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**POPULATION ECOLOGY OF MULE DEER
WITH EMPHASIS ON POTENTIAL IMPACTS
OF GAS AND OIL DEVELOPMENT
ALONG THE EAST SLOPE OF THE
ROCKY MOUNTAINS, NORTHCENTRAL MONTANA**

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VITA

Helga Beate Ihsle was born July 24, 1955 in Berlin, Germany to Gertrude and Wolfgang Ihsle. She graduated from Van Nuys High School, Van Nuys, California in June 1973. In June 1979 she received a Bachelor of Science degree in Fish and Wildlife Management from Montana State University, Bozeman. In January 1980 she began studies toward a Master of Science degree in Fish and Wildlife Management.

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ABSTRACT

A study was conducted on the East Front of the Rocky Mountains in northcentral Montana from June 1980 to September 1981. It was the second phase of a 2-part investigation designed to collect quantitative baseline information on mule deer seasonal distribution, movements, population characteristics, and habitat use on a representative portion of the East Front subject to gas and oil exploration and development. Six, and possibly 7, population units were delineated by winter range origin. A total of 6,000 to 7,000 mule deer were included in these units. Monitored deer showed a high degree of fidelity to seasonal ranges. Three out of 78 marked deer were known to have dispersed from one winter range to another. Mean winter home range size for females was larger in 1980-1981 (6.0 km^2) than 1979-1980 (4.6 km^2). Three summer range segments were confirmed from previous work. Of 22 radio-collared deer, 14% were residents, 59% summered east of the Continental Divide, and 27% summered west of the Continental Divide. Mean summer home range was 6.4 km^2 in 1979, 3.5 km^2 in 1980, and 1.4 km^2 in 1981 for female deer. Population estimates indicated that the population wintering on the study area increased by 6% from 1980 to 1981. Ratios of fawns per 100 adults were lower (49.8 in early winter, 49.8 in late winter) in 1981 than in 1980 (69.3 in early winter, 61.7 in late winter). This decrease was attributed to a higher proportion of non-productive yearlings in the population. The age structure and high proportion of males (19 antlered per 100 non-antlered) indicated a healthy population that could withstand greater harvest than occurred during the study. At least 90% of deer summering north of the Sun River and west to the South Fork of the Flathead River winter on the study area. Winter ranges were separated by low deer use zones. Low deer use zones had a lower percentage of moderate to steep slope categories and a lower proportion of southerly aspects than core winter ranges. Mule deer apparently preferred moderate slopes, higher elevations, south and east aspects, and limber pine timber types within core winter ranges. Impacts of gas and oil exploration were difficult to assess due to the low intensity of activity, the mild winter conditions, and low density of deer in the vicinity of the only active well sites during this study. Implications of more intense development were discussed.

INTRODUCTION

The east slope of the Rocky Mountains in northcentral Montana provides winter habitat for a large mule deer (*Odocoileus hemionus*) population. This area has a high potential for gas and oil production, and commercial quantities of gas have already been discovered. By October, 1981, 4 producing gas wells had been drilled between the Muddy and Dupuyer Creek drainages. At least 3 additional wells will be completed in 1982 on this area, and seismic lines are continually being surveyed by several companies. Knowledge of mule deer wintering along the East Front is essential if impacts of gas and oil exploration on this species are to be ascertained.

This study, conducted from June 1980 through September 1981, represents the second phase of a 2-part investigation. The first phase was conducted from June 1979 through September 1980 (Kasworm 1981). These studies were designed to collect baseline information on mule deer, including seasonal distribution, movements, population dynamics, and habitat use, to evaluate potential conflicts between hydrocarbon exploration and deer, and to develop management guidelines.

Previous studies and management surveys on deer in this area by Montana Department of Fish, Wildlife and Parks (MDFWP) personnel have provided some information on range use, food habits, reproduction and population trends (Schallenberger 1966, McCarthy et al. 1978, 1979,

1980). Background information on the area is available from studies on grizzly bear (*Ursus arctos*) (Sumner and Craighead 1973, Hamlin and Frisina 1975, Schallenberger 1974, 1976, Jonkel 1976, 1977, Schallenberger and Jonkel 1978, 1979, 1980, and Aune 1981), Rocky Mountain bighorn sheep (*Ovis canadensis*) (Schallenberger 1966, Erickson 1972, Frisina 1974), Rocky Mountain elk (*Cervus elaphus*) (Picton 1960, Knight 1970, Picton and Picton 1975), and Rocky Mountain goats (*Oreamnos americanus*) (Thompson 1981).

