Ecological characteristics of the Armstrong mule deer winter range, Bridger Mountains, Montana
by Richard Andrew Bucsis

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University

Abstract:
A study was conducted in the Bridget Mountains of southwestern Montana from July 1972 through June 1974 to provide current information on the ecological characteristics of the Armstrong Mule Deer Winter Range. Emphasis was placed upon distribution, production, and utilization of key mule deer browse plants. Fourteen habitat types were recognized and described: Festuoa idahoensis/'Agropyron spioatum h.t., Agropyron spioatum/Agropyron smithii h.t., Purshia tridentata/ Agropyron spioatum h.t., Purshia tridentata/Artemisia tridentata h.t., Artemisia tridentata/Festuoa idahoensis h.t., Juniperus soopuiorum-Purshia tridentata/Agropyron spioatum h.t., Juniperus sooputorum-Purshia tridentata/Festuoa idahoensis h.t., Juniperus sooputorum-Purshia tridentata/Artemisia tridentata h.t., Aoer glabrum/Philadelphus lewisii h.t., Popuius tremuloides-Prunus virginiana/Symphorioarpos aibus h.t., Pseujdotsuga menziesii/Prunus virginiana h.t., Pseudotsuga menziesii/Symphorioarpos h.t., Pseudotsuga/Festuoa idahoensis h.t., and Pseudotsuga menziesii/Carex geyeri h.t. Total forage production of big sagebrush, antelope bitterbrush, and Rocky Mountain juniper was determined on six shrubland habitat types. These 3 species comprised 44, 7, and 49 percent, respectively of the 71,069 kilograms of the total forage yield for 1972. Fifty-eight and 96 percent of the sagebrush and bitterbrush plants encountered in vegetational analyses were in a severely hedged condition, respectively, while approximately 1/3 of the plants of both species were rated decadent. One and 3 percent, respectively of the living bitterbrush and sagebrush plants tagged in 1973 were dead by 1974. Utilization of sagebrush current annual growth and bitterbrush current annual growth twigs averaged 34 and 53 percent, respectively for the winter of 1972-73 and 40 and 66 percent, respectively for 1973-74. Utilization of sagebrush varied according to site location; plants on the more favorable sites received only slight usage. Sagebrush and bitterbrush combined contributed about 1/3 of the total forage consumed by deer on the area during the winter of 1972-73 with sagebrush comprising the major portion (1.1 pounds/deer day). Bitterbrush contributed an average of 0.22 pounds/deer day, but most of the usage on this species apparently occurred during early winter. On one footslope site cattle utilized 37 percent of the current growth of bitterbrush during the summer-fall of 1973, while on adjacent slopes, where grasses were abundant, cattle utilization of bitterbrush ranged from 8 to 10 percent. The Purshia tridentata/Artemisia tridentata h.t. comprised 31 percent of the shrubland area and was considered the most important habitat type on the area for mule deer during the winter period.

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by

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A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

ABSTRACT

A study was conducted in the Bridger Mountains of southwestern Montana from July 1972 through June 1974 to provide current information on the ecological characteristics of the Armstrong Mule Deer Winter Range. Emphasis was placed upon distribution, production, and utilization of key mule deer browse plants. Fourteen habitat types were recognized and described: *Festuca idahoensis/Agropyron spicatum* h.t., *Agropyron spicatum/Agropyron smithii* h.t., *Purshia tridentata/Agropyron spicatum* h.t., *Purshia tridentata/Artemisia tridentata* h.t., *Artemisia tridentata/Festuca idahoensis* h.t., *Juniperus scopulorum-Purshia tridentata/Agropyron spicatum* h.t., *Juniperus scopulorum-Purshia tridentata/Festuca idahoensis* h.t., *Juniperus scopulorum-Purshia tridentata/Artemisia tridentata* h.t., *Acer glabrum/Philadelphus lewisii* h.t., *Populus tremuloides-Prunus virginiana/Symphoricarpos albus* h.t., *Pseudotsuga menziesii/Prunus virginiana* h.t., *Pseudotsuga menziesii/Symphoricarpos* h.t., *Pseudotsuga/Festuca idahoensis* h.t., and *Pseudotsuga menziesii/Carex geyeri* h.t. Total forage production of big sagebrush, antelope bitterbrush, and Rocky Mountain juniper was determined on six shrubland habitat types. These 3 species comprised 44, 7, and 49 percent, respectively of the 71,069 kilograms of the total forage yield for 1972. Fifty-eight and 96 percent of the sagebrush and bitterbrush plants encountered in vegetational analyses were in a severely hedged condition, respectively, while approximately 1/3 of the plants of both species were rated decadent. One and 3 percent, respectively of the living bitterbrush and sagebrush plants tagged in 1973 were dead by 1974. Utilization of sagebrush current annual growth and bitterbrush current annual growth twigs averaged 34 and 53 percent, respectively for the winter of 1972-73 and 40 and 66 percent, respectively for 1973-74. Utilization of sagebrush varied according to site location; plants on the more favorable sites received only slight usage. Sagebrush and bitterbrush combined contributed about 1/3 of the total forage consumed by deer on the area during the winter of 1972-73 with sagebrush comprising the major portion (1.1 pounds/deer day). Bitterbrush contributed an average of 0.22 pounds/deer day, but most of the usage on this species apparently occurred during early winter. On one footslope site cattle utilized 37 percent of the current growth of bitterbrush during the summer-fall of 1973, while on adjacent slopes, where grasses were abundant, cattle utilization of bitterbrush ranged from 8 to 10 percent. The *Purshia tridentata/Artemisia tridentata* h.t. comprised 31 percent of the shrubland area and was considered the most important habitat type on the area for mule deer during the winter period.

INTRODUCTION

Big game management in Montana, since the mid 1950's has been based largely on data from annual surveys used to determine condition and utilization trends of key forage species on critical winter range sites. These data together with population and harvest data are used to set bag limits and season lengths designed to balance big game populations with their food supplies (Mussehl and Howell 1971). By the early 1960's game managers and biologists began to express concern about the adequacy of the range survey techniques and procedures and whether survey data generally reflected an essential ecological relationship between the wild ungulate population and its habitat (Mackie 1972). In 1970 the Montana Department of Fish and Game established a research project to evaluate basic range survey methods, concepts, and criteria (Mackie *op. cit.*).

This study was established as a segment of the range evaluation project. Specific objectives were: (1) to provide basic information on physical, biological, and ecological attributes of an important, browse-type winter range for use in evaluating mule deer *(Odocoileus hemionus)* use and habitat relationships; and (2) to evaluate distribution, production, and utilization of important browse forage species on the winter range. The location was the Armstrong winter range which lies along the west slope of the Bridger Mountains, 20 miles north of Bozeman in Gallatin County, Montana. Field studies were

conducted full time during the summers of 1972 and 1973 and part time during fall, winter, and spring from October, 1972 through May 1974. The study was conducted concurrently with two investigations on range use, food habits, seasonal distribution, and population characteristics of the mule deer herd (Schwarzkoph 1973 and Hamlin 1974).

The first biological study of mule deer and their use of the Armstrong winter range was conducted by Wilkins (1957) during 1955 and 1956. Emphasis was placed upon mule deer food habits, range use and agriculture relationships. Browse utilization and condition trend surveys were conducted subsequently by the Montana Department of Fish and Game in the spring from 1957 through 1960 and 1965 through 1967. The general consensus from these earlier studies and most observers since has been that key forage plants, especially antelope bitterbrush *(Purshia tridentata)*, were in poor condition and possibly deteriorating as a result of overuse by mule deer. Management efforts have generally been directed toward reducing mule deer numbers to allow forage plants and supplies to recover and thereby maintain or increase the carrying capacity of the range.

DESCRIPTION OF THE STUDY AREA

The Armstrong mule deer winter range encompasses approximately 1260 acres of lower mountain and footslopes between North Cottonwood Creek and Bill Smith Creek, which form the northern and southern boundaries of the study area, respectively (Fig. 1). Elevations range from 5,250 to 7,803 feet.

McMannis (1955) described the Bridger Mountain Range as extending in a gently curving arc from Bridger Canyon northward for 23 miles to Blacktail Mountain. It forms part of the southwestern rim of the Crazy Mountain Basin and is bounded on the west by the Gallatin Valley, on the north by the Maudlow Basin, and on the south by a major oblique fault. Elevations range from 5,000 to 9,665 feet. Geologically, the Bridger Range is characterized by folds and faults consisting of exposed steeply dipping Paleozoic sediments which are flanked by Precambrian arkoses in the region of the study area. Specific rock types are sandstones, limestone, shale, siltstone, and conglomerates. Valley fills consist of Quaternary deposits of gravel fans, river gravels and muds, talus, morainal deposits, and avalanche debris. The area north of Ross Peak shows some evidence of glaciation.

The Armstrong winter range is situated along a westerly projecting convexity or "toe" of the main Bridger range. This "toe" is created as the base of the main mountain range gradually deviates from a

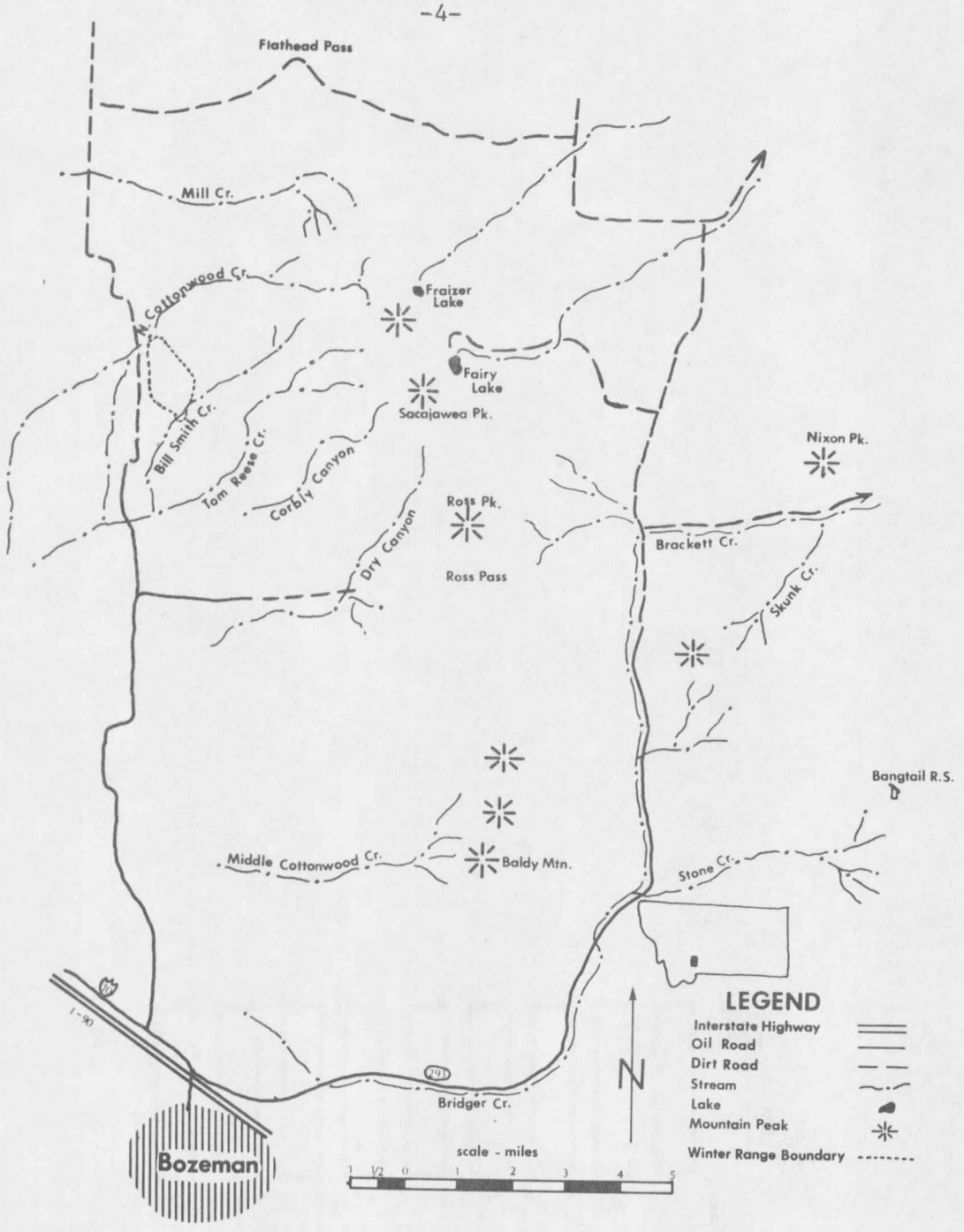

Figure 1. Map of the Bridger Range showing major features and the location of the study area.

north-south orientation to one of northwest-southeast direction (Fig. 2). Because of this the northern portion of the study area is generally of west-facing aspect dissected by east-west drainages which have created steep north and south facing sub-slopes or topographic units. From the central portion to the southern boundary of the area, the aspect changes gradually to the southwest and south where northeast-southwest and north-south drainages create steep southeast, northwest, east, and west facing sub-slopes. Slope declivities are severe with slope gradients commonly 50 percent or more. A footslope region borders around the base of the main mountain. This area is characterized by rocky, fairly regular terrain which gradually slopes off toward the valley floor. Typical slope angles range from 10 to 15 percent.

Climatological data for Belgrade located 10 miles to the southwest at 4,451 feet elevation show a mean annual temperature of 41.9 degrees F. January was the coldest month and July was the warmest with average temperatures of 17.1 and 66.7 degrees F, respectively. Average annual precipitation was 13.43 inches. May and June were the wettest months with average precipitation of 2.15 and 2.57 inches, respectively, while February was the driest with 0.38 inches. Average annual snowfall from 1953 through 1972 was 44.1 inches.

Approximately 64 percent of the study area is privately owned with the remainder public land administered by the U.S.D.A. Forest Service,

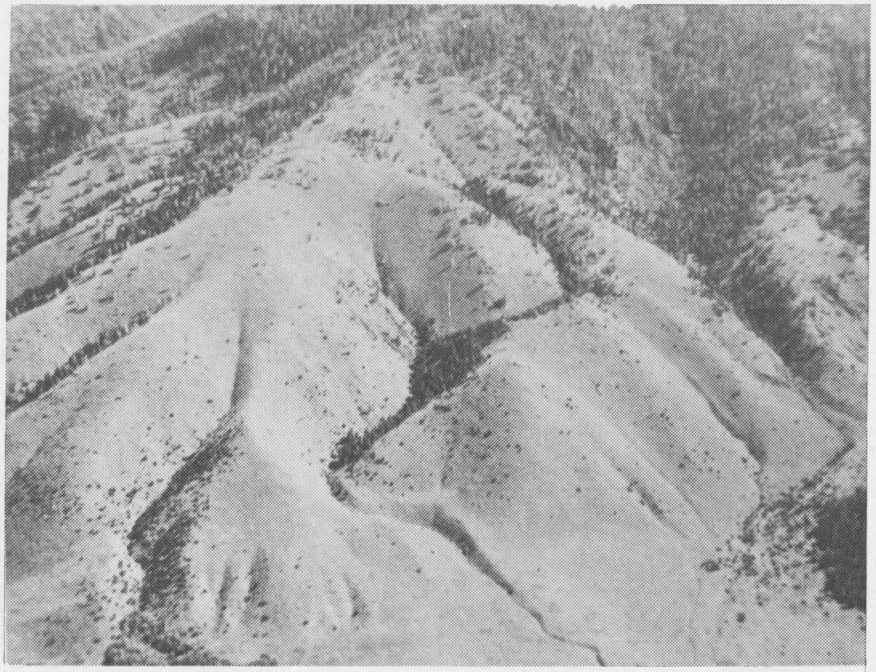

Figure 2. The Armstrong Winter Range topographical features and relationships.

Gallatin National Forest.

Livestock graze both private and public lands, but much of the area is either inaccessible or receives only light use because of the precipitous, rocky terrain. Grazing is primarily by cattle during summers on the national forest lands (U.S.D.A. Forest Service 1973) and summer-fall or winter-spring on private lands along the lower margin of the study area (Claude Maher 1973, personal communication). Commercially valuable timber is lacking on most of the study area as

well as on adjacent summer range. The only significant timber removal occurred prior to 1900 when larger Douglas-fir *(Pseudotsuga menzeisii)* trees were logged on accessible, lower north facing slopes. Croplands occur along the lower periphery of the area on sites sufficiently free of large rock to permit tillage. Principal crops are small grains, pasture grasses, and mixed hays.

Mule deer concentrate on the area in large numbers from late November through mid May or early June. A few deer are observed throughout the year. Wilkins (1957), citing local residents, reported that deer were quite scarce and infrequently seen as late as 1948. By the time of his study (1955-56), deer were common, with a large wintering population evidenced by overuse of browse plants and damage to agriculture products. Schwarzkoph (1973) estimated the wintering population to be about 173 animals. Winter classifications along the west slopes of the Bridger Range, including the study area, from 1971 through 1974 (Schwarzkoph 1973, Mackie personal communication) show an adult sex ratio of 39 males:100 females. Fawn:doe ratios on the study area were 68:100 for December 1972 (Schwarzkoph 1973) and 46:100 during December 1973 (Hamlin 1974). Over winter losses of fawns were estimated at about 21 percent along the west slope of the Bridgers during 1971-72 (Mackie 1974, personal communication) and about 24 percent on the study area during 1973-74 (Hamlin 1974). Schwarzkoph (1973) reported finding 19 and 18 winter-kill carcasses for the winters of

1971-72 and 1972-73, respectively, of which 21 were fawns, 15 were very old females, and 1 was a very old male. All had been in poor physical condition at time of death. Data persented by both Schwarzkoph (1973) and Hamlin (1974) indicated that fawns and some females were entering the winter with omental fat reserves close to the critical level. Hamlin (1974) concluded from several indices that considerably fewer deer are present on the range at this time as compared with 1955-56.

Small numbers of Rocky Mountain elk *(Cervus canadensis)* have also used the study area during recent winters with observations increasing each year. These animals apparently do not spend the entire winter on the area but rather move on and off throughout the season. Elk observations are usually single animals or small groups of 5-20. Rocky Mountain goats *(Oreamnos americanus)* are commonly observed on mule deer summer range east of the study area but have never been seen on the deer winter range.

PROCEDURES

Vegetational Analyses

Tentative habitat types and plant communities on the study area were established through field reconnaissance and outlined as overlays on colored aerial photographs supplied by the U.S.D.A. Forest Service. Refinements were made on the basis of subsequent vegetational analyses. Final classification of types followed Mueggler and Handl (1973) and Pfister *et al.* (1973) with some modification where particular species compositions and abundances encountered in the field were not described by these authors.

Vegetational characteristics and relationships of the various habitat and community types were measured using the point-centered quarter method (Cottam and Curtis 1956) and a modification of the canopy coverage technique (Daubenmire 1959). From one to ten stands representative of each habitat type were selected for analysis, depending upon their relative importance, occurrence, and distribution on the study area. Twenty sampling points, spaced approximately 15 meters apart, were established in a 4X5 or 5X4 point rectangular pattern across a representative portion of each stand. Occasionally the spacing was increased or decreased or the basic sampling pattern was altered to fit a particular stand. Each transect and sampling point was permanently marked for future identification and study.

