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Dr. E. Charles Meslow

A herd of re-introduced California bighorn sheep (*Ovis canadensis californiana*) was studied from 15 June 1976 to 31 August 1977.

Thirteen major and seven minor habitats were delineated and described. Habitat use by bighorns was observed throughout the study and a habitat preference value (H.P.V.) was calculated based on use by ewe-lamb groups. Certain habitats were highly preferred for foraging or resting by bighorns during different seasons of the year, probably because of the physical and vegetative characteristics they offered.

Examination of daily activity patterns of ewe-lamb groups revealed that they primarily fed in the morning, rested at mid-day, and again fed toward evening during all seasons.

Comparison of the activity budgets (time allotment for the various activities) between the sex and age groups within seasons disclosed statistical differences in all seasons. In spring lambs foraged less and pursued other activities more than ewes or rams. In summer, rams foraged less than lambs and lambs foraged less than ewes. The reverse trend was noted for resting activity. These trends were probably related

energy demands of each sex and age class. In fall and winter no difference was found between the activity budgets of ewes and lambs. Adult rams, however, spent less time foraging and more time resting and pursuing other activities than ewes or lambs. This was related to energy demands and the rut.

Estimated herd size fluctuated between 128 and 180 individuals with most of the change attributable to birth and subsequent mortality of lambs. Factors responsible for lamb mortality were not identified but losses appeared related to parasites and disease. Between 1976 and 1977 the population increased very little.

Population Characteristics and Habitat Utilization of Bighorn Sheep, Steens Mountain, Oregon

by

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POPULATION CHARACTERISTICS AND HABITAT UTILIZATION OF BIGHORN SHEEP, STEENS MOUNTAIN, OREGON

INTRODUCTION

Historically, California bighorn sheep were native to much of southeastern Oregon and were abundant on Steens Mountain (Bailey 1936). Shooting, fostered by the mining boom, and parasites and diseases introduced by domestic livestock, particularly sheep, were apparently responsible for the decline of bighorn sheep in southeastern Oregon; the last one was seen on Steens Mountain around 1915 (P. Ebert 1975, unpublished report, ODFW, Portland, Oregon).

In December 1960 and April 1961, 11 California bighorn sheep (five rams, five ewes, one female lamb) were captured by Oregon Department of Fish and Wildlife (ODFW) personnel from the reintroduced herd on Hart Mountain National Antelope Refuge in south-central Oregon and released on the east face of Steens Mountain (Figure 1).

The herd grew to approximately 45 animals before the first harvest of rams was held in 1968 (Table 1). During 1968-1977, 36 bighorn rams were removed by hunting.

In December of 1974 and 1975, low lamb-ewe ratios and an apparent stabilization of the population at an estimated 100 individuals was reported (Table 1). Concern by ODFW personnel for the mechanics behind the herd's stabilization was the prime impetus for this study.

The primary purpose of this study was to document the dynamics of the bighorn sheep herd sex and age structure on Steens Mountain. In addition, bighorn activity patterns and bighorn habitat use and preference were documented.

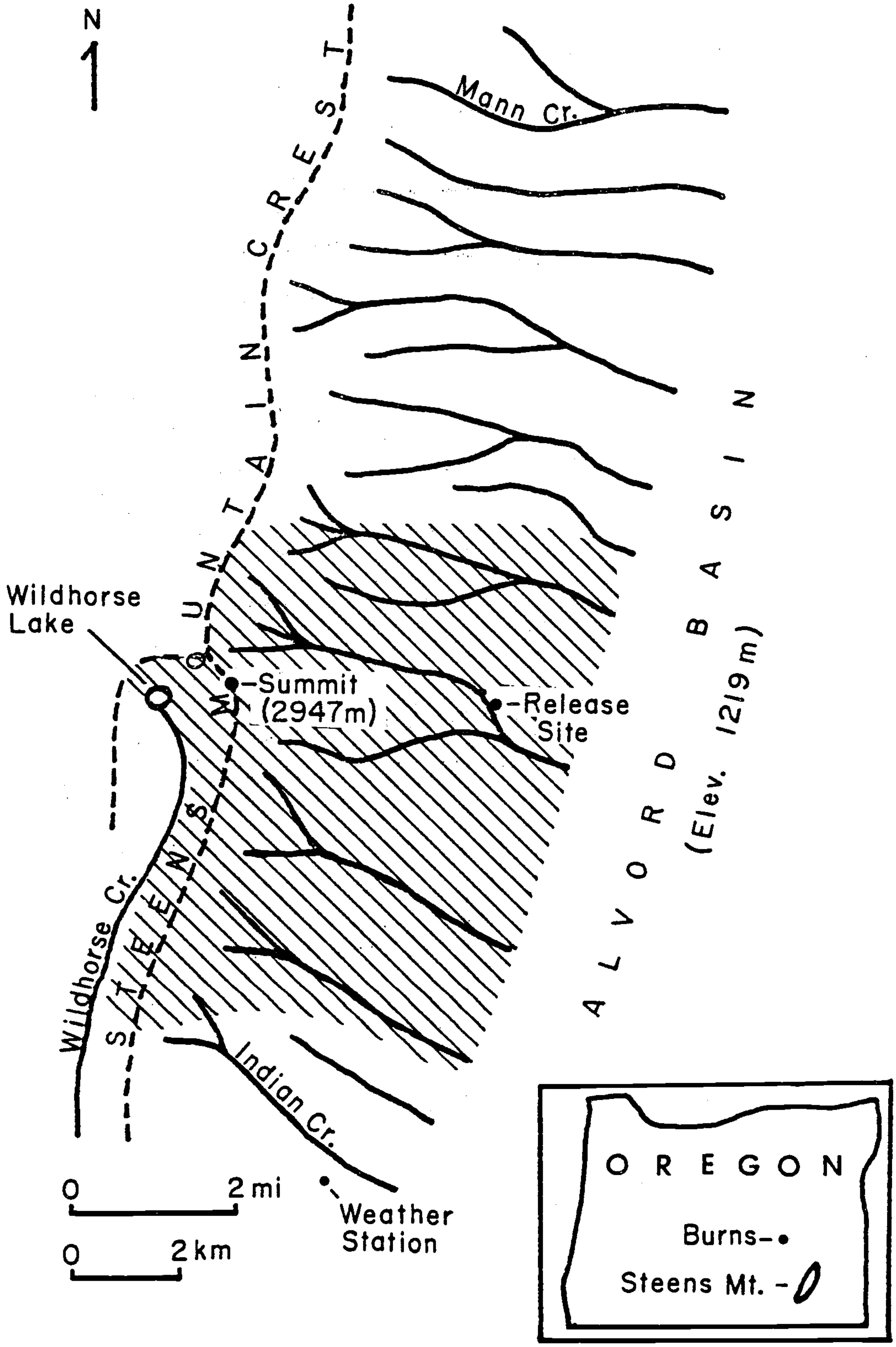

Figure 1. Location of the study area, Steens Mountain, Oregon, 1976-77. Shaded area represents the range occupied by ewe-lamb groups.

Table 1. Herd composition of bighorn sheep in December, 1965-1975, Steens Mountain, Oregon (Data from ODFW files, Hines, Oregon).

Year	Ewes	Lambs	Rams	Lambs/ ewe (%)	Rams/ ewe (%)	Total number observed	Rams harvested[a]	Approximate population[b]
1975	31	9	16	29	52	56	7	100
1974	21	6	18	29	86	45	5	100
1973	16	8	12	50	75	36	1	100
1972	14	8	8	57	57	30	3	90
1971	12	6	16	50	133	34	1	80
1970	6	5	6	83	100	17	2	70
1969	5	5	3	100	60	13	2	55
1968	6	4	3	67	50	13	2	45
1967	6	5	5	83	83	16	-	45
1966	3	2	2	67	67	7	-	40
1965	1	1	2	100	200	4	-	35

[a]Hunting of rams began in 1968.

[b]Based on sightings of sheep made throughout the year.

DESCRIPTION OF STUDY AREA

Steens Mountain is a fault-block mountain located in Harney County, Oregon, approximately 96 km south of Burns (Figure 1). Elevation at the base is 1250 m; the crest of the mountain varies to 2947 m.

Bighorn inhabit the rugged east face, an area approximately 20 km N-S and 5 km E-W. The study area included that area eastward of the mountain crest to the 1524 m level and was bounded on the north by Mann Creek, on the south by Indian Creek, and included a portion of Wildhorse Creek, an area of 9894 hectares (Figure 1). Bighorns were observed within the area the year-round. The herd was not migratory although sheep use was precluded at higher elevations during winter by deep snow cover.

Mean annual precipitation during 1969-1977 was 42.1 cm (range 30.5 cm - 50.3 cm). Mean maximum and minimum temperatures for the months of January and July were 2.8^{o}C and -5.6^{o}C and 29.7^{o}C and 15.2^{o}C respectively. Temperatures during the study were near normal, but precipitation during the July-September period of 1976 was greater than normal (13.7 cm vs. 4.5 cm) and less than normal during the October-March period of 1976-77 (10.1 cm vs. 30.4 cm).

The vegetation of the Steens was varied and patchy in distribution reflecting the steep broken topography; in general it conformed to the desert-steppe category of Franklin and Dyrness (1973).

Land-use on most of the study area was administered by the Bureau of Land Management (BLM), Burns District. Records of livestock grazing on the study area were largely unavailable. Evidently the area received the greatest grazing pressure, primarily by domestic sheep, in the early

1900's (Pers. Comm., 20 February 1977, William Bright, BLM, Burns, Oregon). During the study, the only livestock use on the east face was by cattle. Several prospectors maintained mining claims within the study area but no active mining was practiced.

MATERIALS AND METHODS

Travel on the study area was primarily by foot. During summer and fall frequent overnight stays enabled collection of early-morning and late-evening observations. Bighorns were located with aid of 9X35 binoculars and a 20X spotting scope. Observation points were not preselected. Attempts to enumerate sheep from both fixed-wing aircraft and helicopters were unsuccessful.

Bighorn Population Analysis

Bighorn distribution and population characteristics were based on accumulation of almost daily sightings. Since low lamb production and/or survival was suspected, observations were concentrated on the ewe-lamb cohort. Attempts were made to equitably observe the areas used by ewe-lamb groups.

Once a bighorn group was sighted, each individual in the group was classified according to the sex and age classification of Geist (1971), however, rams with heavily broomed horns, regardless of the length of curl, were assigned to Class IV. Because of brooming, horns of few bighorn rams on the Steens reach full curl.

Only sightings of complete groups of sheep were used in computation of the various sex and age ratios. At least 50 adult ewes with accompanying sheep of other sex and age classes were classified each month; there were approximately 50 ewes in the population.

On several occasions circumstances allowed minimum counts of various cohorts to be obtained. Every effort was made to insure that no duplication was involved in these minimum counts. Minimum known counts and ratios of certain sex and age cohorts were used to construct the 1976-1977 population model.

While a bighorn group was under observation, the activity of each individual in the group and the habitat in which that individual was located were recorded at 5-minute intervals. These point observations were expressed as hours of sheep activity. Activities recognized were: foraging, resting (bedding) and other (standing, moving, loafing, playing and courtship behavior).

The year was divided into four seasons: spring (1 April through 15 June), summer (16 June through 30 Sept.), fall (1 Oct. through 30 Nov.), and winter (1 Dec. through 31 Mar.).

Habitat Analysis

Habitat analysis of bighorn ranges by Smith (1954) and Hickey (1975) in Idaho, Shepherd (1975) in Colorado and Sheehy's (Pers. Comm. 20 August 1976, Dennis P. Sheehy, ODFW, Hines, Oregon) analysis of mule deer (*Odocoileus hemionus*) habitat on the west slope of Steens Mountain aided in delineation of sheep habitats as did Daubenmire's (1968) plant association criteria. Habitat names reflect physical and vegetational features which allowed differentiation between vegetative types and were repeated from canyon to canyon over the study area. Mapping was done on acetate overlays on high resolution, U-2, color infra-red aerial photographs during ground reconnaissance. After delineation, habitats were corrected for horizontal distortion and transferred to a 7.5' U.S. Geological Survey topographic map. Acreage of each habitat was calculated and corrected for vertical distortion and slope.

Percent of sheep use in a habitat divided by the percent of the study area that habitat occupied established a habitat preference value (H.P.V.) for each habitat. A value of 1.0 indicated the habitat was used in proportion to its availability.

Vegetational characteristics of each habitat were measured using a modification of the methods employed by Poulton and Tisdale (1961). A 50 m transect was placed in representative stands of each habitat. The line was placed diagonally across the slope to remove effects of horizontal banding of vegetation. Rooted frequency of each plant species present was measured in 30 X 60 cm plots (30 X 30 cm for meadow) placed at 5 m intervals along the transect. Herbaceous cover was ocularly estimated to the nearest 5 percent. Shrub and canopy cover were measured using the line intercept method (Canfield 1941). Density (plants/m^2) of major shrubs and trees was measured in a 1 X 50 m plot which had the line transect as one side. Only shrubs and trees rooted within the plot were counted. Shrub height to the nearest cm and tree height to the nearest 0.1 m were measured at 10 m intervals along the transect. Percent slope and aspect were recorded at each transect location.

Descriptions of habitats used by bighorn were based on a minimum of three transects placed on different slopes and in different canyons. Vegetation on habitats too small or variable to be measured by transect (streamchannel, rocky draws, cirque basins and inclusions of *Prunus*, *Elymus* and *Holodiscus*) was evaluated ocularly after the methods of Winward and Youte (1976:29). For this study frequency was defined as the percent of the plots for a habitat in which a particular plant was noted while constancy was defined as the percent of the transects for a habitat in which a particular plant was noted. Frequency and constancy values calculated from transect data and estimated dominance values from the ocular data were used to describe each habitat. Plant dominance within a habitat was based on frequency and constancy or high ocular values for a particular plant species.

Because of its fault-block nature and east exposure, west aspects were uncommon on Steens Mountain. Habitats found on north and south or north, south and east aspects were considered to be common to all aspects (Table 2).

Table 2. Descriptive characteristics of the various habitats, Steens Mountain, 1976-77.