STUDY AREA

The 2,725 square kilometer (km^2) study area (Fig. 1) was located in and adjacent to the Sawtooth Range along the east slope of the Rocky Mountains in western Teton, Pondera, and Flathead Counties, Montana. It was bordered on the north by the Blackfoot Indian Reservation and on the south by the Sun River. Important drainages on the study area included Birch Creek, Muddy Creek, the Teton River, Deep Creek, the Middle Fork of the Flathead River, and the Sun River. The center of the area was approximately 40 km west of Choteau.

Most (85%) of the area consisted of public lands administered by the Lewis and Clark and Flathead National Forests. Remaining lands were administered by the Bureau of Land Management (BLM) or owned by private organizations, private individuals, and the State of Montana. The BLM administered 95% of the mineral rights on the study area.

Geology

Geological characteristics of the study area have been described by Gieseke (1937), Deiss (1943) and Johns (1970). The East Rocky Mountain Front is composed of a combination of parallel north-south extending ridges, characterized by abruptly sloped east faces and moderate west facing slopes, separated by precipitous drainage valleys. During the early Cenozoic era, the Lewis overthrust pushed late Precambrian and Paleozoic limestone and shales over more recent Mesozoic sediments, creating a situation conducive to petroleum

Figure 1. Map of the East Front study area showing major features.

deposition and accumulation. Glaciation and erosion have created the buttes, ridges, and foothills dissected by small drainages that characterize mule deer winter ranges along the mountain front. Elevations range from 1,311 meters (m) to 1,798 m on winter ranges and from 1,707 m to 2,863 m on summer ranges.

Climate

Climatological data for 3 weather stations along the East Front are presented in Table 1. Gibson Dam (GD) was located at the southern end of the study area. The Choteau (CH) and Blackleaf (BL) stations represent midway points. Blackleaf was closer to the Front, but data were incomplete for some months; therefore, Choteau was included to show trends.

Average annual precipitation at these stations ranged from 35 to 56 centimeters (cm). Winter precipitation was higher than average in 1978-1979 and 1979-1980 (Kasworm 1981) and lower than average in 1980-1981.

Average annual temperature in the area is about 5°C. The 3 winters covered during this study were climatically very different. Temperatures in 1978-1979 were much lower than average, in 1979-1980 they were approximately average (Kasworm 1981), and in 1980-1981 they were slightly above average. Very strong southwesterly chinook winds characterize this area and can influence deer behavior and distribution on the winter ranges.

Table 1. Average temperature ($^{\circ}\text{C}$), total precipitation (cm), total snowfall (cm), and deviation from the long term average for 3 weather stations along the East Front from October 1980 through September 1981 (U.S. Dept. of Commerce 1980-1981).

Month	Station ^a	Temperature		Precipitation		
		Mean	Deviation from the long term average	Amount	Deviation from the long term average	Snowfall
Oct 1980	GD	8.2	+1.1	3.30	+ .33	--
	BL	8.1	+1.5	3.48	+2.31	7.6
Nov 1980	GD	2.6	+1.9	1.17	-1.88	11.4
	CH	4.2	+3.2	.18	- .91	7.6
Dec 1980	GD	-3.0	- .2	2.85	+ .48	24.1
	BL	-7.2	-3.1	1.57	+ .15	2.8
Jan 1981	GD	.1	+5.4	.41	-2.06	--
	BL	.1	+7.4	.84	- .71	--
Feb 1981	GD	-1.1	+1.8	1.73	- .15	27.9
	CH	.4	+3.3	.23	- .86	3.8
Mar 1981	GD	2.4	+4.0	2.11	- .51	--
	BL	2.2	+4.0	5.82	+4.14	--
Apr 1981	GD	5.9	+1.8	.66	-3.23	0
	BL	6.2	+2.5	Trace	-3.58	Trace
May 1981	GD	9.3	+ .7	17.70	+9.55	0
	CH	11.6	+ .7	8.61	+2.97	0
June 1981	GD	11.7	- .5	4.11	-6.45	0
	CH	14.4	- .4	2.31	-5.97	0
July 1981	GD	16.6	+ .1	4.78	+1.30	0
	BL	17.4	+ .4	3.07	- .51	0
Aug 1981	GD	17.4	+1.5	4.04	+ .41	0
	BL	18.9	+2.6	5.61	-1.91	0
Sep 1981	GD	12.8	+1.5	1.24	-2.67	0
	BL	13.2		.51		0

^aGD = Gibson Dam, BL = Blackleaf, CH = Choteau.

Land Use

Winter Range

The Ear Mountain Game Range and the Blackleaf Game Range, administered by MDFWP, were located on the study area. Livestock grazing was prohibited on both areas. Most (90%) mule deer winter range, however, is located on private and public land used for livestock grazing during spring, summer, and fall.