Where possible, stands were selected to include representation of a type at elevations above and below 7,000 feet and any variation in occurrence by slope exposure. Exposure and percent slope of sampled stands were estimated using a K & F pocket transit. Elevation was determined with a Thommen pocket altimeter and verified by a U.S.G.S. topographic map.

Grass-Forb Types

In stands of the grass-forb type, canopy coverage of each taxon and forage class (grasses, forbs, and shrubs) was recorded by class in a 2X5 decimeter plot located at each of the 20 sampling points. Bare ground, litter, and rock were also recorded by coverage class. Coverage classes were: class 1=0-5 percent; 2=5-25 percent; 3=25-50 percent; 4=50-75 percent; 5=75-95 percent; and 6=95-100 percent.

Low-Shrub and Juniper Types

In low shrub and juniper dominated types, density, crown area/volume, and form/age class distributions were determined for each shrub and tree species. Density was estimated using the point-centered quarter technique. Crown area and volume were determined by recording two diameters, one through the major axis of the canopy (a) and another at a right angle through the minor axis (b) and average crown height (h) to the nearest centimeter for the nearest shrub in each quadrant. Plant area and volume were calculated as:

$PA = \frac{\pi ab}{4}$ and PV=PA(h). Form and age classes followed criteria outlined by Cole (1958). In addition, the canopy coverage of each shrub species was recorded by class in a 4X10 decimeter frame placed in the upslope left hand quadrant off of each point and the canopy coverage of each species and forage class was recorded within a 2X5 decimeter frame built within the 4X10 decimeter frame. Advantages of using a 4X10 decimeter plot in sampling coverage of shrubs such as *Artemisia* is discussed by Pyrah (1973).

Montane Forest and Aspen Types

The densities of tree and shrub species were determined using the point-centered quarter technique. Crown area/volume and form/age class distributions were determined for each shrub species as in the low shrub types. Diameter at breast height (dbh) was recorded for the nearest tree in each quadrant. Overstory crown coverage was estimated for each stand by recording four densiometer (Lemmon 1956) readings at each sampling point. Canopy coverages of shrubs and grasses and forbs were estimated by species in the same manner as in the low shrub types.

Importance values for shrub and tree species were calculated by summing the relative density, relative dominance, and relative frequency values for each stand (Cox 1972). Average areal coverage for each species of shrub and average dbh for trees were used to calculate

relative dominance values for a particular stand.

Common and scientific names of plants followed Booth (1950) and Booth and Wright (1959). Plants not immediately recognized in the field were collected, identified in the laboratory, and verified in the Montana State University Herbarium.

Forage Production and Utilization

Production

Estimates of total browse forage produced and available by habitat type and location on the winter range were made using basic plant densities and crown areas obtained in vegetational analyses together with regression equations developed to express crown area-twig number and/or twig weight relationships. Peek (1970) has shown high correlation between crown area and current leaf and twig production for 3 woody species. To establish these equations, 20 antelope bitterbrush *(Purshia tridentata)* and 20 big sagebrush *(Artemisia tridentata)* plants of various size were collected from the area at the end of the 1972 growing season. Each plant was measured (2 crown diameters and height to the nearest centimeter), cut at ground level, and taken to the laboratory where all current annual growth twigs one inch or longer were clipped and counted. Twigs were subsequently oven dried at 90°C for 24 hours, weighed individually to the nearest .01 gram, and measured for length to the nearest .5 millimeter and diameter to the

nearest .1 millimeter at base of twig (Basile 1966). Root crowns were also collected for evaluation of age-size-forage production relationships and the age structure of these species on the study area. Age determination followed Lonner (1972) and included sectioning, staining, and counting annual growth rings in transverse sections of the lower stem or root crowns. Ten typical size bitterbrush and 10 big sagebrush plants were collected at the end of the 1973 growing season and similarily treated for comparisons of forage production occurring in 1972. Available foliage yields of Rocky Mountain juniper *(Juniperis scopulorum)* were determined by sampling 20 randomly selected trees in a manner similar to that of Mason and Hutchings (1967). The height, crown diameter and basal stem diameter of each tree was measured and its foliage was classified as sparse, medium or dense on the basis of relative compactness. A "sample weight unit" with average foliage and fruit (a typical branch) was selected and used as a standard for estimating fruit and foliage yield. The number of weight units within reach of deer on each tree were counted. Foliage and fruit were then clipped from the "sample unit", oven dried and weighed. An estimate of total weight of foliage and fruit was computed by multiplying the number of weight units by the weight of the "sample unit". To check the accuracy of the yield estimates, all foliage and fruit, within deer reach, on every 5th tree was clipped, oven dried, and weighed and compared with the estimated weight values.

Utilization

Utilization of bitterbrush and big sagebrush during fall and winter, 1972-73 and 1973-74, was determined by post-browsing surveys. Two procedures were employed in each survey: (1) an estimate of the percentage of the number of available current annual growth twigs (CAGT) browsed (Cole 1958); and (2) an estimate of the length and/or weight of twig material removed by deer (Lyon 1970). Twenty plants were sampled in each stand of the shrub types as the nearest plant of bitterbrush and/or big sagebrush to each point previously established for vegetational analyses. These plants were tagged at the time of utilization survey in the spring of 1973 and remeasured in the spring of 1974. Regression equations developed for clippings collected during production analyses were applied to mean diameter of current growth (DCG) to estimate mean lengths and/or weights of CAGT before browsing. In addition, mean diameter at point of browsing (DPB) was determined to investigate its usefulness in the prediction of mean length and/or weight of CAGT browsed, thus eliminating the need of measuring both length and/or weight and DCG of unused CAGT after browsing.

Summer-Fall Utilization of Key Browse Species by Livestock

Livestock utilization of bitterbrush was evaluated on one portion of the study area grazed by cattle during the summer and fall. In mid-October 1973, following removal of the cattle, three 25 plant utilization and condition trend survey transects (Cole 1958) were

established and measured in the pasture. One transect at the base of the slope, another at mid-slope, and the third at the upper limits of bitterbrush distribution. These were remeasured during the spring of 1974 to ascertain total utilization and separate the summer - fall livestock use from winter game use.

Climatic Characteristics and Conditions

Precipitation, temperature, relative himidity, wind mileage, solar radiation and snow depths on the area were recorded from the fall of 1972 throughout the study.

Two weather stations were established in October 1972. One was located on the Armstrong Ranch at the periphery of the winter range (5300 feet elevation), the other on the mountain slope in a fenced exclosure at a site reasonably representative of the majority of the winter range (5850 feet elevation). The lower station included a standard weather bureau rain gauge, hygrothermograph, and solar radiation recorder. The upper station held a hygrothermograph and weather bureau type anemometer. One additional weather station containing only a hygrothermograph was established in the spring of 1973 on a north facing slope in the Douglas-fir habitat type (5800 feet elevation).

Four maximum-minimum thermometer stations were established in February 1973 to obtain records of temperature variations in different habitat types at various elevations and exposure during the winter

months. A snow course transversing the winter range provided records of snow depths and characteristics at various elevations, habitat types, slopes, and exposures during both winters.

Edaphic Characteristics

Two composite soil samples were collected for each stand in which vegetation measurements were conducted and from various vegetation types on mule deer summer range between the study area and the Gallatin-Bridger Canyon Divide. The samples were obtained at a depth of 6 inches. One set of the samples was analyzed by the Montana State University Soil Testing Laboratory for pH, organic matter content, salt hazard, and amounts of phosphorus, potassium, calcium, magnesium, and sodium. The second was analyzed for soil texture as described by Sims (1970). To analyze morphological differences in soils in the various vegetation types, 8 soil pits were excavated to the depth of approximately 30 inches in representative stands at various elevations on the winter range. Mr. Bernard Schaff (Montana State University Soils Department) checked the soils for thickness of horizons, distinctness of boundary, texture, color, structure, and moist consistency. The position of each site, parent material, erosion, surface runoff, infiltration rate, permeability, water holding capacity, and soil drainage class were described and submitted to the Soil Conservation Service which provided the classification. The soils were placed within the

series as presently known. Further study of the soils in the area may place some of them in a different, but closely related series (Shelby Brownfield, S.C.S., 1974 personal communication).

RESULTS

Vegetation

General characteristics of the vegetation of the Armstrong winter range have been described previously by Wilkins (1957) and Schwarzkoph (1973). Wilkins recognized three vegetational types: A montane forest type characterized by Douglas-fir forest with an undertory of browse and sedge species which occurred at elevations between 5,800 and 8,600 feet; a sagebrush-bitterbrush type, occurring on the steep mountain base between 5;600 and 6,400 feet, which was characterized by big sagebrush, bitterbrush, Rocky Mountain juniper, bunchgrasses, and forbs; and a bunchgrass prairie type, which occurred on the alluvial fan below 6,000 feet and consisted of bunchgrass-forb stands interspersed with some big sagebrush. Local stands of deciduous trees and shrubs occurring in more moist situations and agriculture areas away from the base of the mountain were included in the bunchgrass prairie type. Schwarzkoph generally followed this description, but designated two vegetation zones each divided into vegetational types. The Bunchgrass Prairie Zone essentially comprised the bunchgrass prairie type of Wilkins, while the Douglas-Fir Zone included Wilkins' lower montane forest and sagebrush-bitterbrush types.

My classification divided the area into "habitat types" (hereafter abbreviated as h.t.) in the sense of Daubenmire (1952:302).

Types were designated on the basis of characteristic or "dominant" plant species as determined by relative coverage composition and density in sampled stands. In most cases, type designations followed the classifications of Mueggler and Handl (1973) for mountain shrub and grassland habitat types in southwestern Montana and Pfister, Arno, Kovalchik, and Presby (1973) for forest habitat types of central and eastern Montana.

A total of 14 types were delineated. Their mosaic-like distribution on the study area (Fig. 3) reflects the irregular topography and variable edaphic characteristics of the area as well as successional stages and past disturbance by domestic and wild ungulates. Also abrupt altitudinal changes (relief of 1000 feet or more within ½ mile) influence micro-climatic conditions which are reflected in vegetational differences associated with elevation.

Tree and shrub densities, importance values, species composition, and constancy, coverage, and frequency percentages for the vegetation in the various habitat types are presented in Tables 1, 2, and 3. Data relative to textural classification and chemical analyses of soils associated with vegetational types on mule deer summer range between the study area and the Gallatin-Bridger Canyon Divide and not discussed in this report are presented in Appendix Table 1.

← North

Figure 3. Aerial view of the habitat types comprising the Armstrong Mule Deer Winter Range:

1. *Festuca idahoensis/Agropyron spicatum*
2. *Agropyron spicatum/Agropyron smithii*
3. *Purshia tridentata/Agropyron spicatum*
4. *Purshia tridentata/Artemisia tridentata*
5. *Artemisia tridentata/Festuca idahoensis*
6. *Acer glabrum/Philadelphus lewisii*
7. *Populus tremuloides-Prunus virginiana/Symphoricarpos albus*
8. *Juniperus scopulorum-Purshia tridentata/Artemisia tridentata*
9. *Juniperus scopulorum-Purshia tridentata/Agropyron spicatum*
10. *Juniperus scopulorum-Purshia tridentata/Festuca idahoensis*
11. *Pseudotsuga menziesii/Prunus virginiana*
12. *Pseudotsuga menziesii/Symphoricarpos albus*
13. *Pseudotsuga menziesii/Festuca idahoensis*
14. *Pseudotsuga menziesii/Carex geyeri*

TABLE 1. CONSTANCY, CANOPY COVERAGE, AND FREQUENCY OF LOW GROWING TAXA FOR HABITAT TYPES AS DETERMINED BY EXAMINATION OF TWENTY 2X5 DECIMETER PLOTS FOR HERBACEOUS PLANTS AND TWENTY 4X10 DECIMETER PLOTS FOR SHRUBS AND LOW TREES ON EACH OF 38 SITES.

	Habitat Type							
Taxa[1]	FEID/ AGSP[2] 3 sites	AGSP/ AGSM 1 site	PUTR/ AGSP 6 sites	PUTR/ ARTR 10 sites	ARTR/ FEID (foot-slopes) 4 sites	ARTR/ FEID (mountain slopes) 3 sites	ACGL/ PHLE 2 sites	POTR-PRVI/ SYAL 1 site
GRASSES AND SEDGES:								
Agropyron smithii		100/2/80[3]	17/tr[4]/tr	10/tr/tr	25/tr/1			
Agropyron spicatum	100/6/69	100/2/20	100/10/73	100/6/69	100/6/39	100/4/55	100/2/18	
Bromus anomalus								100/1/20
Bromus carinatus						33/tr/5		
Bromus japonicus		100/tr/10						
Bromus tectorum	67/1/14	100/9/80	100/7/64	90/3/46	25/tr/9			
Carex saximontana					25/tr/3		100/2/20	
Danthonia unispicata	67/2/29		67/1/14	40/1/4	50/3/40	33/1/3	50/tr/3	
Elymus cinereus								100/3/20
Festuca idahoensis	100/21/91	100/1/5	50/tr/8	100/6/51	100/6/38	100/11/75	100/2/20	
Festuca pratensis							50/tr/8	

TABLE 1. (Continued)

Taxa	Habitat Type							
	FEID/ AGSP 3 sites	AGSP/ AGSM 1 site	PUTR/ AGSP 6 sites	PUTR/ ARTR 10 sites	ARTR/ FEID (foot-slopes) 4 sites	ARTR/ FEID (mountain slopes) 3 sites	ACGL/ PHLE 2 sites	POTR-PRVI/ SYAL 1 site
Koeleria cristata	100/3/68	100/1/10	83/2/33	90/2/39	75/2/39	100/2/42	100/1/10	
Melica spectabilis							100/tr/10	
Poa canbyi			17/1/10					
Poa pratensis	33/tr/2	100/22/100		10/tr/1	50/3/14		50/tr/8	100/14/60
Poa secunda	33/tr/12	100/tr/5	50/1/21	20/tr/3			50/tr/3	
Poa sp.				8/1/5		33/tr/7	100/1/28	
Stipa comata	33/1/13	100/tr/5		10/tr/tr	50/7/45			
Unidentified Grasses				10/tr/1	25/tr/3		50/1/13	
Total Grasses and Sedges	100/33/100	100/37/95	100/22/96	100/20/99	100/28/95	100/18/97	100/10/73	100/18/70
FORBS:								
Achillea millefolium	100/4/59	100/7/65	100/1/16	100/2/31	100/3/52	100/3/50	100/1/13	100/3/20
Agastache urticifolia							100/4/23	
Agoseris glauca		100/tr/5						
Allium cernuum	33/tr/1			20/tr/2				
Allium sp.							100/1/8	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Alyssum alyssoides	100/1/39	100/1/75	80/3/73	100/2/88	50/1/19	33/tr/3	100/tr/8	
Antennaria anaphaloides	67/tr/3		33/tr/2	40/tr/3		66/1/13		
Antennaria parvifolia	33/tr/3			10/tr/1	50/tr/5		50/tr/5	
Antennaria rosea							50/tr/3	
Apocynum androsaemifolium	33/1/11		33/3/16	20/tr/5				
Arenaria congesta	67/1/19		17/tr/1	40/tr/6	75/1/11	33/1/10		
Arenaria serpyllifolia		100/2/45			25/1/11	25/1/11		
Arnica cordifolia							100/5/28	
Arnica sororia	33/tr/7							
Artemisia ludoviciana		100/2/10	33/1/3	30/tr/2	75/1/8			
Aster modestus							50/tr/5	
Balsamorhiza sagittata	100/12/65	100/5/45	100/13/60	100/19/64	75/8/35	100/22/68	100/4/13	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Campanula rotundifolia	33/tr/2					33/tr/2		
Castilleja rhexifolia							100/tr/5	
Cerastium arvense	100/3/75		100/1/36	100/4/60	100/2/50	100/5/83	50/tr/5	
Chrysopsis villosa	33/tr/3	100/4/70	83/2/21	60/1/8	50/tr/4	33/tr/2	100/1/5	
Cirsium undulatum			50/tr/4	10/tr/tr				100/2/10
Collinsia parviflora							100/1/20	
Collomia linearis	33/tr/7	100/2/70	30/tr/3	70/1/14	50/tr/5	66/tr/12	50/tr/8	
Comandra umbellata	100/2/32		50/tr/3	90/1/10	75/tr/11	100/1/23		
Conimitella williamsii							50/tr/5	
Delphinium bicolor							50/tr/3	
Erigeron pumilus	33/tr/5					33/1/5		
Eriogonum umbellatum				10/tr/1		33/tr/2		
Fragaria virginiana							100/4/35	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Gaillardia aristata				30/tr/2		33/2/17		
Galium aparine								100/5/50
Gaura coccinea			17/tr/1	10/tr/tr				
Geranium viscosisimum		100/8/50		20/tr/1	75/3/23		100/tr/5	
Helianthella uniflora	33/1/8	100/tr/10		20/1/3	50/1/10	33/1/12	50/tr/3	
Heracleum lanatum							50/4/13	100/2/10
Heuchera parvifolia							50/tr/3	
Hieracium cynoglos-soides	100/1/19	100/tr/5		40/tr/3	25/tr/3	100/1/8		
Hydrophyllum capitatum				10/tr/1			100/2/20	
Liatris punctata			17/tr/1				50/tr/3	
Lithospermum arvense		100/1/35	33/tr/6	40/tr/14			50/tr/3	
Lithospermum ruderale	33/tr/1	100/5/25	33/tr/3	70/tr/6	100/1/18	33/1/3		
Lomatium cous							50/1/5	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Lomatium dissectum							50/1/5	
Lupinus sericeus	100/7/58	100/30/100	33/1/3	80/2/14	100/5/45	67/2/17	50/tr/8	
Mertensia ciliata							50/tr/5	
Microseris nutans	33/tr/2			10/tr/1				
Microsteris gracilis	33/tr/3							
Monarda fistulosa		100/2/10			100/4/20			100/3/30
Myositis sylvatica			17/tr/4				100/1/15	100/3/30
Opuntia polyacantha			17/tr/2					
Orthocarpus tenuifolius	33/1/15							
Perideridia gairdneri						33/tr/2		
Phacelia linearis				20/tr/2			50/tr/3	
Phlox longifolia	67/tr/13		17/tr/3	50/tr/10				
Polygonum bistortoides	33/tr/2						50/tr/3	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Polygonum douglasii			33/tr/3	30/tr/tr	25/tr/4	33/tr/2		
Potentilla gracilis					25/tr/1	33/tr/2		
Prunella vulgaris								100/2/10
Ranunculus acriformis							50/1/10	
Sedum lanceolatum	33/tr/3						50/2/5	
Smilacina racemosa							100/2/18	
Solidago sp.						33/tr/2		
Taraxacum officinale		100/tr/5		10/tr/tr			100/2/40	100/6/40
Tragopogon dubius	100/tr/13	100/tr/15	83/tr/7	80/1/14	75/tr/8	67/tr/8	50/tr/3	100/tr/10
Urtica dioica							50/2/3	100/1/20
Valeriana sitchensis								100/4/20
Woodsia scopulina							100/4/38	
Zigadenus venenosus	67/tr/15	100/tr/5		10/tr/tr		33/tr/2	50/tr/3	