	HABITAT[a]													
Characteristic	Meadow (n=5)	Cliffrock (n=5)	Shrub-FEID (Draw subtype) (n=3)	Shrub-FEID (Major subtype) (n=3)	Shrub-AGSP (n=4)	Cliffrock-shrub (n=10)	Mountain mahogany (n=7)	Scree (n=4)	Cliffrock-talus (n=3)	Juniper (n=3)	Dense shrub (n=3)	Ceonothus (n=3)	Dense Mtn. mahogany (n=3)	Aspen (n=2)
Herbaceous cover (%)	76.7	16.1	50.5	48.3	24.3	23.5	22.4	20.5	11.7	10.2	32.5	15.2	11.2	31.0
Shrub cover (%)	6.5	2.6	21.7	9.8	7.7	19.1	11.6	7.8	15.8	8.0	26.0	71.2	6.2	4.9
Canopy cover (%)	0	0	0.4	0	0	0	24.2	0	0	8.2	0	0.2	93.4	81.6
Shrub height (cm)	23.3	10.8	44.1	33.7	37.4	37.8	46.5	12.7	32.7	41.0	58.9	57.2	37.9	121.2
Tree height (m)	0	0	0	0	0	0	4.0	0	0	5.3	0	0	5.6	5.2
Shrub density (pl/m^2)	0.2	0.2	1.3	1.3	0.4	1.0	0.7	1.0	0.6	0.8	0.9	2.1	0.5	0.3
Tree density (pl/m^2)	0	0	0.1	0	0	0	0.1	0	0	0.01	0	0.08	0.2	0.6
Aspect	All	All	N	N	S,E	All	All	All	All	All	All	All	All	All

Table 2. (continued)

Characteristic		HABITAT[a] Meadow (n=5)	Cliffrock (n=5)	<u>Shrub-FEID</u> (Draw subtype) (n=3)	<u>Shrub-FEID</u> (Major subtype) (n=3)	<u>Shrub-AGSP</u> (n=4)	Cliffrock-shrub (n=10)	Mountain mahogany (n=7)	Scree (n=4)	Cliffrock-talus (n=3)	Juniper (n=3)	Dense shrub (n=3)	Ceonothus (n=3)	Dense Mtn. mahogany (n=3)	Aspen (n=2)
Slope range (%)	L	35	56	37	55	40	34	50	36	36	46	12	31	6	37
	H	110	200	70	65	66	91	90	66	68	70	60	56	28	61
Elevational	L	6500	6000	5000	5000	5000	7000	5000	8000	5000	5000	5000	5500	5000	5500
Range (m)	H	9600	9670	8400	8400	7100	9200	8400	9670	6800	5700	6900	7200	6500	6500
Hectares[b]		438	1809	1235		2217	1379	357	507	763	321	236	275	234	11

[a]"n" indicates the number of transects used in the individual habitat description.

[b]Streamchannel (81 ha) and talus (31 ha) make up the remainder of the 9894 ha total.

RESULTS AND DISCUSSION

Habitat Characteristics

A total of 13 major (large in size, continous in distribution) habitats and seven minor (small in size, discontinuous in distribution) habitats were delineated and described in the study area (Tables 2 and 3; Appendix Tables 3 and 4). One habitat (talus, 31 ha) was devoid of vegetation and was not noted in the vegetative description. Individual transect data are on file at the Cooperative Wildlife Research Unit at Oregon State University. Plant names and symbols were patterned after Hitchcock and Cronquist (1973), and Garrison et al. (1976).

Habitats used by bighorns

Of the 20 habitats delineated on the study area, nine were used by bighorns. These are described below.

Meadow. Meadow was one of the smallest habitats used by bighorns. It was found at mid to high elevations on all aspects. Meadow was found along streams, around springs, below semi-permanent snowdrifts and on seeps. The herbaceous cover of 77 percent was the most dense of any habitat on the study area. Inclusions of cirque basin habitat (Table 3) were found within and included as part of the meadow habitat.

Cliffrock. Cliffrock was found from low to high elevations on all aspects but the majority was at mid to high elevations. The steepest slopes were encountered here, varying from 56 to 200 percent. This habitat had the lowest diversity of plant species of any habitat used by bighorns. Terracing within the habitat was common with the majority of vegetation growing on the flatter portions of the terrace where soil

Table 3. Principal plants found in each habitat, Steens Mountain, 1976-77. Numbers in parenthesis are the respective frequency and constancy or ocular values for each plant.

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Meadow (n=5)[a]	Shrubby cinquefoil (8/40)[b] (Potentilla fruticosa)	Sedge (36/100) (Carex spp.) Wood-reed grass (22/100) (Cinna latifolia) Hairgrass (22/60) (Deschampsia caespitosa)	Gray's licorice root (48/100) (Lingusticum grayi) Longstalked clover (40/80) (Trifolium longipes) Alpine shooting star (18/80) (Dodecatheon alpinum)
Cliffrock (n=5)	Mountain gooseberry (8/20) (Ribes montigenum) Shrubby goldenweed (2/20) (Happlopappus suffruticosus) Shrubby cinquefoil (2/20)	Bottlebrush squirreltail (20/80) (Sitanion hystrix) Long tongue mutton blue-grass (12/60) (Poa longiligula)	Sticky cinquefoil (24/60) (Potentilla glandulosa) Yarrow (14/60) (Achillea millefolium) Steens Mountain thistle (10/60) (Cirsium peckii)
Cliffrock-shrub (n=10)	Mountain big sagebrush (25/90) (Artemisia tridentata vaseyana)	Bottlebrush squirreltail (29/100) Thurbers needlegrass (18/60) (Stipa thurberiana)	Tailcup lupine (50/100) (Lupinus caudatus) Violets (26/60) (Viola spp.) Silver phacelia (14/60) (Phacelia hastata)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Shrub-FEID (Major subtype) (n=3)	Low sagebrush (37/100) (*Artemisia arbuscula*) Green rabbitbrush (17/100) (*Chrysothamnus vicidiflorus*) Mountain snowberry (10/67) (*Symphoriocarpus oreophilus*)	Idaho-fescue (87/100) (*Festuca idahoensis*) Sandberg's bluegrass (67/100) (*Poa sandbergii*)	Tapertip hawksbeard (23/67) (*Crepus acuminata*) Spur lupine (23/67) (*Lupinus laxiflorus*) Blue stickweed (23/67) (*Hackelia jessicae*)
Shrub-FEID (Draw subtype) (n=3)	Mountain big sagebrush (37/100) Mountain snowberry (17/67) Green rabbitbrush (13/67)	Idaho fescue (80/100) Bluegrasses (*Poa* spp.) Bottlebrush squirreltail (10/100)	Yarrow (50/100) Tailcup lupine (23/67) Tapertip hawksbeard (20/67)
Shrub-AGSP (n=4)	Mountain big sagebrush (10/50)	Bluebunch wheatgrass (40/100) (*Agropyron spicatum*) Cheatgrass brome (25/75) (*Bromus tectorum*) Sandberg's bluegrass (13/75)	Tailcup lupine (18/75) Skeletonweed (20/50) (*Lygodesmia spinosa*)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Scree (n=4)	Shrubby goldenweed (20/50) Low sagebrush (10/25) Shrubby cinquefoil (10/25)	Bottlebrush squirreltail Sandberg's bluegrass (18/50)	Needleleaf sandwort (25/50) (*Arenaria aculeata*) Longstalked clover (15/75) Mugwort (18/50) (*Artemisia vulgaris*)
Mountain mahogany (n=7)	Curlleaf mountain mahogany (*Cercocarpus ledifolius*) Mountain big sagebrush (23/86) Creambush spirea (11/43) (*Holodiscus dumosus*)	Bottlebrush squirreltail (30/100) Bluebunch wheatgrass (13/43) Thurbers needlegrass (11/43) Bluegrasses	Tailcup lupine (33/86) Blue stickweed (14/29) Houndstongue hawksbeard (13/29) (*Hieracium cynoglossoides*)
Cliffrock-talus (n=3)	Low sagebrush (23/100) Prickly phlox (10/67) (*Leptodactylon pungens*)	Bluebunch wheatgrass (37/100) Cheatgrass brome (43/100) Sandberg's bluegrass (17/100)	Rigid peavine (10/67) (*Lathyrus rigidus*)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Juniper (n=3)	Western juniper (*Juniperus occidentalis*) Gray rabbitbrush (10/67) Creambush spirea (10/33)	Cheatgrass brome (63/100) Bluebunch wheatgrass (33/100) Sandberg's bluegrass (13/67) Longtongue mutton bluegrass (10/67)	Tailcup lupine (10/100) Ball-headed mint (10/33) (*Monardella odoratissima*)
Aspen (n=2)	Quaking aspen (10/100) (*Populus tremuloides*) Ninebark (30/100) (*Physocarpus malvaceus*) Bittercherry (10/50) (*Prunus emarginata*)	Purple wildrye (60/100) (*Elymus aristatus*) Bearded wheatgrass (40/100) (*Agropyron caninum*) Bromegrasses (*Bromus* sp.)	Kelloggia (55/100) (*Kelloggia galloides*) Butterweed groundsel (50/100) (*Senecio serra*) Microseris (20/50) (*Microseris nutans*)
Dense shrub (n=3)	Mountain big sagebrush (47/100) Mountain snowberry (7/67)	Bottlebrush squirreltail (40/100) Thurbers needlegrass (17/67) Big bluegrass (17/67) (*Poa ampla*)	Tailcup lupine (27/67) Menzies silene (27/33) (*Silene menzesii*) Giant horsemint (23/33) (*Agastache urticifolia*)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Ceonothus (n=3)	Oregon grape (63/100) (*Berberis repens*) Snowbrush ceonothus (53/100) (*Ceonothus velutinus*)	Bottlebrush squirreltail (57/100) Thurbers needlegrass (40/100) Big bluegrass (20/100)	Kelloggia (43/100) Houndstongue hawksbeard (17/67)
Dense mountain mahogany (n=3)	Curlleaf mountain mahogany Oregon grape (10/33)	Bottlebrush squirreltail (40/100) Thurbers needlegrass (20/67) Big bluegrass (7/67)	Kelloggia (27/67) Sweetanise (10/33) (*Osmorhiza occidentalis*)
Streamchannel (n=3)	Black cottonwood (3)[c] (*Populus angustifolia*) Wood's rose (3) (*Rosa woodsii*) Scoulers willow (3) (*Salix scouleriana*)	Purple wildrye (2) Cheatgrass brome (2)	Nettle (4) Common monkeyflower (3) (*Mimulus guttatus*) Mugwort (2) Steens Mountain thistle (2) Yarrow (2)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Prunus (n=5)	Common chokecherry (5) (*Prunus virginiana*) Bittercherry (4) (*Prunus emarginata*) Mountain big sagebrush (2) Creambush spirea (2)	Purple wildrye (1) Bromegrasses (1) Bottlebrush squirreltail (1) Thurbers needlegrass (1) Big bluegrass (1)	Nettle (2) Giant horsemint (2)
Rocky draws (n=3)	Creambush spirea (2)	Bottlebrush squirreltail (3) Sandberg's bluegrass (2)	Mugwort (4) Steens Mountain thistle (3) Ball-headed mint (3)
Holodiscus (n=2)	Creambush spirea (5)	Cheatgrass brome (2) Idaho fescue (2) Sandberg's bluegrass (2)	Various
Elymus (n=1)	Mountain big sagebrush (5)	Giant wildrye (5) (*Elymus cinerus*) Mountain brome (4) (*Bromus marginatus*) Thurbers needlegrass (3) Bearded wheatgrass (3)	Tailcup lupine (3) Silver-leaf phacilia (3)

Table 3. (continued)

Habitat	CLASS OF PLANT		
	Trees/shrubs	Grasses/grasslikes	Forbs
Cirque basins	Arctic willow (5) (*Salix arctica*) Shrubby cinquefoil (5)	Sedges (4) Rushes (3) (*Juncus* spp.)	Diverse-leaved cinquefoil (*Potentilla diversifolia*)

[a]"n" denotes the number of transects or ocular estimates used to describe the habitat.
[b]Frequency/constancy values.
[c]Ocular value.

development was most advanced. Several rocky draws (Table 3), higher in soil and/or moisture content sustained a plant flora different from the majority of the habitat. Inclusions of meadow habitat were frequent.

Cliffrock-shrub. Found on all aspects from mid to high elevations, this habitat consisted of a vegetated component as well as frequent rock outcroppings and rims. It offered bighorns an area in which to forage within escape cover. Cliffrock-shrub also contained rocky draws (Table 3).

Scree. This habitat was found at higher elevations on all aspects. It was usually found beneath masses of cliffrock and was composed of rubble accumulation from cliffrock habitats. Soil development was minimal. The habitat received limited use by bighorns.

Shrub-FEID. This habitat was found primarily on north aspects from low to mid elevations mostly within the winter range of the bighorn. It had the second highest herbaceous cover of any habitat used by bighorns. It occupied colder sites, was covered by snow most of the winter and was used less by bighorns than many other habitats.

Two sub-types, based on vegetation, comprised this habitat (Tables 2 and 3). The major subtype was found on shallow soils and had low sagebrush (*Artemisia arbuscula*) as the principal shrub. The smaller, draw sub-type was found in draws and exhibited deeper soils with mountain big sagebrush (*Artemisia tridentata vaseyana*) as the dominant shrub.

Within the general habitat, inclusions of *Prunus* and *Holodiscus* (Table 3) were found. Both inclusions were very dense and low-growing.

No sheep use was noted but deer were frequently flushed from them.

Shrub-AGSP. Found at lower elevations on south and east aspects, this habitat was preferred by bighorns during fall and winter. Inclusions of *Elymus*, *Holodiscus* and *Prunus* were present.

Cliffrock-talus. Found at lower elevations on all aspects, this habitat consisted of cliffrock out-croppings with talus interpieces. The cliffrock was very sparsely vegetated, but the interpieces supported some vegetation. Inclusions of *Prunus* and *Holodiscus* were present. The habitat received limited use by all bighorns during the winter, rams were frequently located within the habitat in summer (see Distribution section).

Mountain mahogany. This habitat was found at low to mid elevations on all aspects. Its' structure was quite variable depending on the site. Site characteristics varied from deep soils to rocky and cliff-like substrates. Bighorns used rockier areas as escape cover and for lambing.

Juniper. Juniper was found at lower elevations primarily on south and east aspects. The shrub-bunchgrass understory was similar to the Shrub-AGSP habitat. The juniper habitat received little use by bighorns--perhaps because the juniper tree overstory limited visibility.

Habitats not used by bighorns

Several habitats were not used by sheep: aspen, dense shrub, ceonothus, dense mountain mahogany, and streamchannel. In general, these habitats all exhibited combinations of a) dense shrub or tree cover; b) poor visibility; c) gentle slopes; d) occupied lower portion of a slope, and e) lack of escape cover or were further from escape cover than other habitats. They were generally of small size and were commonly inhabited by deer. Another habitat, talus, was rocky, devoid of vegetation, and received no use by bighorns.

Habitat Use and Preference

Numerous studies have documented range use by bighorns (Smith 1954, Crump 1957, Buechner 1960, Oldemeyer et al. 1971, Erickson 1972, Pallister 1974, Frisina 1974, Stewart 1975) but only Lauer and Peek (1976) attempted to assign a value to habitat preference by bighorns. A concurrent study of California bighorns in Oregon by Kornet (1978) on Hart Mountain in south-central Oregon also assigned habitat preference values to habitats. Consideration of availability of each habitat coupled with use by bighorns can assign relative importance to bighorn habitats.

The drier than normal weather from October 1976 through March 1977 resulted in less snowfall and allowed more of the study area to be available to the bighorns during fall, winter and spring than in more "normal" years. The entire study area was considered available to sheep during spring, summer and fall. The upper boundary for the winter range (2286 m) was established by computing the mean elevation of the upper half of all sheep sightings in the winter.

Deep snow and green vegetation was observed to greatly influence habitat use by the sheep throughout the year. Bighorns avoided deep snow when possible and moved to utilize new grass growth, especially in late winter and early spring. Similar observations were made by Lauer and Peek (1976) in Idaho.

Use of habitat by bighorns (Table 4) was examined statistically for

Table 4. Bighorn sheep habitat use by activity and season, Steens Mountain, 1976-77.

