



Habitat use by mule deer of the Armstrong Winter Range, Bridger Mountains, Montana
by Heidi Behrens Bailey Youmans

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Fish and Wildlife Management

Montana State University

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Abstract:

A study of winter habitat usage by mule deer was conducted on the Armstrong Winter Range in the Bridger Mountains of southwestern Montana during the winters of 1976-77 and 1977-78. Objectives were to ascertain the extent of individual variability in habitat use and to evaluate the reliability of conventional estimates of winter range use. A total of 19 deer wearing radio transmitter collars were monitored from the ground, and from the air during weekly surveys in a Supercub aircraft. Conventional ground observations were obtained of neckbanded and unmarked deer. The number of marked deer on the winter range totaled 58 and 76 for the 1976-77 and 1977-78 winters, respectively. Relocations of instrumented and neckbanded individuals indicated the existence of three major winter range units. Instrumented animals exhibited larger home ranges during the first, mild winter than during the second, more severe winter, and north unit deer were characterized by more extensive movements than middle unit deer both winters. A substantial bias toward open habitats in observations of neckbanded and unmarked deer favored the use of instrumented deer for habitat use assessment. During the 1976-77 winter, deer use was concentrated on the forested upper portion of the winter range with only 19% of the total use by instrumented deer occurring in shrub/grass types. Percent total use of shrub/grass and forest types by instrumented deer during the 1977-78 winter was 39% and 54%, respectively. Core home range preference ratios for individual habitat types and for shrub/ grass and forest habitat categories varied widely among individuals.

But preference ratios less than 1 for total shrub/grass types and greater than 1 for total forested types were common to all instrumented individuals of the north and middle range units, indicating a common preference for forested types. Habitat types most selected were the JUSC-PUTR/FEID and PSME/FEID types of the north unit and the PSME/SYAL and PSME/PRVI types of the middle unit. Temporal variation in habitat usage and home range size during the 1977-78 winter reflected snow depth and crust conditions. Snow depths of 36-48 cm with a non-supportive surface crust prompted deer congregation in forested habitats offering less severe snow conditions. Habitat use patterns observed on the winter range suggested a strategy of energy conservation rather than forage gathering. Daytime deer activity reached a peak the first half of March, at the start of accelerated snowmelt. Largest group size and greatest number of individuals sighted per observation period were recorded at that time.

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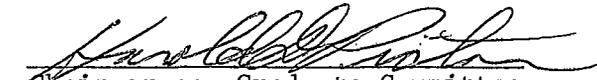
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Head, Major Department


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TABLE OF CONTENTS

	<u>Page</u>
VITA	ii
ACKNOWLEDGMENT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	v
LIST OF FIGURES	vii
ABSTRACT	viii
INTRODUCTION	1
DESCRIPTION OF THE STUDY AREA	3
METHODS	7
-Distribution and Movements	7
-Habitat Use	8
Collection of Weather Data	9
RESULTS	11
-Distribution and Movements	11
-Habitat Use	23
Winter 1976-77	23
Winter 1977-78	26
-Temporal Variation in Movements and Habitat Usage	34
Microclimatic Variation on the Study Area	45
Population Characteristics and Behavior	47
DISCUSSION	51
APPENDIX	57
LITERATURE CITED	62

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1 U.S. Weather Bureau Climatological Data, MSU Weather Station, Bozeman, and severity indices, November through May, 1976-77 and 1977-78	12
2 Phenology of lilac (<i>Syringa vulgaris</i>) development and growth in Bozeman	13
3 Mean monthly relocation elevations for instrumented deer on the Armstrong Winter Range, winters 1976-77 and 1977-78	14
4 (Appendix) Dates of arrival and core home range establishment for instrumented deer on the Armstrong Winter Range, winters 1976-77 and 1977-78	58
5 A comparison of home range size indices for instrumented deer of the Armstrong Winter Range, winter 1977-78	18
6 Home range size indices for instrumented deer of the Armstrong Winter Range, winters 1976-77 and 1977-78	21
7 (Appendix) Means of average activity radii for marked deer of the Armstrong Winter Range, winters 1972-73 through 1977-78	59
8 Percent total use of each habitat type of the Armstrong Winter Range by mule deer during the winter of 1976-77, as determined by three sampling techniques	24
9 (Appendix) Mean daily maximum and minimum temperatures recorded by hygrothermograph located on the Armstrong Winter Range, winters 1976-77 and 1977-78	60
10 Percent total use of each habitat type by instrumented deer of the north unit of the Armstrong Winter Range, winter 1977-78	28
11 Percent total use of each habitat type by instrumented deer of the middle unit of the Armstrong Winter Range, winter 1977-78	29

<u>Table</u>		<u>Page</u>
12	Percent total use of each habitat type by instrumented deer of the south unit of the Armstrong Winter Range, winter 1977-78	30
13	Habitat preference ratios (percent use/percent area occupied within core home range) for instrumented deer of the Armstrong Winter Range, winter 1977-78	33
14	Percent total use of each habitat type of the Armstrong Winter Range by mule deer during the winter of 1977-78, as determined by four sampling techniques	35
15	Mean group size and mean number of individuals sighted per ground observation period, winter 1977-78	49
16	(Appendix) Contents of five mule deer rumen samples collected on the Armstrong Winter Range, winter 1977-78	61

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1 Map of the Bridger Range showing major features and location of the Armstrong Winter Range	4
2 Aerial view of the Armstrong Winter Range and distribution of habitat types defined by Bucsis (1974) and Pac (1976)	6
3 Aerial view of the Armstrong Winter Range showing boundaries of the north, middle and south range units . . .	16
4 Temporal variation in relative usage of shrub/grass and forest habitat categories by instrumented deer compared to ground and aerial deer observations, winter 1977-78 . . .	37
5 Temporal variation in relative usage of shrub/grass and forest habitat categories by instrumented deer of the north, middle and south units of the Armstrong Winter Range, winter 1977-78	38
6 Temporal variation in usage of creek bottom habitats west of the Armstrong Winter Range by instrumented deer of the north range unit, winter 1977-78	39
7 Temporal variation in mean polygon home range size for instrumented deer of the north, middle and south units of the Armstrong Winter Range, winter 1977-78	44

ABSTRACT

A study of winter habitat usage by mule deer was conducted on the Armstrong Winter Range in the Bridger Mountains of southwestern Montana during the winters of 1976-77 and 1977-78. Objectives were to ascertain the extent of individual variability in habitat use and to evaluate the reliability of conventional estimates of winter range use. A total of 19 deer wearing radio transmitter collars were monitored from the ground, and from the air during weekly surveys in a Supercub aircraft. Conventional ground observations were obtained of neckbanded and unmarked deer. The number of marked deer on the winter range totaled 58 and 76 for the 1976-77 and 1977-78 winters, respectively. Relocations of instrumented and neckbanded individuals indicated the existence of three major winter range units. Instrumented animals exhibited larger home ranges during the first, mild winter than during the second, more severe winter, and north unit deer were characterized by more extensive movements than middle unit deer both winters. A substantial bias toward open habitats in observations of neckbanded and unmarked deer favored the use of instrumented deer for habitat use assessment. During the 1976-77 winter, deer use was concentrated on the forested upper portion of the winter range with only 19% of the total use by instrumented deer occurring in shrub/grass types. Percent total use of shrub/grass and forest types by instrumented deer during the 1977-78 winter was 39% and 54%, respectively. Core home range preference ratios for individual habitat types and for shrub/grass and forest habitat categories varied widely among individuals. But preference ratios less than 1 for total shrub/grass types and greater than 1 for total forested types were common to all instrumented individuals of the north and middle range units, indicating a common preference for forested types. Habitat types most selected were the JUSC-PUTR/FEID and PSME/FEID types of the north unit and the PSME/SYAL and PSME/PRVI types of the middle unit. Temporal variation in habitat usage and home range size during the 1977-78 winter reflected snow depth and crust conditions. Snow depths of 36-48 cm with a non-supportive surface crust prompted deer congregation in forested habitats offering less severe snow conditions. Habitat use patterns observed on the winter range suggested a strategy of energy conservation rather than forage gathering. Daytime deer activity reached a peak the first half of March, at the start of accelerated snowmelt. Largest group size and greatest number of individuals sighted per observation period were recorded at that time.

INTRODUCTION

Winter is a critical season for year-round resident wildlife of northern latitudes. Big game animals are often found in high densities during this period on traditional wintering areas which are very limited in size and extent. The relative importance of environmental requirements of wintering animals must be better understood to facilitate accurate assessment and wise management of these vital winter ranges.

Deer exhibit morphological, physiological and behavioral adaptations which allow them to modify their energy requirements with respect to limited winter resources. Hoffman and Robinson (1966) found thyroid activity of white-tailed deer (*Odocoileus virginianus*) to be lowest during the winter. Silver *et al.* (1969) reported lowered basal and fasting metabolic rates, and Seal *et al.* (1972) documented lowered metabolic rates as well as depressed thyroid activity during winter by white-tailed deer. Voluntary reduction in winter forage intake and in general activity were recorded by Ozoga and Verme (1970) and Wood *et al.* (1962). Range use strategies and behavior exhibited by deer are undoubtedly conducive to survival on a particular winter range and reflect existing environmental conditions.

The objectives of the present study were to examine habitat use by mule deer of the Armstrong Winter Range, ascertain the extent of individual variability in habitat usage and to evaluate

the reliability of conventional estimates of winter range use. Field research was conducted during the periods December 15, 1976 to April 1, 1977 and December 1, 1977 to April 1, 1978.

Several previous studies of the ecological characteristics of the Armstrong Winter Range and its associated mule deer population have been conducted. Investigations of mule deer food habits and range use initiated by Wilkins (1957) were followed by Schwarzzkoph (1973) and Hamlin (1974), who provided additional information on seasonal distribution and population characteristics. Ecological attributes of the winter range and production and utilization of key browse species were examined by Bucsis (1974). Morton (1976) further evaluated nutritional attributes of several important winter forage species. Summer and fall distribution and habitat use by mule deer associated with the Armstrong Winter Range were described by Pac (1976). Late winter-spring distribution and population trends have been monitored since 1975 and were reported by Mackie *et al.* (1976), Mackie and Stewart (1976), Mackie and Knowles (1977) and Mackie *et al.* (1978).

DESCRIPTION OF THE STUDY AREA

The Bridger Mountain Range, the geological features of which have been described by McMannis (1955), is located in southwestern Montana. Seven major mule deer winter ranges have been identified in the Bridger Mountain complex, and distribution and population studies have indicated the existence of rather distinct herd units associated with each of these major winter range areas (Mackie *et al.* 1978). Migratory deer associated with the Armstrong Winter Range spend the remainder of the year in the main portion of the Bridger Range bounded by Flathead Pass on the north and Ross Pass on the south (Mackie *et al.* 1978). They generally arrive on the winter range in November and December and depart during May and June.

The Armstrong Winter Range is located on a southwestern exposure of the Bridger Range, approximately 32 km north of Bozeman (Fig. 1). Bucsis (1974) described this area as encompassing 510 ha of lower mountain and footslopes, bounded by North Cottonwood Creek on the north and Bill Smith Creek on the south. Elevations range from 1600 to 2378 m. The northern half of the study area is characterized by a west-facing aspect, cut by east-west drainages while the southern portion changes from a south to a southwest aspect with north-south and northeast-southwest drainages. The terrain is typified by steep inclines with slope gradients occasionally exceeding 50 percent.