A small subdivision is located on a portion of the Ear Mountain winter range. A few guest ranches are located in this area and in the Sun River drainage.

White-tailed deer (*Odocoileus virginianus*), elk, bighorn sheep, mountain lion (*Felis concolor*), black bear (*Ursus americanus*), and coyotes (*Canis latrans*) commonly occur on mule deer winter range. This area also provides important habitat for a grizzly bear population.

Hydrocarbon exploration activity on the study area commenced in the 1950's but was followed by 20 years of no activity. Recent activity began in 1979, and the first new well was drilled in 1980. The renewed interest in oil and gas development has led to marked increases in road building, seismic line blasting, drilling, helicopter traffic, and human disturbance.

Summer Range

Most of the summer range lies within the Lewis and Clark and

Flathead National Forests. This area includes portions of the Bob Marshall and Great Bear Wildernesses.

Some livestock grazing allotments exist on BLM and Forest Service land. A small ski resort is located on the Teton road in the Lewis and Clark National Forest. Timber harvest occurs in small amounts. This area has important recreational values for backcountry use as well as supplying habitat for elk, white-tailed deer, mountain goats, bighorn sheep, black bears, and grizzly bears.

Vegetation

Vegetation on the study area was discussed in detail by Kasworm (1981). Lower elevations were characterized by short grass prairie and shrublands interspersed with buttes and ridges covered by limber pine (*Pinus flexilis*) savannahs and forests. Aspen (*Populus tremuloides*) and cottonwood (*Populus trichocarpa*) stands were scattered along drainages and foothills. At higher elevations, Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and sub-alpine fir (*Abies lasiocarpa*) dominated the forests. Sagebrush (*Artemisia tridentata*) or shrubby cinque-foil (*Potentilla fruticosa*) and grassland habitat types were also common at higher elevations. Extensive areas of seral grass/shrublands were found on burned sites.

METHODS

Seasonal Distribution and Population Dynamics

Deer were captured using a helicopter drive net (Beasom et al. 1980) or baited panel traps (Lightfoot and Maw 1963) and were marked with radio transmitting collars or 10-cm-wide Armor-tite neckbands (Mackie et al. 1978). A total of 149 deer were marked during 1978-1981. Twenty-five were equipped with radio-transmitting collars, and 122 were outfitted with individually recognizable neckbands. Two fawns, captured by hand, were marked with orange ear tags in 1980.

Radio relocation flights for my segment of the study were made twice a month, weather permitting. A total of 60 flights were conducted from March 1979 through October 1981 using either a Piper Super Cub equipped with a 3-element Yagi antenna or a rotational antenna or a Cessna 180 outfitted with twin whip antennas.

Radio relocations from both segments of the study (1979-1980 and 1980-1981) were analyzed using the TELDAY computer program (Lonner 1981) for calculation of seasonal home range sizes and activity centers used by radio-equipped deer. Chi-square and analysis of variance techniques (Snedecor and Cochran 1980) were used to test differences in home range size and consistency between population segments, individual deer, and years. Analyses were run on a Honeywell Level 66 computer.

Winter distributions, sex ratios, and population estimates were determined by helicopter (Bell 47G 3B-2) surveys conducted in January,

March, and April of 1981. Population estimates were derived as Lincoln indexes from observations of marked and unmarked deer as described by Overton and Davis (1969). These surveys were compared with results from surveys in 1980 (Kasworm 1981).

Ground observations were conducted on each of 5 winter ranges at least twice a month from January through March 1981. Deer were classified as bucks (males >1 year), does (females >1 year), or fawns (<1 year) through January and later as adults (>1 year) or fawns (<1 year). Observations were plotted on 1:24,000 topographic maps. Slope, aspect, and habitat type at each sighting were noted.

Hunters were checked on 9 days during the 1980 hunting season to determine hunting pressure, hunter distribution, and the location, sex, and age of deer shot. Hunter-killed deer were aged by tooth replacement and wear (Robinette et al. 1957). Collar returns from marked deer were used to determine location and timing of mortality.

Habitat Characteristics and Use

Vegetation cover-type maps and measurements made for most winter range sites were presented by Kasworm (1981). I described, typed, and mapped 1 additional winter range, fall and spring transition areas, low-use areas, and drill sites using techniques and habitat descriptions similar to those described by Pfister et al. (1977) and Mueggler and Stewart (1980). Plant taxa were verified in the Montana State

University Herbarium. Nomenclature followed Hitchcock and Cronquist (1973).

Availability of vegetation types, slope, aspect, and elevation within seasonal range units was determined using a random sampling technique (Marcum and Loftsgaarden 1980) in conjunction with vegetation-type and topographic maps. Range units and observed deer use of habitat within units were compared using Chi-square analyses (Snedecor and Cochran 1980). Five rumens were collected on the study area and analyzed using macro-histological methods developed by Wilkins (1957).