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
Unidentified Forbs	33/tr/3	100/tr/10	50/tr/12	20/tr/2		33/tr/8	50/tr/3	
Total Forbs	100/39/100	100/72/95	100/26/99	100/38/99	100/31/97	100/43/95	100/45/80	100/31/100
SHRUBS AND LOW TREES:								
Acer glabrum							100/25/25	
Amelanchier alnifolia			33/tr/3				100/2/8	
Artemisia frigida			50/tr/5			33/tr/3		
Artemisia tridentata			66/tr/3	90/7/31	100/24/68	100/11/55	50/1/8	
Berberis repens			33/1/12	10/tr/tr			50/1/8	
Clematis columbiana							50/tr/5	
Crataegus douglasii								100/2/10
Juniperus scopulorum			17/tr/1	20/tr/1	25/tr/2			
Philadelphus lewisii							100/20/38	

TABLE 1. (Continued)

Taxa	Habitat Type							
	FEID/ AGSP 3 sites	AGSP/ AGSM 1 site	PUTR/ AGSP 6 sites	PUTR/ ARTR 10 sites	ARTR/ FEID (foot-slopes) 4 sites	ARTR/ FEID (mountain slopes) 3 sites	ACGL/ PHLE 2 sites	POTR-PRVI/ SYAL 1 site
Populus tremuloides								100/4/30
Prunus virginiana			67/1/6				100/3/30	100/7/50
Purshia tridentata			100/7/33	100/4/21		67/1/2		
Rosa nutkana			67/1/7	20/tr/tr	100/tr/8		100/1/15	100/10/60
Spiraea betulifolia							100/3/35	
Symphoi-carpos albus			33/tr/4				100/12/58	100/26/70
Total Shrubs and Low Trees			100/10/53	100/11/47	100/25/75	100/12/58	100/64/83	100/49/100
LICHEN AND MOSS							100/3/25	
BARE GROUND	100/14/92	100/7/75	100/22/85	100/19/93	100/10/63	100/17/90	100/4/25	
GRASSES	100/37/100	100/37/95	100/23/96	100/22/99	100/34/95	100/21/97	100/14/73	100/10/70
FORBS	100/30/100	100/46/95	100/23/99	100/29/99	100/25/98	100/35/95	100/33/80	100/29/100

TABLE 1. (Continued)

Taxa	Habitat Type: FEID/AGSP 3 sites	AGSP/AGSM 1 site	PUTR/AGSP 6 sites	PUTR/ARTR 10 sites	ARTR/FEID (foot-slopes) 4 sites	ARTR/FEID (mountain slopes) 3 sites	ACGL/PHLE 2 sites	POTR-PRVI/SYAL 1 site
SHRUBS			100/7/36	100/10/31	100/23/58	100/12/37	100/50/88	100/40/100
Selaginella densa	100/10/45	100/1/5	18/1/6	20/tr/3	25/2/13		100/3/15	
ROCK	100/5/66		100/16/93	100/7/78	100/4/43	100/7/73	100/7/43	
LITTER	100/30/100	100/4/100	100/23/97	100/37/99	100/45/98	100/38/97	100/14/80	100/12/90

[1]Includes those taxa with a canopy coverage of 0.5 percent or greater or a frequency of 5 percent or greater in at least one site.

[2]First two letters of generic and specific name, e.g., FEID/AGSP = *Festuca idahoensis*/*Agropyron spicatum*, of those species used in naming the habitat type.

[3]Constancy (percent occurrence among sites)/canopy coverage (percent of area covered)/average frequency (percent occurrence among plots).

[4]tr = trace; a value less than 0.5 percent.

TABLE 2. CANOPY COVERAGE AND FREQUENCY OF LOW GROWING TAXA FOR HABITAT TYPES AS DETERMINED BY EXAMINATION OF TWENTY 2X5 DECIMETER PLOTS FOR HERBACEOUS PLANTS AND TWENTY 4X10 DECIMETER PLOTS FOR SHRUBS AND LOW TREES ON EACH OF 38 SITES.

	Habitat Type							
Taxa[1]	JUSC-PUTR/AGSP[2] 1 site	JUSC-PUTR/FEID 1 site	PSME/SYAL 1 site	PSME/PRVI 1 site	PSME/FEID 1 site	PSME/CAGE (lower north slope) 1 site	PSME/CAGE (upper west slope) 1 site	JUSC-PUTR/ARTR 1 site
GRASSES AND SEDGES:								
Agropyron spicatum	9[3]/64	5/57		1/35	2/50			2/45
Bromus ciliatus					tr[4]/10			
Bromus tectorum	5/71			1/10				
Carex geyeri			14/60			45/100	42/80	
Carex Saximontana					tr/10			
Danthonia unispicata				tr/5				4/45
Elymus cinereus			15/65			tr/5		
Festuca idahoensis		14/71	tr/5		9/55			2/20
Koeleria cristata		tr/14	tr/5		2/40			3/55
Phleum pratense					1/30			
Poa canbyi	tr/7							
Poa pratensis			1/5	1/20	14/65			
Poa secunda								tr/15
Poa sp.						1/10	tr/10	7/55
Stipa comata								1/25
Total Grasses and Sedges	14/93	19/86	31/75	3/55	29/100	46/100	46/100	19/100
FORBS:								
Achillea millefolium	tr/7	1/57	tr/15	4/25	3/40		7/85	
Allium sp.					tr/5			

TABLE 2. (Continued)

Taxa	Habitat Type							
	JUSC-PUTR/AGSP 1 site	JUSC-PUTR/FEID 1 site	PSME/SYAL 1 site	PSME/PRVI 1 site	PSME/FEID 1 site	PSME/CAGE (lower north slope) 1 site	PSME/CAGE (upper west slope) 1 site	JUSC-PUTR/ARTR 1 site
Alyssum alyssoides	3/71	tr/14	tr/5					
Antennaria anaphaloides		tr/14						
Antennaria parvifolia			tr/10		tr/5			
Antennaria racemosa			4/25			9/60		
Aquilegia flavescens						3/45		
Arenaria congesta		8/86			tr/5			tr/5
Arnica cordifolia					6/45	tr/15	2/10	
Arnica sororia				tr/5				
Artemisia ludoviciana								tr/5
Aster modestus			5/40				17/60	
Aster perelegans			3/30			1/35		
Balsamorhiza sagittata	2/21	4/29		tr/5	3/45		2/15	13/35
Campanula rotundifolia		1/29					2/20	
Cerastium arvense	tr/7	2/71	tr/5	tr/5	2/35			1/20
Chrysopsis villosa	8/57							1/30
Collinsia parviflora				1/20	tr/10			
Collomia linearis		tr/14		tr/10	1/20			tr/15
Comandra umbellata								tr/5
Conimitella williamsii			1/20		1/50	1/20		
Epilobium angustifolium							tr/5	
Erigeron speciosus					tr/5		1/10	
Erigeron sp.		1/29						
Fragaria virginiana			10/75		11/65	2/50	5/35	
Gaillardia aristata		1/29			tr/10			
Galium aparine				1/45				

TABLE 2. (Continued)

Taxa	Habitat Type: JUSC-PUTR/AGSP 1 site	JUSC-PUTR/FEID 1 site	PSME/SYAL 1 site	PSME/PRVI 1 site	PSME/FEID 1 site	PSME/CAGE (lower north slope) 1 site	PSME/CAGE (upper west slope) 1 site	JUSC-PUTR/ARTR 1 site
Geranium viscosisimum					tr/10			
Geum triflorum		1/43						
Goodyera oblongifolia						tr/10		
Helianthella uniflora			tr/5		3/40			
Heuchera parvifolia					tr/5	tr/5		
Hieracium cynoglossoides		1/29	tr/5		tr/10			
Hydrophyllum capitatum					tr/5			
Lithospermum arvense								tr/15
Lithospermum ruderale						tr/5		tr/10
Lupinus sericeus								4/30
Lupinus sulphureus						3/30		
Mertensia ciliata						tr/5		
Microseris nutans				tr/5				
Micrositeris gracilis				tr/5				
Monarda fistulosa								5/20
Opuntia polyacantha	3/7							
Phlox longifolia	tr/7			tr/5				
Polygonum bistortoides					tr/5			
Sedum lanceolatum		1/43						
Smilacina racemosa					tr/5	10/45		
Taraxacum officinale				tr/5	3/40			1/20
Tragopogon dubius	tr/7			tr/10				
Valeriana sitchensis					tr/5			
Woodsia scopulina					3/55			

TABLE 2. (Continued)

Taxa	Habitat Type							
	JUSC-PUTR/AGSP 1 site	JUSC-PUTR/FEID 1 site	PSME/SYAL 1 site	PSME/PRVI 1 site	PSME/FEID 1 site	PSME/CAGE (lower north slope) 1 site	PSME/CAGE (upper west slope) 1 site	JUSC-PUTR/ARTR 1 site
Zigadenus venenosus				tr/5	tr/5			1/35
Unidentified Forbs	tr/14		tr/5		1/30	1/15		1/20
Total Forbs	18/93	22/100	33/95	9/65	42/100	29/95	37/100	37/95
SHRUBS AND LOW TREES:								
Acer glabrum						1/5		
Amelanchier alnifolia			tr/5		5/30			
Artemisia frigida	tr/7							
Artemisia tridentata	tr/7	tr/14			1/5			6/30
Berberis repens				2/20		tr/5	1/25	
Clematis columbiana						2/5		
Crataegus douglasii	1/7							
Juniperus communis							2/5	
Juniperus scopulorum	4/21			12/15	1/5			5/5
Philadelphys lewisii				3/15				
Prunus virginiana	4/14	tr/14		20/55		tr/5		1/5
Pseudotsuga menziesii		tr/14						
Purshia tridentata	2/36	5/14						12/30
Ribes lacustre			tr/5			tr/5		
Rosa nutkana				2/5				1/5
Spiraea betulifolia		1/28	1/20	4/25			7/55	
Symphoricarpos albus			18/50	5/65	5/30	1/10		
Vaccinium membranaceum						14/30		
Total Shrubs and Low Trees	12/67	7/40	19/50	48/45	12/40	19/55	10/75	25/60

TABLE 2. (Continued)

Taxa	Habitat Type							
	JUSC-PUTR/AGSP 1 site	JUSC-PUTR/FEID 1 site	PSME/SYAL 1 site	PSME/PRVI 1 site	PSME/FEID 1 site	PSME/CAGE (lower north slope) 1 site	PSME/CAGE (upper west slope) 1 site	JUSC-PUTR/ARTR 1 site
LICHEN AND MOSS		tr/14	tr/10			15/55		
BARE GROUND	35/100	29/71	tr/15	1/10	1/30		3/15	6/40
GRASS	16/93	23/86	31/100	4/55	30/100	42/100	50/100	24/100
FORBS	18/93	18/100	27/95	10/65	38/100	30/95	35/100	28/95
SHRUBS	17/43	1/57	16/50	25/65	5/35	13/45	5/55	22/60
Selaginella densa		8/57	6/40	5/20				10/45
ROCK	11/100	26/100		17/90	tr/5		6/50	8/40
LITTER	29/93	20/100	31/95	41/95	25/100	25/100	23/100	13/95

[1]Includes those taxa with a canopy coverage of 0.5 percent or greater or a frequency of 5 percent or greater in at least one site.

[2]First two letters of generic and specific name, e.g., FEID/AGSP = *Festuca idahoensis/Agropyron spicatum*, of those species used in naming the habitat type.

[3]Canopy coverage (percent of area covered)/average frequency (percent occurrence among plots).

[4]tr = trace; a value less than 0.5 percent.

TABLE 3. CANOPY COVERAGE, ABSOLUTE DENSITIES, RELATIVE DENSITIES, AND IMPORTANCE VALUES OF VARIOUS SHRUBS AMONG SHRUBLAND HABITAT TYPES.

Species	PUTR/AGSP	PUTR/ARTR	ARTR/FEID (footslope)	ARTR/FEID (mountain slope)	JUSC-PUTR/AGSP	JUSC-PUTR/FEID	JUSC-PUTR/ARTR	POTR-PRVI/SYAL
Amelanchier alnifolia	tr[1]/56/3[2]	+[3]/6/tr			+/168/5			+/106/22
Artemisia frigida					tr/+/+			
Artemisia tridentata	tr/65/17	7/3565/175	24/7530/292	11/4851/288	tr/198/13	tr/926/60	9/2358/110	
Berberis repens	tr/+/+							
Crataegus douglasii					1/168/8			2/158/34
Juniperus scopulorum	tr/20/22	tr/52/10	tr/63/3	+/24/6	4/509/103	+/1191/156	10/472/78	
Populus tremuloides								4/1213/169[4]
Prunus virginiana	1/50/9	+/31/2			4/846/36	tr/132/10		7/580/67
Pseudotsuga menziesii				1/31/3		tr/132/10		
Purshia tridentata	7/1622/235	4/2052/111		tr/57/4	2/3817/136	5/1191/64	1/177/92	
Ribes viscosissimum							+/59/8	
Rosa nutkana	1/163/13	tr/23/2	tr/100/5				1/177/12	10/53/10
Spiraea betulifolia						1/+/+		
Symphoricarpos albus	tr/37/1							26/+/+
Total	10/2013/300	12/5729/300	25/7693/300	12/4906/300	12/5706/300	7/3706/300	30/4716/300	49/2109/300

[1]tr = trace, a value less than 0.5 percent.

[2]Canopy coverage/absolute density/importance value (relative density + relative dominance, based on crown area + relative frequency).

[3]+ = present but not encountered during density measurements.

[4]Canopy coverage for *Populus tremuloides* for trees less than 6 feet in height, however, density value and importance value includes all trees encountered.

Festuca idahoensis/Agropyron spicatum (FEID/AGSP) h.t.

This type occurs on the footslope and lower, steep west-facing mountain slopes up to 6,200 feet on the northern portion of the study area (Figs. 3 and 4). Collectively, it comprises approximately 11 percent (57.1 hectares or 141 acres) of the winter range. Associated soils are the deepest and least rocky of any on the study area. Vegetational coverage and litter accumulations are high (Table 1) reducing surface erosion to a minimum despite the severe steepness and openness of the slopes. Idaho fescue *(Festuca idahoensis)* and bluebunch wheatgrass *(Agropyron spicatum)* are the dominant and distinguishing species (Table 1). One-spike oatgrass *(Danthonia unispicata)*, junegrass *(Koeleria cristata)*, and downy chess brome *(Bromus tectorum)* occur in lesser amounts. Major forbs are yarrow *(Achillea millefolium)*, arrowleaf balsamroot *(Balsamorhiza sagittata)*, silky lupine *(Lupinus sericeus)*, field chickweed *(Cerastium arvense)*, and pale bastard toadflax *(Commandra umbellata)*. A few shrubs, including common snowberry *(Symphoricarpos albus)*, Oregon grape *(Berberis repens)*, chokecherry *(Prunus virginiana)*, nootka rose *(Rosa nutkans)* occur, but were not encountered in any of the sampling plots.

Analyses of soil samples from three sites indicated that soils are sandy loam in texture, slightly acid to neutral, low to very low in phosphorus content, high in potassium content, medium in organic

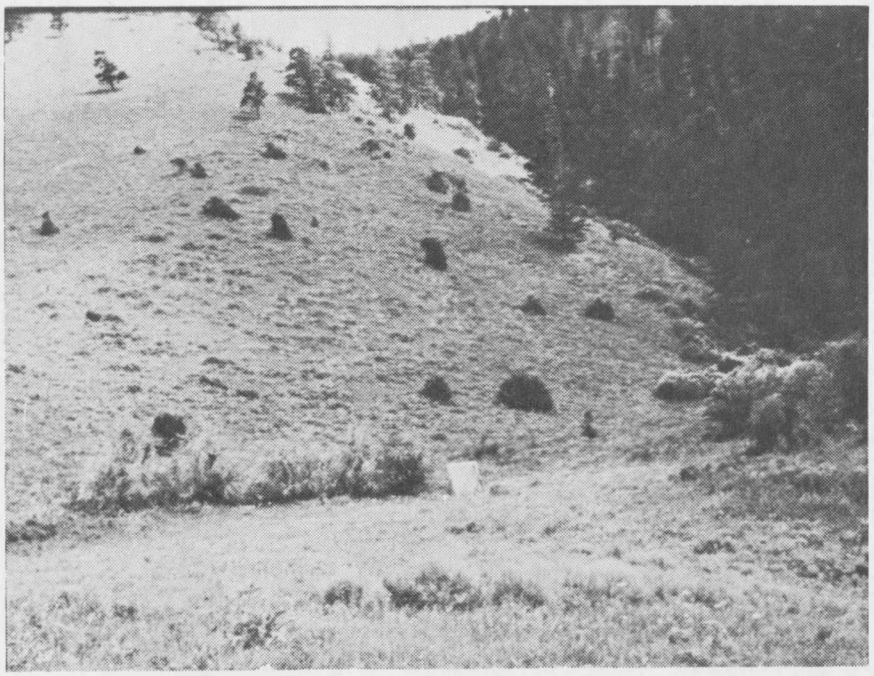

Figure 4. Douglas-fir type upper right, big sagebrush type lower center, antelope bitterbrush type center, and Idaho fescue/ bluebunch wheatgrass type upper left.

matter content, and very low in salt content (Table 4).

Soil profiles for one site on the footslope and another on the mountain slope were identical and were classified as an Ess loam of the loamy- skeletal, mixed family of the Argic Cryoboralls:

A1 0-4" Brownish black (10YR 3/2) sandy loam; strong granular structure; friable; clear boundary.

B21 4-11" Brownish black (10YR 3/2) loam; moderate angular blocky structure; friable; clear boundary.

B22t 11-20" Brown (7.5YR 4/3) gravelly clay loam; moderate-strong angular blocky; friable; clear boundary.

TABLE 4. EDAPHIC CHARACTERISTICS OF VARIOUS STANDS BY HABITAT TYPE INCLUDING TEXTURAL CLASSIFICATION, pH, FIVE IMPORTANT ELEMENTS, ORGANIC MATTER AND SALT HAZARD ON THE ARMSTRONG WINTER RANGE.