Vegetational characteristics of the Armstrong Winter Range were summarized by Bucsis (1974), who described 14 habitat types on the

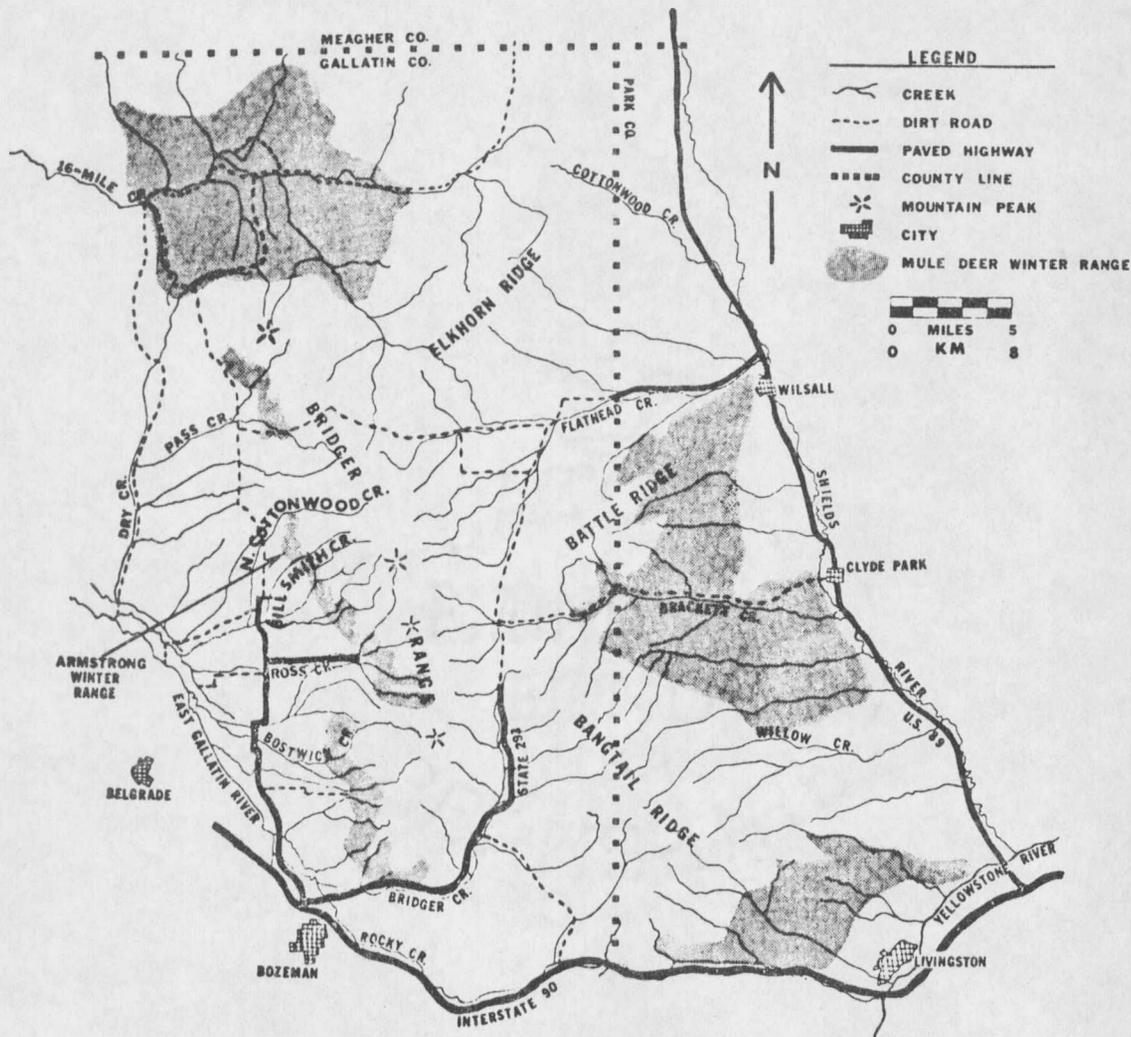


Figure 1. Map of the Bridger Range showing major features and location of the Armstrong Winter Range.

area, to a resolution of 1.2 ha. His classification scheme followed Mueggler and Handl (1973) and Pfister *et al.* (1973). Habitat type classification of the forested portion of the study area above 2015 m has since been modified by Pac (1976), after Pfister *et al.* (1974). The heterogeneity of the study area with respect to elevation, topography and edaphic characteristics is reflected in the mosaic distribution of the 16 designated habitat types (Fig. 2).

Records from the Montana State University weather station show a mean annual temperature of 6.3°C and mean annual precipitation of 47.5 cm for the period 1947 through 1977 (U.S. Weather Bureau). Mean total precipitation and mean monthly temperature for November through April are 17.2 cm and -1.3°C, respectively. This station is considered to be subject to weather conditions similar to those of the west slope of the Bridgers.

Although historically primarily a mule deer wintering area, the Armstrong Winter Range and immediate vicinity is also utilized by approximately 50 elk (*Cervus elaphus canadensis*) during the winter and spring. They range more widely than the deer and are generally observed in forested habitats, singly or in small groups.



Figure 2. Aerial view of the Armstrong Winter Range and distribution of habitat types defined by Bucsis (1974) and Pac (1976).

1. *Festuca idahoensis*/*Agropyron spicatum* (FEID/AGSP)
2. *Agropyron spicatum*/*Agropyron smithii* (AGSP/AGSM)
3. *Purshia tridentata*/*Agropyron spicatum* (PUTR/AGSP)
4. *Purshia tridentata*/*Artemisia tridentata* (PUTR/ARTR)
5. *Artemisia tridentata*/*Festuca idahoensis* (ARTR/FEID)
6. *Acer glabrum*/*Philadelphus lewisii* (ACGL/PHLE)
7. *Populus tremuloides*-*Prunus virginiana*/*Symphoricarpos albus* (POTR-PRVI/SYAL)
8. *Juniperus scopulorum*-*Purshia tridentata*/*Artemisia tridentata* (JUSC-PUTR/ARTR)
9. *Juniperus scopulorum*-*Purshia tridentata*/*Agropyron spicatum* (JUSC-PUTR/AGSP)
10. *Juniperus scopulorum*-*Purshia tridentata*/*Festuca idahoensis* (JUSC-PUTR/FEID)
11. *Pseudotsuga menziesii*/*Prunus virginiana* (PSME/PRVI)
12. *Pseudotsuga menziesii*/*Symphoricarpos albus* (PSME/SYAL)
13. *Pseudotsuga menziesii*/*Festuca idahoensis* (PSME/FEID)
14. *Pseudotsuga menziesii*/*Carex geyeri* (PSME/CAGE)
15. *Pseudotsuga menziesii*/*Agropyron spicatum* (PSME/AGSP)
16. *Pseudotsuga menziesii*/*Calamagrostis rubescens* (PSME/CARU)

METHODS

Distribution and Movements

Emphasis was placed upon obtaining relocations of radio-marked deer to evaluate mule deer distribution and movements on the Armstrong Winter Range. A total of 19 individuals were equipped with transmitter collars, each consisting of an AVM transmitter and lithium battery encapsulated in dental acrylic, connected to an antenna, and inserted in Tygon tubing or molded PVC plastic pipe. Fourteen individuals (9 does and 5 bucks) were under surveillance during the winter of 1976-77. Sixteen individuals (12 does and 4 bucks) were available during the winter of 1977-78, 11 of which had worn functional transmitters the previous winter.

Ground relocations of instrumented animals were made on foot with the use of an AVM Model LA12 receiver and a hand-held three element Yagi antenna. Use of biotelemetry on the study area is hampered by the rugged topography, making it possible to use triangulation only to a very limited extent. Therefore, only those relocations verified with a visual sighting or made at close range with certainty were recorded. An attempt was made to obtain at least one reliable relocation per instrumented deer during each day spent on the study area.

Aerial relocations of instrumented animals were obtained during 28 flights in a Piper Supercub aircraft equipped with a three element Yagi antenna. Flights were made at weekly intervals, weather

permitting, during the winter of 1977-78 and during February and March of 1977. The general distribution of mule deer and extent of deer activity on the winter range were also noted during these flights.

All relocation data for instrumented deer were analyzed using a Xerox Sigma 7 computer with an animal distribution and movement computer program developed by Terry N. Lonner, Montana Department of Fish and Game.

Habitat Use

Information on mule deer habitat usage was obtained through ground and aerial surveillance of instrumented individuals, augmented by observations of neckbanded and unmarked animals. During the course of previous studies on the area, and during the present study, deer were trapped and marked with four inch wide individually color coded neckbands made of Armor-tite fabric (Mackie *et al.* 1975). Fifty-eight deer wearing recognizable neckbands or transmitter collars were observed on the study area by the end of April, 1977, and 76 by the end of April, 1978. Conventional ground observations of marked and unmarked mule deer were obtained with the aid of a 32X spotting scope and binoculars.

All ground and aerial mule deer observations and relocations were marked on aerial photograph maps and the following parameters were

recorded whenever possible: group size, sex and age classes, markings, habitat type, cover, snow depth, activity, exposure, slope and elevation. Behavioral interactions were noted when the presence of the investigator was undetected. When movement to another habitat type occurred by undisturbed animals, the new location was recorded as an additional observation for purposes of habitat type usage.

A dot grid overlay was utilized to compute the proportion of total area occupied by each habitat type for winter range units and for individual core home ranges. The percentage of total relocations within each habitat type was assumed to be directly proportional to usage of each type by the animal concerned.

Collection of Weather Data

Temperature and relative humidity were monitored on the study area during both winters with the use of a hygrothermograph. It was located in an enclosure on a west facing slope at an elevation of 1783 m. During the 1976-77 winter, weekly readings were taken from a maximum-minimum thermometer located on a north facing forested slope, at an elevation of 1768 m. During the 1977-78 winter, 6 maximum-minimum thermometers were used to record temperature extremes in different habitat types at various elevations and exposures. They were read at approximately weekly intervals, then

moved to new locations.

Wind direction and velocity at a height of 1 m were measured with a Dwyer manometric windmeter during ground observation periods the second winter.

Snow depth and conditions were monitored during the course of obtaining deer observations. During February and March of 1977, black and white photographs were taken of the winter range from a distance of 1.6 km in order to establish a record of snow cover on the area. Pictures were taken at intervals of 4-7 days. During the 1977-78 winter, a Kodak Analyst Super 8 time lapse camera was used for this purpose. It was installed 1.6 km southwest of the winter range and was connected to a timing device which allowed 20 frames to be exposed daily.

RESULTS

Distribution and Movements

The winters of 1976-77 and 1977-78 were quite different in severity as indicated by monthly climatological data (U.S. Weather Bureau) and severity indices (Picton and Knight 1971) listed in Table 1. The former was an "open" winter with relatively mild temperatures, light snowfall and frequent periods of snow melt which kept south and west facing slopes of the winter range free of snow most of the season. The latter was characterized by more average temperatures and snowfall. Snow cover was present on the winter range from December through the first half of March and the absence of melting allowed for substantial snow accumulations to persist during January and February. Snow melt progressed rapidly during March, and phenological data from Bozeman (Table 2) indicate that plant growth and development during the spring of 1978 was the earliest since records were established in 1954. Phenological development during the spring of 1977 was the second earliest recorded during the same time period (D.K. Scharff. pers. comm.).

The contrast in severity between the two winters was reflected by deer distribution and range use patterns seen each year. Mild conditions of the winter of 1976-77 severely limited deer observations and relocations. Some deer spent at least a portion of the winter on summer or intermediate range areas, while others spent most of the season in heavily forested habitats in the vicinity of

Table 1. U.S. Weather Bureau Climatological Data, MSU Weather Station, Bozeman, and severity indices, November through May, 1976-77 and 1977-78.

		Ave. Temp. (°C)	Ppt. (cm)	SNOW			Severity Index ¹
				Total (cm)	Max. Depth (cm)	No. Days on Ground	
NOV	1976	1.9	.51	9.9	10	4	- 415
	1977	-.2	3.02	30.5	20	11	+ 260
DEC	1976	-.9	.56	8.4	8	8	- 232
	1977	- 3.8	3.02	32.2	20	22	+ 315
JAN	1977	-.9	1.52	34.3	23	31	+ 583
	1978	- 5.4	2.62	34.8	30	31	+ 842
FEB	1977	1.0	.15	2.5	8	17	- 322
	1978	- 3.2	2.21	38.4	28	28	+ 892
MARCH	1977	-.6	6.07	68.6	20	23	- 184
	1978	2.9	1.88	11.7	25	19	+ 59
APRIL	1977	8.9	1.45	14.5	20	4	- 875
	1978	7.2	2.36	3.6	trace	0	- 692
MAY	1977	10.2	9.75	8.6	0	1	- 946
	1978	9.8	10.26	2.5	0	0	- 886
NOV-	1976-77	3.0	20.1	146.8	23	88	- 2391
MAY	1977-78	1.0	25.4	153.7	30	111	+ 790

¹+ values indicate greater severity (Picton and Knight 1971).