Gas and Oil Impacts

Type, location, and duration of hydrocarbon-related activity on the study area was noted, mapped, and monitored when possible. Several approaches were used in attempts to measure direct mule deer responses to activity. Efforts to conduct track surveys were hampered by the absence of adequate snow cover. When possible, aerial transects were flown near active well locations to count and record the distribution of deer in relation to drill sites. An observation of behavioral responses to seismic activity was made on 1 occasion. Distributions of radio-marked mule deer prior to and after hydrocarbon activity were compared.

RESULTS

Seasonal Distribution, Movements, and Home Ranges

Seasonal Distribution and Movements

Kasworm (1981) delineated 6 winter ranges on the study area. I delineated 1 additional winter range, Swanson Ridges, located adjacent to the Dupuyer Creek winter range (Fig. 2). It may represent an extension of the latter or a secondary range used in mild winters and/or at high mule deer population densities. The total and core area sizes for each winter range based on 1980-1981 and earlier (Kasworm 1981) deer distributions are given in Table 2.

Transition areas (Table 2) were delineated from observations during spring and fall, 1979-1981. Some radio-collared deer from summer ranges west of the Continental Divide (WOD segment) used the transitional range extensively for 2-3 months in the fall before moving onto the winter range. Migratory deer summering east of the Divide (EOD segment) and resident deer (RES segment) either stayed on their individual summer ranges as long as possible before moving directly to the winter range or moved onto transitional range up to 8 weeks after WOD deer. WOD deer moved onto transitional areas with the first severe snow storms in late October-early November of 1980 and 1981. Migratory deer moved back onto transitional range enroute to summer ranges in late May-early June of 1981, about the same time as in 1979 and 1980 (Kasworm 1981).

Figure 2. Map of the East Front study area (Kasworm 1981) showing total and primary winter ranges, and transitional ranges as observed during 1979-1980, and 1980-1981.

Figure 2. Continued.

Table 2. Areas (km^2) of population units, total and primary winter ranges, and associated transition ranges of mule deer on the East Front during 1979-1981.

Winter Range Location of Population Unit	Total Population Unit	Total Winter Range	Primary Winter Range	Associated Transition Range
Scoffin Butte	339	26.6	10.2*	
Dupuyer Creek		31.6	13.4*	
Swanson Ridges		29.2	10.6	24.9
Blackleaf-Teton	328	80.8	20.9*	53.5
Ear Mountain	375	44.0*	16.6*	47.1
Long Ridge		37.6*	23.9*	
Castle Reef	1056	38.9*	18.1*	12.3
Total		288.7		

*Kasworm (1981)

Overall, 6 (27%) of the deer with functional radio collars summered west of the Continental Divide, 13 (59%) summered east of the Divide but off the winter range, and 3 (14%) were yearlong residents on or in proximity to the winter range. Approximately 63% of the deer radioed on the Blackleaf-Teton winter range summered west of the Divide, the highest proportion for any winter range.

Tentative yearlong herd ranges or population units (Mackie et al. 1980) of mule deer associated with the 5 major winter ranges on which

radio-collared deer occurred are shown in Figure 3. These ranges were estimated from the summer distribution of radio-collared and neck-banded deer relocated during the summers of 1979, 1980, and 1981 (Fig. 4). Collared deer from the Blackleaf-Teton winter range were relocated as far west as the Spotted Bear Ranger Station (57 air km) in summer. One doe, marked on the Scoffin Butte winter range, was sighted in the summer of 1977 and subsequently killed in the winter of 1978 near Glacier National Park, approximately 64 airline kilometers northwest of its winter range. A doe from the Castle Reef winter range was relocated 37 airline kilometers to the west, near White River Pass.

Home Ranges

Home range sizes, based on all relocations during 1979-1981, are given in Table 3. Total summer range used by 7 deer for which 3 years of data were available averaged 8.9 km^2 in 1979, 3.5 km^2 in 1980, and 1.4 km^2 in 1981. The decrease between years was significant (ANOVA, $p < .05$). Deer summering west of the Continental Divide individually used significantly larger total summer home ranges ($\bar{x} = 13.8 \text{ km}^2$) than EOD deer ($\bar{x} = 8.5 \text{ km}^2$) for the 3 years. WOD deer also used larger annual summer home ranges than EOD deer (ANOVA, $p < .05$). Summer home ranges of EOD deer were significantly larger in 1979 (6.0 km^2) than in 1980 (2.9 km^2) and 1981 (1.4 km^2). Annual summer home ranges

Figure 3. Map of the East Front study area showing tentative population units associated with winter ranges observed during 1979-1981.