Habitat	Spring Activity (hrs)[a]				Summer Activity (hrs)				Fall Activity (hrs)				Winter Activity (hrs)			
	Foraging	Resting	Other[b]	Total	Foraging	Resting	Other	Total	Foraging	Resting	Other	Total	Foraging	Resting	Other	Total
Meadow	16	T[c]	T	16	597	46	15	658	80	34	11	125	80	5	5	80
Cliffrock	130	127	73	330	157	679	149	985	18	51	39	108	26	70	37	133
Cliffrock-shrub	379	179	36	594	670	370	62	1102	111	22	3	136	124	34	13	171
Shrub-AGSP	28	1	3	32	10	3	3	16	249	69	39	357	1105	263	82	1450
Shrub-FEID	72	3	7	82	56	48	9	113	25	5	3	33	31	T	4	35
Mtn. mahogany	139	134	46	319	33	62	7	102	3	4	3	10	37	20	10	67
Other[d]	64	36	8	108	89	66	9	164	33	16	11	60	144	28	25	197
Total	828	480	173	1481	1612	1274	254	3140	519	201	109	829	1537	420	176	2133

[a] Hours of sheep observation.
[b] Includes standing, moving, playing, loafing and courtship behavior.
[c] "T" indicates trace (< 0.5 hrs).
[d] Includes use of all remaining habitats.

total use, foraging use and resting use within seasons and between seasons. Highly significant statistical differences were found in all tests (Tables 5-10). Consequently the hypothesis that bighorns used habitat in proportion to its availability was rejected. To determine which habitats were preferred a habitat preference value (H.P.V.) for total bighorn use was computed (Table 11). Additional analysis of data resulted in development of habitat preference values for foraging (Table 12) and resting (Table 13).

Confidence limits based on expected (percent habitat available) and observed (percent observation) values (Tables 11-13) of habitat use were computed after New et al. (1974) so an idea of the precision of the habitat preference values could be obtained. A description of how the habitats were used by bighorns follows.

Meadow

The meadow habitat was preferred during all seasons except spring (Table 11), and was preferred for foraging (Table 12). Meadows offered diverse, lush vegetation to bighorns during most of the year and they responded as evidenced by the high preference values for foraging (summer 8.4, fall 3.5, winter 2.1, Table 12). In fall, meadow was preferred for resting (3.8, Table 13). During this season the moist meadow sites had dried enough to offer the sheep cool ground on which to bed. Meadow was not preferred in spring (Table 11) when ewes with young lambs frequented more rugged habitats than meadow. Meadows were also slower to "green-up" in spring than some other habitats (i.e., cliffrock-shrub, mountain mahogany) which were preferred by sheep at that time.

Table 5. Results of chi-square tests for differences in total habitat use by bighorns within seasons.

Season	X^2	d.f.	P <
Spring	2627.8	6	0.01[a]
Summer	4630.5	6	0.01[a]
Fall	556.4	6	0.01[a]
Winter	1427.6	6	0.01[a]

[a]Highly significant, $P < 0.01$.

Table 6. Results of contingency chi-square tests for differences in total habitat use by bighorns between seasons.

Seasons	X^2	d.f.	P <
Spring vs. summer	720.9	6	0.01[a]
Spring vs. fall	974.0	6	0.01[a]
Spring vs. winter	1869.7	6	0.01[a]
Summer vs. fall	1443.5	6	0.01[a]
Summer vs. winter	3159.9	6	0.01[a]
Fall vs. winter	271.4	6	0.01[a]

[a]Highly significant, $P < 0.01$.

Table 7. Results of chi-square tests for differences in habitat use by bighorns for foraging within season.

Season	X^2	d.f.	P <
Spring	1257.4	6	0.01[a]
Summer	5550.8	6	0.01[a]
Fall	483.2	6	0.01[a]
Winter	1261.2	6	0.01[a]

[a]Highly significant, $P < 0.01$.

Table 8. Results of contingency chi-square tests for differences in habitat use by bighorns for foraging between seasons.

Seasons	X^2	d.f.	P <
Spring vs. summer	515.1	6	0.01[a]
Spring vs. fall	572.5	6	0.01[a]
Spring vs. winter	1263.5	6	0.01[a]
Summer vs. fall	851.9	6	0.01[a]
Summer vs. winter	1980.7	6	0.01[a]
Fall vs. winter	184.3	6	0.01[a]

[a]High significant, $P < 0.01$.

Table 9. Results of chi-square tests for differences in habitat use by bighorns for resting within seasons.

Season	X^2	d.f.	P <
Spring	1248.6	6	0.01[a]
Summer	1627.8	6	0.01[a]
Fall	129.2	6	0.01[a]
Winter	276.7	6	0.01[a]

[a]Highly significant, $P < 0.01$.

Table 10. Results of contingency chi-square tests for differences in habitat use, by bighorns for resting between seasons.

Seasons	X^2	d.f.	P <
Spring vs. summer	260.1	6	0.01[a]
Spring vs. fall	325.8	6	0.01[a]
Spring vs. winter	466.1	6	0.01[a]
Summer vs. fall	525.2	6	0.01[a]
Summer vs. winter	959.7	6	0.01[a]
Fall vs. winter	93.5	6	0.01[a]

[a]Highly significant, $P < 0.01$.

Table 11. Habitat as a percent of the study area available; percent of the total bighorn observations within; and habitat preference values (H.P.V.) of habitats used by bighorn sheep each season, Steens Mountain, 1976-77. H.P.V. = percent of observation ÷ habitat percent of study area available, "+" indicates preference, "-" indicates avoidance, "o" indicates neither preference or avoidance for the habitat at the 0.01 level (Neu et al. 1974).

Habitat	Spring (Apr. - June 15)			Summer (June 16 - Sept.)			Fall (Oct. - Nov.)			Winter (Dec. - Mar.)		
	% avail. (9894)[a]	% obs. (1480)[b]	H.P.V.	% avail. (9894)[a]	% obs. (3140)[b]	H.P.V.	% avail. (9894)[a]	% obs. (830)[b]	H.P.V.	% avail. (6547)[a]	% obs. (2133)[b]	H.P.V.
Meadow	4.4	1.2^{-}	0.3	4.4	21.0^{+}	4.8	4.4	15.0^{+}	3.4	2.1	3.7^{+}	1.8
Cliffrock	18.3	22.2^{+}	1.2	18.3	31.3^{+}	1.7	18.3	13.0^{-}	0.7	9.8	6.3^{-}	0.6
Cliffrock-shrub	13.9	40.2^{+}	2.9	13.9	35.1^{+}	2.5	13.9	16.5^{o}	1.2	4.4	8.0^{+}	1.8
Shrub-AGSP	22.5	2.1^{-}	0.1	22.5	0.5^{-}	0.0	22.5	43.1^{+}	1.9	33.9	67.9^{+}	2.0
Shrub-FEID	12.5	5.5^{-}	0.4	12.5	3.6^{-}	0.3	12.5	3.9^{-}	0.3	17.0	1.7^{-}	0.1
Mountain mahogany	3.6	21.5^{+}	5.9	3.6	3.3^{o}	0.9	3.6	1.2^{-}	0.3	4.6	3.2^{-}	0.7
Other	24.8	7.3^{-}	0.3	24.8	5.2^{-}	0.2	24.8	7.3^{-}	0.3	28.2	9.2^{-}	0.3

[a]Hectares of range available (see text).
[b]Hours of sheep observation.

Table 12. Habitat as a percent of the study area; percent of bighorn sheep foraging observations within; and habitat preference values (H.P.V.) for foraging each season, Steens Mountain, 1976-77. H.P.V. = percent of observation ÷ habitat percent of study area available. "+" indicates preference, "-" indicates avoidance, "o" indicates neither preference or avoidance for the habitat at the 0.01 level (Neu et al. 1974).

Habitat	Spring			Summer			Fall			Winter		
	% avail. (9894)[a]	% obs. (828)[b]	H.P.V.	% avail. (9894)[a]	% obs. (1612)[b]	H.P.V.	% avail. (9894)[a]	% obs. (519)[b]	H.P.V.	% avail. (9894)[a]	% obs. (1537)[b]	H.P.V.
Meadow	4.4	1.9^{-}	0.4	4.4	37.0^{+}	8.4	4.4	15.4^{+}	3.5	2.1	4.5^{+}	2.1
Cliffrock	18.3	15.7^{o}	0.9	18.3	9.7^{-}	0.5	18.3	3.5^{-}	0.2	9.8	1.7^{-}	0.2
Cliffrock-shrub	13.9	45.8^{+}	3.3	13.9	41.6^{+}	3.0	13.9	21.4^{+}	1.5	4.4	8.1^{+}	1.8
Shrub-AGSP	22.5	3.4^{-}	0.2	22.5	0.6^{-}	0.0	22.5	47.9^{+}	2.1	33.9	71.9^{+}	2.1
Shrub-FEID	12.5	8.7^{-}	0.7	12.5	3.5^{-}	0.3	12.5	4.8^{-}	0.4	17.0	2.0^{-}	0.1
Mtn. mahogany	3.6	16.8^{+}	4.7	3.6	2.1^{-}	0.6	3.6	0.6^{-}	0.2	4.6	2.4^{-}	0.5
Other[c]	24.8	7.7^{-}	0.3	24.8	5.5^{-}	0.2	24.8	6.4^{-}	0.3	28.2	9.4^{-}	0.3

[a]Hectares of range available.
[b]Hours of foraging observation.
[c]Includes the remainder of the study area.

Table 13. Habitat as a percent of the study area; percent of bighorn sheep resting observations within; and habitat preference values (H.P.V.) for foraging each season, Steens Mountain, 1976-77. H.P.V. = percent of observation ÷ habitat percent of the study area available. "+" indicates preference, "-" indicates avoidance, "o" indicates neither preference or avoidance for the habitat at the 0.01 level (Neu et al. 1974).

Habitat	Spring			Summer			Fall			Winter		
	% avail. (9894)[a]	% obs. (480)[b]	H.P.V.	% avail. (9894)[a]	% obs. (1274)[b]	H.P.V.	% avail. (9894)[a]	% obs. (201)[b]	H.P.V.	% avail. (6547)[a]	% obs. (420)[b]	H.P.V.
Meadow	4.4	T[c]	0.0	4.4	3.6^{o}	0.8	4.4	16.9^{+}	3.8	2.1	1.2^{o}	0.6
Cliffrock	18.3	26.5^{+}	1.4	18.3	53.3^{+}	2.9	18.3	25.4^{o}	1.4	9.8	16.7^{+}	1.7
Cliffrock-shrub	13.9	37.3^{+}	2.7	13.9	29.0^{+}	2.1	13.9	10.9^{o}	0.8	4.4	8.1^{+}	1.8
Shrub-<u>AGSP</u>	22.5	0.2^{-}	0.0	22.5	0.2^{-}	0.0	22.5	34.3^{+}	1.5	33.9	62.6^{+}	1.8
Shrub-<u>FEID</u>	12.5	0.6^{-}	0.0	12.5	3.8^{-}	0.3	12.5	2.5^{-}	0.2	17.0	T^{-}	0.0
Mtn. mahogany	3.6	27.9^{+}	7.8	3.6	4.9^{+}	1.4	3.6	2.0^{o}	0.6	4.6	4.7^{o}	1.0
Other[d]	24.8	7.5^{-}	0.3	24.8	5.2^{-}	0.2	24.8	8.0^{-}	0.3	28.2	6.7^{-}	0.2

[a] Hectares of range available.
[b] Hours of resting observation.
[c] "T" indicates trace.
[d] Includes the remainder of the study area.

Cliffrock

Cliffrock had highest preference values in spring (1.2) and summer (1.7) (Table 4), and was preferred for resting during all seasons (Table 13). The habitat functioned as a place of security in which bighorns rested. It was most important for resting in summer (2.9, Table 13) when ewes sought it as security with their young lambs. Habitats similar to cliffrock were described by Blood (1963a), Irvine (1969) and Geist (1971) as lambing habitat. Cliffrock was not preferred during the rest of the year--most likely because of its sparse vegetation. The true value of cliffrock is recognized when one considers that it is essential to bighorns in terms of escape cover (Woolf 1968, Geist 1971, Frisina 1974). Although in this study cliffrock was not highly preferred, mere presence of the cliffrock habitat for escape cover possibly governed the extent to which other habitats were utilized. During the entire study sheep were rarely seen more than 400 meters from a habitat such as cliffrock that offered escape cover.

Cliffrock-shrub

The cliffrock-shrub habitat was preferred during all seasons (Table 11). It was preferred for foraging during all seasons (Table 12) and was preferred for resting during spring, summer and winter and used in proportion to its availability in fall (Table 13). This habitat offered a vegetational component in conjunction with an escape component in cliffrock out-croppings. Here sheep foraged continually near escape cover as was documented by Oldemeyer et al. (1971), Erickson (1972) and Frisina (1974) which probably explains why cliffrock-shrub was a highly preferred habitat year-round. Most of the habitat was found at higher elevations. Vegetative growth in this habitat was more advanced in spring than in other habitats of similar elevation and aspect (meadow, scree, cliffrock) because snowmelt occurred sooner.

Shrub-*AGSP*

The shrub-*AGSP* habitat was preferred during fall (1.9) and winter (2.0) only (Table 11). It was used approximately twice as much in proportion to its availability for both foraging and resting during these seasons (Tables 12, 13). Elevational availability possibly was an important factor governing bighorn use and preference for the shrub-*AGSP* habitat. It was not preferred during spring and summer (Table 11) because the bighorn herd in general was found at higher elevations while this habitat was at lower elevations. In fall and winter, colder temperatures and deep snow cover and less available forage at higher elevations probably forced bighorns down slope where they selected this habitat. Lauer and Peek (1976) in Idaho found bighorns to show preference for a similar habitat during winter. Bluebunch wheatgrass, where present, has been recorded as an important winter forage plant for bighorns (Smith 1954, Sugden 1961, Demarchi 1965, Blood 1967, Berwick 1968, Constan 1972). Forage type, absence of snow cover and warmer conditions presented by south and east aspects (Table 2) were probably responsible for preference for this habitat by bighorns.

Even though the shrub-*AGSP* habitat was not preferred during spring and summer, year-round management should be structured to insure this habitat is preserved for bighorns in a condition that will give them the most benefit during the critical winter period.

Shrub-FEID

The shrub-FEID habitat was avoided during all seasons (Tables 11-13). It was located on the cooler north aspects where snow cover lasted longer. Idaho fescue has been noted as part of the bighorn diet in several studies (Schallenberger 1966, Blood 1967, Constan 1972, Pallister 1974, Stewart 1975). Constan (1972) in Montana felt bluebunch wheatgrass was preferred to Idaho fescue by bighorns. Bighorns may have avoided the shrub-FEID habitat because of colder temperatures, presence of snow cover and a preference for other forages such as bluebunch wheatgrass.

Mountain mahogany

Mountain mahogany was avoided throughout most of the year (Table 11). It was, however, highly preferred by bighorns in the spring (5.9, Table 11) when heavy use by ewes during and following lambing was noted. In spring the habitat was preferred for both foraging (4.7, Table 12) and resting (7.8, Table 13). Throughout the remainder of the year the limited use this habitat received by bighorns was for resting where it was either preferred (summer, Table 13) or used in proportion to its availability (fall, winter, Table 13). This preference and use probably was related to the thermal and visual cover the habitat offered to the bighorns.

Other habitats used by bighorns

Three habitats received little use by bighorns throughout the year (juniper, scree, cliffrock-talus). Juniper was found in limited amounts at lower elevations. Although the understory plant flora was similar to that of the shrub-AGSP habitat, bighorns avoided it perhaps because the juniper trees reduced visibility and escape cover within the habitat was not abundant.

The cliffrock-talus habitat was found at lower elevations, while the scree habitat was found primarily at higher elevations. Both habitats were sparsely vegetated and were found on rocky substrates; they were used less than in proportion to their availability by bighorn. All other habitats were not used by bighorns.