Table 2. Phenology of lilac (*Syringa vulgaris*) development and growth in Bozeman.¹

YEAR	EARLY BUD STAGE ²	LUSH FULL BLOOM
1954-1970 Mean	12 May	8 June
1977	25 April	28 May
1978	20 April	28 May

¹Data provided by Donald K. Scharff, Professor, Biology Dept., Montana State University.

²Early bud stage = first sight of flower buds; leaf buds are open and new growth is about 1 inch long.

the upper boundary of the winter range. Unusually wide deer dispersion and high elevation sightings were recorded during both the January and March helicopter surveys of the area (R.J. Mackie, pers. comm.). Most neckbanded individuals were not sighted on the winter range until spring green-up in late March and April. The spring green-up period was the only time that the lower portion of the winter range was used intensively.

Winter conditions of 1977-78 forced the wintering mule deer population to utilize the lower portion of the winter range during the entire winter, in contrast to the previous year. The dissimilarity between winters in elevational use of the Armstrong Winter Range by instrumented deer is illustrated in Table 3. Differences between mean elevation of relocations is particularly striking for

Table 3. Mean monthly relocation elevations for instrumented deer on the Armstrong Winter Range, winters 1976-77 and 1977-78.

MONTH	MEAN (m)		MAXIMUM (m)		MINIMUM (m)	
	1976-77	1977-78	1976-77	1977-78	1976-77	1977-78
DEC	----	1763	----	1896	----	1680
JAN	1926	1738	2034	1881	1820	1619
FEB	2198	1824	2363	1908	2006	1683
MARCH	1969	1858	2195	1982	1768	1738

the month of February.

The time of arrival on the winter range differed among individuals (Appendix Table 4) but the relative order of appearance the second winter was similar to that noted the first. Arrival dates for instrumented deer spanned a period of a month both years; December 15 to January 19 the first winter and November 16 to December 17 the second. During the fall of 1977, four does utilized fall intermediate ranges or "holding areas" (Pac, 1976) before traveling to the winter range. Two bucks and a doe exhibited erratic, wide-ranging movements during November while another buck and two does proceeded directly to the winter range from their respective summer ranges. Once within the Armstrong Winter Range boundary, some individuals exhibited exploratory movements (Baker, 1978) for variable periods of time before settling on a core home range to spend the rest of the winter (Appendix Table

4). Others proceeded directly from their fall intermediate ranges or summer home ranges to their respective winter core home ranges where they remained for the duration of the season.

Relocation data for instrumented and neckbanded deer suggest that the portion of the Armstrong Winter Range below 1980 m elevation is actually comprised of three major winter range units, or zones of use. Boundaries of these three winter range units were determined from the superimposed 1977-78 winter home range boundaries obtained for 16 instrumented deer and 58 neckbanded individuals which were observed regularly (Fig. 3). The existence of these zones of use is supported by relocation data from late February and March of 1975 and 1976 (R.J. Mackie, pers. comm.) and by my own observations during March and April of 1977. Use of only one particular winter range unit is evident for almost all marked does, but the winter home ranges of marked bucks tend to be larger than those of does and to overlap into an adjacent winter range unit. The north and south winter range units are similar in that they are characterized by a west to southwest exposure with north facing subslopes and declivities of 26-30°. The middle unit has a predominately southern exposure with 28-35° slopes and a more heterogeneous topography than the other two units. Instrumented deer are identified as to which winter range unit each uses; N for north end, M for middle and S for south end.

Commonly used mathematical expressions of animal movement include

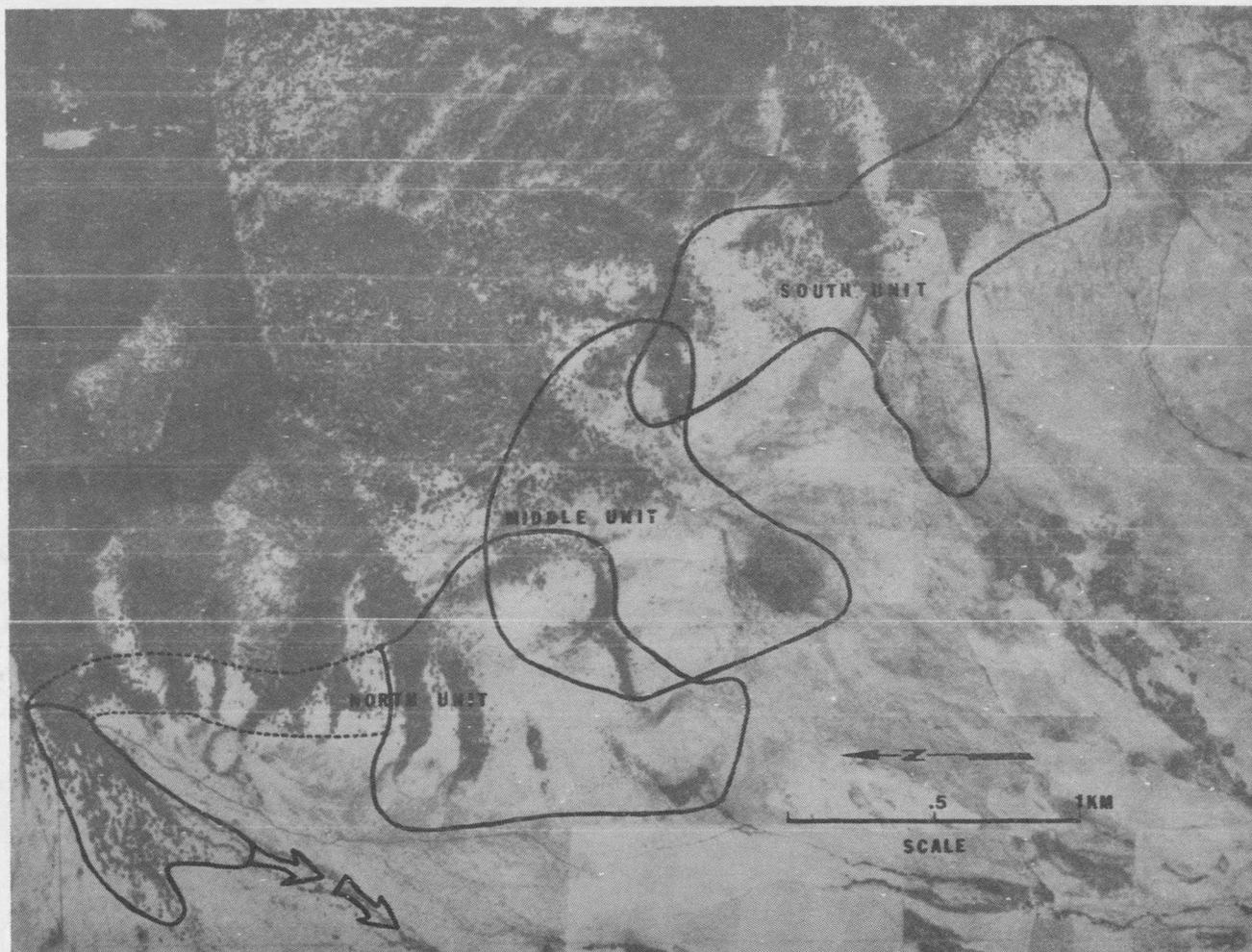


Figure 3. Aerial view of the Armstrong Winter Range showing boundaries of the north, middle and south range units. Solid lines delineate areas of primary use; dashed lines indicate secondary use.

polygon home range, standard diameter and average activity radius. Polygon home range size is determined by connecting the outermost relocation points of an animal's home range and determining the area of the resulting polygon (Mohr, 1947). The standard diameter is calculated from individual distance measurements from the geographic activity center to each relocation point, and is defined as a circle of one standard diameter which will contain 68.26 percent of all relocations (Harrison, 1958). The average activity radius is the average distance between the geographic activity center and each relocation point (Hayne, 1949).

Adequate data were gathered during the winter of 1977-78 to compare the usefulness of each of the above expressions in interpretation of seasonal mule deer movement. Winter-long polygon home ranges, standard diameters and average activity radii calculated for 9 individuals are listed in Table 5. Values obtained from aerial and from ground relocations are listed separately from those determined from combined aerial and ground relocations.

Two north end deer, 176[♂] and 372[♀], each show the largest polygon home range for combined aerial and ground relocations and the smallest for ground relocations only. Both individuals were characterized by extensive linear movements along creek channels, which made it impossible to keep track of them by ground means during parts of the winter. Although their diverse movements are reflected in very

Table 5. A comparison of home range size indices for instrumented deer of the Armstrong Winter Range, winter 1977-78.

ANIMAL ID.	TYPE AND NO. OF FIXES	POLYGON H.R. (KM ²)	VARIANCE	STD. DIAM. (KM)	VARIANCE	AVE. ACT. RADIUS (KM)	VARIANCE
176♂ ⁴ N	¹ T 25	8.19		3.17		1.43	
	² G 13	3.26	4.18	2.29	.28	1.09	.04
	³ A 12	6.50		3.57		1.58	
372♀N	T 64	2.73		1.43		.60	
	G 48	2.33	.03	1.25	.05	.51	.02
	A 16	2.52		1.79		.81	
477♀N	T 65	.73		.72		.30	
	G 49	.67	0	.69	0	.29	0
	A 16	.56		.76		.33	
173♀N	T 50	.72		.75		.34	
	G 37	.62	.01	.72	0	.32	0
	A 13	.49		.84		.39	
1273♂M	T 44	1.53		1.21		.57	
	G 32	1.52	.13	1.26	.01	.60	0
	A 12	.77		1.02		.48	
1675♀M	T 44	1.11		.84		.36	
	G 34	1.11	.11	.86	0	.37	0
	A 10	.40		.71		.33	
175♀M	T 67	.87		.80		.36	
	G 51	.87	.05	.82	0	.37	0
	A 16	.41		.73		.34	
177♀M	T 61	.75		.72		.32	
	G 45	.73	.05	.76	.01	.35	0
	A 16	.27		.55		.25	
1974♀M	T 65	.56		.81		.38	
	G 49	.56	.02	.82	0	.38	0
	A 16	.28		.79		.38	

¹T = Total ground and aerial relocations

²G = Ground relocations only

³A = Aerial relocations only

⁴Winter range units; N = north, M = middle and S = south

large polygon home range sizes, these figures greatly overestimate the area actually used.

The home ranges of 477♀N and 173♀N were characterized by several major activity centers with irregular use between and surrounding them. They are adequately described by the polygon home range expression, and the extent of movement exhibited by these individuals was better detected by frequent ground relocations than by weekly aerial relocations (Table 5).

Polygon home range values provide an accurate description of home range sizes for individuals of the middle range unit, with one exception. Buck 1273 exhibited a circuitous movement pattern which resulted in a donut-shaped winter home range. The polygon home range figure overestimated the area he actually used by 41 percent. The other individuals of the middle unit were characterized by compact seasonal home ranges, used in a homogeneous fashion. For all instrumented deer of this unit, the polygon home range determined from combined ground and aerial relocations was very comparable to the figure derived from ground relocations only (Table 5), suggesting that ground surveillance by itself was adequate to define winter home range size.

Discrepancies between figures derived by ground and aerial methods indicate that weekly aerial sampling underestimated spatial use by more than one half for all individuals except 176♂⁷N and

3729N. This trend emphasizes the importance of more frequent relocations for assessment of home range size and extent of movement.

Lonner (1978) stated that the standard diameter expression serves as a good index to home range size and that sample size discrepancies are not as apparent when using this expression as they are with the polygon home range technique. Variances of standard diameters, average activity radii and polygon home ranges for each instrumented individual of the Armstrong Winter Range (Table 5) reflect the lesser effect of sample size upon the former two expressions. Although the average activity radius expression detects substantial differences in home range size among individuals, it is less indicative of moderate size differences than is the standard diameter. The relative constancy of the standard diameter and average activity radius as compared to the polygon home range favors the use of the former two indices when comparing data for which there is a large discrepancy in sample size or in sampling frequency. It is also important to consider the movement pattern peculiar to each individual when interpreting home range size indices.