Figure 4. Locations of summer and winter home ranges for collared mule deer on the East Front during 1978-1981.

Table 3. Summer and winter home range sizes (km^2), number of relocations (N), and seasonal home range means (km^2) for mule deer on the East Front during 1979-1981.

Animal I.D.	Sex	SRS ^a	Winter 1979		Summer 1979 ^b		Winter 1980 ^b		Summer 1980 ^b		Winter 1981		Summer 1981		Winter 79-81		Summer 79-81	
			Size	N	Size	N	Size	N	Size	N	Size	N	Size	N	Size	N	Size	N
Scoffin-Dupuyer																		
1001	F	EDD	2.4	5	13.4	17	6.1	9	.3	10	3.6	7	.3	12	12.5	21	15.0	33
1002	F	EDD	2.5	5	7.0	13	6.3	8	.8	11	.8	4	.5	7	10.7	17	7.0	31
1003	F	EDD	1.9	5	3.6	14												
1004	F	EDD	3.3	6	2.1	15	3.5	8	3.1	9	3.0	8	1.1	7	10.5	22	5.0	31
2001	M	EDD									.7	4	2.6	7				
Blackleaf-Teton																		
3001	F	WDD	7.4	7	5.5	1D	7.4	7	.3	8	13.0	8	1.4	6	26.7	22	5.5	18
3002	F	WDD	3.1	7	13.5	9	2.6	9	7.7	6	5.7	1D			9.4	26	19.7	21
3003	F	WDD	1.0	7	9.2	8	1.7	8	6.1	7	6.8	11	4.9	6	12.2	26	12.8	15
3004	F	WDD	8.4	5	1.7	7	3.5	7	1.4	7	6.9	8			12.6	20	8.6	2D
3005	F	EDD	8.3	4	4.0	14	1.5	4	1.1	7	10.3	15			4.2	12	5.0	21
3007	F	RES			2.9	13	2.7	8							3.5	15		
3008	F	WDD	1.0	7			3.0	6	1.1	7	5.3	10	.2	6	16.0	16	1.6	13
3009	F	EDD					3.6	5	3.2	7	2.4	7	2.6	6	8.5	12	7.2	13
Ear Mountain																		
4002	F	EDD	1.9	4	12.1	12	4.5	7	10.7	11	6.7	8	.6	6	10.8	19	21.5	27
4004	F	EDD	.9	4	2.8	10	8.0	1D	2.3	11	2.4	7			14.0	21	3.5	21
4005	F	EDD					3.4	5	2.7	5	7.1	10	3.1	5	11.7	15	9.8	10
4006	M	WDD					3.6	6	3.2	6	6.0	9	34.0	6	13.0	15	34.8	12
Castle Reef																		
6001	F	EDD			3.0	7	0.8	5	1.6	8	11.8	9			5.6	14	Changed Summer Range	
6002	F	RES			8.4	15	6.5	5	5.0	13	.4	4	.7	6	6.9	9	8.6	34
6003	F	EDD					13.3	6	.5	9	10.2	7	.3	5	20.9	13	.8	14
6004	F	RES					2.7	5	11.1									
6005	M	EDD							5.8	5								
			$\bar{x}=3.4$		$\bar{x}=6.4$		$\bar{x}=4.6$		$\bar{x}=3.5$		$\bar{x}=6.0$		$\bar{x}=1.4$		$\bar{x}=14.2$		$\bar{x}=8.9$	
			SD=2.9		SD=4.3		SD=3.0		SD=3.0		SD=3.8		SD=1.5		SD=8.7		SD=6.2	

^a Summer Range Segment = EDD = East of Divide, WDD = West of Divide, RES = Resident.

^b Kasworm (1981).

^c Average for females only.

^d Standard Deviation for females only.

of WOD deer were not statistically different (ANOVA, $p > .05$) between years but averaged 7.5 km^2 in 1979, 3.3 km^2 in 1980, and 2.2 km^2 in 1981.

Total winter home range used by individual radio-collared deer over the 3 years averaged 14.2 km^2 . Winter home range size for individual years averaged 3.4 km^2 in 1979, 4.6 km^2 in 1980, and 6.0 km^2 in 1981. There were no statistical differences in the average size of winter home ranges between years or between winter ranges for the same year.

Fidelity

Fidelity of radio-collared animals to summer range was strong. Only 1 of 16 females for which 2 or more years of data were available changed its summer range between years. That doe switched ranges between 1979 and 1980.