Other Components of Habitat

Two components of habitat could not be measured but may have been important to the bighorn population: minerals and water.

Minerals

Researchers working with Rocky Mountain bighorns (*Ovis canadensis canadensis*) have called attention to the importance of mineral (salt) licks (Couey 1950, Smith 1954, Berwick 1968, Geist 1971, Kiess 1976).

The importance of mineral licks to Rocky Mountain bighorns may be related to the low mineral content of granitic soils in their range (Smith 1954:68, Buechner 1960:119).

No salt or mineral licks were found on the study area. In addition, bighorns were not observed to use mineral block stations put out for cattle grazing the bighorn winter range. It is possible that there were no mineral concentrations present on the study area that would serve as "licks" for the sheep. However, sheep frequently licked the surface of rocks, possibly sampling mineral deposits left by water evaporation. The soils of the Steens are of volcanic origin (Fuller

1931) and possibly do not have any mineral deficiencies. Sugden (1961) in British Columbia did not observe California bighorns to use mineral licks; the soils on his study area were of volcanic and sedimentary origin.

Gross mineral deficiencies were probably non-existent on the study area.

Water

Several authors have reported the importance of water to desert bighorns (Russo 1956, Jones et al. 1957, Buechner 1960, Welles and Welles 1961, Irvine 1969). Availability of water has not yet been identified as a problem with any Rocky Mountain bighorn or California bighorn herd.

On the study area, water was readily available throughout the spring and summer. In the fall and winter, snowfall and cold temperatures rendered many sources of water unavailable-either permanently or periodically. During these times, sheep were observed licking ice and eating snow in addition to drinking free water. No definite watering schedule was noted. The abundant supply of watering areas perhaps made the practice of going to water more incidental than regular.

Bighorn Activity Patterns

Quantitative information concerning activity patterns of bighorns was limited. Blood (1963a) recorded some bighorn sheep activity in southern British Columbia. Geist (1971) noted activity patterns of Stone's sheep (*Ovis dalli stonei*) in northern British Columbia. Woolf (1968) recorded activity patterns of Rocky Mountain bighorns in Colorado. Kornet (1978) on Hart Mountain in south-central Oregon observed activity patterns of a California bighorn herd. These studies allowed some comparisons of sheep activity between four different geographic areas.

Activities documented in this study were recorded during daylight hours only. The nature and extent of bighorn activity during darkness is essentially unknown. Geist (1971), Woolf (1968), and Blood (1963a) noted limited night activity which my observations support. On several occasions sheep were observed foraging when darkness fell. Groups that had bedded at dark were found as far as 400 to 800 m from the bedding area at first light. Some movement must have taken place after dark or during twilight.

Seasonal activity patterns of ewe-lamb groups

California bighorn ewe-lamb groups on Steens Mountain exhibited peaks of feeding activity in early morning and late evening in all seasons (Figure 2). When bighorns were not feeding they were usually resting. Activity classed as "other" was usually of very short duration (< 5 min) and distributed throughout the day. The ewe-lamb groups appeared to utilize the cooler portions of the day for increased activity during spring and summer. This pattern did not change during the colder portion of the year (Figure 2). Geist (1971) in British Columbia observed female Stone's sheep to shift all activity away from early morning periods to the warmer portions of the day during winter. With Stone's sheep rams he saw a pattern similar to that observed with ewe-lamb groups on the Steens during summer and fall but observed them to act similar to female Stone's sheep during winter. He felt that this reflected a selection for energy conservation during winter. Davis and Taylor (1939) working with desert bighorns in Texas described a pattern

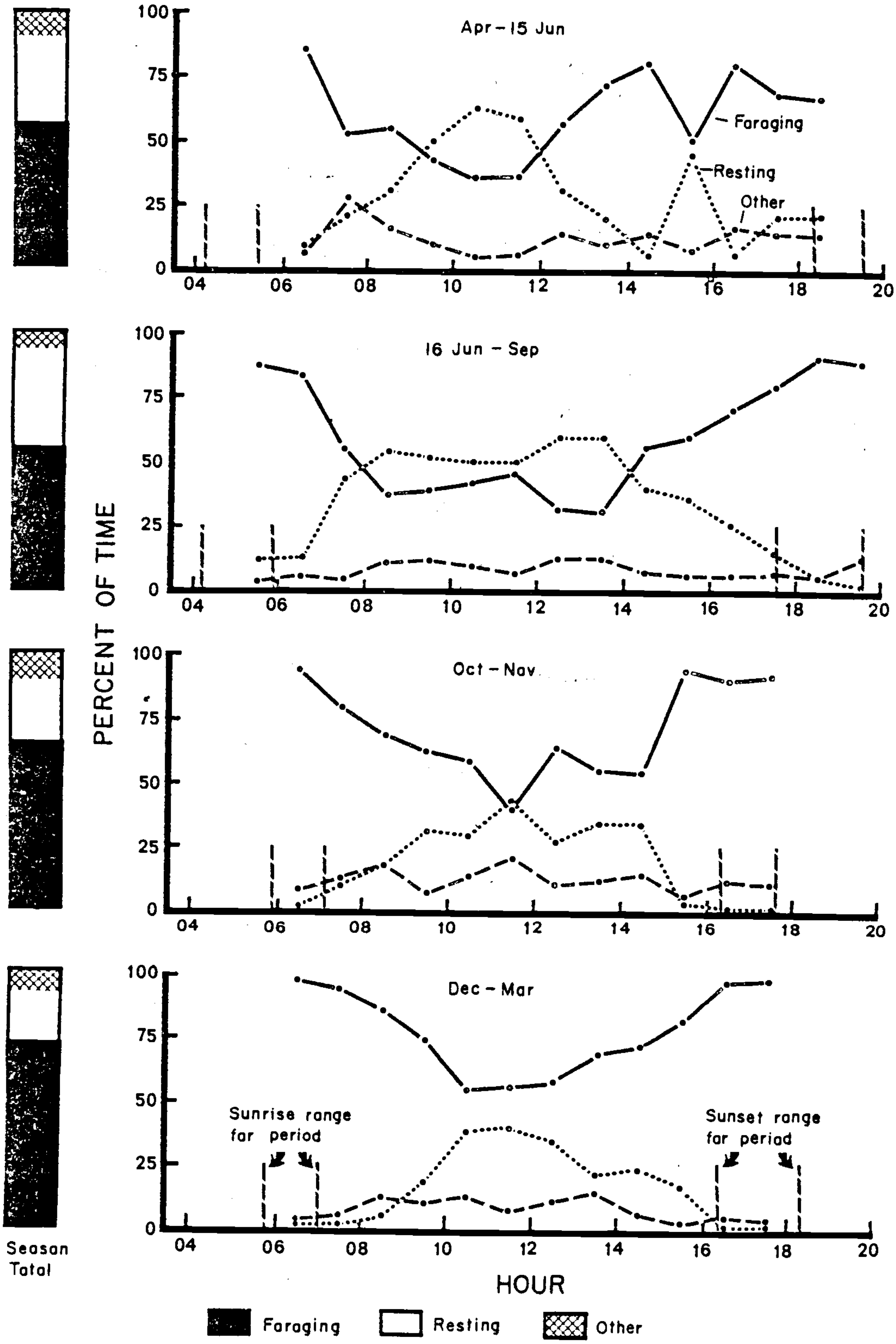

Figure 2. Daily activity of ewe-lamb groups by season, Steens Mountain, 1976-77.

of activity similar to that of the Steens bighorn herd.

Woolf (1968:56) in Colorado did not see any definite pattern of activity for Rocky Mountain bighorns. He described bighorn activity as "...a constant search for food broken by frequent bedding intervals."

Kornet (1978) in Oregon observed California bighorns primarily to move from bedding areas in the early morning and feed throughout the remainder of the day in a circuit that returned them to bedding areas at night. She considered the lack of suitable escape terrain for bedding responsible for this pattern.

Winter activity patterns recorded by Blood (1963a:91) differed from the above studies. Blood noted three peaks of activity--one shortly after daybreak, one at mid-day, and one toward sundown. He felt that the lows in activity were used for rumination on the bedding grounds. Peaks of activity similar to those observed by Blood have been expressed by others (Mills 1937, Davis 1938, Smith 1954), but no quantitative data were shown.

Activity budgets of individual sex and age classes

The amount of time spent foraging, resting and performing other activities (Table 14) was converted to percent and plotted by season for ewe, lamb, ram and combined cohorts (Figure 3). A general trend was noted: bighorns spent a smaller portion of daylight hours foraging in summer than in winter with spring and fall being intermediate. Resting activity was the reciprocal of foraging activity. These trends could have been related to several causes: a) less daylight hours available in which to be active in winter, b) poorer forage quality in winter, c) less available forage in winter, d) colder temperatures in winter which

Table 14. Comparison of individual bighorn sex and age activity budgets[a], Steens Mountain, 1976-77.

	Spring				Summer				Fall				Winter			
Sex and age category	Foraging	Resting	Other	Total	Foraging	Resting	Other	Total	Foraging	Resting	Other	Total	Foraging	Resting	Other	Total
Ad. ewes	427	206	39	672	684	405	87	1176	231	84	48	363	699	178	82	959
Lambs	225	175	119	519	509	412	77	998	166	49	24	239	542	142	51	735
Ad. rams	31	14	2	47	186	298	66	550	114	60	36	210	167	65	30	262
Ewe-lamb[b]	797	466	171	1434	1426	976	188	2590	405	141	73	619	1370	355	146	1871
Combined	828	480	173	1481	1612	1274	254	3140	519	201	109	829	1537	420	176	2133

[a]Expressed as hours of sheep observation.
[b]Includes ewes, lambs, and yearlings.

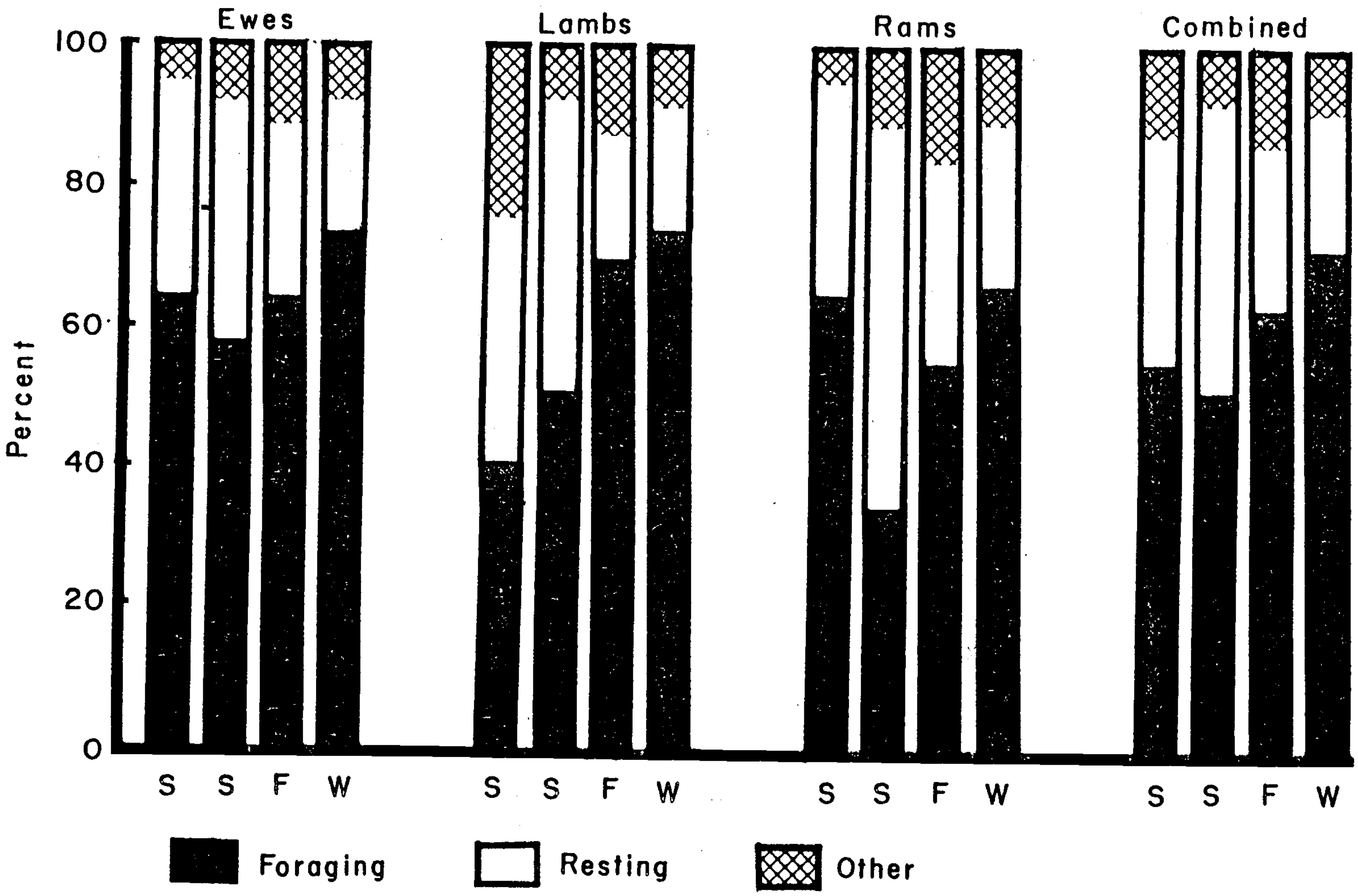

Figure 3. Comparison of time allotment of bighorn sheep sex and age groups for the various activities by season, Steens Mountain, 1976-77.

caused an increase in energy demands. No trend was noted in the "other" category between seasons but the greatest amount of activity in this category occurred in spring (12 percent--primarily playing by newborn lambs) and fall (13 percent--primarily courtship behavior).

Data were examined for differences between the activity budgets of adult ewes, lambs, and adult rams for foraging, resting, and other activity (Table 14). Significant statistical differences were found within each season (Table 15). Consequently, the hypothesis that adult ewes, lambs, and adult rams had similar activity budgets for foraging, resting, and other activity within a season was rejected. Additional statistical analysis showed that certain sex and age classes were different in allotment of their time to the various activities (Table 16).

In spring there was no difference in the activity budgets of adult ewes and adult rams. The activity budget of lambs was different than either adult ewes or adult rams (Table 16). In spring lambs spent a smaller portion of their time foraging and a larger portion of their time pursuing other activities (primarily standing and playing) than adult ewes or adult rams (Table 14). Lambs depend largely on milk for nourishment during the first few weeks of life where a high-nutrition diet is ingested during short frequent nursing intervals. Foraging habits of the lambs develop slowly (Welles and Welles 1961, Geist 1971). Since the lambs needed to forage less, more time was spent in pursuit of other activities.

Activity budgets of all sex and age classes were different in summer (Table 16). Adult rams spent a smaller portion of their time foraging than lambs and lambs spent less time foraging than adult ewes.

Table 15. Results of contingency chi-square tests for differences in sex and age activity budgets within season.

Season	X^2	d.f.	P <
Spring	92.9	4	0.01[a]
Summer	90.0	4	0.01[a]
Fall	11.6	4	0.05[b]
Winter	11.9	4	0.05[b]

[a]Highly significant, $P < 0.01$.
[b]Significant, $P < 0.05$.

Table 16. Results of contingency chi-square tests for differences in activity budgets between individual sex and age groups within each season.