Home range size indices for instrumented deer of the Armstrong Winter Range during the winters of 1976-77 and 1977-78 are listed in Table 6. The largest home ranges exhibited during the winter of 1976-77 belonged to three individuals of the north winter range unit who spent a portion of the winter outside the normal boundary of the

Table 6. Home range size indices for instrumented deer of the Armstrong Winter Range, winters 1976-77 and 1977-78.

ANIMAL ID.	NO. FIXES	POLYGON H.R. (KM ²)	STD. DIAM. (KM)	AVE. ACT. RADIUS (KM)	DISTANCE BETWEEN FIXES (KM)			
					MAX.	MIN.	MEAN	STD. DEV.
<u>WINTER 1976-77</u>								
1173♀N ¹	16	3.07	1.85	.76	2.06	.14	.90	.66
176♂N	12	1.83	1.42	.60	1.43	.15	.65	.36
372♀N	11	1.12	2.26	1.10	1.70	.16	.66	.58
173♀N	16	.98	1.12	.54	.86	.10	.42	.26
MEAN		1.75	1.66	.75	1.51	.14	.66	.46
177♀M	13	.97	1.13	.49	.99	.10	.54	.32
175♀M	17	.92	.92	.41	1.03	.01	.49	.32
973♀M	16	.83	1.00	.47	1.15	.07	.45	.28
2575♀M ²	11	.64	1.02	.42	.86	.16	.55	.27
776♀M	9	.54	1.03	.45	.81	.18	.43	.21
MEAN		.78	1.02	.45	.97	.10	.49	.28
<u>WINTER 1977-78</u>								
176♂N	26	8.19	3.17	1.43	4.44	---	.95	1.15
372♀N	64	2.73	1.43	.60	1.81	---	.44	.44
1173♀N	34	.75	.72	.31	.90	.10	.38	.23
477♀N	65	.73	.72	.30	.72	---	.25	.18
173♀N	50	.72	.75	.34	1.23	.04	.39	.24
MEAN		2.62	1.36	.60	1.82	.03	.48	.45
1273♂M	43	1.54	1.21	.57	1.22	---	.45	.36
1675♀M	44	1.11	.84	.36	1.17	---	.41	.32
175♀M	66	.87	.80	.37	1.26	---	.41	.31
776♀M	48	.82	.79	.35	1.03	---	.39	.29
177♀M	61	.75	.72	.32	1.06	---	.34	.24
1974♀M	65	.56	.81	.38	1.09	---	.32	.26
MEAN		.94	.86	.39	1.14	0	.39	.30
2078♀S	36	.40	.68	.28	.99	---	.31	.22
778♂S	35	.94	.84	.30	1.66	---	.24	.29
MEAN		.67	.76	.29	1.32	0	.28	.26

¹Winter range units; N = north, M = middle and S = south

²Neckbanded individual

winter range, on the north ridge of North Cottonwood Creek. Doe 1173 made two trips to this area; one in February and one in March and buck 176 made one trip in January. Doe 372 spent the entire month of February and the first half of March on this area, which also served as a fall/spring intermediate range for all three individuals. Doe 372 essentially exhibited two geographic centers of activity separated by a distance of two air kilometers, which resulted in a disproportionately large standard diameter and average activity radius (Table 6). The remaining instrumented individuals spent the winter in the vicinity of the upper boundary of the winter range.

With the exception of 176[♂]N and 372[♀]N, instrumented deer exhibited well-defined and compact home ranges during the winter of 1977-78. Buck 176N spent the last half of December north of North Cottonwood Creek before moving west into the Gallatin Valley where he used creek bottom habitats and brushy swales adjacent to grain stubble fields. Accompanied by two forked-horn bucks, he remained approximately 3.25 km west of the winter range during the latter half of January and the first half of February. On February 13, after a heavy snowstorm, he was relocated back on the winter range where he remained until his death in early March. Doe 372N displayed a similar movement pattern but ranged only as far as 1.5 km west of the winter range and returned January 30. At least 21 additional individuals including four neckbanded does, were known to have followed

a range use pattern similar to that of doe 372N.

Two south unit individuals, 2078♀ and 778♂, were instrumented at the beginning of February. Buck 778 spent the winter between Bill Smith and Tom Reese Creeks, south of the Armstrong Winter Range boundary. Doe 2078 used areas on both sides of Bill Smith Creek, as did three neckbanded bucks.

Mean standard diameters and average activity radii (Table 6) indicate that instrumented individuals ranged over a larger area the first winter than they did the second. The greater mean distance between fixes for deer of the north and middle winter range units during the first winter probably reflects the lesser frequency of relocation as well as the greater extent of movement that year. The mean distance between fixes for each winter also indicate that north unit deer were characterized by more extensive movement than middle unit individuals during both years.

Means of average activity radii for marked deer of the Armstrong Winter Range since 1972 are listed in Appendix Table 7.

Habitat Use

Winter 1976-77

Percent total use received by each habitat type of the Armstrong Winter Range, as determined by three sampling techniques, is shown in Table 8. A visual bias toward shrub/grass habitat types is

Table 8. Percent total use of each habitat type of the Armstrong Winter Range by mule deer during the winter of 1976-77, as determined by three sampling techniques.

HABITAT CATEGORY (visual aspect)	HABITAT TYPE	PERCENT TOTAL OBSERVATIONS OR RELOCATIONS		
		GROUND OBS.	AERIAL OBS.	INSTRUMENTED DEER
GRASS	#1 FEID/AGSP	---	1	---
	#2 AGSP/AGSM	---	---	---
SHORT SHRUB/ GRASS	#3 PUTR/AGSP	2	7	1
	#4 PUTR/ARTR	31	19	11
TALL SHRUB/ GRASS	#5 ARTR/FEID	24	9	7
	#6 ACGL/PHLE	---	---	---
	#7 PUTR-PRVI/SYAL	---	---	---
	#8 JUSC-PUTR/ARTR	---	---	---
SHRUB/GRASS ECOTONE	#9 JUSC-PUTR/AGSP	---	---	---
	#10 JUSC-PUTR/FEID	---	---	---
TOTAL SHRUB/GRASS TYPES		61	36	19
FOREST	#11 PSME/PRVI	---	---	---
	#12 PSME/SYAL	6	9	2
	#13 PSME/FEID	---	---	3
	#14 PSME/CAGE	6	8	23
	#15 PSME/AGSP	10	15	8
	#16 PSME/CARU	15	19	24
FOREST ECOTONE		2	13	21
TOTAL FOREST TYPES		39	64	81 ¹
TOTAL INDIVIDUAL OBSERVA- TIONS OR RELOCATIONS		238	225	123

¹Includes 12 percent of total use beyond the upper boundary of the winter range (2260-2410 m elev.) and 13 percent immediately north of North Cottonwood Creek.

evident for ground and aerial observations, compared to relocations of instrumented deer. The relatively small number of relocations of each instrumented deer (ave. 3.2 per month) was not adequate for assessment of individuality in habitat use but did furnish information regarding distribution of deer activity among winter range habitat types which could not have been obtained by any other means.

Heavy use (80 percent) of forested habitat types by instrumented deer (Table 8) reflects the disproportionately heavy deer use received by the forested upper half of the winter range during the mild winter. Of the 19 percent total use of shrub/grass types of the lower winter range recorded for instrumented deer, 8 percent occurred during January and 11 percent occurred during the latter half of March. Use of shrub/grass types was almost exclusively limited to PUTR/ARTR and ARTR/FEID types of the upper south slopes between 1800 and 2070 m. Surveillance of instrumented deer as well as aerial and ground observations failed to detect any use of shrub/grass types during the months of December and February.

January was the most severe winter month (Table 1), characterized by particularly cold temperatures during the first 15 days (Appendix Table 9) with snow depths on west and south slopes of the winter range attaining 30 cm. Fifty-seven percent of relocations of instrumented deer were in timbered types above 1920 m and the remainder were in PUTR/ARTR and ARTR/FEID types. South and west slopes below

1950 m were snow-free during all of February, and very warm temperatures prevailed (Appendix Table 9). Rather than use areas bare of snow, deer appeared to prefer to remain in upper forested areas of the winter range having at least 10-15 cm of snow, and as much as 50 cm. Instrumented deer remained between 2290 and 2410 m elevation during this time period, in the vicinity of the upper boundary of the winter range and on the north ridge of North Cottonwood Creek, in the PSME/CAGE, PSME/CARU and PSME/AGSP habitat types and ridgetop ecotones.

More snow fell during March than during the preceding months (Table 1). Snow cover was present on the lower winter range during the entire month but periods of melting following snow flurries did not allow maximum snow depths on south slopes to exceed 15 cm. Instrumented deer continued to use forested types between 2130 and 2380 m during the first half of the month. Activity shifted to forest and shrub/grass types below 2130 m during the latter half of the month, which coincided with the availability of new spring plant growth on lower slopes. Eight to 10 cm of snow were remaining on south slopes on March 21 but all south and west slopes had been cleared of snow by April 4.

Winter 1977-78

The obviously diverse degrees of use of each habitat type among individuals and large standard deviations indicate individual

differences in habitat selection for north unit (Table 10) and middle unit (Table 11) deer during the 1977-78 winter. A contrast in habitat type usage between the two instrumented individuals of the south unit is also apparent (Table 12). A Chi-square test was used to compare observed mean percentage of use of each habitat type, and of the two major habitat categories on the north and middle units, with values expected if habitat usage were random. Habitat types receiving significantly greater than expected usage were the JUSC-PUTR/FEID type of the north unit and the PSME/PRVI type of the middle unit. Extensive use of creek bottom types off the winter range by north unit instrumented deer ($\bar{x} = 17.8\%$) could not be taken into account in the Chi-square comparison.

For each of the three winter range units, the mean percentage of use of total shrub/grass types was 20-25 percent less than would be expected if these types were used in proportion to the unit area they occupy (Tables 10-12). In contrast, the mean percentage of use of total forested types was greater than the proportional area these types occupy in each unit. Shelter and snow conditions characteristic of creek bottom habitats used by two instrumented deer of the north unit (Table 10) were similar to those in forested habitat types. Shrub communities of creek bottom habitats were associated either with juniper (*Juniperus scopulorum*) or with an aspen-cottonwood (*Populus tremuloides*-*Populus trichocarpa*) or Douglas fir (*Pseudotsuga*

Table 10. Percent total use of each habitat type by instrumented deer of the north unit of the Armstrong Winter Range, winter 1977-78.

HABITAT TYPES OF THE NORTH WINTER RANGE UNIT	PERCENT UNIT AREA	PERCENT TOTAL RELO- CATIONS WITHIN EACH HABITAT TYPE				MEAN	STD. DEV.	CHI- SQUARE ¹
		173 ²	477 ²	372 ²	176 ³			
#1 FEID/AGSP	7	--	--	3	--	.8	1.5	*12.22-
#2 AGSP/AGSM	3	--	--	--	--	---	---	* 6.83-
#3 PUTR/AGSP	3	4	3	3	--	2.5	1.7	.76-
#4 PUTR/ARTR	37	49	32	27	20	32.0	12.4	2.37-
#5 ARTR/FEID	11	6	--	4	4	3.5	2.5	*11.06-
#6 ACGL/PHLE	3	--	2	2	--	1.0	1.2	3.04-
#7 PUTR-PRVI/SYAL	1	--	2	--	--	.5	1.0	2.23-
#9 JUSC-PUTR/AGSP	1	--	2	--	--	.5	1.0	2.23-
#10 JUSC-PUTR/FEID	1	6	6	2	--	3.5	3.0	*20.09+
SHRUB/GRASS/ECOTONE	--	2	2	2	--	1.5	1.0	----
TOTAL SHRUB/GRASS TYPES	67	71	49	43	24	46.8	19.4	*32.39-
#12 PSME/SYAL	24	10	11	14	--	8.8	6.1	*31.01-
#13 PSME/FEID	8	14	14	9	--	9.2	6.6	1.20+
#16 PSME/CARU	2	2	--	--	16	4.5	7.7	0.0
FOREST ECOTONE	--	2	15	8	12	9.2	5.6	----
TOTAL FOREST TYPES	34	28	51 ²	31	32 ³	35.5	10.5	.39+
CREEK BOTTOM HABITAT TYPES OFF THE WINTER RANGE	--	--	--	27	44	17.8	21.6	----

¹*indicates significance ($p < .01$, $DF=1$).

