlox hoodii</u>) | | + | | | | | | + | + | + | | | | | + |
| Sage, Mediterranean (<u>Salvia aethiopsis</u>) | | | | | | + | + | + | | | | | | | |
| Sandwort (<u>Arenaria sp.</u>) | | | | | | | | | | + | | | | | |
| Skeletonplant (<u>Lygodesmia juncea</u>) | | + | | + | | | | | | | | + | | + | |
| Sumpweed, poverty (<u>Iva axillaris</u>) | | | | | | | | | | | + | | | | |
| Tarragon (<u>Artemisia dracunculus</u>) | | | | | | | | | | | + | | | | |
| Violet (<u>Viola sp.</u>) | + | | | | | | | | | | | | | | |
| Yarrow (<u>Achillea millefolium</u>) | | + | | + | | | | + | | | | | | | |
| Shrubs and Trees: | | | | | | | | | | | | | | | |
| Chokecherry, common (<u>Prunus virginiana</u>) | + | | | + | | | | | | | | | | | |
| Currant, wax (<u>Ribes cereum</u>) | | | | | | + | + | | | | | | | | |

| Species | Moist Draw | Bunchgrass | Big Sagebrush- Bunchgrass | Sagebrush Basin | Rock Outcrop | Talus-Shrub | Cliff-Shrub | Grass-Boulder | Bluegrass Flat | Low Sagebrush Plateau | Lakebed Margin | Boulder-Big Sagebrush | Talus-Big Sagebrush | Cliff-Big Sagebrush | Rocky Flat |
|--|------------|------------|------------------------------|-----------------|--------------|-------------|-------------|---------------|----------------|-----------------------|----------------|-----------------------|---------------------|---------------------|------------|
| Gilia, granite (<u>Leptodactylon pungens</u>) | | | | | | | | + | + | | | | | | |
| Goldenweed (<u>Haplopappus</u> sp.) | | | | | | | | + | | | | | | | |
| Juniper, western (<u>Juniperus occidentalis</u>) | | | | + | | | | | | | | | | | |
| Rabbitbrush, green (<u>Chrysothamnus viscidiflorus</u>) | + | + | + | | + | | + | + | + | + | | | | | |
| Rabbitbrush, rubber (<u>Chrysothamnus nauseosus</u>) | | | | | + | + | + | | | | | | | + | |
| Rockspirea (<u>Holodiscus dumosus</u>) | | | | | + | + | + | | | | | | | | |
| Rose, Wood's (<u>Rosa woodsii</u>) | + | | | | | | | | | | | | | | |
| Sagebrush, big (<u>Artemisia tridentata</u>) | | | + | + | + | + | + | + | | | | + | + | + | |
| Sagebrush, low (<u>Artemisia arbuscula</u>) | | | + | + | | | + | + | + | + | | | | | + |
| Snowberry, mountain (<u>Symphoricarpos oreophilus</u>) | + | | + | | + | + | + | | | | | | | | |

*Dr. A. H. Winward assisted in the identification of plant species. Sources used were Hitchcock and Cronquist (1973), Niehaus and Ripper (1976), and Taylor and Valum (1974). Common names are in accordance with Garrison et al. (1976).

APPENDIX B

MANAGEMENT RECOMMENDATIONS

1. A program of periodic censusing would make it possible to discern longterm trends in the status of the bighorn sheep population. Ideally, censuses should be conducted from the ground at two-week or one-month intervals. However, a less frequent schedule of ground and aerial censusing could also be used. Sheep occupied the most accessible terrain for an aerial count during the afternoons of late summer and during the rut. An aerial census should cover the entire length of Hart Mountain and Poker Jim Ridge.
2. A trapping program, with or without transplant operations, could be used to sex, age, weigh, and mark individual representatives of the population. Shackleton (1973) has described a system for gleaning population quality from age, weight, and body measurement data. Marked individuals in the population would be helpful in any censusing procedures and essential to studies of the daily movements of specific sheep, the exchange of individuals between the Hart and Poker Jim Ranges, and the age-specific activities of ewes.
3. The number of cattle utilizing the mountain top and the lower elevations of the sheep range should continue to be carefully regulated. Winter studies or censuses could confirm Rouse's (1964)

suggestions that the bighorn population eventually may be limited by the capacity of its winter range. Cattle numbers may be significant in determining the capacity of the lower elevations to support sheep.

4. Water sources should be protected from disturbance, particularly in dry seasons. At the very least, sheep appear to require access to Willow Creek during autumn droughts and to Bluejoint and Stone Corral Lakes during any dry periods.
5. Human traffic should be minimal near critical bedding, lambing, escape, and feeding areas. This encompasses the northern portion of Hart Mountain, between the Sagebrush Basin and the southern end of the Low Sagebrush Plateau. On Poker Jim Ridge sheep activities are concentrated from the Laird fenceline northward throughout the region of precipitous cliffs, at all elevations.
6. In establishing hunting regulations, it is perhaps significant to note that in the summer of 1977, 70 percent of the rams in the population were congregated on less than 20 percent of the total sheep range. Although hunting pressure in the past has been focused on the southern (Hart) end of the ram range, a shift northward may result in higher hunter success. Also, ram and ewe ranges on Poker Jim Ridge overlapped, making the hunt a source of disturbance to ewe-lamb groups in the area.