Group	X^2	d.f.	P <
	Spring		
Ad. ewes vs. lambs	87.4	2	0.01[a]
Ad. ewes vs. Ad. rams	0.2	2	0.75[c]
Lambs vs. Ad. rams	12.1	2	0.01[a]
	Summer		
Ad. ewes vs. lambs	11.8	2	0.01[a]
Ad. ewes vs. Ad. rams	88.9	2	0.01[a]
Lambs vs. Ad. rams	43.2	2	0.01[a]
	Fall		
Ad. ewes vs. lambs	2.4	2	0.25[c]
Ad. ewes vs. Ad. rams	4.9	2	0.10[b]
Lambs vs. Ad. rams	11.3	2	0.01[a]
	Winter		
Ad. ewes vs. lambs	1.5	2	0.25[c]
Ad. ewes vs. Ad. rams	8.4	2	0.05[b]
Lambs vs. Ad. rams	10.3	2	0.01[a]

[a]Highly significant, $P < 0.01$.
[b]Significant, $P < 0.10$.
[c]Not significant

The reverse was found for resting activity. Energy requirements among sex and age classes may have produced the observed differences in activity budgets. Adult rams needed only to meet requirements of body maintenance while lambs had to meet requirements for body growth and maintenance. Ewes were presented with even higher energy demands for body maintenance, lactation, and past gestation.

Activity budgets of adult ewes and lambs were similar in fall and winter (Table 16). However, adult ram activity was different from that of adult ewes and lambs (Table 16). Adult rams apparently still had smaller energy demands than adult ewes or lambs and consequently they allotted a smaller portion of their time to foraging and a larger portion of their time to resting and other activity. The breeding season probably contributed to the difference in activity budgets between lambs and the adult cohorts, especially in fall and early winter, because lambs did not participate in breeding activity.

Population Characteristics

Distribution

A difference in distribution of the ewe-lamb groups and ram groups was identified during the study. Since their release on the study area in the winter of 1961 the bighorns have inhabited an area of approximately 100 km^2. While ram groups were found throughout the entire study area, ewe-lamb groups occupied only the southern half of the study area (Figure 1). The reason for this difference in distribution was puzzling but was partially explained by the fact that rams are bold and pioneering while ewes and lambs are more sedentary (Geist 1971). The types and juxtaposition of habitats did not appear to differ markedly between drainages and the fact that rams occupied all drainages on the study area supports this statement.

The road systems on Steens Mountain provide recreationists easy access to a large portion of the bighorn range from both the top and base of the mountain. The area inhabited by the ewe-lamb groups was most remote from roads and human activity, especially during the summer. Although ewe-lamb groups are known to be more or less sedentary (Geist 1971), their range has extended three drainages south of the release site, since 1961, while the northern extension has been very limited (Figure 1). Ewes with the reproductive responsibility of a lamb possibly prefer complete familiarity with their surroundings. Hence, they are slow to extend their range in any one direction; a process that becomes even slower or non-existent where disturbance is present.

Hunting of the bighorn herd was not observed to cause bighorns to abandon permanently use of any portions of the study area as observed by by Geist (1971:88). Theoretically, hunting may force bighorns into new areas and ultimately function in range extension. Since the bighorn occupy an isolated mountain, regulated hunting should not be detrimental to the population because there are no suitable alternate areas available that bighorns could move to as stated by Geist (1971:88).

Human disturbance (primarily by recreationists) to the bighorn herd may have been responsible for failure of the ewe-lamb groups to occupy a portion of the study area similar to that of ram groups. Data was collected during summer and fall that supported this claim (manuscript in progress).

Theoretically, if the area occupied by ewe-lamb groups could be increased to equal that of the ram groups, the size of the population could be nearly doubled.

Another difference in use of the study area by ewe-lamb groups and ram groups was noted. In summer, ewe-lamb groups were usually observed at higher elevations while ram groups could be located at any elevation on the study area. This phenomenon was probably related to preference of habitat by the ewe-lamb groups. Most of the cliffrock habitat was located at higher elevations on the mountain and was highly preferred for resting by bighorns during summer (Table 13). Ewes with young lambs probably chose to use areas where cliffrock (escape cover) was most abundant while rams felt comfortable in areas which presented less escape cover. Consequently, there was a difference in elevational use of the study area by these groups.

Sex and age ratios

Ratios are usually expressed as the proportion of the cohort in question per 100 adult ewes. Such figures can be misleading in situations such as the Steens where the adult ewe cohort numbers less than 100 individuals (50+). We chose to express the ratios as a percent of the adult ewe cohort and have displayed actual numbers observed wherever possible (Tables 1 and 17). A ewe was considered to be adult when 2 years of age or older.

Counts of ewes, lambs and yearlings were taken daily and ratios computed for each month (Table 17). Lamb to ewe ratios became erratic during March-May, when ewe-lamb groups broke up for lambing as observed by Irvine (1969). Bands consisting entirely of ewes or of lambs (short-

Table 17. Bighorn sheep ratio and count data, Steens Mountain, 1976-77.

Month	Bighorns observed								Ratio (%)	
	Adult ewes	Lamb	Yrlg ewes	Yrlg rams	Rams by class I	II	III	IV	Lambs:ewe	Yrlg:ewe
1976 June	90	78	11	7	0	16	18	10	87	20
July	172	145	17	30	11	18	21	16	84	27
Aug.	84	66	10	8	14	3	17	12	79	21
Sept.	81	58	9	10	17	2	14	8	72	24
Oct.	55	39	5	3	7	4	20	7	71	15
Nov.	81	53	9	2	10	7	22	15	65	14
Dec.	83	53	10	5	10	17	23	10	64	18
1977 Jan.	55	34	7	3	4	8	4	4	62	18
Feb.	70	44	7	6	5	2	3	2	63	19
Mar.	157	108	11	15	9	8	13	5	69	17
Apr.	51	25	9	5	2	4	0	0	49	28
May	74	67	17	16	1	5	6	3	91	45
June	167	161	51	35	2	16	2	2	96	52
July	53	38	14	13	0	10	9	3	72	51
Aug.	51	36	12	12	0	4	4	1	71	47
Dec.	55	18	12	8	0	6	13	5	33	36
Total 1976	928	678	96	89	87	85	155	89		
Total 1977	396	327	103	81	23	63	54	25		

yearlings) were common. Observability of ewes and lambs (short-yearlings) was not equal during this period; ewes inhabited the most rugged areas and were more difficult to observe. Consequently, ratios obtained during March-May were not used for population analysis.

Although ratios do not reflect actual numbers, they portray relationships between cohorts and, when coupled with known counts of cohorts, may be used to infer the numeric structure and dynamics of a population through time.

Bighorn sheep literature is rich in ratios without specific time frames and sample sizes. Lamb to ewe ratios taken during August cannot be interpreted as production when lambing occurred in May. Likewise, lamb to ewe ratios of December may not accurately represent yearling to ewe ratios the following June. Seasonal ratios can be misleading if monthly ratios do not remain constant through that period. Interpretation of yearling to ewe ratios may be misleading. While yearling ewes consistently remain with ewe-lamb groups, yearling rams may: a) remain with the ewe-lamb-yearling ewe groups (often observed on the Steens), b) associate with mature rams (three sightings on the Steens), c) be observed as singles or form yearling ram groups (frequently observed on the Steens).

Yearling to ewe ratios during 1976 involved a minimum of 11 yearlings (observed in June). With so few yearlings present, ratios tended to fluctuate erratically but did not drop markedly (Table 17), therefore the ratio of yearlings to ewes was averaged over June-February. For this period the average yearling to ewe ratio was 20 percent. Identical procedures were followed for the June-August period of 1977.

Recruitment from the yearling ewe to adult ewe cohort at a given point in time (April 1 for this study) will make the adult ewe cohort larger while the size of the corresponding yearling (lamb) cohort possibly has not changed. On the Steens a minimum of five yearling ewes was recruited into the population on 1 April 1977. Correspondingly the lamb to ewe ratio dropped from 63 percent in February 1977 to an average yearling to ewe ratio of 50 percent in June to August 1977. The five-individual increase in the adult ewe cohort and loss of about four individuals from the lamb cohort during March to May period was responsible for the 13 percent ratio drop. If more than five yearling ewes were recruited to the adult ewe cohort on April 1, lamb loss was less than four during the March to May 1977 period.

Birthdates

The first lambs of 1977 were born in mid-April with the peak of lambing in the last week of April and the first week of May. Single ewes were observed moving to rugged, secluded habitats (cliffrock, mountain mahogany) for lambing about April 1. Kornet (1978) observed a similar lambing season on Hart Mountain in south-central Oregon. The dry winter (Appendix Table 1) of 1976-77 resulted in a lighter than normal snowpack and allowed ewes to use higher elevations (up to 2621 m) and to spread over larger areas for lambing than under more usual conditions. As noted by Geist (1971:250), ewe-lamb groups remained within the security of the rugged habitats for nearly a month before venturing into less rugged areas.

Lamb production

Geist (1971:281) generalized that in American sheep single lambs are the rule; twinning has rarely been observed. Evidence to the contrary is accumulating for California bighorns. Spalding (1966) reported that 4 of 11 pregnant, road-killed California bighorn ewes were carrying twin fetuses. Blood (1961) cited observations of California bighorns in British Columbia which suggested twinning. Brian Wikeem (Pers. Comm., 24 May 1977, Dept. of Plant Science, Univ. of British Columbia, Vancouver) indicated that 2 of an 18 ewe herd in an enclosure at the Okanagan Game Farm, Penticton, gave birth to twin lambs. On the Steens, I observed at least one set of twins in June 1976 and at least three sets in June 1977. This study was conducted during 2 years where mild winter conditions and excellent forage production occurred, both of which may have influenced twinning. If twinning commonly occurs as evidenced above, California bighorn populations have potential for greater rates of increase than other subspecies of bighorn.

The age at which a bighorn ewe will breed is a point of contention among sheep biologists. Buechner (1960) and Geist (1971) indicated that a ewe would bear her first lamb at 3 years of age, but Buechner cited instances were 2-year-old ewes produced lambs. Woodgerd (1964) noted instances on Wildhorse Island in Montana where 2-year-old ewes produced lambs. Welles and Welles (1961) indicated that desert bighorn ewes 18 months of age were sexually mature and should breed. On the Steens, 18-month-old ewes were avidly courted by mature rams.

Lamb to ewe ratios approaching 100 percent must indicate various combinations of the following: a) twinning; b) 2-year-old ewes are dropping lambs; c) older ewes must consistently produce lambs until death. If 2-year-old ewes do not produce lambs or if the proportion breeding changes between years, then the proportion of 2-year-old ewes in the population will affect the ratio of lambs to ewes.

Lamb production (June lamb to ewe ratios) on the Steens in 1976 and 1977 was 87 and 96 percent respectively (Tables 17 and 18). Twinning and the possibility that yearling ewes were bred and dropped lambs were at least partially responsible for these high figures. The fact that two adult ewes on the Steens did not bring lambs to heel in 1977 supports the probability that twinning and yearling ewe breeding contributed highly to total lamb production. These figures indicate few if any lambs lost soon after birth. The Steens production values are higher than those from many areas and are comparable to values presented by Blood (1961:30), Drewek (1970), Woodard et al. (1974), Hickey (1975) and Kornet (1978) (Table 18). Lamb survival the first 7 months after birth in 1976 (64 percent) was comparable to studies by Blood (1961), Erickson (1972) and Frisina (1974) (Table 18). Survival of the 1976 lamb crop and recruitment to the yearling cohort (1 April) on the Steens in 1977 was good (Table 18).

Yearling to ewe ratios for 1976 and lamb to ewe ratios for 1977 on the Steens indicate poor lamb survival for 1975 and 1977 (Table 17 and 18). Poor lamb survival during the first 7 months after birth was noted by Hansen (1967) on a slightly increasing bighorn population in Nevada and by Woodard et al. (1974) in a decreasing population in Colorado. These instances are contrary to the statement by Geist (1971:287): "If lambs survive their first few days of life, they have very low

Table 18. Comparison of lamb:ewe (L:E) and yearling:ewe (Y:E) ratios (%) from several bighorn sheep herds.

	Month after birth															
	1	13	2	14	3	15	4	16	5	17	6	18	7	19	8	20
	L:E	Y:E	L:E	Y:E	L:E	Y:E	L:E	Y:E	L:E	Y:E	L:E	Y:E	L:E	Y:E	L:E	Y:E
Steens 1976[a]	87	20	84	27	79	21	72	24	71	15	65	14	64	18	63	18
Steens 1977[a]	96	52	72	51	71	47							33	44		
Drewek (1970:12)[a]							91	30			77	77				
(increasing)[b]																
Blood (1961:30)[a]	83	18.5	70	10			78	11	73	-	67.5	9	70	12	69	12
(static)	68	61														
Demarchi (1965:63)[a]	57	43														
(increasing)	48	17														
	43	20														
	42	24														
Kornet (1978:33)[a]			91.7	-	86.2	-	84.0	-	77.0	-						
(increasing)																
Hansen (1965:696)[c]	70	15									35	15				
(increasing)																
Hickey (1975:31)[d]					86	17			90	30						
(increasing)																
Woodard et al. (1974:71)[d]	83	11					17	-								
(decreasing)	72	17					22	14								
Erickson (1972:18)[d]													53	40		
(increasing)																
Frisina (1974:17)[d]	72	24											61	24		
(increasing)																

[a] California bighorns
[b] Status of population
[c] Desert bighorns
[d] Rocky Mtn. bighorns

mortality in the following summer...."

On the Steens recruitment to the 2-year-old cohort varied strongly between years: the average yearling to ewe ratio was 20 percent for June 1976 through February 1977 and 50 percent for June through August 1977 (Table 17) indicating a probably two-fold difference in recruitment between 1977 and 1978. Lamb to ewe ratios of December 1977 indicated that yearling to ewe ratios of 1978 will be less than 33 percent (Table 17).

Data from the Steens indicated that the population was increasing at a rate which varied from year to year. Recruitment of varying numbers of yearling females into the adult ewe cohort from year to year may cause erratic fluctuations in numbers of lambs produced each year and the number of yearlings recruited into the population from year to year. Yearling to ewe ratios for the Steens (1976) were comparable to other studies (Table 18).

Lamb mortality

Lamb mortality rates vary greatly among bighorn herds. Accidents and predation are generally credited with only a small portion of lamb losses. No loss of lambs to accident or predation was observed on the Steens. One dead lamb was found but no conclusion to the cause of death was determined.

The primary losses of lambs in other studies have been linked to the lungworm-pneumonia complex (Woodard et al. 1974, Hibler et al. 1976, Forrester and Senger 1964, Buechner 1960).

On three separate occasions unhealthy appearing lambs were observed during the summers of 1976 and 1977. These lambs were not, however, observed to sneeze or cough as reported by Woodard et al. (1974) where lungworm was involved. Rather, such lambs walked very slowly with a hump-backed posture, bedded frequently for long periods of time, failed to forage as frequently as normal appearing lambs, had rough pelage, and exhibited diarrhea. Six additional lambs were observed which showed signs of diarrhea. Attempts to collect unhealthy lambs failed. The most common cause of diarrhea is from gastrointestinal parasitism (Pers. Comm., 15 February 1977, T. P. Kistner, DVM, Dept. of Fisheries and Wildlife, OSU, Corvallis, Oregon). Kistner suggested that the unhealthy lambs observed were suffering from a gastrointestinal parasite--possibly *Nematodirus oirantianus*, which he felt could cause mortality in lambs if they acquired heavy burdens of the parasite. This parasite was found in rams from the same population (Kistner et al. 1977) and the genus was identified in California bighorn populations in California (McCullough and Schneegas 1966) and in British Columbia (Blood 1963b). Fecal samples of all sex and age groups collected throughout the summer and fall of 1976 were analyzed by Kistner and a low level of lungworm (*Protostrongylus stilesi*) larva was reported.