Habitat Type	Stand Number	Soil Texture Percentage Sand	Silt	Clay	Soil Texural Class	pH	Phosphorus ppm[1]	Potassium ppm	Salt mmhos[2]	Organic Matter %	Calcium meg[3]	Magnesium meg	Sodium meg
FEID/AGSP	13	50	42	8	SL[4]	6.8	23(VL)[5]	735(H)	.4	5.8(M)	21.4	4.43	.35
	14	58	34	8	SL	6.7	31(L)	315(H)	.2	4.4(M)	13.4	3.03	.44
	32	52	44	4	SL	6.6	18(VL)	515(H)	.3	5.6(M)	13.4	2.30	.24
AGSP/AGSM	30	48	46	6	SL	6.9	83(H)	705(H)	.3	6.0(M)	20.3	3.03	.27
PUTR/AGSP	6	64	28	8	SL	6.9	20(VL)	135(M)	.2	3.2(L)	14.6	5.00	.51
	15	68	24	8	SL	7.0	10(VL)	115(L)	.6	1.9(VL)	15.4	4.64	.39
	18	66	26	8	SL	7.0	10(VL)	195(M)	.2	2.6(L)	9.8	2.87	.39
	20	74	24	2	LS	6.6	31(L)	245(M)	.2	6.0(M)	12.6	1.72	.27
	28	72	22	6	SL	6.9	23(VL)	125(L)	.2	3.3(L)	12.2	3.48	.27
	35	66	24	10	SL	6.7	13(VL)	115(L)	.2	2.8(L)	13.4	4.43	.27
PUTR/ARTR	2	62	28	10	SL	6.7	23(VL)	185(M)	.2	3.8(L)	17.8	6.23	.44
	3	64	28	8	SL	6.8	25(VL)	305(H)	.3	4.8(M)	17.0	5.00	.35
	4	58	36	6	SL	7.0	18(VL)	305(H)	.2	4.4(M)	15.8	5.00	.54
	5	66	28	6	SL	7.5	15(VL)	235(M)	.3	3.8(L)	13.4	4.10	.51
	7	68	24	8	SL	6.6	20(VL)	165(M)	.3	4.1(M)	18.2	4.51	.44
	8	66	26	8	SL	6.9	15(VL)	175(M)	.2	2.8(L)	12.6	3.61	.51
	9	68	24	8	SL	7.1	40(L)	345(H)	.3	3.8(L)	11.8	2.54	.30
	16	66	28	6	SL	6.7	20(VL)	185(M)	.2	4.0(L)	15.0	3.36	.48
	33	72	22	6	SL	6.8	23(VL)	115(L)	.2	3.5(L)	12.2	3.20	.20
	36	72	22	6	SL	6.6	28(VL)	225(M)	.2	3.3(L)	9.8	2.46	.24
ARTR/FEID	1	44	46	10	L	6.7	31(L)	615(H)	.4	6.1(H)	19.8	3.36	.35
(Footslopes)	12	62	34	4	SL	6.6	48(L)	515(H)	.4	6.0(M)	20.2	2.71	.44
	17	70	26	4	SL	6.6	31(L)	395(H)	.4	5.0(M)	13.0	3.03	.44
	31	38	52	10	St.L	6.5	25(VL)	305(H)	.2	5.3(M)	12.2	2.46	.30

TABLE 4. (Continued)

Habitat Type	Stand Number	Soil Texture Percentage Sand	Silt	Clay	Soil Texural Class	pH	Phosphorus ppm	Potassium ppm	Salt mmhos	Organic Matter %	Calcium meg	Magnesium meg	Sodium meg
ARTR/FEID (mountain slopes)	10	70	24	6	SL	6.4	25(VL)	275(H)	.3	5.1(M)	12.6	2.54	.35
	11	70	22	8	SL	6.8	34(L)	395(H)	.3	3.9(L)	12.2	2.46	.44
	19	70	24	6	SL	7.1	25(VL)	255(H)	.4	3.8(L)	11.8	2.13	.44
JUSC-PUTR/ ARTR	29	62	34	4	SL	6.5	23(VL)	265(H)	.1	5.0(M)	9.8	1.72	.24
JUSC-PUTR/ FEID & AGSP	25	74	20	6	SL	7.0	20(VL)	105(L)	.2	4.3(M)	18.2	4.10	.51
PSME/SYAL	22	56	36	8	SL	6.2	63(M)	565(H)	.6	11.0(H)	26.2	3.77	.48
PSME/PRVI	34	66	30	4	SL	6.5	123(H)	505(H)	.4	5.7(M)	32.6	3.20	.27
PSME/FEID	37	56	36	8	SL	6.2	18(VL)	325(H)	.1	6.0(M)	16.6	3.00	.27
PSME/CAGE (upper)	21	51	41	8	L	6.6	45(L)	455(H)	.6	6.0(M)	25.8	2.71	.30
PSME/CAGE (lower)	23	52	38	10	L	6.3	48(L)	435(H)	.5	6.0(M)	20.2	2.71	.39
POTR-PRVI/ SYAL	38	58	36	6	SL	6.8	18(VL)	645(H)	.4	6.1(H)	27.8	3.77	.27

[1]ppm = pounds per one million pounds of soil.

[2]mmhos = milimhos, 1 mho = $\frac{1}{\text{ohm}}$.

[3]meg = milliequivalents per 100 grams of soil.

[4]SL = silt loam, LS = loamy sand, L = loam, and St. L = silty loam.

[5]Ratings from Montana Soils Testing Laboratory Report, ST - Form 3, Jan. 8, 1971: VL = very low, L = low, M = medium, and H = high.

C1 20"+ Brown (7.5YR 4/3) gravelly loam; massive structure; friable.

These footslope and mountain slope soils are on 10 and 58 percent slopes, respectively, and were formed in colluvium material. Infiltration rate is moderate; available water holding capacity is medium; permeability is medium; and they are well drained.

Agropyron spicatum/Agropyron smithii (AGSP/AGSM) h.t.

This habitat type is limited to an area of 13 hectares or 32 acres of footslope on the lower central portion of the study area (Fig. 3). It makes up approximately 2.5 percent of the total area. The soils are fairly deep and free of rock. Although bluebunch wheatgrass and western wheatgrass *(Agropyron smithii)* are present only in relatively small quantities (Table 1), they may be considered the normal dominant climax vegetation for this type (Mueggler personal communication). Kentucky bluegrass *(Poa pratensis)* has apparently replaced these species due to past overgrazing and is now the dominant grass. Booth (1950) states that this species thrives upon moist, well drained soils that are pastured or heavily trampled. An abundance of downy chess brome may be attributed to rodent activity, which had created disturbed areas favored by this species, in the one stand examined. Idaho fescue and junegrass are present in minor amounts. Principal forbs are yarrow, arrowleaf balsamroot, golden-aster *(Chrysopsis villosa)*, sticky geranium *(Geranium viscosismum)*, western gromwell *(Lithospermum ruderale)*, and silky lupine. Of minor importance,

but noticeably present, are horse mint *(Monarda fistulosa)*, narrow-leaved collomia *(Collomia linearis)*, cudweed sagewort *(Artemisia ludoviciana)*, and thymeleaved sandwort *(Arenaria serpyllifolia)*. The only shrub present is nootka rose, which occurs irregularly in small clumps.

Analysis of one soil sample indicated a sandy loam texture, neutral pH, high phosphorus and potassium content, medium amount of organic matter, and very low salt content (Table 4).

Purshia tridentata/Agropyron spicatum (PUTR/AGSP) h.t.

This type occurs on approximately 36.4 hectares (90 acres) or 7 percent of the study area (Figs. 3 and 4). Its distribution is limited primarily to lower (below 6100 feet), very steep mountain slopes of south, southwest and southeast exposure. Because of their steepness and orientation to sun and wind, the physical environment of these sites may be more severe than elsewhere on the study area. The soils are thin and very rocky, and bedrock outcroppings are common. The type also occurs on footslope alluvial deposits associated with the flood plain of Bill Smith Creek. The highly rocky and sandy soils of this fan are excessively well drained, a characteristic which apparently favors deep rooting species such as antelope bitterbrush and bluebunch wheatgrass (Nord 1965 and Heady 1950). Except for early annuals, shallow rooted plant species were rarely encountered at this

site. Overall, bluebunch wheatgrass and downy chess brome are the most important grasses (Table 1). Canby bluegrass *(Poa canbyi)*, one-spike oatgrass, and junegrass occur in minor quantities. Pale alyssum *(Alyssum alyssoides)*, spreading dogbane *(Apocynum androsaemifolium)*, arrowleaf balsamroot, and narrowleaved collomia are common forbs. Antelope bitterbrush is the only important shrub with plant densities averaging 1622/hectare or 656/acre (Table 3). Big sagebrush, fringed sagewort *(Artemisia frigida)*, chokecherry, and nootka rose occur frequently, but as scattered individuals or in small clumps.

Samples were obtained from the soils of six sites within this type. Five of these were on the mountain slope, the sixth was located on the alluvial fan associated with Bill Smith Creek. Analytical data (Table 4) indicate that soils associated with stands on the mountain slope are very similar. They tend to be sandy loam in texture, slightly acid to neutral, very low in phosphorus content, medium to low in potassium content, low to very low in organic matter content, and very low in salt content. The soil of the alluvial fan was loamy sand, slightly acid, low in phosphorus content, medium in potassium content, medium in organic matter content, and very low in salt content.

The soil profile at a mountain slope site was a Sharrot loam, cold variant of the loamy-skeletal, mixed family of the Lithic

Cryocrepts:

A1 0-3" Brown (7.5YR 4/3) sandy loam; moderate gravel structure; friable; clear boundary.

B2 3-8" Brown (7.5YR 4/3) gravelly loam; weak sub-angular blocky structure; friable; abrupt boundary.

Rock 8"+

This soil is on a 60 percent slope and was formed in residuum material. Infiltration rate is moderate; available water holding capacity is very low; permeability is medium; and the soil is well drained.

The soil profile at the alluvial fan site was a Shook gravelly loam of the loamy-skeletal, mixed family of the Pachic Cryoborolls:

A 0-3" Brownish black (10YR 2/3) gravelly loam; moderate granular structure; friable; clear boundary.

B21 3-9" Brownish black (10YR 2/3) gravelly loam; weak sub-angular blocky structure; very friable; gradual boundary.

B22 9-19" Dark brown (10YR 3/3) gravelly sandy loam; weak sub-angular blocky structure; very friable; gradual boundary.

C 19"+ Dull yellowish brown (10YR 4/3) gravelly sandy loam; massive structure; very friable.

This site had a slope of 11 percent with the soil formed in old alluvium. Infiltration is moderate; available water holding capacity is very low; permeability is rapid; and the soil is excessively well

drained.

Purshia tridentata/Artemisia tridentata (PUTR/ARTR) h.t.

Characterized by mixed stands of antelope bitterbrush and big sagebrush (Figs. 5 and 6) this important habitat type occupies approximately 57.9 hectares or 143 acres (11.5 percent of the winter range). It occurs across most of the area on rather dry and rocky, steep southerly and southwesterly exposed slopes below 6400 feet. In a few locations it also occurs on the footslope (Fig. 3). Soils are generally deeper and less rocky than in the areas occupied by the *Purshia tridentata/Agropyron spicatum* h.t. Average densities of antelope bitterbrush and big sagebrush are 2052/hectare (830/acre) and 3565/hectare (1443/acre), respectively (Table 3). Other shrubs present in minor amounts are Oregon grape, Rocky Mountain juniper, and nootka rose. Prevalent forbs are arrowleaf balsamroot, field chickweed, and silky lupine (Table 1). Common grasses are bluebunch wheatgrass, Idaho fescue, junegrass, downy chess brome, and one-spike oatgrass.

Analyses of the soils of ten sites indicated a sandy loam texture, slightly acid to weakly alkaline conditions, generally low phosphorus content, generally medium to high potassium content, low to medium organic matter content, and very low salt content (Table 4).

Figure 5. Close up view of bitterbrush and sagebrush plants within the antelope bitterbrush/big sagebrush habitat type.

Figure 6. Antelope bitterbrush/big sagebrush habitat type.

The profile for this type was a Hoodle loam of the loamy-skeletal, mixed family of the Argic Cryoborolls:

A1 0-3" Dark brown (7.5YR 3/3) sandy loam; moderate granular structure; very friable; clear boundary.

B21t 3-10" Dark brown (10YR 3/3) gravelly sandy clay loam; moderate sub-angular structure; very friable; clear boundary.

B22t 10-15" Brown (7.5YR 4/4) gravelly clay loam; moderate sub-angular structure; very friable; clear boundary.

C 15"+ Brown (7.5YR 4/4) gravelly sandy loam; massive structure; very friable.

This soil is on a 55 percent slope and was formed in old alluvium. Infiltration rate is moderate; available water holding capacity is low; permeability is medium; and the soil is well drained.

Artemisia tridentata/Festuca idahoensis (ARTR/FEID) h.t.

This well represented type occurs on approximately 84.2 hectares (208 acres) or 17 percent of the study area. Its distribution appeared to be influenced by elevation, exposure, and related soil moisture. Characteristic sites generally appeared less harsh than those where the *Purshia tridentata/Artemisia tridentata* h.t. exists. It is found on footslopes, on southwest, south, and west facing mountain slopes, and on ridges below 7000 feet (Figs. 3 and 7). Soils in these locations are fairly deep and relatively rock free, except at the higher

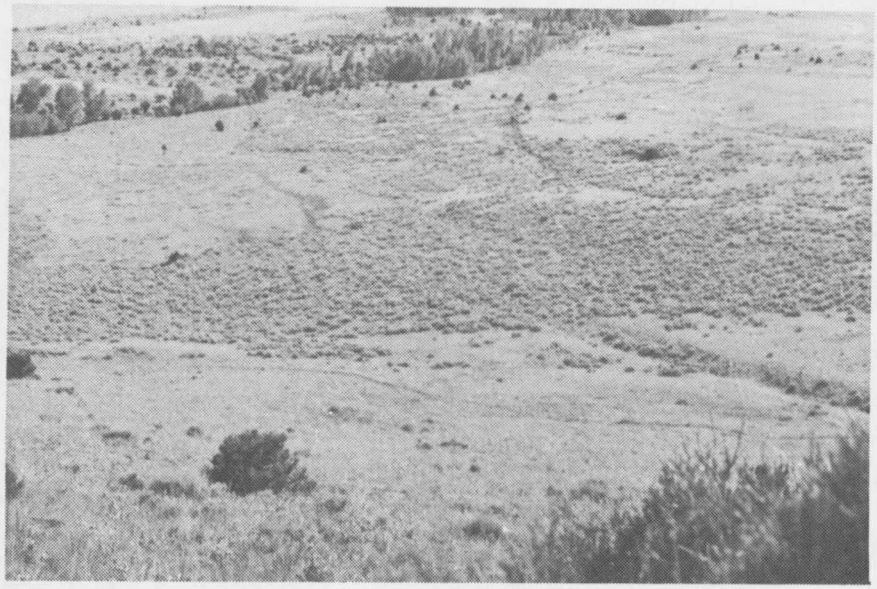

Figure 7. Big sagebrush stand on footslope site.

Figure 8. Dense stand of sagebrush on footslope in foreground and on mountain slope at upper right.

elevations. The dominant plant is big sagebrush, with an average plant density of 6382/hectare or 2583/acre (Table 3 and Fig. 8). Understory varied according to stand location. On the footslopes major associated grasses are bluebunch wheatgrass, Idaho fescue, junegrass, Kentucky bluegrass, and needle-and-thread *(Stipa comata)* (Table 1). Common forbs are yarrow, arrowleaf balsamroot, field chickweed, sticky geranium, silky lupine, and horse mint. Commonly occurring understory species on the mountain slopes are bluebunch wheatgrass, one-spike oatgrass, Idaho fescue, junegrass, yarrow, arrowleaf balsamroot, field chickweed, and silky lupine.

Soil samples obtained from 7 sites, including both footslope and mountain slope areas. Data for 4 footslope sites showed soils to be sandy loam to loam in texture, slightly acid, very low to low in phosphorus content, high in potassium content, medium to high in organic matter content, and very low in salt content (Table 4).

The soil profile at one footslope site was a Shook gravelly loam of the loamy-skeletal, mixed family of the Pachic Cryoborolls:

A1 0-4" Brownish black (7.5YR 2/2) sandy loam; strong granular structure; very friable; clear boundary.

B21 4-9" Brownish black (7.5YR 2/2) sandy loam; weak sub-angular blocky structure; very friable; clear boundary.

B22 9-15" Brownish black (10YR 3/2) sandy clay loam; weak prismatic (breaking into sub-angular blocks) structure; very friable;

gradual boundary.

B23 15-25" Brownish black (10YR 3/2) sandy loam; weak sub-angular blocky structure; friable; gradual boundary.

C 25"+ Brownish black (10YR 3/2) gravelly sandy loam; massive structure; friable.

This soil occurs on a 13 percent slope and was formed in colluvium. Infiltration rate is moderate; available water holding capacity is low; permeability is medium; and the soil is well drained.

Top soils from the 3 mountain slope sites were sandy loam in texture, slightly acid to neutral, very low to low in phosphorus content, high in potassium content, low to medium in amounts of organic matter, and very low in salt content (Table 4).

The soil profile at a mountain slope site was a Hoodle loam of the loamy-skeletal, mixed family of the Argic Cryoborolls:

A1 0-3" Black (10YR 2/1) sandy loam; moderate granular structure; very friable; clear boundary.

B21 3-8" Black (10YR 2/1) loam; moderate sub-angular blocky structure; very friable; gradual boundary.

B22t 8-13" Brownish black (10YR 3/2) gravelly clay loam; moderate sub-angular blocky structure; very friable; gradual boundary.

B23t 13-22" Brown (10YR 4/3) gravelly clay loam; moderate sub-angular blocky structure; friable; gradual boundary.

C 22"+ Brown (7.5YR 4/4) gravelly sandy loam; massive structure;

very friable.

This soil occurs on a 45 percent slope and was formed in colluvium material. Infiltration rate is moderate; available water holding capacity is low; permeability is medium; and the soil is well drained.

Juniperus scopulorum-Purshia tridentata/Agropyron spicatum (JUSC-PUTR/AGSP) h.t.

This relatively minor type occurs as a single stand of 1.2 hectares (3 acres) along the sides of a northeast-southwest orientated draw at approximately 5600 feet elevation (Fig. 3). Antelope bitterbrush and Rocky Mountain juniper are dominant shrubs with densities of 3817/hectare (1545/acre) and 509/hectare (206/acre), respectively (Table 3). Mountain maple *(Acer glabrum)* and chokecherry occur as scattered clumps in and near the draw bottom. Prominant grasses are bluebunch wheatgrass and downy chess brome (Table 2). Some of the more prevalent forbs are pale alyssum, arrowleaf balsamroot, and golden aster.

Juniperus scopulorum-Purshia tridentata/Festuca idahoensis (JUSC-PUTR/FEID) h.t.

This is a minor type (3.6 hectares or 9 acres) associated with northwest facing exposures along two small draws at low elevation (Fig. 3). Dominant shrubs are Rocky Mountain juniper, antelope bitterbrush, and big sagebrush with plant densities of 1191/hectare (482/acre), 1191/hectare (482/acre), and 926/hectare (374/acre),

respectively (Table 3 and Fig. 9). Limber pine *(Pinus flexilis)* and Douglas-fir *(Pseudotsuga menziesii)* occur as mature and young trees (Fig. 9), indicating that this type may be seral to the limber pine-Douglas-fir climax series which occurs at higher elevations on adjoining mule deer summer range (Mueggler 1974, personal communication). Bluebunch wheatgrass, and Idaho fescue are the important grasses (Table 2). Common forbs are yarrow, ballhead sandwort *(Arenaria congesta)*, arrowleaf balsamroot, and field chickweed.

A composite soil sample for this and the previous h.t. indicated a sandy loam texture, neutral acidity, medium phosphorus content, high potassium content, high organic matter amounts, and very low salt content (Table 4).

Juniperus scopulorum-Purshia tridentata/Artemisia tridentata (JUSC-PUTR/ARTR) h.t.