All radio-collared deer returned to the same winter range on which they were trapped, and only 1, a doe, significantly changed its activity center within a winter range between years. Three neck-banded males were known to have changed winter ranges between 1980 and 1981. One, a yearling trapped at Antelope Butte in 1980, wintered west of the Continental Divide near the Spotted Bear Ranger Station in 1981. The others, a yearling and a 3-1/2-year-old, were trapped

at Ear Mountain in 1980 and relocated the following winter at Castle Reef.

Population Dynamics

Fewer animals were seen during helicopter surveys of winter ranges in 1981 than in 1980 (Table 4). The March survey provided the best 1981 winter population estimate since the reduced proportion of marked animals observed in April indicated some prior movement of deer to transition ranges. A non-stratified Lincoln index estimate from the March survey data indicated a population of 6,014 on the study area in late winter 1981, an increase of about 6% over March 1980.

The highest proportions of bucks were recorded on the Scoffin Butte and Castle Reef winter ranges. The January 1981 helicopter survey indicated the sex ratio was 19 antlered bucks:100 antlerless deer (Table 5) for the winter ranges surveyed.

Ground observations on 5 winter ranges (Table 6) showed no statistical differences in sex (antlered:antlerless) and age (fawn:adult) ratios between areas. Fawn:adult ratios were lower in 1981 than in 1980 during both early (January-February) and late (March-April) winter classifications (Table 7). Chi-square analysis of ratios for individual winter ranges indicated that Dupuyer Creek and Castle Reef contributed most to the decrease between years.

Table 4. Total numbers and proportions of marked animals observed, and Lincoln index estimates during March and April for helicopter surveys of mule deer between Birch Creek and Sun River, 1980-1981.

Winter Range	1980			1981								
	March		April	March		April						
	Actual Count	Marked Animals Present		Actual Count	Marked Animals Present							
Scoffin	524	4	588	3	5	579	21	36	403	18	36	
Dupuyer	699	20	603	17	24	642	4	9	523	10	13	
Blk-Teton	250	14	33	269	24	338	7	13	365	12	21	
Ear Mtn.	376	18	24	214	13	24	338	9	13	401	5	14
Castle	<u>896</u>	<u>2</u>	<u>8</u>	<u>1,047</u>	<u>7</u>	<u>12</u>	<u>677</u>	<u>11</u>	<u>21</u>	<u>306</u>	<u>6</u>	<u>23</u>
Subtotal	2,745	58	94	2,721	64	98	2,564	52	92	1,998	51	107
Long Ridge	<u>743</u>						<u>825</u>			<u>308</u>		
Total	3,488						3,399			2,306		
Proportion of marked animals seen		0.617		0.653				0.565			0.476	
Subtotal Lincoln Index (excluding Long Ridge)		4,449		4,167				4,536			4,197	
Total Lincoln Index		5,653						6,014			4,838	

Table 5. Number and classification of deer in the early winter helicopter survey on the East Front on January 12-13, 1981 on 5 winter ranges.

Area	Total	Buck	Antlerless Animals	Does	Fawns	Uncl.	Bucks:100 Does & Fawns
Scoffin	118	31	87	31	30	26	35.6
Dupuyer	542	68	474	31	32	411	14.3
Blackleaf	40	1	39	17	15	7	2.6
Ear Mtn.	122	10	112	74	38	0	8.9
Castle	615	119	496	258	225	13	24.0
Totals	1,437	229	1,208	411	340	457	19.0

Table 6. Numbers and percent composition of adult and fawn mule deer on 5 winter ranges on the East Front, January through April 1981.

	Location	% Adult	(number)	% Fawn	(number)	Fawns: 100 Adults
January	Scoffin	60.9	(167)	39.1	(107)	64
	Dupuyer	73.9	(139)	26.1	(49)	35
	Blk-Teton	61.9	(96)	38.1	(59)	61
	Ear Mtn.	60.0	(117)	40.0	(78)	67
	Castle	71.4	(95)	28.6	(38)	40
February	Scoffin	68.4	(195)	31.6	(90)	46
	Dupuyer					
	Blk-Teton	85.0	(17)	15.0	(3)	18
	Ear Mtn.	68.9	(91)	31.1	(41)	45
	Castle	69.9	(121)	30.1	(52)	43
March	Scoffin	72.3	(120)	27.7	(46)	38
	Dupuyer	67.9	(205)	32.1	(97)	47
	Blk-Teton	72.0	(134)	28.0	(52)	39
	Ear Mtn.	64.7	(139)	35.3	(76)	55
	Castle					
April	Scoffin	64.0	(80)	36.0	(45)	56
	Dupuyer	61.9	(91)	38.1	(56)	61
	Blk-Teton	64.0	(64)	36.0	(36)	56
	Ear Mtn.	66.0	(93)	34.0	(48)	52
	Castle	64.8	(103)	35.2	(56)	54

Table 7. Early and late winter fawn:adult ratios for mule deer and Chi-square test values with associated significance levels (p) on the East Front in 1980 and 1981.