+indicates that observed use was greater than that expected if habitat use were random.

-indicates that observed use was less than that expected if habitat use were random.

²Includes 11% of total relocations in the PSME/CAGE habitat type of the upper winter range where this individual spent the latter half of March.

³Includes 4% of total relocations in a PSME/AGSP habitat type north of North Cottonwood Creek.

Table 11. Percent total use of each habitat type by instrumented deer of the middle unit of the Armstrong Winter Range, winter 1977-78.

HABITAT TYPES OF THE MIDDLE WINTER RANGE UNIT	PERCENT UNIT AREA	PERCENT TOTAL RELOCATIONS WITHIN EACH HABITAT TYPE						MEAN	STD. DEV.	CHI- SQUARE ¹	
		175♀	776♀	177♀	1974♀	1273♂	1675♀				178♀
#2 AGSP/AGSM	4	--	--	--	--	--	--	--	--	*15.38-	
#3 PUTR/AGSP	13	8	6	9	3	--	10	4	5.7	3.6	*15.99-
#4 PUTR/ARTR	27	17	13	22	8	7	24	22	16.1	7.0	*22.66-
#5 ARTR/FEID	11	8	17	17	1	5	19	13	11.4	6.9	0.0
#8 JUSC-PUTR/ARTR	3	2	--	--	3	--	2	2	1.3	1.2	1.27-
SHRUB/GRASS ECOTONE	--	--	4	5	1	5	5	--	2.8	2.4	----
TOTAL SHRUB/GRASS TYPES	58	35	40	53	16	17	60	41	37.4	16.6	*54.69-
#11 PSME/PRVI	6	17	13	10	30	32	5	6	16.1	11.0	*65.42+
#12 PSME/SYAL	9	5	4	7	6	7	7	17	7.6	4.3	1.80-
#13 PSME/FEID	6	7	6	14	--	10	7	--	6.3	5.0	0.0
#14 PSME/CAGE	2	3	2	--	--	10	--	2	2.4	3.6	0.0
#15 PSME/AGSP	8	--	4	--	20	5	5	17	7.3	8.0	0.0
#16 PSME/CARU	11	12	11	10	14	7	5	9	9.7	3.0	.38-
FOREST ECOTONE	--	20	19	5	13	12	12	6	12.4	5.7	----
TOTAL FOREST TYPES	42	64	59	46	83	83	41	57	61.8	16.4	*54.69+

¹* indicates significance (p<.01, DF=1).

+ indicates that observed use was greater than that expected if habitat use were random.

- indicates that observed use was less than that expected if habitat use were random.

Table 12. Percent total use of each habitat type by instrumented deer of the south unit of the Armstrong Winter Range, winter 1977-78.

HABITAT TYPES OF THE SOUTH WINTER RANGE UNIT	PERCENT UNIT AREA	PERCENT TOTAL RELOCA- TIONS WITHIN EACH H.T.		MEAN
		778 [♂]	2078 [♀]	
#3 PUTR/AGSP	21	--	11	
#5 ARTR/FEID	7	--	6	
#10 JUSC-PUTR/FEID	2	--	11	
SHRUB/GRASS ECOTONE	--	6	--	
TOTAL SHRUB/GRASS TYPES	51 ¹	24 ²	28	26
#12 PSME/SYAL	27	32	28	
#14 PSME/CAGE	8	--	26	
#15 PSME/AGSP	15	38	11	
FOREST ECOTONE	--	6	6	
TOTAL FOREST TYPES	50	76	71	73

¹Includes sagebrush slopes between Bill Smith and Tom Reese Creeks which have not been habitat typed, but comprise 21 percent of the total south unit area.

²Includes 18 percent total use of sagebrush slopes referred to above.

menziessi) overstory.

To facilitate further clarification of individuality in habitat selection, "core" home ranges were delineated for each instrumented animal. Baker (1978) redefined home range in a temporal sense, and distinguished between a home range and a familiar area. He described the familiar area as a collection of habitats; a proportion of the total ever encountered by an individual, within which it is capable of finding its way from any one point to any other. Some of the habitats within the familiar area are exploited while others are not, but any habitat may be revisited periodically for purposes of reassessment or during exploratory forays. Yet other habitats are neither exploited nor revisited, but their spatial positions and characteristics are stored with varying degrees of detail in the animal's memory. Baker (1978) defined home range as the collection of habitats utilized during a specified time period, within the familiar area. I will refer to Baker's definition of home range as the "core" home range.

Ten of the twelve instrumented individuals monitored winter-long exhibited occasional diverse movements to locations outside their regularly used core home ranges. Polygon home ranges for these individuals were adjusted by elimination of such relocations and percentages of the core home ranges occupied by each habitat type were computed. Winter core home ranges averaged 34 percent smaller

than polygon home ranges. A ratio of percent use to percent area was obtained for each habitat type, for each individual. A value of 1 indicates that the percent use was equal to the percent area that the habitat type occupied within the core home range. A value greater than 1 indicates that the percent use was greater than the percent area, implying selection, while the opposite is true for values less than 1.

Preference ratios for individual habitat types and for shrub/grass and forest habitat categories within core home ranges vary widely among individuals (Table 13). However, preference ratios less than one for total shrub/grass types and greater than one for total forested types, for all individuals of the north and middle range units indicate a common preference for forest types. Corresponding figures for the two south unit deer are approximately equal. Habitat types most selected included the JUSC-PUTR/FEID and PSME/FEID types of the north unit and PSME/SYAL and PSME/PRVI types of the middle unit. The former three types are located on north-facing sub-slopes between 1740 and 1860 m elevation and form narrow strips of cover, varying from 150 m to 250 m at the widest point. The PSME/PRVI type is a round clump of timber approximately 500 m in diameter, located at the base of the middle unit at an elevation of 1680 m. Percent canopy coverage values for the PSME/FEID, PSME/SYAL and PSME/PRVI types are 59, 57, and 64, respectively (Bucsis 1974).

Table 13. Habitat preference ratios (percent use/percent area occupied within core home range) for instrumented deer of the Armstrong Winter Range, winter 1977-78.¹

HABITAT CATEGORY (visual aspect)	HABITAT TYPE	Habitat Preference Ratios															
		NORTH UNIT				MIDDLE UNIT								SOUTH UNIT			
		173 ♀	477 ♀	372 ♀	X	175 ♀	776 ♀	177 ♀	1974 ♀	1273 ♂	1675 ♀	178 ♀	X	STD. DEV.	778 ♂	2078 ♀	X
GRASS	#1 FEID/AGSP	-- ²	--	.83	.28	==	==	==	==	==	==	==		==	==		
	#2 AGSP/AGSM	--	--	==		--	--	--	--	--	--	==		==	==		
SHORT SHRUB/ GRASS	#3 PUTR/AGSP	.67	.38	.71	.59	.47	.38	.50	.19	--	.71	.31	.37	.23	==	.65	
	#4 PUTR/ARTR	.98	.68	.86	.84	.67	.56	.77	.40	.54	.75	.81	.64	.15	==	==	
TALL SHRUB/ GRASS	#5 ARTR/FEID	.33	--	.80	.38	.58	1.21	1.64	.10	.28	1.33	1.3	.86	.62	--	.54	
	#6 ACGL/PHLE	--	.50	--	.17	==	==	==	==	==	==	==		==	==		
TALL SHRUB/ GRASS	#7 POTR-PRVI/SYAL	--	2.0	==	.67	==	==	==	==	==	==	==		==	==		
	#8 JUSC-PUTR/ARTR	==	==	==		.33	--	--	.60	--	.50	.33	.25	.25	==	==	
TOTAL SHRUB/GRASS TYPES	#9 JUSC-PUTR/AGSP	--	1.0	--	.33	==	==	==	==	==	==	==		==	==		
	#10 JUSC-PUTR/FEID	3.5	3.5	1.0	2.67	==	==	==	==	==	==	==		--	1.83		
TOTAL SHRUB/GRASS TYPES		.91	.71	.81	.81	.55	.70	.83	.31	.29	.89	.73	.61	.24	1.33	.82	1.08
FOREST	#11 PSME/PRVI	==	==	==		2.57	2.60	2.0	4.28	5.33	.83	1.4	2.72	1.59	==	==	
	#12 PSME/SYAL	.90	1.20	.65	.92	2.0	.44	1.67	.75	.54	1.75	1.64	1.26	.65	.59	.76	
	#13 PSME/FEID	1.33	1.23	2.50	1.69	1.0	1.0	1.27	--	2.50	.88	--	.95	.85	==	==	
	#14 PSME/CAGE	==	==	==		1.0	1.0	--	--	1.43	--	--	.49	.63	--	1.62	
	#15 PSME/AGSP	==	==	==		--	.50	--	1.54	1.0	1.0	2.0	.86	.75	1.72	.85	
	#16 PSME/CARU	1.0	--	--	.33	.80	.85	.71	.70	.88	.45	.69	.72	.14	==	==	
TOTAL FOREST TYPES		1.20	1.96	1.46	1.54	1.91	1.37	1.29	1.69	1.93	1.20	1.35	1.53	.30	.93	1.08	1.0

¹A value of 1 indicates that the percent total use is equal to the percent area. A value greater than 1 indicates that the percent use was greater than the percent area. The reverse is true for values less than 1.

²-- indicates that use was not recorded

== indicates that the habitat type was not present within the core home range of the indicated individual.

These types provide shallow snow depths beneath conifer crowns and a great deal of edge, providing good visibility and access to adjacent slopes. The junipers of the JUSC-PUTR/FEID type provide sheltered bedding spots at their bases, which were heavily used. All four types were utilized for feeding as well as resting.

Usage percentages for each habitat type of the winter range, as determined by four sampling techniques are listed in Table 14. A visual bias toward shrub/grass habitat types is clearly evident for ground observations and for sightings of neckbanded individuals. The mean number of relocations obtained per individual (53.4 and 8.4 for instrumented and neckbanded deer respectively) and frequency of relocation as well as the observational bias associated with sightings of neckbanded and unmarked individuals, favors the use of instrumented animals for assessment of habitat use. Aerial surveys were the most effective means of determining the extent of deer activity occurring in creek bottom habitats west of the winter range.

Temporal Variation in Movements and Habitat Usage

The winter of 1977-78 was divided into seven biweekly time intervals for determination of changes in habitat usage and for convenient description of weather and snow conditions affecting those changes. Temporal variation in usage of forested versus shrub/grass habitat type categories, as determined by ground and aerial

Table 14. Percent total use of each habitat type of the Armstrong Winter Range by mule deer during the winter of 1977-78, as determined by four sampling techniques.