Yearling survival

No instances of yearling mortality were observed. Data from several studies of Rocky Mountain bighorns presented by Geist (1971:293) indicated a 10 percent mortality rate for yearlings. Lack of mortality rates of California bighorns warranted use of Rocky Mountain bighorn mortality rates for this study. This rate was applied to the yearling cohort for the population model of the Steens bighorn population.

Geist (1971) also indicated that a yearling to ewe ratio of 20 percent must be produced to maintain a "poor quality, stable population"; a ratio of 40 percent or better was needed for an "increasing, high quality population." By these criteria the status of the Steens bighorn herd was felt to be somewhere between a "poor quality" and a "high quality" population.

Adult survival

No instances of natural mortality of adults were observed. Geist (1971:294) calculated survival values for healthy adult Rocky Mountain bighorns between 2 and 6 years of age. Ewes and rams had an apparent survival of nearly 95 and 97 percent respectively. Lack of mortality rates of California bighorns warranted application of these rates to the Steens Mountain herd.

Sex ratio

Geist's (1971) review of sheep literature indicated the sex ratio at birth to be 50:50. Survival of ram and ewe lambs was reported to vary from population to population (Woodgerd 1964, Geist 1971, Woodard et al. 1974). Survival of ewe and ram lambs on the Steens appears to be nearly equal: in June 1976, 11 yearlings were observed (6 female, 5 male); in May 1977, 22 yearlings were observed (11 female, 11 male). Equal sex ratio for yearlings was assumed in the population analysis.

1976-77 Population Model

The rugged, broken nature of the terrain on the study area made complete census difficult, so the model of the Steens Mountain bighorn population has been based on minimum counts of certain sex and age cohorts coupled with ratios involving other cohorts (Figure 4).

For this model, the first step was to establish the ewe curve (Figure 4), which was based on the following: a) 55 ewes were counted in December 1977, b) at least 5 yearling ewes were recruited into the population in April 1976; c) a 5 percent mortality rate was applied to the ewe cohort (Geist 1971:294). Working backwards in time from December 1977 to June 1976, 54 ewes should have been present in the population in June 1976. The average ratio of yearlings to ewes from June 1976 to February 1977 was 20 percent (Table 17). An average yearling to ewe ratio of 20 percent with 11 yearlings in the population indicated 55 ewes were present in the population in June 1976. This agreed closely with the 54 ewes projected earlier; these calculations formed a minimum base for the ewe segment of the population. Other minimum counts of ewes (both adult and yearling) were 42 and 47 in August of 1976 and 1977 respectively.

The ewe cohort estimates, established above, coupled with lamb to ewe ratios (Table 17) generated estimates of the lamb cohort (Figure 4).

The yearling estimates were generated with a starting minimum count of 11 in June 1976 and application of a 10 percent mortality rate through February 1977. For 1977 a mean yearling to ewe ratio of 50 percent (June-August) was used to attain a starting yearling base in June 1977: a 10 percent mortality rate was applied through December 1977.

The adult ram estimates were based on a breeding season (17 Oct. to 20 Dec. 1976) ram to ewe ratio of 67 percent. From December 1976 the estimate was projected both to June 1976 and December 1977. Known hunter harvest (8 in 1976; 5 in 1977), a 3 percent natural mortality

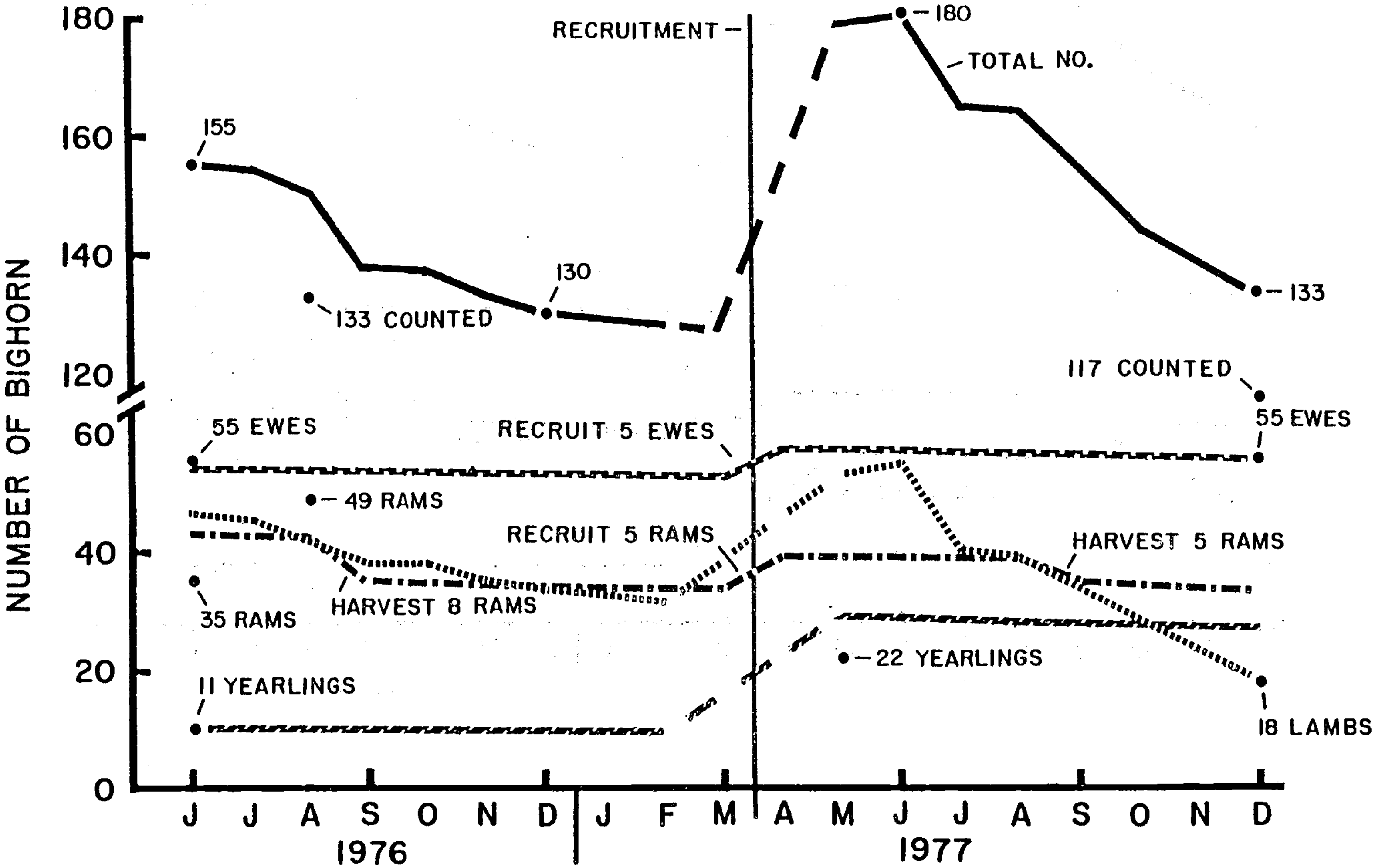

Figure 4. Population model of the Steens Mountain bighorn herd, 1976-77.

rate (Geist 1971:294) and recruitment of five rams into the population on April 1, 1977 were implemented in construction of the line. Thirty-five adult rams were counted in June 1976 (Figure 4).

The population numbered approximately 130 sheep in December 1976 and if no abnormal loss of bighorns occurred since August 1977, about 133 sheep should have been present in December 1977. On December 6 and 7, 1977, 117 sheep were actually counted on the study area. The estimated population fluctuated between 128 and 180 sheep from March to June 1977, with most of the change being attributable to birth and subsequent loss of lambs. If survival of the lamb crop could be enhanced the population should experience more rapid growth.

The ram population estimate (Figure 4) may have been a conservative estimate of the total ram herd depending on whether all adult rams participated in the rut. If this estimate was representative of the population, management policies concerning harvest should be carefully examined. For instance, in 1977, five rams were assumed recruited into the population and five rams were harvested. No account for natural mortality or hunter crippling loss was made. A breeding ratio of two mature rams for every three ewes (67 percent during the period of the rut) was probably reproductively sound (Sugden 1961:26, Buechner 1960).

RECOMMENDATIONS

Based on the results of this study several recommendations have been drawn. Although most of these are unique to the Steens Mountain bighorn herd, they may be modified or provide insight for similar situations in other areas.

1) Ratio and count data can be collected during four, 1-week or less periods which will provide the manager herd size and reproductive success. These counts should be conducted from the ground during the following suggested periods which are based on a reproductive year for bighorns:

Period #1: Ratio data should be collected in early June. It will give the manager an idea of lamb production and yearling to ewe ratios.

Period #2: Ratio data should be collected in August to give the manager an idea of lamb survival and yearling to ewe ratios.

Period #3: An attempt for a complete count and ratio data should be attempted during the peak of the rut (mid-November) when all sex and age classes are together. It will give the manager an idea of herd size and composition, lamb survival and yearling to ewe ratios.

Period #4: Ratio data should be collected during late-February. It will give the manager another figure on lamb survival and yearling to ewe ratios which when coupled with the complete count data would give the manager an idea of the number of yearlings which will be present in the population the following June (after recruitment).

Data collected during Periods 1 and 3 will provide the manager with the most useful information on the herd. Period 2 will provide the next most important and Period 4 the least important information on herd dynamics.

All animals observed during these periods should be classified to sex and age after Geist (1971:53-57). A special attempt should be made to classify yearling ewes separate from adult ewes to make lamb-ewe ratios more understandable.

2) Since lamb loss appears to be the primary restraint on herd growth at the present time and since most of the loss occurs in the June-September period, additional field study might be done during this time in an attempt to pinpoint causes of lamb mortality.

3) The habitat descriptions and habitat use by bighorns obtained in this study can be used as a guide in examining areas for future transplants. For example, adequate escape cover (cliffrock) and forage (water) on a year-round basis are two primary items that should be present.

4) Restrictions should be placed on human-use on Steens Mountain during certain periods of the year in an attempt to expand distribution of bighorn ewe-lamb groups. Trap and transplant programs on the Steens could be used to accelerate the expansion in distribution. Any such program should be closely monitored and the results evaluated.

5) Land-use policies should insure that habitats preferred by bighorns are maintained for them. During the study no conflict between bighorns and other herbivores (wild or domestic) was observed. Use of

the lower portions of the shrub-AGSP and shrub-FEID habitats by sheep and other herbivores could conflict in winters of deep snow. Use of preferred habitats by other herbivores should be regulated to insure sufficient amounts of space or forage remain to meet the needs of the bighorn herd throughout the year.

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APPENDIX

LIST OF APPENDIX TABLES

Table 1. Monthly and annual precipitation as recorded (in inches), Andrews Weston Mine (elev. 1463 m), Steens Mountain, Oregon, 1969-77.

Month	Year								
	1969[a]	1970	1971	1972	1973	1974	1975	1976	1977
Jan.	-	4.86	2.63	3.13	1.67	1.16	3.17	1.37	1.58
Feb.	-	0.26	0.61	1.33	1.16	1.16	2.13	1.67	0.52
March	-	1.97	3.05	2.57	1.00	2.19	2.17	1.23	0.74
April	-	1.05	0.55	1.12	1.53	1.87	1.25	0.99	1.13
May	-	0.50	1.28	1.72	1.01	0.48	0.61	0.20	1.90
June	-	2.16	1.48	0.92	0.66	0.38	1.11	0.47	0.77
July	-	0.09	1.16	T[b]	0.24	1.38	0.43	1.50	0.16
Aug.	-	0.06	0.08	0.37	0.23	0.03	1.91	2.31	0.68
Sept.	0.21	0.70	2.34	0.63	1.28	0.00	0.09	1.60	0.59
Oct.	2.02	1.04	0.86	0.85	1.52	0.74	2.87	0.65	-
Nov.	0.58	4.77	2.09	2.15	3.98	0.76	0.99	0.02	-
Dec.	4.06	2.86	2.91.	2.56	1.88	3.71	0.95	0.00	-
Annual	-	19.82	19.04	17.35	16.16	13.86	17.68	12.01	-

[a] Weather station installed in 1969.

[b] Trace

Table 2. Average monthly temperatures (degrees fahrenheit), Andrews Weston Mine (elev. 1483 m), Steens Mountain, Oregon 1969-77.

Month	Year								
	1969[a]	1970	1971	1972	1973	1974	1975	1976	1977
Jan.	-	33.1	31.7	28.8	27.9	27.5	30.9	31.1	25.8
Feb.	-	38.2	34.2	34.5	35.0	34.2	31.8	34.7	37.7
March	-	38.7	35.9	43.8	37.5	38.1	35.9	33.8	35.9
April	-	39.3	44.9	42.7	44.5	43.4	37.1	43.1	50.5
May	-	54.7	53.5	56.6	58.3	52.7	51.6	57.2	47.0
June	-	65.0	60.4	64.8	64.3	68.7	59.7	59.7	68.9
July	-	73.7	70.7	72.0	73.9	71.3	74.2	72.5	71.6
Aug.	-	74.4	76.3	72.9	73.0	70.6	66.3	63.4	73.7
Sept.	64.0	54.8	56.3	57.0	60.9	66.1	65.1	62.6	60.8
Oct.	45.7	45.2	45.5	49.9	49.8	51.8	49.0	52.0	-
Nov.	40.3	39.1	37.9	36.4	37.8	40.1	36.4	44.2	-
Dec.	34.7	26.1	27.5	25.8	35.4	31.7	34.5	33.4	-
Avg. Annual	-	47.9	47.9	48.8	49.9	49.7	47.7	48.9	-

[a]Weather station installed in 1969.

Table 3. Frequency (FR) and constancy (CO) values of plants in the habitats measured by line transect, Steens Mountain, 1977.