This type is limited to 6.1 hectares (15 acres) of footslope area between the *Agropyron spicatum/Agropyron smithii* and *Pseudotsuga menziesii/Prunus virginiana* habitat types (Fig. 3). The soils are fairly deep, but contain many large rocks. In addition to physiographic differences, this type is also unlike the other Rocky Mountain juniper habitat types in that large quantities of big sagebrush and no pine or fir occur. The dominant shrubs are Rocky Mountain juniper, antelope bitterbrush, and big sagebrush with densities of 472/hectare (191/acre), 1650/hectare (668/acre), and 2358/hectare

Figure 9. Rocky Mountain juniper-antelope bitterbrush/Idaho fescue stand showing Douglas-fir and limber pine invasion.

(954/acre), respectively (Table 3). The big sagebrush and antelope bitterbrush plants are relatively large and although browsed heavily, they seem to be fairly robust. Big sagebrush rated slightly higher in importance than the other two dominant shrubs. The dominant grass is an unidentified *Poa* (probably Kentucky bluegrass). Other common grasses are bluebunch wheatgrass, one-spike oatgrass, Idaho fescue, and junegrass (Table 2). Commonly occurring forbs are yarrow, arrow-leaf balsamroot, silky lupine, and horse mint. The soils in this type are sandy loam in texture, slightly acid, very low in phosphorus content, high in potassium content, medium in organic matter content, and very low in salt content (Table 4).

Acer glabrum/Philadelphus lewisii (ACGL/PHLE) h.t.

This type occurs as small stands on the lower ends of minor east-west drainages. This type reflects both occurrence as an ecotone between the forest communities of the northerly aspect and shrub communities of the opposite south-facing slopes and its position in the bottoms of draws where rather mesic consitions prevail. Important shrubs are mountain maple, mock orange *(Philadelphus lewisii)*, and common snowberry (Table 1). Approximately 50 grass and forb species were encountered. Many of these occurred in only trace amounts, but a few were well represented. The more important herbaceous plants include bluebunch wheatgrass, Idaho fescue, nettle-leaf giant hyssop *(Agastache urticifolia)*, arnica *(Arnica cordifolia)*, arrowleaf balsamroot, Virginia strawberry *(Fragaria virginiana)*, cow parsnip *(Heracleum lanatum)*, and Rocky Mountain woodsia *(Woodsia scopulina)* (Table 1).

Populus tremuloides-Prunus virginiana/Symphoricarpos albus (POTR-PRVI/SYAL) h.t.

This type occurs as a single, small stand (1.2 hectares or 3 acres) on a hydric site surrounding the origin of a small spring fed creek in the lower center of the area (Fig. 3). Quaking aspen *(Populus tremuloides)* provides a tall overstory. Chokecherry, black hawthorn *(Crataegus douglasii)*, serviceberry *(Amelanchier alnifolia)*, and willow *(Salix* spp.*)* comprise a tall shrub layer, while nootka

rose and common snowberry occur as low shrubs (Table 3). Common grasses and forbs (Table 1) include giant wild-rye *(Elymus cinereus)*, Kentucky bluegrass, yarrow, wavyleaf thistle *(Cirsium undulatum)*, bedstraw *(Galium aparine)*, cow parsnip, horse mint, alpine forget-me-not *(Myosotis sylvatica)*, and common dandelion *(Taraxacum officinale)*.

Soil associated with this type are sandy loam in texture, of neutral acidity, very low in phosphorus content, high in potassium content, high in organic matter content, and very low in salt content (Table 4).

Psuedotsuga menziesii/Prunus virginiana (PSME/PRVI) h.t.

This type is unusual and possibly unique to the study area. It occurs as a small isolated stand encompassing approximately 5.3 hectares (13 acres) of footslope away from the mountain base. The site is an island-like area of large rocks and boulders setting slightly above the surrounding terrain (Fig. 3). Douglas-fir dominates an overstory which includes quaking aspen as scattered individuals and in groves near the lower end of the stand (Table 5). Rocky Mountain juniper and chokecherry are abundant throughout, while mock orange, common snowberry, and white spiraea *(Spiraea betulifolia)* occur commonly (Table 2). The area is reasonably depauperate of herbaceous species. Present in small quantities are bluebunch wheatgrass, downy

TABLE 5. DENSITIES, AVERAGE DIAMETERS AT BREAST HEIGHT (DBH), AND OVERHEAD CANOPY COVERAGE OF DOUGLAS-FIR TREES IN FOUR HABITAT TYPES.

Habitat Type	Young	Mature	Dead	Average DBH	Percent Overhead Coverage
PSME/SYAL		258/68	124/33	25	57
PSME/CAGE (upper)	51/13[1]	91/23	264/65	31	59
PSME/CAGE (lower)	112/15	346/46	290/39	19	61
PSME/FEID		434/100		25	59
PSME/PRVI	6/4	163/96		37	64

[1]Absolute density/relative density.

chess brome, Kentucky bluegrass, yarrow and bedstraw.

The soil in this stand is sandy loam, slightly acid, high in phosphorus and potassium content, medium in organic matter content, and very low in salt content (Table 4).

Pseudotsuga menziesii/Symphoricarpos albus (PSME/SYAL) h.t.

This type is found at lower elevations (5700 to 6700 feet) where the montane forest extends downward into the grass and shrub types on fairly dry, steep north and northwest facing slopes (Figs. 3 and 4). It is minor in extent, occurring on about 33.2 hectares or 82 acres (7 percent of the winter range). Douglas-fir provides overstory cover with the low growing vegetation dominated by common snowberry, elk sedge *(Carex geyeri)*, and inland giant wild-rye (Table 2). Commonly occurring forbs are raceme pussytoes *(Antennaria racemosa)*,

asters *(Aster modestus* and *Aster perelegans)*, and Virginia strawberry. Many of the Douglas-fir trees within this habitat type (as in much of the Bridger Mountain Range in general) are dead or dying. Approximately 33 percent of the trees in the sampled stand were dead (Table 5) as a result of past budworm infestations and recent occurrence of red belt or winter dessication (U.S. Forest Service 1972). Existing fir trees were predominantly mature, with seedlings and/or young trees absent in most locations (Table 5).

Soil analyses indicated sandy loam texture, slightly acid condition, medium phosphorus content, high potassium content, high organic matter content, and very low salt content (Table 4).

The profile for one site was a Ess gravelly loam of the loamy-skeletal, mixed family of the Argic Cryoborolls:

O1 2-0" Brownish black (10YR 3/1); abrupt boundary.

A1 0-3" Brownish black (10YR 3/2) gravelly loam; weak granular structure; friable; clear boundary.

B21t 3-12" Brownish black (10YR 3/2) gravelly sandy clay loam; weak sub-angular blocky structure; very friable; gradual boundary.

B22t 12-24" Dull yellowish brown (10YR 4/3) gravelly sandy clay loam; weak sub-angular blocky structure; very friable; clear boundary.

C 24"+ Brown (10YR 4/4) gravelly sandy loam; massive structure; very friable.

This soil occurs on a 55 percent slope and was formed in colluvium material. Infiltration rate is moderate; available water holding capacity is low; permeability is medium; and the soil is well drained.

Pseudotsuga menziesii/Festuca idahoensis (PSME/FEID) h.t.

This minor type is limited to northwest-facing slopes at lower elevations. The Douglas-fir overstory is rather open permitting good light penetration and development of undergrowth typical of adjacent bunchgrass stands. Idaho fescue, bluebunch wheatgrass, junegrass, and Kentucky bluegrass are the dominant grasses (Table 2). Common forbs are yarrow, arnica, arrowleaf balsamroot, field chickweed, Virginia strawberry, one flower helianthella *(Helianthella uniflora)*, and common dandelion. Shrubs, including Rocky Mountain juniper, serviceberry, and common snowberry are common, while sagebrush may occur as scattered plants in the more open areas.

Soils of this type are sandy loam in texture, slightly acid, very low in phosphorus content, high in potassium content, medium in organic matter content, and very low in salt content (Table 4).

Pseudotsuga menziesii/Carex geyeri (PSME/CAGE) h.t.

This is the most extensive type on the winter range, occurring on approximately 202.3 hectares or 500 acres of north, northwest, and west facing slopes from the mountain base to the upper limits of the

study area (Fig. 3). Although these fir stands typically are rather dense, about one-half of the mature trees are dead and many more are dying (Table 5). Young trees are relatively scarce, although reproduction is apparent on scattered sites. Understory composition is quite variable, depending upon aspect and elevation. Elk sedge is very common throughout the type, constituting more than 40 percent of the ground cover (Table 2). On north facing slopes, at lower elevations, raceme pussytoes, yellow columbine *(Aquilegia flavescens)*, Virginia strawberry, sulphur lupine *(Lupinus sulphureus)*, and feather Solomon's seal *(Smilacina racemosa)*, are common forbs. Common shrubs are mountain maple, rock clematis *(Clematis columbiana)*, common snowberry, and thinleaved huckleberry *(Vaccimium membranaceum)*. Understory forb and shrub vegetation on upper slopes of westerly aspect are somewhat similar to the lower areas except for a few species. Aster, arrowleaf balsamroot, roundleaf harebell *(Campanula rotundifolia)*, and white spiraea commonly occur only at higher elevations, while thinleaved huckleberry, rock clematis, feather Solomon's seal, sulphur lupine, raceme pussytoes, and yellow columbine were found only in stands at lower elevations. Soil of stands at both low and high elevations are loam in texture, slightly acid, low in phosphorus content, high in potassium content, medium in organic matter content, and very low in salt content (Table 4). Strips and patches of rock rubble commonly occur interspersed throughout this type at the higher elevations.

Climatological Characteristics and Conditions

Temperatures were generally slightly warmer on the study area during the winter months (December through March) of 1972-73 than the 22 year averages for the Belgrade weather station located in the valley 10 miles to the southwest (Table 6). April temperature was about 5 degrees cooler on the study area. During the remainder of the year temperatures for the two locations were very similar.

Average monthly temperatures during 1973 differed very little between weather stations located at different sites on the study area (Table 6). The station located on the mountain slope in the *Purshia tridentata/Artemisia tridentata* h.t. was considered to exemplify the mule deer winter range weather conditions. At this station in 1973, January was the coldest month with a mean temperature of 18.8 degrees F, while August was the warmest month with a mean of 68.8 degrees F.

Bi-monthly minimum and maximum temperatures recorded for sites in the *Pseudotsuga menziesii/Symphoricarpos albus* and *Purshia tridentata/Artemisia tridentata* h.t. are plotted in Figure 10. The two sites are very close together, occurring on opposite sides of an east-west orientated ridge. The *Pseudotsuga menziesii/Symphoricarpos albus* h.t. site was a north facing slope at 6,400 feet, while the *Purshia tridentata/Artemisia tridentata* h.t. site was a southerly exposure at 6,350 feet. Minimum temperatures during the winter and spring periods generally were slightly lower on the *Pseudotsuga*

TABLE 6. MEAN MONTHLY TEMPERATURES FOR THREE WEATHER STATIONS AND MONTHLY PRECIPITATION ON THE ARMSTRONG WINTER RANGE DURING 1973 COMPARED WITH THE 22 YEAR AVERAGES (1952-73) AT BELGRADE, MONTANA.

	Temperature[1]				Precipitation[2]	
	Armstrong Winter Range					
Year Month	Armstrong Ranch	PUTR/ARTR h.t.	PSME/SYAL h.t.	Belgrade	Armstrong Ranch	Belgrade
1973						
Jan.	22.0	18.8		17.1	1.11	0.65
Feb.	27.2	27.0		23.5	0.54	0.38
March	33.3	31.2		28.8	0.59	0.84
April	36.7	33.8		40.1	2.96	1.18
May	49.3	49.4	48.3	50.7	1.21	2.15
June	56.4	57.6	56.0	58.7	2.83	2.57
July	66.3	68.2	65.5	66.7	1.30	0.99
Aug.	67.7	68.8	64.9	65.6	2.02	1.17
Sept.	55.0	54.1	55.3	54.4	4.10	1.20
Oct.	45.6	46.4	45.3	44.2	1.27	1.07
Nov.	30.0	29.9	32.6	30.7	1.75	0.70
Dec.	29.2	29.8		21.5	0.80	0.53
Mean	43.1	43.7		41.8	20.48	13.43
1974						
Jan.	19.3	20.3			1.03	
Feb.	30.4	30.4			0.88	
March	32.8	31.2			1.41	
April	42.0	43.2			2.29	

[1]Degrees Fahrenheit.

[2]Inches.

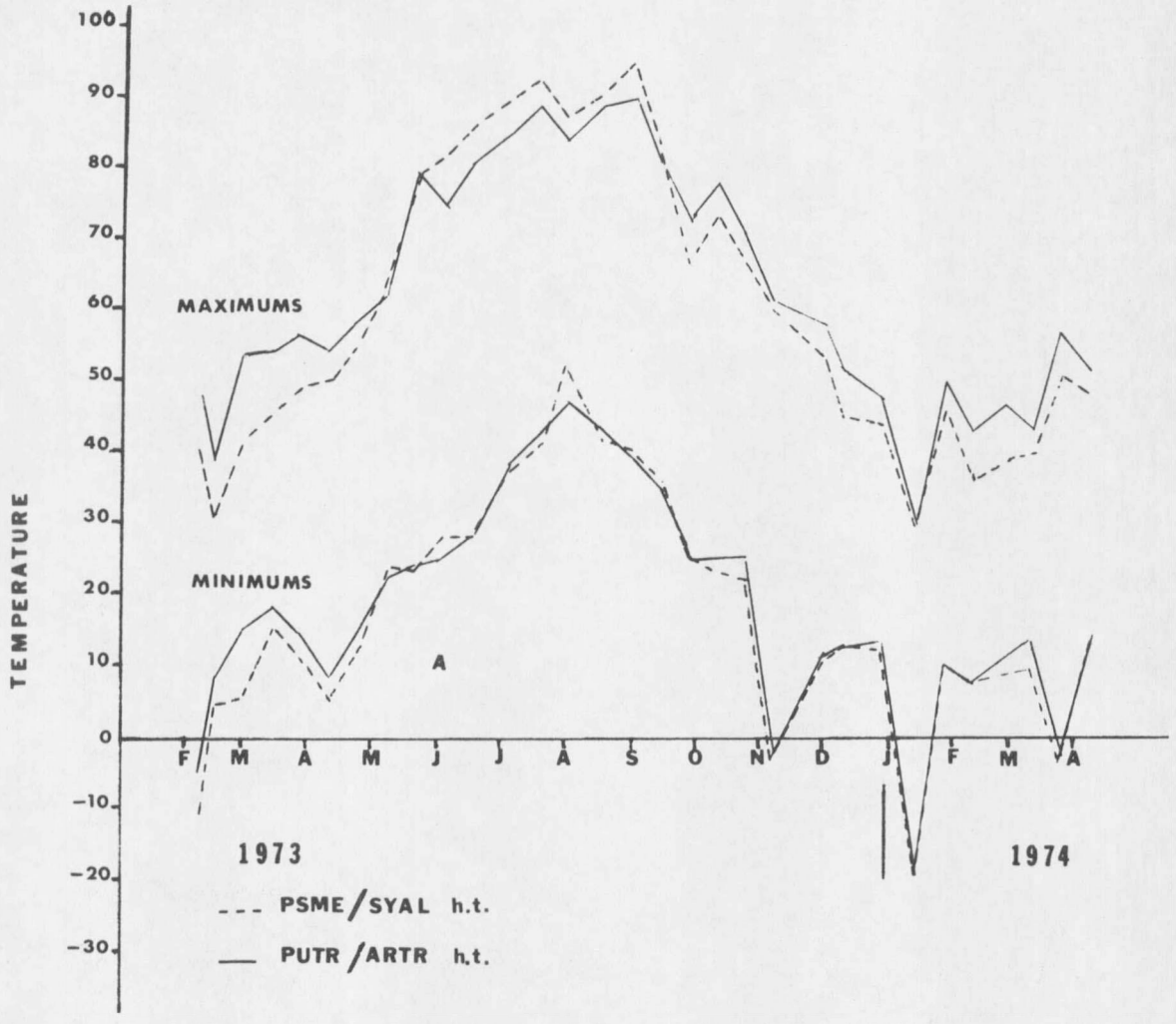

Figure 10. Bi-monthly minimum and maximum temperatures at sites in the PSME/SYAL h.t. (6400 feet) and the PUTR/ARTR h.t. (6350 feet) on the Armstrong Winter Range.

menziesii/Symphoricarpos albus h.t. site than on the *Purshia tridentata/Artemisia tridentata* h.t. site. During the remainder of the year the minimums were generally very similar. The greatest site difference in temperature occurred in maximum readings between the two sites. The *Pseudotsuga menziesii/Symphoricarpos albus* location had 2-6 degree lower temperatures than the *Purshia tridentata/Artemisia tridentata* site during fall, winter, and spring but from mid-May through mid-September was 2-4 degrees warmer.

The total precipitation at the Armstrong Ranch during 1973 was 20.48 inches. August was the wettest month with 4.1 inches and February was the driest with 0.54 inches (Table 6). The relatively large amount of rainfall for August probably was atypical. May and June typically are the wettest months at Belgrade, with 22 year precipitation means of 2.15 and 2.57 inches, respectively. February is normally the driest month at Belgrade with mean precipitation of 0.38 inches.

In 1973 36, 56, and 8 percent of the days were generally clear, intermittently cloudy or brightly overcast, and heavily overcast, respectively (Table 7). September through December had the largest number of heavily overcast days, averaging 6 days per month. July and August had 21 and 20 relatively clear days, respectively and no heavily overcast days. November and December had the fewest number of clear days with 2 and 5 clear days, respectively.

TABLE 7. NUMBER OF DAYS PER MONTH WHICH WERE GENERALLY CLEAR (C), MODERATELY CLOUDY = INTERMITTENLY CLOUDY TO BRIGHT OVERCAST (M), AND HEAVILY OVERCAST (O) DURING THE PERIOD FROM NOVEMBER 1, 1972 THROUGH APRIL 27, 1974.

	1972			1973			1974		
	C	M	O	C	M	O	C	M	O
Jan.				8	21	2	2	16	13
Feb.				15	13		3	22	3
March				13	18		7	24	
April				5	24	1	6	21	
May				11	20				
June				10	19	1			
July				21	10				
Aug.				20	11				
Sept.				12	13	5			
Oct.				11	15	5			
Nov.	4	10	2	2	21	7			
Dec.	5	20	6	5	18	8			
Total				133	203	29			

Snow cover and accumulation was quite variable depending upon vegetational cover, elevation, and aspect (Fig. 11). Generally, south and southwest facing mountain slopes with shrubby vegetation retained snow for only a day or two, even after major storms. Wind action and a favorable winter sun angle contributed to the rapid snow melt, and snow persisted on these slopes only if air temperatures were extremely cold. Westerly exposed, open slopes did not clear as quickly or as completely as the south and southwest facing slopes. Snow depth and persistence on all open slopes increased with elevation.