HABITAT CATEGORY (visual aspect)	HABITAT TYPE	PERCENT TOTAL OBSERVATIONS OR RELOCATIONS									
		GROUND OBS.	NECKBANDED DEER	AERIAL OBS.	INSTRUMENTED DEER	NORTH UNIT		MIDDLE UNIT		SOUTH UNIT	
						INST. DEER	NB. DEER	INST. DEER	NB. DEER	INST. DEER	NB. DEER
GRASS	#1 FEID/AGSP	--	--	--	--	1	1	--	--	--	--
	#2 AGSP/AGSM	--	--	--	--	--	--	--	--	--	--
SHORT	#3 PUTR/AGSP	7	12	10	5	4	5	6	13	6	31
SHRUB/	#4 PUTR/ARTR	56	64	21	20	32	77	16	63	--	22
GRASS	#5 ARTR/FEID	5	7	4	7	4	5	11	7	3	15
TALL	#6 AGL/PHLE	--	--	1	--	1	--	--	--	--	--
	#7 POTR-PRVI/SYAL	--	--	--	--	--	--	--	--	--	--
SHRUB/	#8 JUSC-PUTR/ARTR	1	1	2	2	--	--	2	2	--	2
GRASS	#9 JUSC-PUTR/AGSP	--	1	--	--	--	1	--	--	--	--
	#10 JUSC-PUTR/FEID	2	2	2	2	4	1	--	1	6	10
SHRUB/GRASS ECOTONE		12	4	10	3	3	3	4	5	3	1
TOTAL SHRUB/GRASS TYPES		83	91	50	39	49	93	39	91	18	81
FOREST	#11 PSME/PRVI	1	1	6	9	1	--	16	3	--	1
	#12 PSME/SYAL	2	1	3	10	8	1	7	--	29	2
	#13 PSME/FEID	1	1	4	7	10	1	6	1	--	1
	#14 PSME/CAGE	1	--	3	4	4	--	2	--	13	1
	#15 PSME/AGSP	4	2	4	7	1	--	8	2	25	10
	#16 PSME/CARU	2	1	2	6	2	--	10	--	--	2
FOREST ECOTONE		3	--	6	11	10	--	12	1	5	1
TOTAL FOREST TYPES		14	6	28	54	36	2	61	7	72	18
UNCLASSIFIED TYPES OFF THE ARMSTRONG WINTER RANGE		3	1	20	6	15	2	--	--	9	--
TOTAL INDIVIDUAL OBSERVATIONS OR RELOCATIONS		2658	641	1275	659	221	296	369	252	68	93

observations as well as surveillance of instrumented deer, is illustrated in Figure 4. Ground observations indicated a relatively constant degree of use of each habitat category compared to aerial observations or relocations of instrumented deer.

Temporal changes in use of the two major habitat categories by instrumented deer of the three winter range units are compared in Figure 5. The extent of use of areas outside the boundary of the winter range by deer of the north unit is shown in Figure 6.

Description of conditions during the associated time intervals follows.

December 16-31. Daily high and low temperatures recorded by the hygrothermograph located on the study area averaged -3.7 and -9.9°C . Snow depth was uniform on the base and the slopes of the winter range and increased from 10 to 33 cm during this time period. On December 17 deer were scattered over the entire winter range at elevations below 2040 m. By December 21 deer activity was concentrated on the lower periphery below 1830 m, and damage to haystacks by both deer and elk had occurred in the vicinity. The snow remained fluffy and did not impede deer locomotion or pawing behavior during feeding.

January 1-15. Daily high and low temperatures averaged $-.6$ and -5.9°C . Midday temperatures allowed the snow to become heavy and soggy in areas not protected from the sun. The crust present on

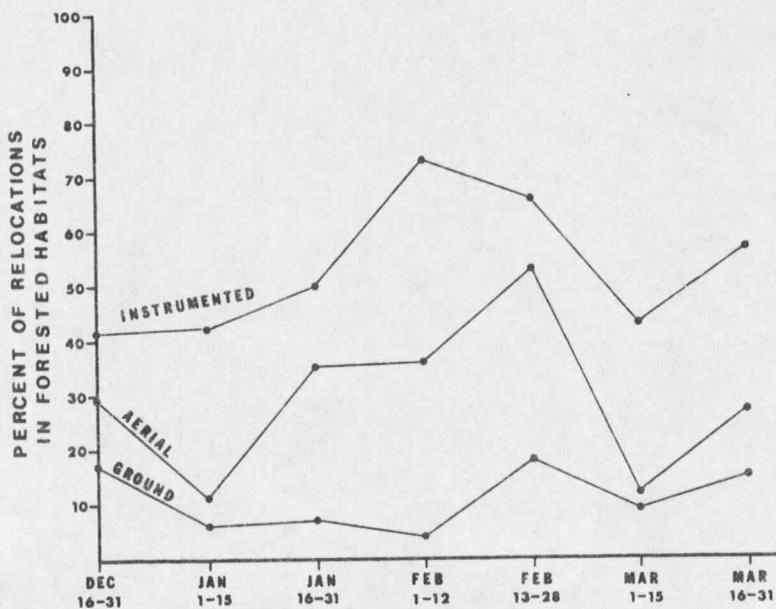
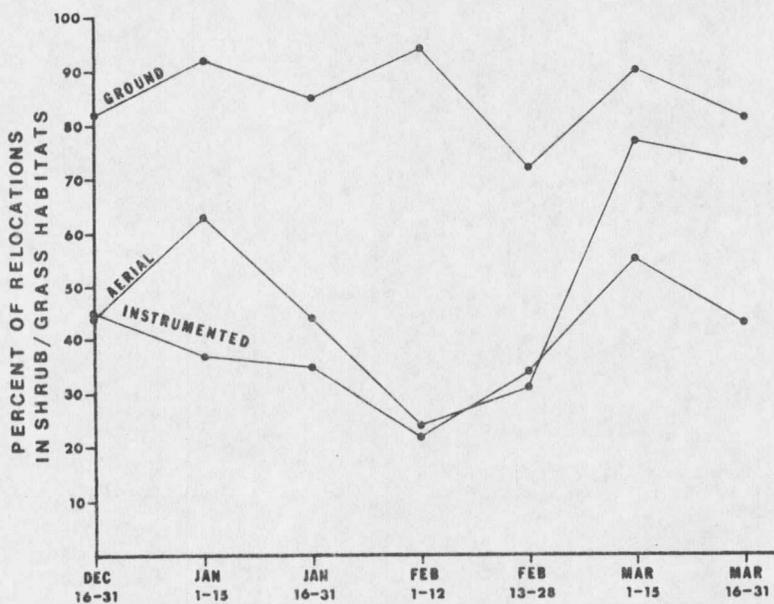


Figure 4. Temporal variation in relative usage of shrub/grass and forest habitat categories by instrumented deer compared to ground and aerial deer observations, winter 1977-78.

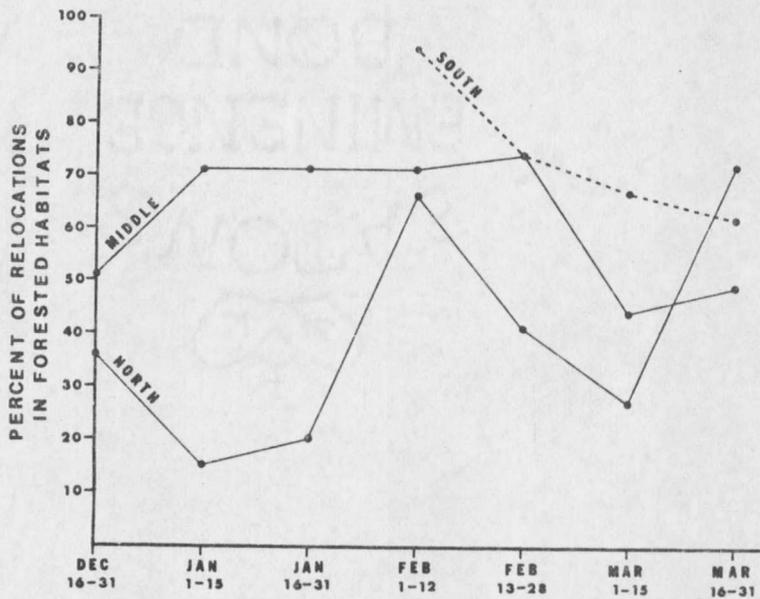
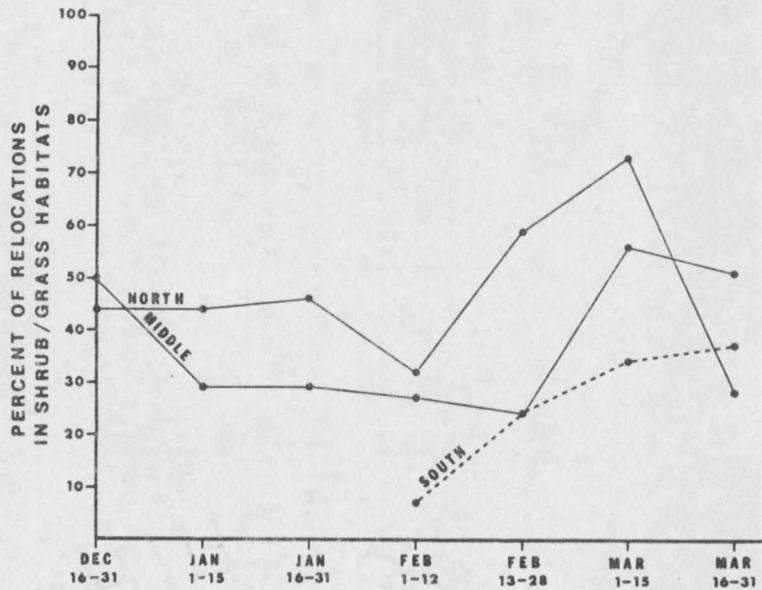


Figure 5. Temporal variation in relative usage of shrub/grass and forest habitat categories by instrumented deer of the north, middle and south units of the Armstrong Winter Range, winter 1977-78.

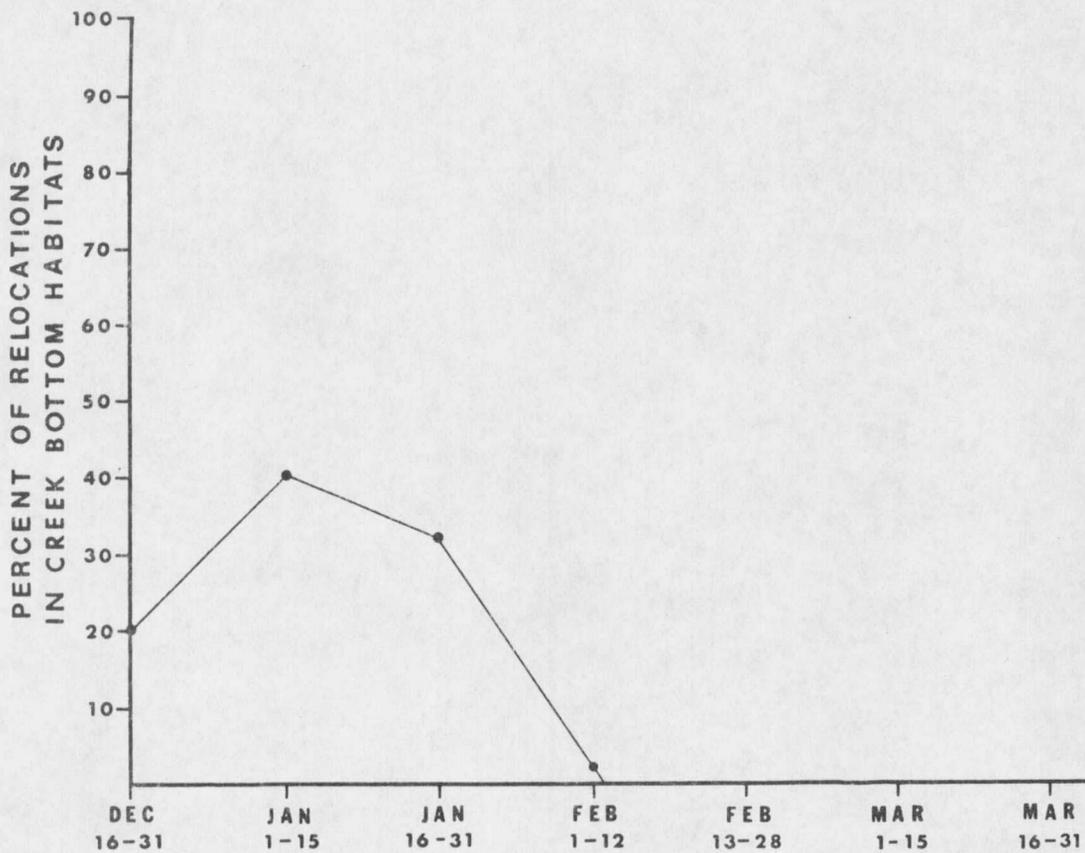


Figure 6. Temporal variation in usage of creek bottom habitats west of the Armstrong Winter Range by instrumented deer of the north range unit, winter 1977-78.

steep slopes at lower temperatures was not adequate to support the weight of a deer but it was substantial enough to impede locomotion. Deer of the south unit heavily used the PUTR/AGSP type adjacent to Bill Smith Creek at the lower periphery of the winter range while activity of north unit deer was concentrated in the channels of North Cottonwood Creek, extending 1 km west of the lower boundary. Activity of middle unit deer was concentrated in the PSME/PRVI, PSME/SYAL and PSME/FEID habitat types below 1890 m and south slopes adjacent to these types. Approximately 14 cm of new snow fell during this time period but melting and compaction left 36 cm at the base, 30 cm on west slopes and 23 cm on south slopes by mid-month.