Habitats / Plant species[a]	Meadow n=5[b] (ME)		Cliffrock shrub n=10 (CS)		Shrub/FEID (Ridge) n=3 (SF)		Shrub/FEID (Draws) n=3 (SF)		Cliffrock n=5 (CR)		Cliff-talus n=3 (CT)		Mtn. mahogany n=7 (MM)		Shrub/AGSP n=4 (SA)		Scree n=4 (SC)		Juniper n=3 (JU)		Aspen n=2 (AS)		Dense mtn. mahogany n=3 (DM)		Ceonothus n=3 (CE)		Dense shrub n=3 (DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
TREES																												
CELE							P						P		P				P		P		P		P			
JUOC							P				P		P		P				P				P		P			
POTR																					10	100						
PREM							P						P		5	25			P		10	50	3	33	P			
PRVI					P[c]		3	33											7	33	P		P		P			
SHRUBS																												
AMAL							P				P		P						P		P							
ARAR			3	20	37	100	3	33			23	100	1	14	P		10	25	7	33								
ARTRTR																			P									
ARTRVA	P		25	90	P		37	100	P		3	33	23	86	10	50			3	33	P		3	33	7	33	47	100
BERE													4	14									10	33	63	100	3	33
CEVE																							P		53	100		
CHNA			P		P		P				P		1	14	3	25			10	67			P					
CHVI	P		5	50	17	100	13	67			P		P		3	25			P		P						P	
HASU			5	30					2	20					P		20	50					P		3	33		
HODU			7	40	P		P		P		3	33	11	43	P				10	33			7	33	P		P	
JUCO	P								P								P											
KAMI	2	20																										
LEPU			7	20	P		P				10	67	1	14			8	25	P								7	33
PHMA																					30	100						
POFR	8	40	P						2	20							10	25										
PUTR													P															
RICE	P		1	10	P		P										3	25			P		P				P	
RIMO	P		P						8	20							P								P			
ROWO							P												3	33			P					
SAAR	2	20																										
SASC	2	20																			P							
SYOR			3	33	10	67	17	67			P		7	43	P				P		5	50	3	33	P		7	67
TECA																			P									
VACA	4	20																										
GRASSES																												
AGCA	8	20											1	14							40	100	7	33			17	33

Table 3. (continued)

Plant species	(ME)		(CS)		(SF)		(SF)		(CR)		(CT)		(MM)		(SA)		(SC)		(JU)		(AS)		(DM)		(CE)		(DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
AGSP			3	10	23	67	17	33			37	100	13	43	40	100			33	100							10	33
AGVA	14	80																										
BRCA	4	20																										
BRIN			11	40									9	29	P						25	50	P		P		20	33
BRMA							3	33													10	50	P		P		P	
BRTE					10	67	20	33			43	100	3	14	25	75			63	100			P				P	
CILA	22	100	P						6	20																		
DAIN	10	40																										
DECA	22	60																										
ELAR							3	33													60	100	3	33				
FEID	4	20	8	20	87	100	80	100	P		17	33	4	14			13	50	3	33							3	33
FEOV	2	20																										
FESC			P																									
HEKI			8	40					6	20	P		4	29													P	
HOBR																							P					
KOCR	20	40							P																			
MEST													P															
MURI	2	20																										
OPHY													P				P											
PHAL	18	100																										
POAM			7	30			13	100					14	43	3	25							7	67	20	100	17	67
POCU			P		3	33			P				P				3	25										
POLO			2	10			7	67	12	60					3	25			10	67	10	100					P	
PONE	2	20	1	10	3	33	13	33	P														P					
POPR	2	20																			5	50						
POSA	4	20	5	20	67	100	17	67	8	20	17	100	11	43	13	75	18	50	17	67					P		7	33
SIHY	P		29	100	P		10	100	20	80	P		30	100	15	50	38	100	P				40	100	57	100	40	100
STOC	P		7	30									9	14	10	25	3	25										
STTH			18	60			10	33	4	20			11	43	8	25	P						20	67	40	100	17	67
TRSP	6	20	P						4	40							10	25										
GRASSLIKES																												
Carex spp.	36	100	P						2	20			3	29	3	25	3	25			20	100	3	33	7	67	P	
Juncus spp.	20	60							4	20							3	25					3	33				
PERENNIAL FORBS																												
ACMI	12	40	2	10	3	33	50	100	14	60	P		7	29	P		P				10	50	P		P			
ACCO	4	40																										
AGUR			4	20			P				P										10	50					23	33
AGAU	P		P																									
AGGR	P												P		3	25												
Allium spp.																					10	50						
ANAN							20	33					4	14														
ANRO	2	20					3	33	P								P											

Table 3. (continued)

Plant species	(ME)		(CS)		(SF)		(SF)		(CR)		(CT)		(MM)		(SA)		(SC)		(JU)		(AS)		(DM)		(CE)		(DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
APAN																			P									
APDI			P		3	33			P		P		1	14	5	25											P	
ARAC			1	10					4	20					P		25	50										
ARNU	4	20							P				P				8	25										
ARCO							20	33					9	14											P		7	33
ARLO	4	20							2	20							P											
ARVU	4	40	P				P		6	20							18	50										
Aster spp.	8	60					P		P																			
ASCU															P													
BASA					17	33							P		3	25			3	33								
BRGR			P																									
CAMA					3	33	7	33			P		P															
CAAP			3	30	P				P				P														P	
CACH			2	20									P															
CAMI	2	20	P						2	20																	3	33
CAST									P								P											
CEBE	14	20							P								15	50										
CHDO													P		3	25			P									
CIDO	6	40	P																									
CIPE	6	60	3	20					10	60					P		13	25							P		7	33
CRAC			2	20	23	67	20	67			3	33	P		3	25			P						3	33	10	33
CRAT					P								P															
CRNU									2	20																		
CYPE			4	20					2	20	7	33	P															
CYFR													P															
DEDE	2	20																										
DOAL	18	80																										
DRSP	2	20	4	20					6	60																	7	33
EPAL	6	20							2	20							3	25										
EPAN																									P			
EPGL	8	40																										
EPOB									4	20							5	25										
ERCO									2	20																		
ERLI					P								3	14	P													
ERCA									P								5	25										
ERHE			5	40			3	33			3	33	3	29			8	50	3	33			3	33	P			
ERMI													1	14					P									
EROV									2	20							P											
ERST			4	20													3	25										
ERUM			5	10					6	40	3	33	1	14	P		3	25	P									
ERVI															P													
ERLA											3	33			P		P										P	
ERCI															3	25												
EUOC			P								P								3	33								

Table 3. (continued)

Plant species	(ME)		(CS)		(SF)		(SF)		(CR)		(CT)		(MM)		(SA)		(SC)		(JU)		(AS)		(DM)		(CE)		(DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
FRSP	4	40	P						2	20			P															
GAMU			5	30							3	33	P		P				3	33					P		3	33
GEAF	P																											
GEPR	2	20																										
GETR							P		2	20							P											
HADI	2	20																										
HAJE			3	20			23	67					14	29									P		3	33	13	67
HAMA			P						8	40							P											
HEHO	18	60	P						P																			
HELA	4	20																										
HECY			2	10					4	40							P											
HICY							3	33					13	29											17	67	P	
HYCA					7	33	3	33																			10	33
HYFO	14	60																										
IVBA									P																			
IVGO																	3	25										
KEGA			1	10																	55	100	27	67	43	100	20	33
LALA			2	10			7	33	2	20			3	14			P				10	50	7	33			10	33
LAPA			2	10																								
LARI											10	67	P		13	25												
LIGR	48	80																										
LINU			7	20																								
LIPE									P								P											
LIPA					3	33									P						P							
LIRU																			P									
LUCA	2	20	50	100	3	33	33	67	6	20	P		33	86	18	75	P		10	100	P		P		P		27	67
LULA					23	67	27	33							P													
LYSP															20	50												
MACA															3	25			3	33							P	
MAGR													6	14	3	25			3	33			P		3	33		
MEAL			P																									
MEOB							17	67																				
MINU	16	40			20	67	20	67			3	33	P		3	25	3	25			20	50			3	33	3	33
MIPR	12	40																										
MOOR			5	40					6	20	P		1	14	3	25	P		10	33							P	
MOCO	2	20																										
OSOC			P										1	14									10	33			3	33
PAFI	14	40																										
PEAT	6	40																										
PEBR			P						P				P															
PEDA			1	10					4	20	3	33	P				P											
PEDE											P		P															
PERY	P								2	20							3	25										
PESP					P										P				P									
PHGL													P										P					

Table 3. (continued)

Plant species	(ME)		(CS)		(SF)		(SF)		(CR)		(CT)		(MM)		(SA)		(SC)		(JU)		(AS)		(DM)		(CE)		(DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
PHHA	P		14	60			P		4	40	P		9	14	3	25	8	25	P				7	33	3	33	13	67
PHHE											P				3	25			P									
PHDI					7	33																						
PHLO					3	33	23	33																				
POPU									P																			
PODI	2	20							2	20																		
POGL	2	20							24	60							5	50					3	33				
RUOC	2	20																										
SAAR	6	20																										
SAOC	P																											
SEDE			7	20	P				P		7	33	P															
SELA	P				3	33			16	20			P				10	50										
SECA			3	20					P		7	33					18	25										
SECR	2	20	2	10					6	20							P											
SECY	P																											
SEFR			P						12	40							P											
SEIN															3	25												
SESE			1	10									P								50	100					P	
SETR	4	40																										
SIME																											27	33
SIOR	4	20	1	10	7	33	20	67	2	20			3	14			3	25									3	33
SMST																									3	33		
SONA	8	20							2	20							5	25										
SPUM									P								P											
STTE																			P									
SWPE	P																											
THOC	P						10	33					P								P		P		3	33	7	67
THFL			3	20					2	20	P		P				P											
THSA																					5	50						
TRDU											P		1	14	P						5	50					3	33
TRLO	40	80							4	20							15	75										
URDI																					P							
VAAC			7	10					6	20			P															
VECA	10	80																										
VESE	P																											
VEWO	P																											
Viola spp.	2	20	26	60	3	33			4	20			4	14	3	25	15	50					3	33	3	33	7	67
ZIEL	P																											
ANNUAL FORBS																												
ARGL	2	20											1	14														
CHAL			P				P						7	29							P		P				3	33
CLRH							7	33					3	14	5	25					30	100	3	33	3	33		
COPA			1	10	43	100	33	100					24	43	20	50			7	33	70	100	3	33	23	67	3	33
COGR																											P	

Table 3. (continued)

Plant species	(ME)		(CS)		(SF)		(SF)		(CR)		(CT)		(MM)		(SA)		(SC)		(JU)		(AS)		(DM)		(CE)		(DS)	
	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO	FR	CO
COLI					P								10	43	P						35	50	P		7	67	7	33
CREC							3	33			7	33	P		18	50					10	50	20	67			3	33
CARA	P		7	40	10	67	3	33			P		3	29	3	25	5	25			P				7	33	3	33
LEPE																			20	33								
MIGR							7	67					6	14											3	33		
MINA			P																									
PODO	2	20	5	30							3	33	11	29	25	50	3	25			45	100	10	67	13	67	3	33
SIAL															5	50			7	33	5	50					3	33
Unk.	8	40	4	20							7	67	4	43	3	25											3	33

[a]Plant symbols and names patterned after Garrison et al. (1976); plant symbols with respective scientific and common names listed in Appendix Table 5.
[b]"n" denotes the number of transects used in the individual habitat description.
[c]The letter "P" denotes the plant was found within the stand but was not encountered within the sample plot.

Table 4. Mean values of plants in habitats measured by ocular estimate, Steens Mountain, 1977[a].

Plant species[b]	Stream-channel n=3[c] (STCH)	*Prunus* n=5 (PR)	Rocky draws n=3 (RD)	*Holodiscus* n=2 (NO)	Cirque basins n=1 (CB)	*Elymus* n=1 (EL)
TREES						
CELE	1	1[d]				
JUOC	1	P				
POAN	3					
POTR		1				
PREM	3	4				
PRVI	4	5				
SHRUBS						
AMAL	1	1				
ARAR	1	P	1			
ARTRTR	1	P				
ARTRVA		2	1	2		5
BERE	1	1				
CEVE		P				
CHNA	3	1				
CHVI	P	1	P	2		2
COST	1					
HASU			1			
HODU	1	2	2	5		
JUCO			1		1	
KAMI					3	
LEPU				1		
POFR			1		5	
PUTR		1				
RICE	1	1	P	1		
RIMO					1	
ROWO	3	1		2		
SAAR					5	
SASC	3	1	1			
SACE	1	P				
SYOR	1	1		2		
VACA					3	
GRASSES						
AGCA	1	1		1		3
AGSP	P	1	P			
AGEX	1					
AGVA	1				1	
BRCA		1				
BRIN		1				
BRMA	P	P				4
BRTE	2	1		2		

Table 4. (continued)

	(STCH)	(PR)	(RD)	(HO)	(CB)	(EL)
CAPU	1	1				
CILA	P		1			
DAIN			1			
DAUN			P			
DECA	P	P			2	
DEEL	1					
ELAR	2	1				2
ELCI	1	P				5
FEID				2		
GLEL	1					
HEKI			P	1		
PHAL	1	P	P		1	
PHPR	1					
POAM	1	1		1		2
POCU			P			
POLO	1	P	1			
POPR	1	P			1	
POSA		P	2	2		
SIHY	1	1	3	1		1
STOC						2
STTH		1	1			3
TRSP			1		1	
GRASSLIKES						
Carex spp.	1	P	1	1	4	2
Juncus spp.	1				3	
PERENNIAL FORBS						
ACMI	2	1	1	1		1
AGUR	1	2	2	1		2
Allium spp.						1
AQFO		P				
ARDI	P					
ARAC			1			
ARNU			1			
ARCO	P			1		
ARLO			P			
ARLU	P					
ARVU	2		4			
Aster spp.	P	P			1	1
ATFI			P			
BRGR	P	P	1			
CALE					2	
CAMA	P					
CAAP			2			
CACH			1			
CAMI					1	

Table 4. (continued)

	(STCH)	(PR)	(RD)	(HO)	(CB)	(EL)
CEBE					1	
CENU	1					
CIDO	1					
CIPE	2		3			2
CIVU	1	P				
CLLI	2					
COMA	P					
CRAC	P					1
CRAT				1		
CYPE	P		P	1		
CYFR			P	1		
DEDE			P	1		
DOAL			P		1	
DRSP			P			
EPAL			P			
EPAN	P					
EPGL	2					
EPOB			1			
EQLA	P					
ERCO			1			
ERHE	1			1		
ERUM			1			
EUOC	1	P	2			
GAMU		1				
GEAF					1	
GETR	P		P			
HAJE		P		1		2
HAMA			P			
HEHO			P		1	
HELA		P	1			
HECY			1			
HERU	P					
HYCA	P	P				
HYFO	1		P			
IVBA			P			
KEGA		1				
LALA	1	P		1		2
LIGR	P		P			
LINU			P			
LIPE			P			
LUCA	1	1	1	1		3
MAGR		1				2
MINU	P		P			
MIGU	3					
MILE	1					
MIPR					1	
MOOR	1	P	3	1		
OSOC	1	1		1		

Table 4. (continued)

	(STCH)	(PR)	(RD)	(HO)	(CB)	(EL)
PEAT					1	
PEBR			1			
PEDA			1			
PEDE	P					
PERY			P			
PHGL		P				
PHHA	P	1	1			3
PHHE	P					1
PHRA	1					
POVI					1	
PODI					3	
POGL	1		2			
RUOC	2		1			
RUCR	1					
SCLA	P		1			
SEDE	P		2			
SELA			1			
SECA			1			
SECR			1			
SECY			1			
SEIN				1		
SESE	1	1		1		2
SIME		P				
SIOR			P			
SMST	P	P				
SOCA		P				
SONA					1	
STTE	1	P				
SWPE					2	
TAOF	P					
THOC	P	P				
THSA		P				
TRDU	P					
TRLO			1			
URDI	4	2	1	1		
VECA	1					
VETH	2	1				
VEAN	1					
Viola spp.	P		P			
ZIEL					2	
ANNUAL FORBS						
ARGL		P				
CHAL	P	1				
CLRH	P	P				
COPA		1		2		1
COLI		1		1		1

Table 4. (continued)

	(STCH)	(PR)	(RD)	(HO)	(CB)	(EL)
CREC		P		1		2
GARA		P		1		
HEAN	P					
PODO		1				2
SIAL		P		1		
Unk.	P					

[a]Ocular rating estimate taken from Winward and Youte (1976:29).
[b]Plant symbols and names patterned after Garrison et al. (1976); plant abbreviations with respective scientific and common names listed in Appendix Table 5.
[c]"n" denotes the number of ocular estimates used in the individual habitat description.
[d]"P" indicates the mean ocular estimate value was less than one.