Stands of large big sagebrush plants on both high ridges and on footslopes usually trapped snow. Because the slope angle of these

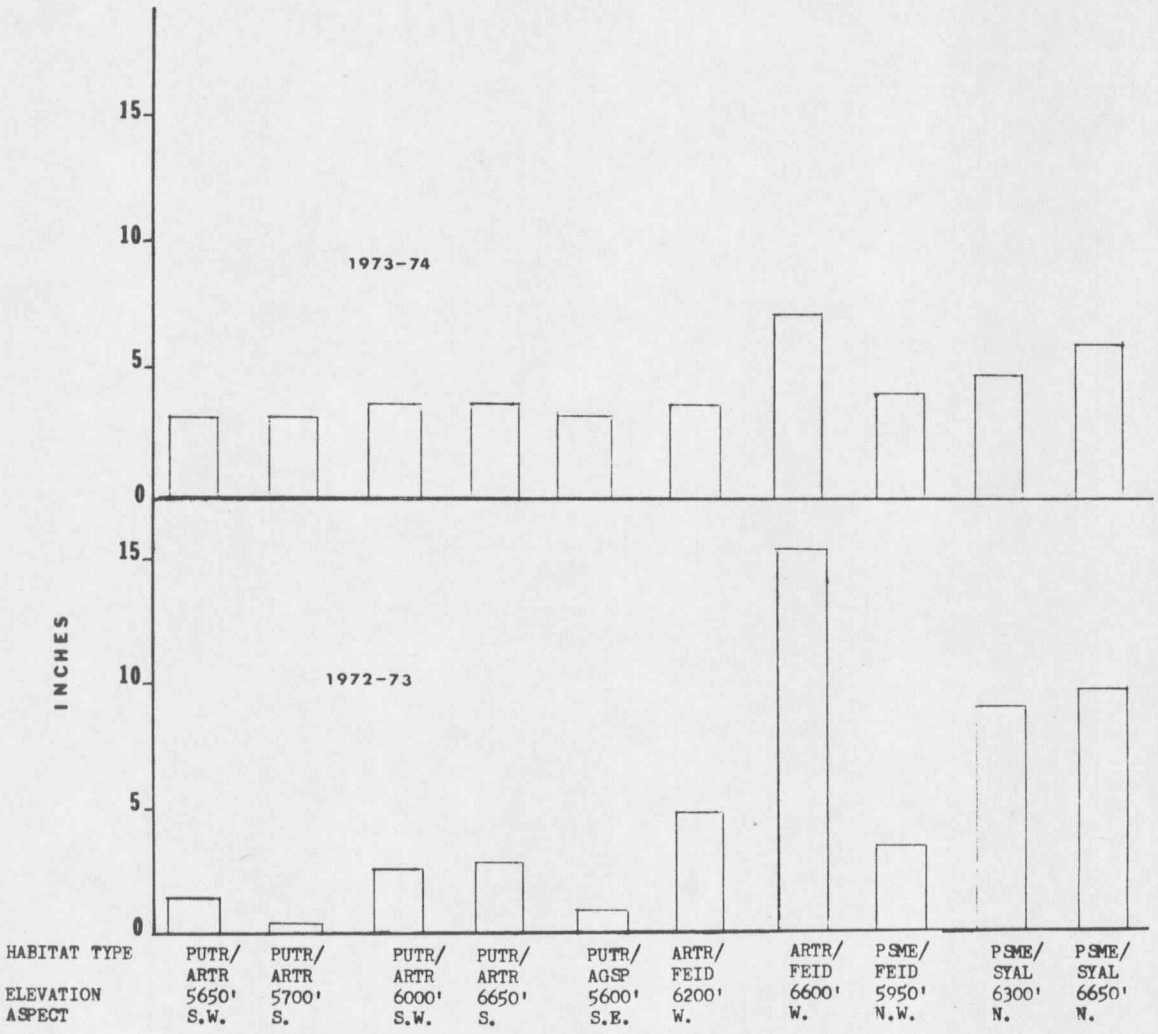

Figure 11. Average snow depth on the ground at two week intervals during the winters of 1972-73 and 1973-74 by habitat type, elevation, and aspect on the Armstrong Winter Range.

sites was slight, melting of snow was greatly retarded and as a result it commonly accumulated to depths of 12-24 inches.

In the Douglas-fir types the topographical and vegetational shading and protection from the wind prevented rapid melting, and snow usually accumulated. Depths of 12-16 inches were common in fir types at lower elevations, while above 7,000 feet snow depths reached 24 inches or more rendering them impassible to deer from January through mid-April. Dense fir stands usually had shallower snow depths than nearby more open stands.

The prevailing winds on the area were from the west and southwest. The weather bureau type anemometer located on a southwest facing mountain slope in the *Purshia tridentata/Artemisia tridentata* h.t. recorded an average of 1,624 miles of wind per month from April, 1973 through April, 1974. March and April had the greatest amounts of wind, while September and November had the least (Fig. 12). Generally, the greatest amount of wind occurred during the winter and spring periods when it played an important role in clearing snow from slopes important to mule deer at the time.

Browse Production

Current annual growth production of big sagebrush and antelope bitterbrush and total foliage yield of Rocky Mountain juniper were measured for habitat types which comprised the shrubland portion of the study area. These species were selected because of their relative

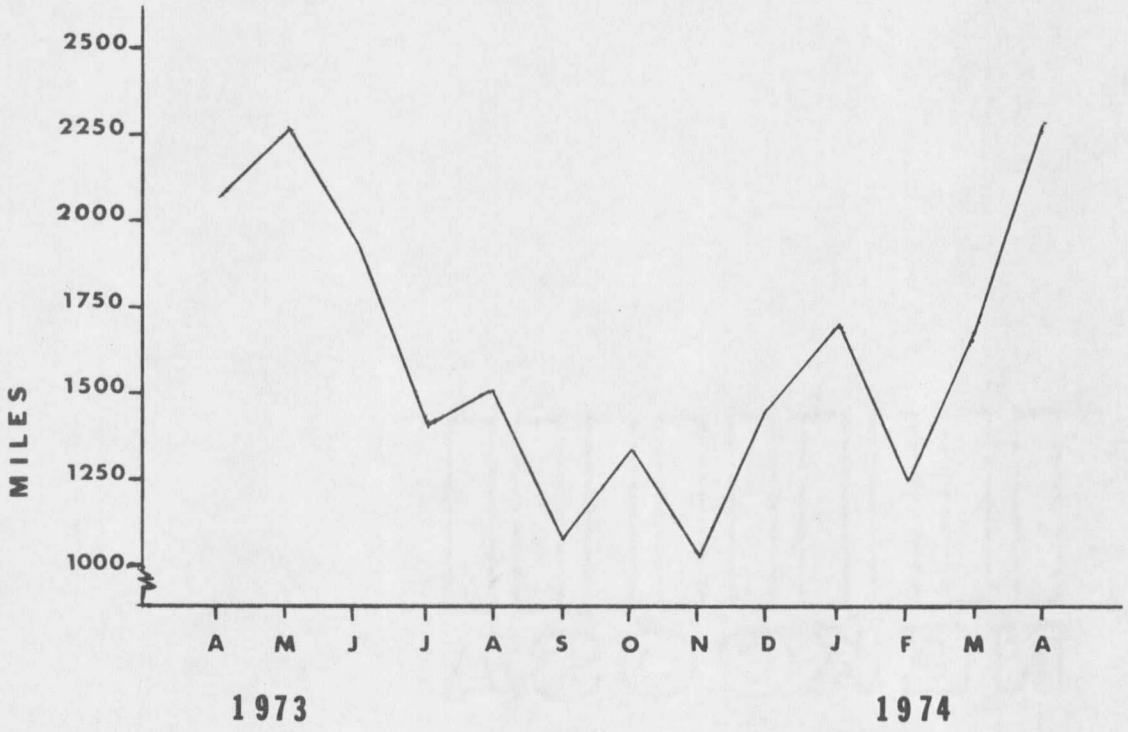

Figure 12. Total miles of wind per month recorded on anemometer located on the mountain slope in PUTR/ARTR h.t. on the Armstrong Winter Range during the period April 1, 1973 through April 27, 1974.

abundance and importance to wintering mule deer as indicated by general observations and previous food habit studies on the area (Wilkins 1957). Other browse species which occur, including chokecherry, serviceberry, mountain maple, nootka rose, common snowberry, Oregon grape, and white spiraea, were encountered mostly in small, local stands and scattered clumps or as inconspicuous, dispersed individuals. Douglas-fir is also browsed and may be important locally to some deer, or during some years as indicated by the hedged condition of smaller trees, general observations and its occurrence as 67 percent of a mule deer rumen sample analyzed by Schwarzkoph (1973). Although information concerning forage availability and yield of these species would be useful, time and/or the lack of suitable sampling procedures did not permit their measurement during this study.

Simple linear regressions for relationships between plant crown area and current annual growth twig (CAGT) production by antelope bitterbrush and big sagebrush during 1972 and 1973 are shown in Table 8. This table also shows the linear relationships between crown area and plant age as well as between basal diameter and length and weight of CAGT for these species. The relationships between crown area and total foliage yield (weight of all twigs and leaves) and between basal stem (or trunk) diameter and forage yield for Rocky Mountain juniper for 1973 are also given in Table 8. Although correlation coefficients were generally high, the linear relationships between crown area and

TABLE 8. REGRESSION EQUATIONS FOR CROWN AREA - TWIG AND PLANT AGE; TWIG DIAMETER - WEIGHT AND LENGTH RELATIONSHIPS FOR BIG SAGEBRUSH AND ANTELOPE BITTERBRUSH - TOTAL FOLIAGE YIELD - CROWN AREA AND BASAL STEM DIAMETER RELATIONSHIPS FOR ROCKY MOUNTAIN JUNIPER.

Species[3] / Parameter[4]	1972[1] Mean	Correlation Coefficient	Slope	Y Intercept	1973[2] Mean	Correlation Coefficient	Slope	Y Intercept
Big Sagebrush								
Crown Area	6060				5757			
No. of Twigs	616	.69	.058	259.65	421	.81	.089	- 94.16
Length Twigs	2713	.69	.26	1142.57	2107	.81	.45	-470.79
Weight Twigs	66.6	.69	.0074	21.62	12.0	.79	.002	-5.056
Plant Age	22.3	.60	.0008	17.31				
Twig Diameter	1.25				1.23			
Twig Length	4.4	.79	7.567	-5.047	5.0	.74	6.294	-2.722
Twig Weight	.05	.84	.145	-.134	.05	.85	.118	- .093
Antelope Bitterbrush								
Crown Area	7531				6605			
No. of Twigs	523	.82	.052	129.68	536	.59	.066	94.26
Length Twigs	4552	.81	.45	1128.56	5899	.59	.74	1036.84
Weight Twigs	48.1	.74	.0044	14.86	45	.66	.006	-.375
Plant Age	26.8	.48	.0006	21.97				
Twig Diameter	1.52				1.47			
Twig Length	8.7	.74	9.251	-5.397	11.0	.80	10.614	-4.590
Twig Weight	.12	.84	.235	- .235	.17	.78	.279	- .244
Rocky Mountain Juniper								
Crown Area					58521			
Weight Twigs					4155	.74	.061	606.95
Stem Basal Diameter(cm)					18	.49	315.39	-1505.86

TABLE 8. (Continued)

[1]Twenty each big sagebrush and bitterbrush plants.

[2]Ten each big sagebrush and bitterbrush plants and 20 juniper plants.

[3]The 1972 big sagebrush and 1973 juniper foliage includes leaf material, 1973 big sagebrush and 1972-73 bitterbrush foliage = twigs only.

[4]Crown area in square centimeters, twig length in centimeters, weight in grams, and twig diameter at base of current growth in millimeters.

CAGT production differed between years for both bitterbrush and sagebrush. These differences probably reflect differences in both sample size and twig production and growth between 1972 and 1973. The mean crown area of bitterbrush plants in the 1973 collection was smaller than that of the 1972 collection, but the numbers and total lengths of CAGT per plant were greater, while the mean weight of twigs per plant was only slightly less. Numbers and lengths of sagebrush twigs were also disproportionate with crown area size between the two year's collections (Table 8). The occurrence of these discrepancies suggest that it may be necessary to collect plants and develop new regressions each year to accurately estimate production for a given season.

Estimates of CAGT yield for antelope bitterbrush and CAGT and leaf yield for big sagebrush (Table 9) are based on regression equations for 1972 when plant densities and crown areas were measured in vegetaional sampling. Total foliage yield for Rocky Mountain juniper (Table 9) was estimated by applying the regression equation developed by clippings during the fall of 1973 to crown areas measured in sampling during 1972.

Total browse produced and potentially available to mule deer for the three species was 375 kilograms/hectare (335 pounds/acre) or 71,069 kilograms (156,679 pounds) for the 189.4 hectares (468 acres) of shrubland habitat types on the Armstrong Winter Range. It is unlikely that all of this material was actually "available" forage. The

TABLE 9. MEAN CROWN AREA, DENSITY, AND CURRENT ANNUAL GROWTH TWIG PRODUCTION FOR BIG SAGEBRUSH AND ANTELOPE BITTERBRUSH DURING 1972 AND FOLIAGE YIELD FOR ROCKY MOUNTAIN JUNIPER DURING 1973 ON 6 SHRUBLAND HABITAT TYPES.

Species[1] Habitat Type	Mean Crown Area (m^2)	Plants/ Hectare	Number Twigs/ Hectare	Length(cm) Twigs/ Hectare	Weight(gm) Twigs/ Hectare	Size[2] Habitat Type	Yield[3] for Habitat Type
Big Sagebrush							
PUTR/ARTR	.2266	3565	1,393,915	6,167,450	135,470	57.9/31	7,844/25
JUSC-PUTR/ARTR	.4127	2358	1,160,136	5,215,896	122,616	6.1/3	748/2
PUTR/AGSP	.2275	65	25,480	112,580	2,470	36.4/19	90/tr[4]
ARTR/FEID	.2731	6382	2,667,676	11,806,700	268,044	84.2/44	22,569/72
JUSC-PUTR/AGSP	.1139	198	64,548	284,724	5,940	1.2/1	7/tr
JUSC-PUTR/FEID	.1616	926	326,878	1,445,486	31,484	3.6/2	113/tr
Overall Mean	.2397	3238			Total	189.4	31,371
Antelope Bitterbrush							
PUTR/ARTR	.2119	2052	492,480	4,272,264	49,248	57.9/31	2,852/56
JUSC-PUTR/ARTR	.6313	1650	755,700	6,548,850	70,950	6.1/3	432/8
PUTR/AGSP	.2685	1622	436,318	3,790,614	43,794	36.4/19	1,594/31
ARTR/FEID	.1715	33	7,194	62,700	726	84.2/44	63/1
JUSC-PUTR/AGSP	.1209	3667	707,731	6,134,891	73,340	1.2/1	88/2
JUSC-PUTR/FEID	.1322	1191	235,818	2,053,284	25,011	3.6/2	90/2
Overall Mean	.2237	1423			Total	189.4	5,119
Rocky Mountain Juniper							
PUTR/ARTR	2.9006	52			122,980	57.9/31	7,121/21
JUSC-PUTR/ARTR	4.7369	472			1,641,616	6.1/3	10,014/29
PUTR/AGSP	4.2631	20			63,800	36.4/19	2,322/7
ARTR/FEID	.896	47			54,050	84.2/44	4,551/13
JUSC-PUTR/AGSP	3.6002	509			1,419,601	1.2/1	1,704/5
JUSC-PUTR/FEID	2.4105	1191			2,462,988	3.6/2	8,867/26
Overall Mean	2.7754	120			Total	189.4	34,579
					Grand Total		71,069

TABLE 9. (Continued)

[1]Big sagebrush and Rocky Mountain juniper foliage weights include leaf material, antelope bitterbrush weights are twig material alone.

[2]Hectares/percent of total.

[3]Available (below 6 feet) weight in kilograms/percent of total.

[4]tr = trace, less than 0.5 percent.

majority of the antelope bitterbrush and many big sagebrush plants on the area had become "clubbed" in response to past heavy browsing. Doubtlessly this growth form presented a formidable barrier to browsing on twigs within the plant crowns.

Big sagebrush and Rocky Mountain juniper were the most important browse plants, contributing 44 and 49 percent of the total yield for the shrubland area, respectively (Table 10). The relative importance of big sagebrush reflects its high densities in the *Purshia tridentata/Artemisia tridentata*, *Juniperus scopulorum-Purshia tridentata/Artemisia tridentata*, and *Artemisia tridentata/Festuca idahoensis* h.t. together comprised 75 percent of the shrubland type on the area (Fig. 14) and produced 97 percent of the total big sagebrush yield (Table 10, Fig. 15).

Although Rocky Mountain juniper was not abundant in most habitat types (Table 9, Fig. 13) and juniper dominated types were of small extent (Fig. 14), the large size and thick foliage of the plants enabled it to contribute heavily to the total foliage yield. Also, more than one years growth was represented in the green foliage yield. Mason and Hutchings (1967) considered 30 percent of the foliage to be current growth for Utah juniper *(Juniperus osteosoermus)*.

The majority of the yield by weight for antelope bitterbrush (87 percent) occurred in the *Purshia tridentata/Artemisia tridentata* and *Purshia tridentata/Agropyron spicatum* h.t. (Fig. 15). While these

TABLE 10. DISTRIBUTION OF TOTAL FORAGE PRODUCTION BY WEIGHT (KILOGRAMS) FOR BIG SAGEBRUSH, ANTELOPE BITTERBRUSH, AND ROCKY MOUNTAIN JUNIPER AMONG 6 SHRUBLAND HABITAT TYPES.

Species	Habitat Types													
	PUTR/ARTR		PUTR/AGSP		ARTR/FEID		JUSC-PUTR/ ARTR		JUSC-PUTR/ AGSP		JUSC-PUTR/ FEID		Total	
Big Sagebrush	7,844[1]	44/25[2]	90	2/tr[3]	22,569	83/72	148	7/2	7	tr/tr	113	1/tr	31,371	44[4]
Antelope Bitterbrush	2,852	16/56	1,594	40/31	63	tr/1	432	4/8	88	5/2	90	1/2	5,119	7
Rocky Mountain Juniper	7,121	40/21	2,322	58/7	4,441	17/13	10,014	89/29	1,704	95/5	8,867	98/26	34,579	49
Total	17,817	25[5]	4,016	6	27,183	38	11,194	16	1,799	3	9,070	13	71,069	100

[1]Weight in kilograms.

[2]Percent of total yield for the habitat type/percent of total yield for the species.

[3]tr = trace, less than .5 percent.

[4]Percent of total yield for a species among all habitat types.

[5]Habitat type percentage of total yield for all species.