Area	1980		1981		χ^2	p	1980		1981		χ^2	p
	J-F ^a	N	J-F	N			M-A ^b	N	M-A	N		
Scoffin Butte	69.2	687	54.4	559	4.71	.04	60.0	48	45.5	291	.73	.39
Dupuyer Creek	65.7	575	35.3	188	11.31	<.01	66.7	275	51.7	449	2.59	.11
Blackleaf-Teton	75.8	232	54.9	175	2.45	.12	58.4	331	44.4	286	2.53	.11
Ear Mountain	64.4	171	57.2	327	.37	.54	61.6	202	53.5	356	.60	.44
Castle Reef	69.8	416	41.7	306	10.45	<.01	60.9	148	54.4	159	.23	.63
Overall					21.10	<.01					6.46	.01

^a January-February.

^b March-April.

Fawn:adult ratios accumulated by Hunting Districts (Table 8) were lower in 1981 than in 1980 but were close to the long-term average.

Table 8. Fawns:100 adult mule deer for 1979-1980, 1980-1981, long term means, and standard deviations for populations on the East Front in 2 MDFWP management units from 1961-1979.

MDFWP Unit	Time	1979- 1980	1980- 1981	$\bar{x}^a$	N	Standard Deviation
441	Winter	70.8	50.2	51.3	18	13.6
	Spring	61.3	47.8	45.8	10	9.6
442	Winter	68.8	49.3	52.8	17	12.7
	Spring	61.9	53.7	46.5	12	11.9

^aFigures are not directly comparable because:

MDFWP - Winter = December-March

Spring = April-May

1979-1981 - Winter = January-February

Spring = March-April.

Fawn:adult ratios derived from deer handled in helicopter drive netting operations during 1980 and 1981 (Table 9) did not differ statistically from ground counts on the same area during the same month (χ^2 , $p > .05$). The drive-net samples, however, indicated some changes in the age structure of deer on the study area between 1980 and 1981 (Fig. 5).

Yearlings comprised 54% of mule deer examined at a checking station maintained for 9 days during the 1980 hunting season (Table 10). Thirty-nine percent of the mule deer checked were females killed during

Figure 5. Age class distribution (%) for mule deer captured during drive-netting on the East Front in 1980 and 1981.

Table 9. Numbers and percentages of sex and age classes for mule deer captured during drive-netting on the East Front in 1981.

Age Class	0.5	1.5	2.5	3.5	4.5	5.5	6.5+	%
Males	5	2	1	3	3	1	1	38
Females	6	5	1	7	2	1	4	62
%	26	17	5	24	12	5	12	N = 42

Table 10. Numbers and percentages (by sex and age classes) of mule deer checked during 9 days at the Teton Check Station in autumn 1980.

Age Class	0.5	1.5	2.5	3.5	4.5	5.5	6.5+	Unk	%
Males	4	13	0	2	0	2	1	3	61
Females	2	7	0	3	2	1	0	1	39
%	16	54	0	14	5	8	3		N = 41

the first week when either sex harvest was permitted. Forty-one percent of checked animals were white-tailed deer (Table 11). Hunter success during the check (approximately 10%) was similar to the statewide average (John Cada pers. comm.). Eighty-four percent of the hunters were from counties near the study area. Most (93%) in this sample hunted in hunting districts 441, 442, and 450 (Table 12).

Of the total mule deer marked on winter ranges within the study area from 1973 to 1980, 75% were females (Table 13). As of April 1981,

Table 11. Data on deer hunters and deer harvest from check stations on the East Front study area during autumn 1980.

Date	Check Station	No. of Parties	No. of Hunters	No. of Animals	
				Whitetail	Mule Deer
10-26-80	Blackleaf	15	37	1	0
10-26-80	Teton	56	133	8	14
10-29-80	Teton	20	50	1	8
11-1-80	Teton	26	62	4	2
11-2-80	Teton	49	119	1	7
11-8-80	Teton	23	52	5	0
11-9-80	Teton	39	98	6	2
11-11-80	Teton	18	32	0	0
11-29-80	Teton	24	57	1	5
11-30-80	Teton	34	78	0	3
11-30-80	Dupuyer	<u>2</u>	<u>7</u>	<u>2</u>	<u>0</u>
	Total	306	725	29	41

Table 12. Origin of hunters (%) checked during 9 days by county and hunting districts in autumn 1980 on the study area.