January 16-31. Daily high and low temperatures averaged -2.8 and -9°C . Fifteen cm of new snow fell during the night of January 15. The snow crust formed on steep south and west slopes was not adequate to support the weight of a deer. By January 18, deer from the south unit had moved from the base of the winter range to PSME/AGSP and PSME/SYAL habitat types on the hillside. Most north end deer continued to use creek bottom types with most activity concentrated within .5 km of the lower boundary of the winter range, where a substantial coniferous canopy exists. Deer activity on the middle unit was concentrated in PSME/CARU and ARTR/FEID types on a "bench" area at an elevation of 1951 m and in the PSME/PRVI type at 1680 m. By January 31 snow was 53 cm deep at the base, 48 cm on west slopes and

41 cm on south slopes.

February 1-12. Daily high and low temperatures averaged .8 and -4.9°C . This period was characterized by wet, compacted snow which became crusty all the way through in areas exposed to the sun but the surface crust was still not adequate to support deer. Deer of all three units used timbered areas intensively where shallower snow without a crust could be found beneath conifer crowns. Deer activity was compressed into localized areas, producing "deeryard" conditions. A portion of the north unit population continued to use coniferous cover at the mouth of North Cottonwood Creek while the remainder moved to the southern boundary of the unit. By February 9, individuals of the middle unit began to use portions of the south slopes where melting had occurred adjacent to rock outcrops and bases of junipers. Snow was 43 cm deep at the base, 36 cm on west slopes and 20-30 cm on south slopes February 12.

February 13-28. Daily high and low temperatures averaged .7 and -6.6°C . Sixteen cm of new snow fell during the night of February 12, prompting north unit deer still using creek bottom habitats to move to timbered types on the hillsides. Beginning February 13, the snow crust supported deer at night and during sub-freezing daytime temperatures. Well-used paths connecting congregation areas in timbered types were conspicuous. By February 20, deer began feeding on south slopes, particularly in the vicinity of rock outcrops and

junipers where heat conduction had accelerated snowmelt. Some new plant growth was evident on these selected sites on February 23, and it was actively sought out and dug up by the roots. On February 28 snow was 46 cm deep at the base and bare to 20 cm on south and west slopes.

March 1-15. Daily high and low temperatures averaged .6 and -6.6°C . Eight cm of new snow fell March 1; the last significant snowstorm of the winter. A shift in activity from the north and south ends of the winter range toward south slopes of the middle unit was conspicuous. Deer exhibited voracious feeding behavior and bedded on open slopes to sun themselves between feeding periods. By March 7 the bared south slopes having new plant growth had been badly trampled, and deer use shifted north and south from the middle unit to areas still having snow cover but which had been unavailable previously due to excessive snow depth. On March 15 snow was 28 cm deep at the base, 10 cm on west slopes and mostly bare on south slopes.

March 16-31. Daily high and low temperatures averaged 13.7 and 4.4°C . Deer began to use lower slopes at the base of the winter range as snow receded and new plant growth appeared. Winter conditions were considered to have ended March 20, when all shrub/grass habitat types below 2070 m elevation were accessible, with south slopes bare and up to 15 cm of snow remaining on west slopes. Deer

continued to disperse until virtually all portions of the winter range received use by the end of the month. Feeding activity on open slopes was prevalent during morning and evening hours, but forested areas were used during midday rest periods. Deer of the north unit moved north as snow melted on west slopes while individuals of the middle and south units tended to follow the receding snowline to higher elevations.

Mean polygon home range sizes for instrumented individuals of the three winter range units were calculated for each of the seven time periods described above. North unit deer were characterized by much larger home ranges than middle unit deer during the latter half of December (Figure 7). The decline in home range size for north unit deer during the first half of January coincided with worsening snow conditions, which did not appear to affect the extent of movement of middle unit deer.

Mean home range size was greatest during the latter half of January for deer of both the north and middle units. Low temperatures during this period prevented alternate freezing and thawing of snow with resulting compaction and severe crust formation, characteristic of the first half of the month. A sharp decline in home range size occurred during the first half of February, coinciding with the most severe snow conditions of the winter. A peak in extent of use of timbered habitat types for north and south unit

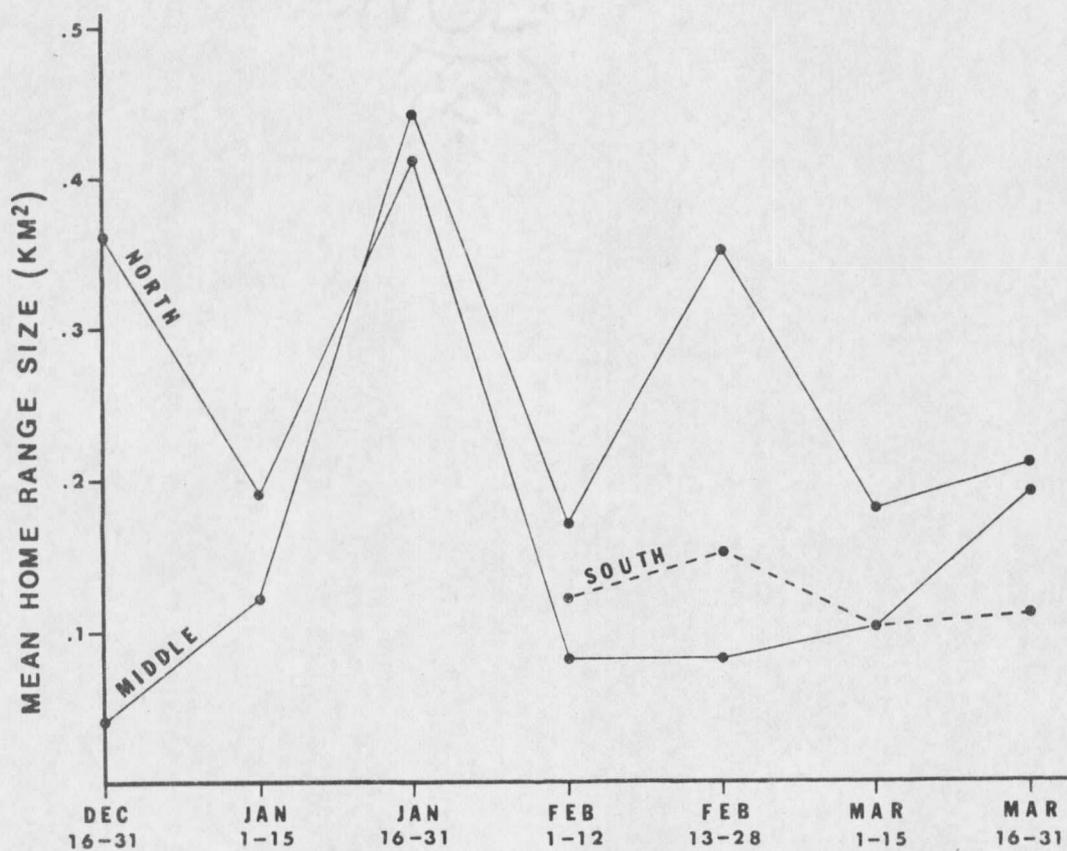


Figure 7. Temporal variation in mean polygon home range size for instrumented deer of the north, middle and south units of the Armstrong Winter Range, winter 1977-78. Buck 176 was not included in calculation of the mean home range size of north unit deer.

deer (Figure 5) was evident as well as "yarding" behavior by the general population in sheltered areas offering most favorable snow conditions. Area exploited by middle unit deer increased sharply during the latter half of February as melting began on south facing slopes of that unit. Home range size for north and south unit deer remained similar to the previous time period.

Polygon home range size as an index of area exploited by individuals is not considered to be as reliable for the month of March as for the previous winter period. It is acknowledged that deer movement took place during nighttime hours over the entire winter but activity was not considered to be extensive until snow conditions ceased to hinder mobility. It is believed that during March, extensive movement was associated with feeding during nighttime hours; particularly after new spring plant growth became available.

Microclimatic Variation on the Study Area

Maximum-minimum thermometers placed in various habitats indicated general ambient air temperature trends on the winter range. Maximum temperatures on south exposures tended to be about 1.1°C warmer than those on southwest slopes and 2.2°C warmer than west slopes. Maximum temperatures were as much as 3.3 to 5.5°C lower in draw bottoms than on south slopes. Maximum temperatures in forested habitats were 1.1 to 2.2°C cooler and minimum temperatures 1.1 to

2.2°C warmer than those on exposed sites.

Most exceptions to this general trend could be explained by temperature inversions. A temperature difference of 13.8°C was apparent between 1780 m (-13.9°C) and 1890 m (0°C) during an aerial survey in January, 1978. The number of deer sighted at the upper elevation during that flight suggested that deer had sought out the warmer ambient air temperature. Data from the maximum-minimum thermometers indicated that inversion situations, although of lesser magnitude than the one described above, are not uncommon on the area.

Temperatures recorded on a rock outcrop during March were 9.4°C and 2.2°C warmer than the respective maximum and minimum temperatures recorded on an adjacent open slope. The favorable microclimate provided by this and similar rock formations made them popular bedding spots on sunny days, and they were also the sites at which new plant growth was first available in February.

Rapid changes in wind direction and velocity are typical on the study area. However, generally moderate wind conditions during the 1977-78 winter made it impossible to determine the extent to which wind affected deer habitat usage. Of 60 day-long observation periods, 50 percent were calm, 13 percent had winds of 1.6-6.5 km/hr, 33 percent were 8.1-16.1 km/hr and 3 percent were 17.7-24.2 km/hr. Staines (1977) determined that the critical wind velocity causing red deer (*Cervus elaphus elaphus*) to seek shelter was about 12.9 km/hr at

temperatures between 2 and 20°C while Loveless (1967) did not observe reaction to wind by mule deer until velocity reached 40.3 km/hr, accompanied by temperatures of -9.4°C or below.

Wind velocity readings taken in various habitat types of the winter range indicated the effectiveness of vegetative shelter in reducing wind velocity. Wind velocities of up to 16.1 km/hr were reduced to half in PSME/FEID, PSME/SYAL and PSME/PRVI types at the 1 m level and were reduced to zero at ground level in the PSME/PRVI type. Winds oriented perpendicular to deep and narrow east-west draws were reduced by more than half at the 1 m height in these draw bottoms.

Population Characteristics and Behavior

Although the number of mule deer present on the Armstong Winter Range during the winter of 1976-77 could not be determined, approximately 200 individuals were present during April of 1977 (Mackie and Knowles 1977). Only two individuals were known to have died during the winter.

Lincoln and Schnabel indices for observations of marked and unmarked deer during the 1977-78 winter indicated a population of approximately 200 deer (Mackie *et al.* 1978). This figure was believed to be low by about 30 individuals due to the disproportionately small number of neckbanded individuals in the north and south winter range units compared to the middle unit, and limited observations of south

unit deer due to their heavy use of timbered habitats. Known deaths during the winter totaled 31. Trends in mule deer numbers and sex and age composition for the Armstrong Winter Range from 1973 to 1978 were presented by Mackie *et al.* (1978).

Winter daytime activity was confined to periods of feeding alternated with rest periods, during which animals were almost always bedded. Ground observations of neckbanded and instrumented individuals suggested that distance traveled during the course of daily activities was very limited. Movement by undisturbed instrumented individuals was rarely detected during the course of day-long observation periods, prior to March.

The first half of March was characterized by both the largest group size and the greatest number of individuals sighted per observation period (Table 15). Daytime activity was at its peak during this period, and deer spent a great deal of time feeding in open habitats after they were made accessible by snowmelt.