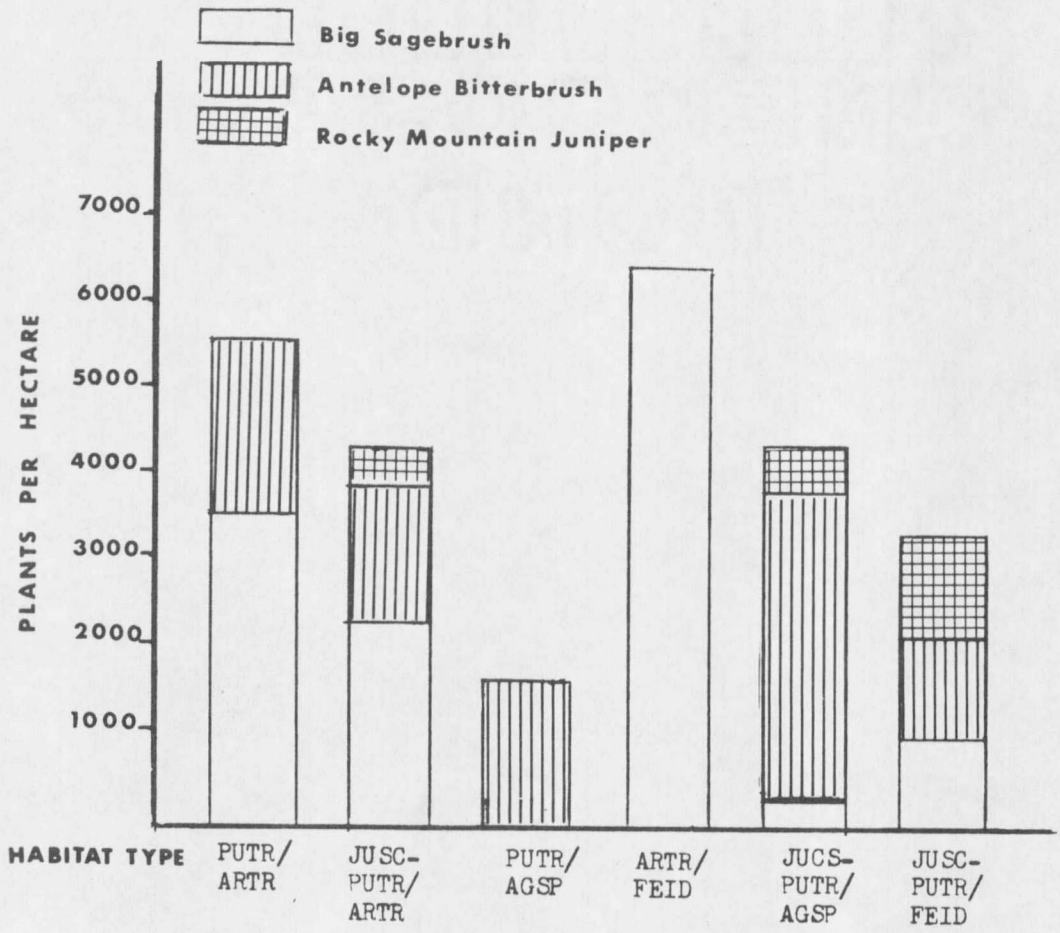

Figure 13. Plant densities of big sagebrush, antelope bitterbrush, and Rocky Mountain juniper in each of six shrubland habitat types.

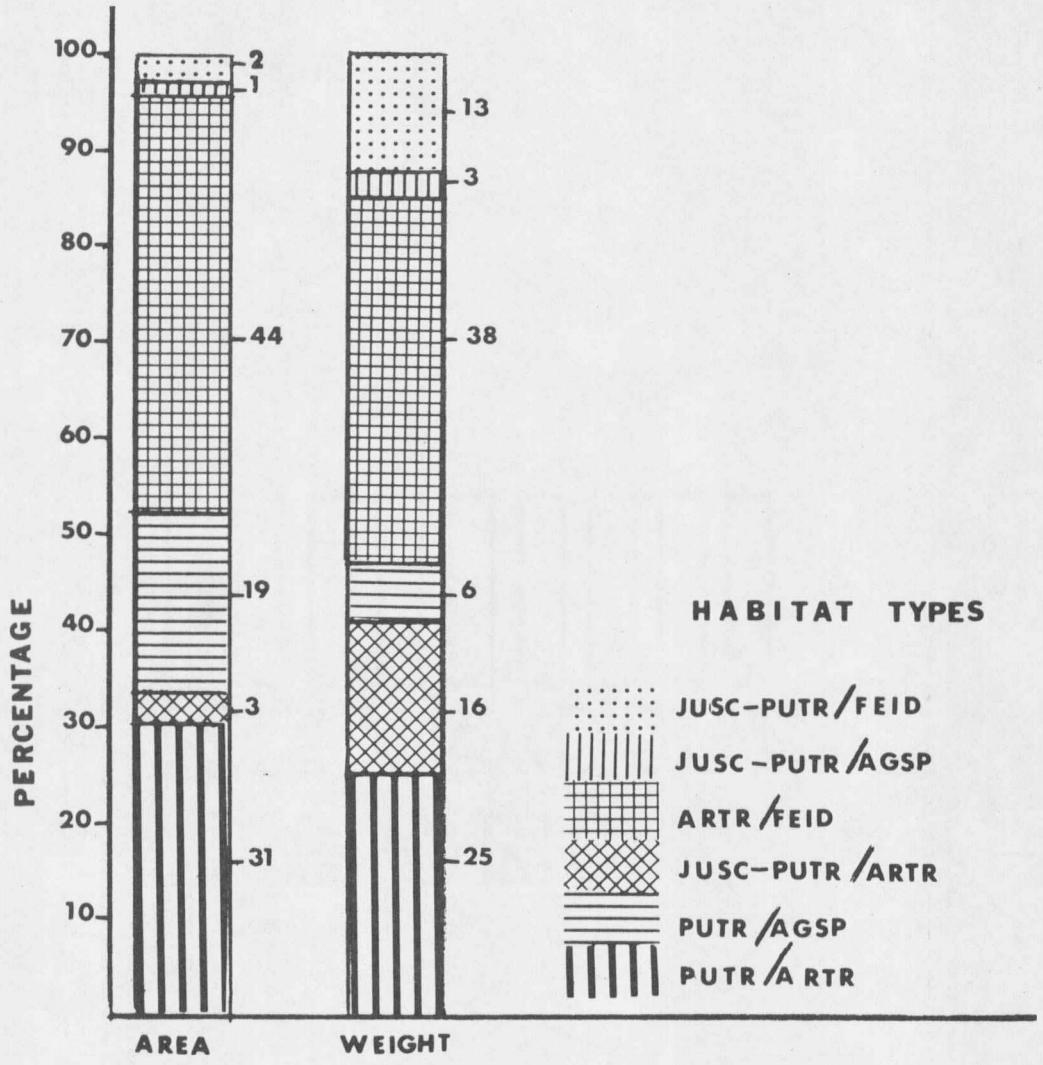

Figure 14. Relative occurrence of 6 habitat types within the shrubland portion of the study area and the distribution of total combined browse (big sagebrush, antelope bitterbrush, and Rocky Mountain juniper) production by weight among these types.

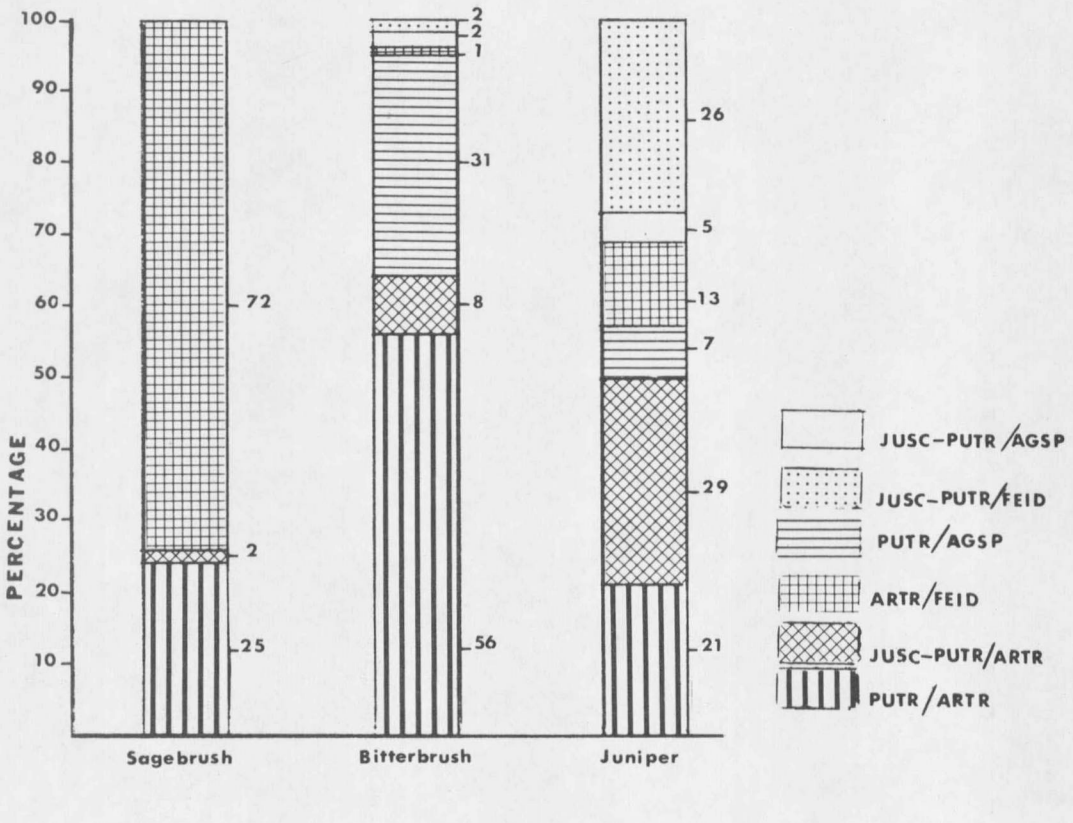

Figure 15. Percentage distributions by weight of available current annual growth of big sagebrush, antelope bitterbrush, and Rocky Mountain juniper among six shrubland habitat types.

types are reasonably extensive, (31 and 19 percent of the shrubland area, respectively) this species did not contribute nearly as much available forage as big sagebrush and Rocky Mountain juniper (Table 10). Unlike the latter two species bitterbrush is deciduous and in some habitat types the plants were smaller and/or of lower densities (Table 9).

The *Artemisia tridentata/Festuca idahoensis* and *Purshia tridentata/Artemisia tridentata* h.t. contributed 38 and 25 percent, respectively, of the total forage yield for the three species combined (Fig. 14, Table 10). This would be expected since these types comprised 75 percent of the total shrubland area. The *Juniperus scopulorum-Purshia tridentata/Artemisia tridentata* and *Juniperus scopulorum-Purshia tridentata/Festuca idahoensis* h.t. made up only 5 percent of the area but contributed 29 percent of the total foliage material. This reflected the heavy contribution of Rocky Mountain juniper foliage yield in these two types to the total yield (Table 10).

Age Distribution and Condition of Big Sagebrush and Antelope Bitterbrush

The mean ages of 20 big sagebrush and 17 antelope bitterbrush plants collected for forage production studies were 22 and 27 years, respectively (Table 11). These plants ranged in age from 8 to 38 years for sagebrush and 13 to 38 years for bitterbrush. An earlier collection by T. N. Lonner (unpublished data) contained 30 sagebrush

TABLE 11. MEAN AND RANGE IN AGE OF BIG SAGEBRUSH AND ANTELOPE BITTERBRUSH PLANTS COLLECTED FROM THE ARMSTRONG WINTER RANGE.

Species	Number of Plants	Mean Age (years)	Range	Std. Dev.
Big sagebrush	20	22	8-38	8
Antelope bitterbrush	17	27	13-38	10
Big sagebrush*	30	27	9-42	8
Antelope bitterbrush*	30	35	20-65	11

*Collected by T. N. Lonner (1972).

plants ranging in age from 9 to 42 years (mean of 27 years) and 30 bitterbrush plants ranging in age from 20 to 65 years (mean of 35 years). My collections were made throughout the area and I may have sampled some younger populations than Lonner, whose collection was made from one stand of the *Purshia tridentata/Artemisia tridentata* h.t. in the center of the winter range. Also, some differences in the application of the age determination technique may have occurred.

Age and form classes and percentage of dead crown were estimated for a total of 1,880 big sagebrush and antelope bitterbrush plants encountered during vegetational sampling of the study area. No seedlings and few young plants were encountered for either species. This paucity of reproduction did not appear to be due to the lack of seed production, at least in the case of bitterbrush. This plant flowered profusely during late May and early June and many seeds were observed on the plants later in the summer period. Many severely hedged sagebrush plants on the drier mountain slopes did not produce flower

stalks during late summer of 1972 and 1973 as did more vigorous and less used plants on the footslope region.

Approximately one-third of the bitterbrush and sagebrush plants measured were rated decadent (Table 12). An average of 40 percent of

TABLE 12. FORM AND AGE CLASS DISTRIBUTIONS FOR BIG SAGEBRUSH AND ANTELOPE BITTERBRUSH PLANTS MEASURED IN VEGETATIONAL ANALYSES.

Species	Number of Plants	Percent Form Class			Percent Age Class				Mean Percent Decadent
		1	2	3	Seedling	Young	Mature	Decadent	
Big sagebrush	1,081	4	38	58	0	tr[1]	64	36	45
Antelope bitterbrush	799	tr	4	96	0	tr	68	32	35

[1]tr = trace, less than 0.5 percent.

the crown area of these plants was dead. This could be a reflection of over browsing, long range climatological change, pathological effects, insect damage, and/or natural phytomorphic characteristics of the plants. Mackie (1973) found that bitterbrush plants protected by exclosures had generally higher percentages of dead crown than browsed plants on five winter ranges in western Montana. My general observations indicated that many big sagebrush plants with only moderate hedging were decadent to some degree. Transect measurements made on the study area by biologists of the Montana Fish and Game Department

from 1957-60 and 1965-66 indicate that high percentages of decadent plants have been characteristic for many years (Table 13).

TABLE 13. PERCENTAGES OF FORM CLASS, AGE CLASS, AND DECADENCY FOR MONTANA FISH AND GAME DEPARTMENT UTILIZATION - CONDITION TREND TRANSECTS.

Species	Form Class			Age Class		
Year	1	2	3	Seedling	Mature	Decadent
Big sagebrush						
1959	0	32	68	0	48	52
1960	0	36	64	0	52	48
1965	4	24	72	0	36	64
1966	8	76	16	0	48	52
Antelope bitterbrush						
1957	0	0	100	0	52	48
1958	0	12	88	0	44	56
1959	0	28	72	0	20	80
1960	2	22	76	0	22	78
1965	2	20	78	0	20	80
1966	0	52	48	0	6	94

Practically all (96 percent) antelope bitterbrush plants were severely hedged (form class 3), while most (96 percent) big sagebrush plants were rated as either moderately (form class 2) or severely hedged (Table 12). Heavy hedging on these species has been commonly reported from past State Fish and Game Department surveys of browse utilization and condition trend on the area (Table 13).

Referring to plants encountered during browse utilization studies for the two years of study, 3 percent of the living big sagebrush plants tagged in 1973 were dead in 1974 (Table 16). There was also a

noticeable shifting of form class ratings for these plants toward the heavier hedged conditions (form classes 2 and 3) in 1974. Five percent of all antelope bitterbrush plants encountered in the 1973 utilization survey were dead as compared to 11 percent dead for sagebrush (Tables 16 and 17). One percent of the living bitterbrush plants tagged in 1973 were dead in 1974 (Table 17). Increased percentages of severely hedged (form class 3) plants were also evident in the 1974 data for this species (Table 17). A comparison between years for age classes is difficult because of the influence of decadency ratings for 1973. All plants encountered, including dead plants, were considered in 1973, whereas only tagged plants were measured in 1974.

Browse Utilization

Post-browsing measurements of current annual growth twigs (CAGT) of big sagebrush and antelope bitterbrush are presented in Tables 14 and 15, together with estimates of twig utilization by length for the winters of 1972-73 and 1973-74. Estimates of the percentages of total numbers of available twigs browsed and total utilization by length of current growth for each species on the primary shrub-dominated habitat types are given in Tables 16 and 17. Problems in discerning current use on Rocky Mountain juniper precluded measurement of utilization for that species.

TABLE 14. MEAN DIAMETERS AT BASE OF CURRENT GROWTH (DCG), MEAN DIAMETERS AT POINT OF BROWSING (DPB), AND ESTIMATED TWIG LENGTH UTILIZED FOR BIG SAGEBRUSH DURING THE 1972-73 AND 1973-74 WINTERS.

Winter Period Habitat Type	Number of Stands	DCG	T[1]	R[2]	Length used	P[3]	DPB	Length used	P[4]
1972-73									
PUTR/ARTR	7	1.46	60	32	28	45	1.24	44	99
ARTR/FEID	5	1.25	44	24	20	45	1.10	33	74
Overall Mean	12	1.37	53	29	24	45	1.18	42	89
1973-74									
PUTR/ARTR	6	1.38	60	24	36	60			
ARTR/FEID	5	1.32	56	27	30	53			
Overall Mean	11	1.35	58	25	33	57			

[1] = estimated length before browsing in millimeters.

[2] = length of un-used portion in millimeters.

[3] = percentage of total twig length browsed = $P = 100\ \frac{(T-R)}{T}$

[4] = percentage of total twig length browsed based on mean twig length of production collection.

Estimates of mean twig length utilization for big sagebrush and antelope bitterbrush (Tables 14 and 15) were computed during the spring of 1973 using two different methods. One method, described by Basile and Hutchings (1966) and Lyon (1970) employed the regression developed for production studies (Table 8) to predict twig length before browsing from the diameter at the base of current growth (DCG) of browsed twigs. Percentage utilization was then calculated as: $P=100\frac{(T-R)}{T}$; where T= predicted mean length of browsed twigs, and R= mean length of twig

TABLE 15. MEAN DIAMETER AT BASE OF CURRENT GROWTH (DCG), MEAN DIAMETER AT POINT OF BROWSING (DPB), AND ESTIMATED TWIG LENGTH UTILIZED FOR ANTELOPE BITTERBRUSH DURING THE 1972-73 AND 1973-74 WINTERS.

Winter Period Habitat Type	Number of Stands	DCG	T[1]	R[2]	Length used	P[3]	DPB	Length used	P[4]
1972-73									
PUTR/ARTR	7	1.74	107	35	72	66	1.41	77	89
PUTR/AGSP	3	1.69	103	42	60	60	1.35	71	82
Overall Mean	10	1.73	106	37	68	64	1.39	75	87
1973-74									
PUTR/ARTR	6	1.60	124	30	94	76			
PUTR/AGSP	2	1.51	115	28	87	76			
Overall Mean	8	1.57	122	30	92	76			

[1]Estimated total length before browsing in millimeters.

[2]Length of un-used portion in millimeters.

[3]Percentage of total twig length browsed = $P=100(\frac{T-R}{T})$.

[4]Percentage of total twig length browsed based on mean twig length of production collection.

remaining after browsing (Basile and Hutchings 1966). The other, used by Peek *et al.* (1971) applied twig diameter at point of browsing (DPB) in place of DCG in the regression equation to directly estimate the length of the browsed portion of the twig. Application of the regression equation developed on DCG to DPB assumes that the DCG-length relationship applies equally to the entire length of the twig; i.e., the twig tapers uniformly from base to tip.

TABLE 16. PLANT CONDITION AND CURRENT ANNUAL GROWTH TWIG UTILIZATION FOR BIG SAGEBRUSH ON MAJOR HABITAT TYPES DURING THE WINTERS OF 1972-73 AND 1973-74.

Winter Period Habitat Type	Number of Stands	Form Class Percentage 1	2	3	Dead[1]	Age Class Percentage Young	Mature	Decadent	Percent Total Twigs Utilized	Percent[2] Total Length Utilized	Percent[3] Total Utilization by Length
1972-73											
PUTR/ARTR	7	4	58	38	15	0	59	41	84	45	38
ARTR/FEID	5	30	41	29	5	0	80	20	60	45	28
Weighted Mean	12	15	51	34	11	0	68	32	74	45	34
1973-74											
PUTR/ARTR	6	3	40	54	3	0	88	12	84	60	51
ARTR/FEID	5	22	46	28	3	0	91	9	56	53	28
Weighted Mean	11	11	43	42	3	0	89	11	71	57	40

[1]Data for 1972-73 are percentages of all plants encountered. Those for 1973-74 are percentages of tagged live plants dying during that year.