Table 5. Partial list of plants encountered during sampling of habitat, Steens Mountain, 1977[a].

Abbreviation	Scientific name	Common name
TREES		
CELE	*Cerocarpus ledifolius*	Curlleaf mtn. mahogany
JUOC	*Juniperus occidentalis*	Western juniper
POAN	*Populus angustifolia*	Cottonwood
POTR	*Populus tremuloides*	Quaking aspen
PREM	*Prunus emarginata*	Bitter cherry
PRVI	*Prunus virginiana*	Common chokecherry
SHRUBS		
AMAL	*Amelanchier alnifolia*	Saskatoon serviceberry
ARAR	*Artemisia arbuscula*	Low sagebrush
ARTRTR	*Artemisia tridentata tridentata*	Basin big sagebrush
ARTRVA	*Artemisia tridentata vaseyana*	Mountain big sagebrush
BERE	*Berberis repens*	Oregon grape
CEVE	*Ceonothus velutinus*	Snowbrush ceonothus
CHNA	*Chrysothamnus nauseosus*	Gray rabbitbrush
CHVI	*Chrysothamnus vicidiflorus*	Green rabbitbrush
COST	*Cornus stolonifera*	Red-osier dogwood
HASU	*Happlopappus suffruticosus*	Singlehead goldenweed
HODU	*Holodiscus dumosus*	Bush rockspirea
JUCO	*Juniperus communis*	Common juniper
KAMI	*Kalmia microphylla*	Alpine laurel
LEPU	*Leptodactylon pungens*	Granite gilia
PHMA	*Physocarpus malvaceus*	Mallow ninebark
POFR	*Potentilla fruticosa*	Shrubby cinquefoil
PUTR	*Purshia tridentata*	Antelope bitterbrush
RICE	*Ribes cereum*	Wax currant
RIMO	*Ribes montigenum*	Mountain gooseberry
ROWO	*Rosa woodsii*	Woods rose
SAAR	*Salix arctica*	Arctic willow
SASC	*Salix scouleriana*	Scouler willow
SACE	*Sambucus cerulea*	Blueberry elder
SYOR	*Symphoriocarpus oreophilus*	Mountain snowberry
TECA	*Tetradymia canescens*	Gray horsebrush
VACA	*Vaccinium caespitosum*	Dwarf blueberry
GRASSES		
AGCA	*Agropyron caninum*	Cutting wheatgrass
AGSP	*Agropyron spicatum*	Bluebunch wheatgrass
AGEX	*Agrostis exarata*	Spike bentgrass
AGVA	*Agrostis variabilis*	Variant bentgrass
BRCA	*Bromus carinatus*	California brome
BRIN	*Bromus inermus*	Smooth brome
BRMA	*Bromus marginatus*	Mountain brome
BRTE	*Bromus tectorum*	Cheatgrass brome

Table 5. (continued)

Abbreviation	Scientific name	Common name
CAPU	Calamagrostis purpurascens	Purple pinegrass
CILA	Cinna latifolia	Wood reed-grass
DAIN	Danthonia intermedia	Timber danthonia
DAUN	Danthonia unispicata	Onespike danthonia
DECA	Deschampsia caespitosa	Tufted hairgrass
DEEL	Deschampsia elongata	Slender hairgrass
ELAR	Elymus aristatus	Purple wildrye
ELCI	Elymus cinereus	Giant wildrye
FEID	Festuca idahoensis	Idaho fescue
FEOV	Festuca ovina	Sheep fescue
FESC	Festuca scabrella	Rough fescue
GLEL	Glyceria elata	Tall mannagrass
HEKI	Hesperochloa kingii	King's fescue
HOBR	Hordeum brachyantherum	Northern meadow barley
KOCR	Koeleria cristata	Prairie junegrass
MEST	Melica stricta	Rock melic
MURI	Muhlenbergia richardsonis	Mat muhly
ORHY	Oryzopsis hymenoides	Indian ricegrass
PHAL	Phleum alpinum	Alpine timothy
PHPR	Phleum pratense	Timothy
POAM	Poa ampla	Big bluegrass
POCU	Poa cusickii	Cusick bluegrass
POLO	Poa longiligula	Longtongue mutton bluegrass
PONE	Poa nevadensis	Nevada bluegrass
POPR	Poa pratensis	Kentucky bluegrass
POSA	Poa sandbergii	Sandberg's bluegrass
SIHY	Sitanion hystrix	Bottlebrush squirreltail
STOC	Stipa occidentalis	Western needlegrass
STTH	Stipa thurberiana	Thurber needlegrass
TRSP	Trisetum spicatum	Spike trisetum
GRASSLIKES		
Carex spp.	Carex spp.	Sedges
Juncus spp.	Juncus spp.	Rushes
PERENNIAL FORBS		
ACMI	Achillea millefolium	Western yarrow
ACCO	Aconitum columbianum	Columbia monkshood
AGUR	Agastache urticifolia	Nettleleaf gianthyssop
AGAU	Agoseris aurantiaca	Orange agoseris
AGGR	Agoseris grandiflora	Large-flowered agoseris
Allium spp.	Allium spp.	Onion
ANAN	Antennaria anaphaloides	Tall pussytoes
ANRO	Antennaria rosea	Rosy pussytoes
APAN	Apocynum androsaemifolium	Spreading dogbane
AQFO	Aquilegia formosa	Sitka columbine
ARDI	Arabis divaricarpa	Spreadingpod rockcress

Table 5. (continued)

Abbreviation	Scientific name	Common name
ARAC	Arenaria aculeata	Needleleaf sandwort
ARNU	Arenaria nuttallii	Nuttall's sandwort
ARCO	Arnica cordifolia	Heartleaf arnica
ARLO	Arnica longifolia	Longleaf arnica
ARLU	Artemisia ludoviciana	Louisiana sagebrush
ARVU	Artemisia vulgaris	Mugwort
Aster spp.	Aster spp.	Aster
ASCU	Astragalus curvicarpus	Curvepod locoweed
ATFI	Athyrium filix-femina	Ladyfern
BASA	Balsamorhiza sagittata	Arrowleaf balsamroot
BRGR	Brickellia grandiflora	Narrow-leaved brickellia
CALE	Caltha leptosepala	Elkslip marshmarigold
CAMA	Calochortus macrocarpus	Sagebrush mariposa
CAAP	Castilleja applegatei	Applegate's paintbrush
CACH	Castilleja chromosa	Desert paintbrush
CAMI	Castilleja miniata	Scarlet paintbrush
CAST	Castilleja steenensis	Steens Mtn. paintbrush
CEBE	Cerastium berringianum	Alpine chickweed
CENU	Cerastuim nutans	Nodding chickweed
CHDO	Chaenactis douglasii	Douglas chaenactis
CIDO	Cicuta douglasii	Western waterhemlock
CIPE	Cirsium peckii	Steens Mtn. thistle
CIVU	Cirsium vulgare	Bull thistle
CLLI	Clematis ligusticifolia	Western virginsbower
COMA	Conium maculatum	Poison hemlock
CRAC	Crepus acuminata	Tapertip hawksbeard
CRAT	Crepus atrabarba	Slender hawksbeard
CRNU	Cryptantha nubigena	Sierra cryptantha
CYPE	Cymopterus petraeus	Rock-loving cymopterus
CYFR	Cystopteris fragilis	Brittle bladder fern
DEDE	Delphinium depauperatum	Slim larkspur
DOAL	Dodecatheon alpinum	Alpine shootingstar
DRSP	Draba sphaeroides	Draba
EPAL	Epilobium alpinum	Alpine willow-herb
EPAN	Epilobium angustifolium	Fireweed
EPGL	Epilobium glandulosum	Common willow-herb
EPOB	Epilobium obcordatum	Rose willow-herb
EQLA	Equisetum laevigatum	Smooth horsetail
ERCO	Erigeron compositus	Rayless fernleaf fleabane
ERLI	Erigeron linearis	Lineleaf fleabane
ERCA	Eriogonum caespitosum	Mat eriogonum
ERHE	Eriogonum heracleoides	Wyeth eriogonum
ERMI	Eriogonum microthecum	Slenderbush eriogonum
EROV	Eriogonum ovalifolium	Cushion eriogonum
ERST	Eriogonum strictum	Strict buckwheat
ERUM	Eriogonum umbellatum	Sulfur eriogonum
ERVI	Eriogonum vimioneum	Broom eriogonum
ERLA	Eriophyllum lanatum	Woolly eriophyllum

Table 5. (continued)

Abbreviation	Scientific name	Common name
ERCI	Erodium cicutarium	Filaree
EUOC	Eupatorium occidentale	Western eupatorium
FRSP	Frasera speciosa	Showy frasera
GAMU	Gallium multiflorum	Shrubby bedstraw
GEAF	Gentiana affinis	Pleated gentian
GEPR	Gentiana prostrata	Moss gentian
GETR	Geum triflorum	Prairiesmoke avens
HADI	Habenaria dilatata	White bogorchid
HAJE	Hackelia jessicae	Jessica stickweed
HAMA	Haplopappus macronema	Discoid goldenweed
HEHO	Helenium hoopesii	Orange sneezeweed
HELA	Heracleum lanatum	Common cowparsnip
HECY	Heuchera cylindrica	Roundleaf alumroot
HERU	Heuchera rubescens	Red alumroot
HICY	Hieracium cynoglossoides	Houndstongue hawkweed
HYCA	Hydrophyllum capitatum	Baldhead waterleaf
HYFO	Hypericum formosum	Western St. Johnswort
IVBA	Ivesia baileyi	Ivesia
IVGO	Ivesia gordonii	Bordon ivesia
KEGA	Kelloggia galioides	Kelloggia
LALA	Lathyrus lanszwertii	Thickleaf peavine
LAPA	Lathyrus pauciflorus	Fewflowered peavine
LARI	Lathyrus rigidus	Rigid peavine
LIGR	Ligusticum grayi	Grays licoriceroot
LINU	Linanthastrum nuttallii	Nuttall's linanthastrum
PIPE	Linium perenne	Perennial flax
LIPA	Lithophragma parviflora	Smallflower woodlandstar
LIRU	Lithospernum ruderale	Wayside gromwell
LUCA	Lupinus caudatus	Tailcup lupine
LULA	Lupinus laxiflorus	Spur lupine
LYSP	Lygodesmia spinosa	Spiny skeletonweed
MACA	Machaeranthera canescens	Hoary aster
MAGR	Machaeranthera grindeloides	Aster
MEAL	Mentzelia albicaulis	Whitestem mentzelia
MEOB	Mertensia oblongifolia	Oblongleaf blueballs
MINU	Microseris nutans	Modding microseris
MIGU	Minulus guttatus	Common monkeyflower
MILE	Minulus lewisii	Lewis monkeyflower
MIPR	Mimulus primuloides	Primrose monkeyflower
MOOR	Monardella odoratissima	Pacific monardella
MOCO	Montia cordifolia	Broadleaved montia
OSOC	Osmorhiza occidentalis	Western sweet-root
PAFI	Parnassia fimbriata	Rocky mountain parnassia
PEAT	Pedicularis attollens	Little elephant's head
PEBR	Pellaea breweri	Brewers cliffbrake
PEDA	Penstemon davidsonii	Davidson's penstemon
PEDE	Penstemon deustus	Scabland penstemon
PERY	Penstemon rydbergii	Rydberg's penstemon

Table 5. (continued)

Abbreviation	Scientific name	Common name
PESP	Penstemon speciosus	Royal penstemon
PHGL	Phacelia glandulosa	Glandular phacelia
PHHA	Phacelia hastata	Silverleaf phacelia
PHHE	Phacelia heterophylla	Varileaf phacelia
PHRA	Phacelia ramosissima	Branching phacelia
PHDI	Phlox diffusa	Spreading phlox
PHLO	Phlox longifolia	Longleaf phlox
POPU	Polemonium pulcherrimum	Skunkleaf polemonium
POVI	Polygonum viviparum	Viviparous bistort
PODI	Potentilla diversifolia	Varileaf cinquefoil
POGL	Potentilla glandulosa	Gland cinquefoil
RUOC	Rudbeckia occidentalis	Blackhead coneflower
RUCR	Rumex crispus	Curly dock
SAAR	Saxifraga arguta	Brook saxifrage
SAOC	Sacifraga occidentalis	Western saxifrage
SCLA	Scrophularia lanceolata	Lanceleaf figwort
SEDE	Sedum debile	Weakstemmed stonecrop
SELA	Sedum lanceolatum	Lanceleaved stonecrop
SECA	Senecio canus	Woolly groundsel
SECR	Senecio crassulus	Thickleaf groundsel
SECY	Senecio cymbalarioides	Cleftleaf groundsel
SEFR	Senecio fremontii	Dwarf mtn. butterweed
SEIN	Senecio integerrimus	Lanbstongue groundsel
SESE	Senecio serra	Butterweed groundsel
SETR	Senecio triangularis	Arrowleaf groundsel
SIME	Silene menziesii	Menzies silene
SIOR	Silene oregana	Oregon silene
SMST	Smilacina stellata	Starry solomonplume
SOCA	Solidago canadensis	Canada goldenrod
SONA	Solidago nana	Low goldenrod
SPUM	Spraguea umbellata	Umtellate pussypaws
STTE	Stephanomeria tenuifolia	Bushwirelettuce
SWPE	Swertia perennis	Alpinebog swertia
TAOF	Taraxicum officinale	Common dandelion
THOC	Thalictrum occidentale	Western meadowrue
THFL	Thelypodium flexuosum	Thelypody
THSA	Thelypodium sagittatum	Slender thelypody
TRDU	Tragopogon dubius	Yellow salsify
TRLO	Trifolium longipes	Longstalk clover
URDI	Urtica dioica	Stinging nettle
VAAC	Valeriana acutiloba	Downy-fruited valerian
VECA	Veratrum californicum	California falsehellabore
VETH	Verbascum thapsus	Flannel mullein
VEAN	Veronica anagallis-aquatica	Water speedwell
VESE	Veronica serpyllifolia	Thymeleaf speedwell
VEWO	Veronica wormskjoldii	Wormskjold speedwell
Viola spp.	Viola spp.	Violets
ZIEL	Zigadenus elegans	Mountain death camas

Table 5. (continued)

Abbreviation	Scientific name	Common name
ANNUAL FORBS		
ARGL	Arabis glabra	Towermustard
CHAL	Chenopodium album	Lambsquarters goosefoot
CLRH	Clarkia rhomboidea	Common clarkia
COPA	Collinsia parviflora	Littleflower collinsia
COGR	Collomia grandiflora	Largeflowered collomia
COLI	Collomia linearis	Narrowleaf collomia
CREC	Cryptantha echinella	Prickly cryptantha
GARA	Gayophytum ramosissimum	Hairstem groundsmoke
HEAN	Helianthus annuus	Common sunflower
LEPE	Lepidium perfoliatum	Clasping pepperweed
MIGR	Microsteris gracilis	Pink microsteris
MINA	Mimulus nanus	Dwarf monkeyflower
PODO	Polygonum douglasii	Douglass knotweed
SIAL	Sisymbrium altissimum	Tumblemustard

[a]Plant symbols and names patterned after Garrison et al. (1976) and Hitchcock and Cronquist (1973).

APPENDIX LITERATURE CITED

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