Coefficients of association (Knight 1970) were computed for 13 instrumented deer and other marked individuals with which each was observed more than twice. Of 111 coefficients of association only 6 (5%) were $\geq .50$ (range = .50-.57, $\bar{x} = .54$), all of which represented associations between adult animals. Forty-two (38%) were between .25 and .50 and 63 (57%) were $\leq .25$. Coefficients of association recorded by Steerey (1979) on the Schafer Creek Winter

Table 15. Mean group size and mean number of individuals sighted per ground observation period, winter 1977-78.

TIME INTERVAL	MEAN GROUP SIZE	MEAN NO. SIGHTINGS/ OBS. PERIOD	NO. OBS. PERIODS
DEC. 16-31	6.0	42	6
JAN. 1-15	7.0	24.8	7
JAN. 16-31	4.6	16.7	9
FEB. 1-12	6.2	19.9	6
FEB. 13-28	8.1	56.1	10
MARCH 1-15	10.2	82.4	11
MARCH 16-30	5.7	48.9	11

Range of the Bridger Mountains were much higher than those observed on the Armstrong Winter Range, with 18% of 225 coefficients of association $\geq .50$. The apparently higher degree of association among individuals of the Schafer Creek population may be due to greater use of open habitats and resulting greater observability of marked animals, or to the marking of more family group members on that range.

Coefficients of association were also calculated for four neck-banded does and four neckbanded fawns strongly suspected of being their respective offspring by virtue of being trapped together in the same Clover trap at least once, and a continuing close association throughout the winter. Coefficients of association for these doe-fawn pairs ranged from .43 to .89 ($\bar{x} = .66$). Two of these does and their fawns were closely associated with one another, shown by coefficients of

association of .74 and .80 between the does and between the fawns respectively. Associations between marked does and unmarked fawns suggested that the duration of doe-fawn bonds was highly variable. Some relationships dissolved as early as December or January while others endured at least through the month of April.

Five mule deer rumen samples obtained during the 1977-78 winter are summarized in Appendix Table 16.

DISCUSSION

Contrasts in the deer distribution pattern, home range size and elevational use of the Armstrong Winter Range between the two winters of study suggest that snow conditions have paramount influence upon range use strategies of mule deer, as concluded by Loveless (1967) and Gilbert *et al.* (1970). Snow, in this study, also appeared to be the stimulus for movement to the winter range as reflected in a difference of one month in the arrival dates of deer between winters.

Although lower slopes were bare of snow during much of the 1976-77 winter, deer activity was associated with forested habitats at the upper elevational boundary of the winter range. It is unclear whether this pattern of range use was indicative of habitat preference contingent on less than critical snow depths, selection of most favorable thermal conditions, or a preference for areas having moderate snow cover rather than bare ground. Deer did appear to prefer to dig through snow cover to feed rather than forage in areas bare of snow. Bruns (1977) found evidence that portions of hoary sage (*Artemisia cana*) beneath the snow contained higher levels of moisture, protein, Ca and P and a lower level of crude fiber than plant parts above the snow.

Extensive use of forested habitat types during the 1977-78 winter appeared to be due to deep snow accumulations and crust formation on open types. Although individual variation in use of habitat types was apparent in usage percentages (Tables 10-12) and in preference ratios (Table 13), preference ratios greater than 1. for collective forest

types were common to all instrumented deer. All four of the types having highest preference ratios (PSME/PRVI, JUSC-PUTR/FEID, PSME/FEID and PSME/SYAL) provided thermal and visual security cover, and the Douglas fir types provided relief from severe snow conditions as well.

Percent snow interception by canopies of the preferred Douglas fir types was approximately 20-23 percent according to the formula: percent interception = $.36 \times$ canopy cover (%) (U.S. Army 1956). Reduced energy expenditure during locomotion and sure footing in shallow snow beneath conifer crowns of these types is advantageous to deer. The forest canopy with its load of intercepted snow is a reflector of infrared energy in that it increases the amount of downward radiation at the ground surface by blocking the clear sky (Moen and Evans 1971). Radiant and convective heat loss is minimized in this type of cover (Moen 1968a), and the effect of downward radiant energy on the snow is apparent by less crusty snow than that found in unprotected areas (Moen and Evans 1971). Ozoga and Gysel (1972) and Moen (1976) listed the major advantages provided by dense mature timber as: narrow thermal ranges, warmest average temperatures, lowest wind flow and least hazardous snow conditions.

Temporal variation in usage of forested versus shrub/grass habitats reflected snow conditions. The dramatic shift from shrub/grass to forest habitat use by north unit deer during the first half of February and the coincident decline in the use of creek bottom types

(Figs. 5 and 6) were associated with the worst snow conditions of the winter. Although habitat usage by middle unit deer did not change during this period, maximal use of forest types was evident for south unit deer also. Snow depths of 36-48 cm on west exposures with a substantial but non-supportive crust prompted deer of these units to congregate in forested types having shallower snow. Kelsall (1969) stated that the ability of ungulates to travel through snow is most affected by its depth, density and hardness and that deer are restricted when snow depth exceeds 40 cm. Gilbert *et al.* (1970) noted that snow more than 46 cm deep essentially precludes use of range by deer. Loveless (1967) found that 25-30 cm impeded deer locomotion and that 51-61 cm essentially precluded deer use.

An increase in use of shrub/grass types during the latter half of February, reaching a peak in mid-March, was evident for deer of all three units. This change in range use reflected increasing accessibility of open habitats due to snow melt, coincident with availability of new spring plant growth, and was accompanied by a peak in daily activity and observability of deer. Extended movements and greater activity in response to warmer temperatures and newly available forage were also documented by Miller (1970) and Moen (1976). Increased daytime use of forested types during the latter half of March appeared due to higher temperatures and presumably increased feeding activity at night. The mean maximum daily

temperature during this period of 13.7°C is outside the comfort range of -9.4 to 7.2°C reported by Loveless (1967) for mule deer in Colorado. He also noted that temperatures between -23.3 and -12.2°C triggered concentrations of deer, and Ozoga and Gysel (1972) found that temperatures below -12.2°C prompted shelter-seeking movements by white-tailed deer in Michigan. Temperatures on the study area rarely dropped below -12°C and no consistent daily reaction to those low temperatures was observed.

Home range sizes for deer of all three units (Fig. 7) showed a striking tendency for north unit deer to be more mobile than middle unit deer at the beginning of the winter. A dramatic reduction in home range size by north and south unit deer was associated with the severe snow conditions of early February. Deer of the north and south units remained rather confined during the latter half of February, whereas deer of the middle unit showed a sharp increase in home range size. The middle unit, with its more heterogeneous topography and prevailing steep south slopes experiences rapid snowmelt and early green-up, allowing greater ease of locomotion and better access to forage than the other two units. Severe snow conditions were more pronounced and prolonged on the north and south units.

Extensive and prolonged use of creek bottom habitats by north unit deer during the second winter indicates that these areas may comprise an important environmental component for that population

segment during more severe winters. The proportionately larger area exploited by deer of this unit during both winters suggests that the resource base is inferior to that of the middle winter range unit and that it is advantageous to range over a larger area to fulfill resource requirements for as long as snow conditions permit.

The three major winter range units may represent three habitats providing the necessary resource components for winter mule deer survival or three major patterns of reaction to and integration of environmental conditions. It is not known whether these range use patterns are a function of individual preferences learned through exploration, tradition stemming from associations with adults as a fawn or a function of habitat "fill" (Mackie, 1978). Individual variation in habitat type usage within and among winter range units probably increases the carrying capacity of the range.

Wallmo *et al.* (1977) concluded that summer forage will support many times the number of deer present but winter forage will not sustain deer at any population level. Instead, the duration and severity of winter relative to the energy reserves of the deer determine the length of time that deer can survive on these ranges. Moen (1968b) pointed out that under conditions of depleted food quality or quantity, cover is physiologically important to deer in that its use may be necessary for maintenance of a positive energy balance. Habitat usage and behavior of the Armstrong Winter Range deer appear to

emphasize a strategy of energy conservation rather than forage gathering.

APPENDIX

Table 4. Dates of arrival and core home range establishment for instrumented deer on the Armstrong Winter Range, winters 1976-77 and 1977-78.

ANIMAL ID.	FIRST RELOCATION WITHIN WINTER RANGE BOUNDARY	ESTABLISHMENT OF CORE WINTER H.R. ¹
<u>WINTER 1976-77</u>		
175 ♀ M ²	12-15-76	-----
1173 ♀ N	12-15-76	-----
173 ♀ N	12-15-76	-----
176 ♂ N	12-29-76	-----
973 ♀ N	1-11-77	-----
372 ♀ N	1-19-77	-----
<u>WINTER 1977-78</u>		
175 ♀ M	11-16-77	11-30-77
1173 ♀ N	11-16-77	12-22-77
176 ♂ N	11-27-77	----- ³
173 ♀ N	11-30-77	11-30-77
1974 ♀ M	11-30-77	11-30-77
177 ♀ M	11-30-77	11-30-77
1273 ♂ M	11-30-77	11-30-77
372 ♀ N	12-17-77	2- 6-78 ³
477 ♀ N	12-17-77	12-17-77
675 ♂ S	12-17-77	12-17-77

¹Core home ranges were not defined for the 1976-77 mild winter.

²Winter range units; N=north, M=middle and S=south.

³Individual used creek bottom habitats west of the Armstrong Winter Range.

Table 7. Means of average activity radii for marked deer of the Armstrong Winter Range, winters 1972-73 through 1977-78.¹

WINTER	AVERAGE ACTIVITY RADII (KM)	
	MALE	FEMALE
1972-73	.42	.35
1973-74	.30	.36
1974-75	.17	.23
1975-76	---	---
1976-77 ²	.60 ³	.58
1977-78 ²	1.0	.37

¹Data prior to 1976-77 from Mackie *et al.* (1976).

²Calculations include instrumented deer only.

³Sample size = 1.

Table 9. Mean daily maximum and minimum temperatures recorded by hygrothermograph located on the Armstrong Winter Range, winters 1976-77 and 1977-78.

TIME INTERVAL	WINTER 1976-77		WINTER 1977-78	
	MAX. (°C)	MIN. (°C)	MAX. (°C)	MIN. (°C)
DEC. 16-31	--data unavailable--		-3.7	-9.9
JAN. 1-15	-5.7 ¹	-12.0	-.6	-5.9
JAN. 16-31	2.6 ²	- 2.2	-2.8	-9.0
FEB. 1-12	6.8	- 1.0	.8	-4.9
FEB. 13-28	5.4	- 1.3	-.7	-6.6
MARCH 1-15	2.3	- 3.8	.6	-6.6
MARCH 16-31	1.4	- 5.2	13.7	4.4

¹Hygrothermograph data unavailable for Jan. 1-3, 1977.

²Hygrothermograph data unavailable for Jan. 18-24, 1977.

Table 16. Contents of five mule deer rumen samples collected on the Armstrong Winter Range, winter 1977-78.¹

FORAGE CLASS	JAN.	FEB.	MARCH		
	adult* % Vol.	fawn* % Vol.	fawn+	adult+ % Vol.	adult-
GRASS	48	12	2	66	--
FORB	Tr ²	10	2	6	12
BROWSE					
<i>Artemisia tridentata</i>	27	14	34	4	21
<i>Berberis repens</i>	--	--	--	Tr	--
<i>Juniperus scopulorum</i>	6	21	6	14	31
<i>Pinus contorta</i>	--	--	--	Tr	--
<i>Pseudotsuga menziesii</i>	--	11	1	1	35
<i>Purshia tridentata</i>	16	12	54	3	--
<i>Ribes</i> spp.	--	1	Tr	--	--
Unid.	--	11	--	--	2
TOTAL BROWSE	49	70	95	22 ³	89
LICHEN	--	8	--	--	--
CACTUS (<i>Opuntia polyacantha</i>)	3	--	--	6	--

¹Femur marrow from all carcasses from which rumen samples were obtained indicated a condition of starvation at the time of death. * indicates a predator-involved death, + indicates a natural death and - indicates that cause of death was undetermined.

²Tr = trace amounts of less than 1 percent.

³Individual (10+ years) had only two loose incisors remaining, probably accounting for the low proportion of browse in her diet.

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