[2]Based upon diameter at base of twig (DCG).

[3]Percent total twigs utilized X percent total length utilized.

TABLE 17. PLANT CONDITION AND CURRENT ANNUAL GROWTH TWIG UTILIZATION FOR ANTELOPE BITTERBRUSH ON MAJOR HABITAT TYPES DURING THE WINTERS OF 1972-73 AND 1973-74.

Winter Period Habitat Type	Number of Stands	Form Class Percentage 1	2	3	Dead[1]	Age Class Percentage Young	Mature	Decadent	Percent Total Twigs Utilized	Percent[2] Total Length Utilized	Percent[3] Total Utilization by Length
1972-73											
PUTR/ARTR	7	0	32	68	5	0	84	16	85	66	57
PUTR/AGSP	3	0	52	48	6	0	79	21	70	60	43
Weighted Mean	10	0	38	62	5	0	82	18	81	64	53
1973-74											
PUTR/ARTR	6	0	13	87	0	0	98	2	88	76	67
PUTR/AGSP	2	0	20	78	3	0	93	8	82	76	62
Weighted Mean	8	0	15	85	1	0	97	3	87	76	66

[1]Data for 1972-73 are percentages of all plants encountered. Those for 1973-74 are percentages of tagged live plants dying during that year.

[2]Based on diameter at base of current growth (DCG).

[3]Percent total twigs utilized X percent total length utilized.

For big sagebrush, mean length utilized was estimated at 24 millimeters using the DCG method and 42 millimeters with the DPB method (Table 14), a difference of 75 percent. Twig length utilization of antelope bitterbrush averaged 68 millimeters on the basis of the DCG method and 75 millimeters for the DPB method (Table 15), a difference of 10 percent. These differences indicate that the assumption of a uniform diameter-length relationship for the entire length of twig may not be valid, especially for sagebrush.

A second problem associated with the DPB method is that it does not directly provide a measure of total unbrowsed twig length from which percentage utilization can be estimated. Unless DCG is also measured to determine total length before browsing, it must be assumed that the mean length twig of twigs collected to develop regression equations (Table 8) can be used. Percentage utilization computed in this manner (see the last columns in Tables 14 and 15) were much greater than those calculated using the DCG method; averaging 98 percent higher for sagebrush and 36 percent higher for bitterbrush. Because the discrepancies in twig length and percentages for length utilization seemed to be related to assumptions made in using the DPB method, I concluded that the DCG method provided a more accurate basis for determining utilization and subsequently used it in 1973-74 browse utilization studies.

The mean diameters at base of current growth of utilized twigs of big sagebrush and antelope bitterbrush (Tables 14 and 15) were larger than the mean DCG of twigs collected to develop the regression equations for production analyses (Table 8). These differences could reflect my clipping larger, more apparent twigs for the utilization sample and/or selection of larger twigs by deer. Also the production studies sampled all twigs from the plant longer than one inch, while twigs measured for utilization represented only the accessible, outer crown twigs which may be stimulated by browsing in the previous year.

Approximately 34 and 40 percent of the total current annual growth of big sagebrush on the study area was utilized during the 1972-73 and 1973-74 winters, respectively (Fig. 16 and Table 16). The heaviest usage of sagebrush occurred in the *Purshia tridentata/Artemisia tridentata* h.t. during both winters. Utilization in this type increased sharply from 38 percent in 1972-73 to 51 percent in 1973-74 while that in the *Artemisia tridentata/Festuca idahoensis* h.t. remained about the same (Table 16).

Utilization of antelope bitterbrush CAGT averaged 53 and 66 percent for the winters of 1972-73 and 1973-74, respectively (Table 17). Like sagebrush, plants in the *Purshia tridentata/Artemisia tridentata* h.t. received the heaviest usage both winters. Usage on this type increased by 10 percent from 1972-73 to 1973-74 (Fig. 16). The largest increase in utilization of bitterbrush occurred on the *Purshia*

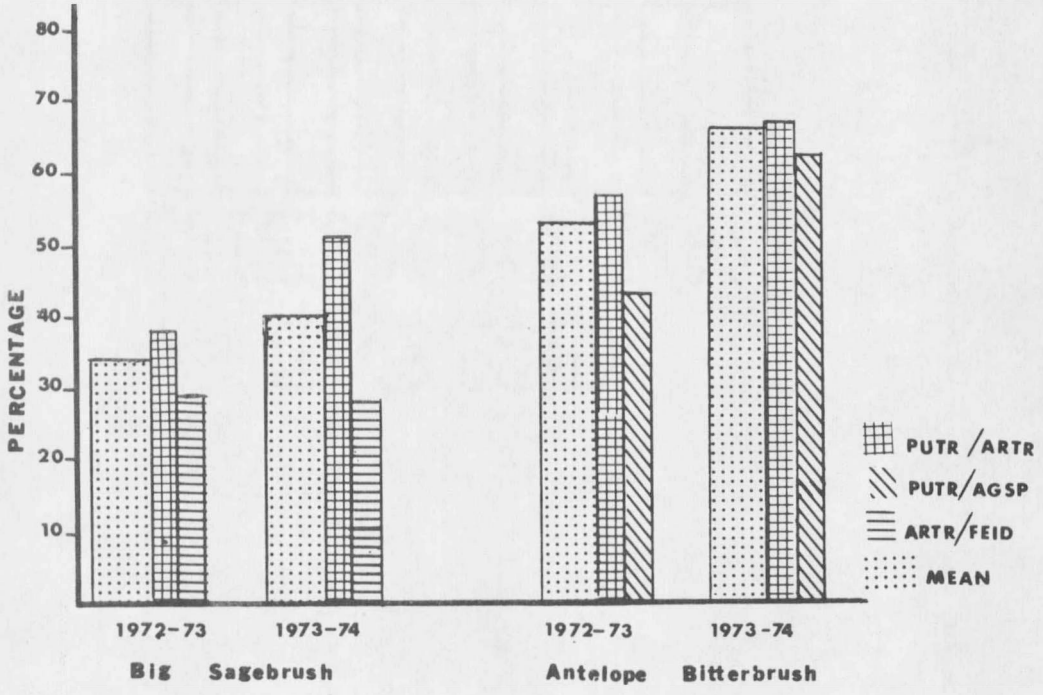

Figure 16. Percentage utilization by length of current annual growth of big sagebrush and antelope bitterbrush on major shrubland habitat types, 1972-73 and 1973-74.

tridentata/Agropyron spicatum h.t., from 43 percent in 1973 to 62 percent in 1974.

Estimated percentages of utilization of twig length of big sagebrush and antelope bitterbrush may approximate utilization by weight. However, when this is done the computed weight values tend to be somewhat overestimated because the distal portion of an outwardly tapering twig weighs less per unit length than a portion of the same twig closer to the base. Assuming that the weighted mean CAGT length utilization for sagebrush in the major shrub habitat types in 1972-73 (34 percent) was a reasonable estimate of utilization of this species for the entire shrubland area, a maximum of 10,666 kilograms were consumed by mule deer during the winter. Approximately 31,371 kilograms current annual growth were available for sagebrush (Table 9). Similarily utilization of antelope bitterbrush during 1972-73 amounted to about 2,713 kilograms, with 5,119 kilograms available.

Assuming that about 175 deer used the study area during the winter of 1972-73 (Schwarzkoph 1973), each animal utilized about 60 kilograms of sagebrush and 15 kilograms of bitterbrush. On a daily basis this amounts to about 0.5 kilograms (1.1 pounds) of big sagebrush and 0.1 kilograms (0.22 pounds) of bitterbrush per animal for the 120 day (December through March) period when most deer were concentrated on the winter range and using browse. Smith (1959) reported that deer fed on varied diets involving sagebrush consumed an average of 2.25 pounds/cwt/day

with sagebrush contributing as much as 1 pound/cwt/day.

Utilization of big sagebrush differed noticeably between sites. Plants of stands on the mountain slopes generally were heavily utilized by mule deer, while the majority of the footslope stands, comprised of larger, more robust plants, were only lightly used. A paucity of moderate-heavily hedged plants on the footslopes indicates that light usage probably has been characteristic of these sites. One stand on the footslope showed 84 percent of the plants in form class 1 (all available, little or no hedging) and only 7 percent utilization of the current annual growth. Light usage of this stand may have been influenced by the presence of relatively large numbers of cattle wintering on the area, greater and more persistent snow accumulation on the footslopes where the large plants trap snow and a low winter sun angle in relation to slope deters snow melt, or as suggested by Powell (1970) the larger, more vigorous big sagebrush plants growing on favorable sites may be less palatable, because they contain significantly greater amounts of volatile oils than shorter, less vigorous plants on less favorable sites. Lowered forage values for big sagebrush have been associated with high volatile oil content by Nagy *et al.* (1964) and Smith *et al.* (1966).

Utilization of other shrubs or grasses and forbs eaten by mule deer wintering on the area was not quantitatively evaluated. Wilkins (1957), Schwarzkoph (1973), and Hamlin (1974) have reported mule deer

use on most shrub species which occur on the winter range. My general observations indicated heavy utilization of chokecherry wherever it occurs within deer reach. Usage on this species often exceeded the current years growth and most plants were comprised primarily of resprouts from older badly damaged stalks. Utilization of other shrubs ranged from moderate to heavy, depending on species and availability. Mock orange, which was abundant and readily available at lower elevations, around areas of broken rock, and in open draw bottoms, showed very little usage, past or present. Among herbaceous plants, utilization of dried arrowleaf balsamroot was quite common, particularly when moistened by rain or snow. This plant appeared to be highly preferred by the deer which pawed through deep snow to obtain the leaves. Available seed heads of balsamroot were almost completely utilized early in the winter. Green shoots of downy chess brome, bluebunch wheatgrass, and Idaho fescue were available and commonly used throughout the winter on south and southwest facing slopes. Schwarzkoph (1973) reported that browse, grasses, and forbs constituted 42, 35, and 21 percent of the instances of use at feeding sites and 46, 50, and 4 percent of the contents of rumen samples, respectively for the winter of 1972-73.

Utilization of Antelope Bitterbrush by Cattle

During the past 30-35 years between 35 and 40 cows have grazed the southeastern quarter of the study area from June through mid-October

(Claude Maher 1973, personal communication). Because of precipitous slopes, the cattle tend to concentrate on lower, more accessible areas until grasses and forbs become depleted. As early as mid-July during years of low rainfall and by August of normal years, the cattle are forced onto the slopes where bunchgrasses remain available. One stand of antelope bitterbrush occurs on the footslope at the western edge of this pasture with others on the open mountain slopes. Observations during the summer of 1973 indicated that as herbaceous plants were depleted on the footslopes the cattle utilized bitterbrush. Since mule deer commonly use this area during the winter, any substantial removal of bitterbrush by cattle would constitute competition with the deer. In the fall of 1973, after the cattle were removed and before the deer moved onto the area, and the spring of 1974, when deer use had ceased, utilization of bitterbrush was measured in stands on footslope and mid and upper mountain slope positions.

The results (Table 18) indicated that cattle removed approximately 37 percent of the bitterbrush CAGT from the footslope site and 8-10 percent of CAGT on the mountain slope sites. Lower levels of utilization were expected on the steep slopes because of their use later in the summer and the abundance of bluebunch wheatgrass which remained green during most of the period the cattle used these areas. Usage of bluebunch wheatgrass appeared to be light to moderate. Cattle utilization of approximately 10 percent of the CAGT of bitterbrush on the

TABLE 18. COMPARISON OF SUMMER-FALL CATTLE UTILIZATION AND TOTAL UTILIZATION OF ANTELOPE BITTERBRUSH ON THREE SITES DURING 1973-74.

Season Slope Position	DCG[1]	T[2]	R[3]	Length Used	P[4]	Percent Total Twigs Utilized	Percent Total Utilization by Length[5]	Age Class Percentage Mature	 Decadent	Form Class Percentage 1	 2	 3
Summer-Fall (1973)												
Footslope	1.54	118	40	78	66	56	37	89	11	0		100
Midslope	1.82	147	46	101	69	11	8	71	29	0	8	92
Slope Summit	1.44	107	28	79	74	14	10	96	4	0		100
Mean	1.60	124	38	86	70	27	18	85	15	0	3	97
Total (1973-74)												
Footslope	1.66	130	28	102	79	90	71	100	0	0		100
Midslope	1.59	123	34	89	72	90	65	100	0	0	20	80
Slope Summit	1.57	121	31	90	74	90	67	100	0	0	8	92
Mean	1.61	125	31	94	75	90	68	100	0	0	9	91

[1]DCG = diameter at base of current growth.

[2]T = estimated total length before browsing in millimeters.

[3]Length of un-used portion in millimeters.

[4]Percentage of total twig length browsed $P = 100\left(\frac{T-R}{T}\right)$.

[5]P times percent total twigs utilized.

slopes while grasses were available and palatable would indicate some preference for this species.

The total combined cattle-deer utilization of bitterbrush on the three sites from the summer of 1973 through spring of 1974 was 68 percent. Total utilization was similar for all sites. Cattle utilization of approximately one-half of the total bitterbrush removed from the footslope stand undoubtedly was competative with deer which later used the area.

About 44 kilograms/hectare (39 pounds/acre) of bitterbrush CAGT were available on the footslope site. The cattle usage thus amounted to nearly 16.3 kilograms/hectare (14.4 pounds/acre) leaving some 28 kilograms/hectare (25 pounds/acre), much of which may not have been readily available for use by deer. This particular stand was small (approximately 4.9 hectares or 12 acres) and its contribution to the total forage production on the winter range was also small. However, on this range and perhaps others where forage supplies are limited, this type and degree of utilization by cattle could result in important competition.

CONCLUSIONS

Assuming an average daily forage requirement for mule deer of about 4 pounds, air-dried (Dasmann 1971), big sagebrush and antelope bitterbrush together supplied a maximum of one-third of the daily forage of deer on the Armstrong Winter Range. Schwarzkoph (1973) reported that these two species combined comprised about 36 percent of the total instances of plant use recorded at feeding sites on this range during the winter. My findings indicated that sagebrush was of relatively greater importance than suggested by the feeding sites while bitterbrush was less important. This difference could be due to the fact that use on sagebrush included both leaves and twigs while use on bitterbrush consisted solely of twigs. Although bitterbrush appeared to be rather highly preferred, as indicated by high average utilization, this key species individually contributed only a minor portion of the forage requirement (0.22 pounds/deer day overall for the winter). Both Wilkins (1957) and Schwarzkoph (1973) noted that the highest usage of bitterbrush occurred during early winter with progressively decreasing use through the season.

Unless the total daily forage requirement of deer on the Armstrong range was less than assumed, various other browse species, forbs, and grasses must contribute a major portion of the forage supply. Utilization of juniper, which exceeded big sagebrush in available browse

yield on the area, was not measured, but the proportion of available material actually browsed did not appear to be great. Heavy useage of grasses and forbs was demonstrated by Schwarzkoph's (1973) findings that these forage classes together constituted 56 and 54 percent of instances of use at feeding sites and of the contents of rumen samples, respectively, during the 1972-73 winter.

The heaviest utilization of sagebrush and bitterbrush occurred in the *Purshia tridentata/Artemisia tridentata* h.t., which is probably the single most important type on the study area. This type comprises 31 percent of the shrubland area and provides a mixture of browse and other species used by deer during the winter in relative abundance as compared with other habitat types. Other shrub types on the area were also well used. The *Purshia tridentata/Agropyron spicatum* h.t. was of particular importance during periods of heavy snowfall. The majority of this type is distributed on the steepest, windswept southern exposures where snow does not accumulate or persist as it does in other areas after a storm.

An important characteristic of this range in general is the occurrence of many different topographical situations, with various vegetational communities, which may be important at different times in relation to weather conditions, snow accumulation, wind direction, and disturbances by man. Thus, under most situations there seems to be someplace the deer can utilize. This results in heavy utilization of

forage supplies on practically all types and portions of the area below approximately 7,000 feet elevation by the end of the winter.

Schwarzkoph (1973) and Hamlin (1974) have reported low productivity and substantial winter mortality of fawns for the deer population using the Armstrong Winter Range. It is commonly accepted that this is indicative of poor range and forage conditions which can involve summer as well as winter ranges.

Sagebrush and bitterbrush reproduction was almost completely lacking on the area. This together with the presence of many dead and partially dead plants of these species may indicate future deterioration of these species populations and changes in forage plant composition and supplies. Heavy annual utilization of shrubs, especially bitterbrush, undoubtedly contribute to these vegetational changes. However, reproduction and young plants also were absent in four small exclosures established on the central portion of the winter range during 1955.

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APPENDIX

APPENDIX TABLE 1. EDAPHIC CHARACTERISTICS OF VEGETATION TYPES ON THE MULE DEER SUMMER RANGE EAST OF THE STUDY AREA TO THE GALLATIN VALLEY - BRIDGER CANYON DIVIDE.

Vegetational Type	Soil Texture Percentage			Soil Texural Class	pH	Phosphorus ppm[1]	Potassium ppm	Salt mmhos[2]	Organic Matter %	Calcium meg[3]	Magnesium meg	Sodium meg
	Sand	Silt	Clay									
Spruce-Fir (closed canopy)	68	12	20	SL[4]	5.3	45(L)[5]	175(M)	.4	6.0(M)	4.8	1.56	.27
Alpine-Meadow (8900 feet)	46	32	22	L	7.4	5(VL)	245(M)	.6	5.8(M)	40.0	2.13	.12
Lodgepole Pine (7500 feet)	40	46	14	L	5.5	79(H)	145(M)	.2	5.6(M)	5.2	1.72	.20
Sedge Meadow	54	36	10	SL	6.8	15(VL)	135(M)	.4	4.4(L)	21.4	3.77	.27
Grass Sedge	52	44	4	SL	6.4	15(VL)	165(M)	.4	6.0(M)	15.0	5.48	.16
Whitebark Pine (8600 feet)	42	50	8	SL	7.5	23(VL)	265(H)	.6	6.1(M)	40.6	1.23	.24
Grass-Forb (mountain meadow)	58	28	14	SL	6.2	66(M)	205(M)	.2	3.4(L)	8.3	1.23	.24
Spruce-Fir (open canopy)	40	50	10	St.L	7.1	18(VL)	135(M)	.7	5.7(M)	39.0	9.84	.24
Alpine-Fir	36	48	16	L	5.2	135(H)	235(M)	.6	6.0(M)	6.8	1.39	.35
Limber Pine-Douglas Fir	56	36	8	SL	6.1	43(L)	305(H)	.3	5.9(M)	15.0	1.80	.35

[1]ppm = pounds per one million pounds of soil.

[2]mmhos = milimhos, 1 mho = $\frac{1}{\text{ohm}}$.

[3]meg = milliequivalents per 100 grams of soil.

[4]SL = silt loam, LS = loamy sand, L = loam, and St. L = silty loam.

[5]Ratings from Montana Soils Testing Laboratory Report, ST - Form 3, Jan. 8, 1971: VL = very low, L = low, M = medium, and H = high.