County Distribution		Hunting District Distribution	
Countries	% of Hunters	Hunting District	% of Hunters
Teton	49	441	32.0
Pondera	21	442	23.0
Cascade	14	450	38.0
Others in Montana	11	406	3.0
		404	0.2
Out of State	1	421	0.4
Unknown	4	444	0.5
		Unknown	3.0

Table 13. Number of male and female radioed and neckbanded deer marked, accounted for, and unaccounted for from 1973-1980 on the East Front from Birch Creek to Sun River.

Sex	Number Marked	Accounted for		Unaccounted for
		Alive	Dead	
Male	31	14	7	10
Female	<u>91</u>	<u>45</u>	<u>9</u>	<u>37</u>
Total	122	59	16	47

the status of 61% of these deer were unknown. Thirteen percent of the total deer marked were known to be dead. The status of 32% of the collared males and 41% of the collared females was unknown. Fawns and yearlings comprised 80% of the unknown males and 19% of the unknown females.

Habitat Characteristics and Use

Habitat Characteristics

Kasworm (1981) described 20 vegetation types on the East Front winter range (Appendix Table 19). I described three additional types, *Pseudotsuga menziesii*/*Symphoricarpos occidentalis*, *Picea engelmannii*/*Smilicina stellata*, and *Abies lasiocarpa*/*Clematis pseudoalpina* (Appendix Tables 19, 20). The amount and percentage of area covered and coefficients of variation in the occurrence of each of 17 types that occurred on 3 zones of low deer use, 2 transitional ranges, and 5 major winter ranges on the study area are presented in Table 14. Low deer use zones

Table 14. Area (km²) and percentages of vegetation cover types for 3 low deer use areas, 2 transition ranges and 5 winter ranges^a on the East Front during 1980-1981. Variations in proportions of cover types among areas are expressed as coefficients of variation (C.V.)^c.

Cover Types ^b	Low Use			Winter Range			Transition		
	Total km ²	Mean %	C.V. %	Total km ²	Mean %	C.V. %	Total km ²	Mean %	C.V. %
Pofr-Fesc	11.36	32.3	105	10.97	14.0	38	2.80	19	74
Pifl-FescI	1.42	3.0	88	8.51	9.4	205	.10	1	141
Pifl-FescII	13.87	29.7	82	9.90	12.5	49	2.23	16	57
Pifl-FescIII	1.66	3.7	87	.25	.5	284	.20	2	141
Pifl-Aspen	.61	1.7	170	.10	.1	22	.05	.5	141
Aspen	1.52	3.0	115	1.77	2.1	68	.61	4	106
Shrub Riparian	3.26	6.3	108	3.93	4.9	40	.05	.5	141
Tree Riparian	2.31	7.0	94	1.00	1.5	224	.05	.5	141
Psme-Spbe	1.18	3.3	126	.10	.1	148	2.88	24.5	61
Psme-Syal	.69	2.3	175				.49	3.0	141
Pien-Smst							.37	2.5	85
Hay Meadow	.25	.7	165	1.94	2.3	82			
Swamp	.86	2.3	176	1.02	1.0	197			
Pifl-Beoc	.12	.3	192						
Abla-Clps	.73	2.0	173				.70	7.0	141
Pifl-Junip				2.38	2.4	138	2.14	17.0	25
Fesc-Agsp				<u>30.05</u>	38.1	30	<u>.08</u>	.5	141
Total	39.84			71.92			12.75		

^aKasworm (1981)

^bSee Appendix Table 21 for key to 4-letter plant species abbreviations.

^cCoefficient of Variation = (SD) 100/mean.

were areas between major winter ranges where few or no deer were observed. They included Volcano Reef, Upper Dupuyer Creek, and Upper Muddy Creek.

Cover types varied greatly in distribution and occurrence among low use zones, as well as between transition areas (Table 14). Those with coefficients of variation less than 100% on low use zones were *Pinus flexilis*/*Festuca scabrella* and riparian tree. For transition areas, types with relatively low variability included *Potentilla fruticosa*/*Festuca scabrella*, *Pinus flexilis*/*Juniperus* spp., *Pinus flexilis*/*Festuca scabrella*, *Pseudotsuga menziesii*/*Spirea betulifolia*, and *Picea engelmannii*/*Smilacina stellata*.

The locations of sampled low deer use zones, transition ranges, and the 1 winter range (Swanson Ridges) not previously described by Kasworm (1981) are shown in Figure 6. Amounts and percentages of vegetation types occurring on individual areas are given in Appendix Table 20.

A summary of Chi-square analyses of differences in the availability of cover types between major winter ranges and low deer use zones, between winter ranges and transition ranges, and between low use zones and transition areas is presented in Table 15. Winter ranges differed significantly from low-use zones in the occurrence of all types except aspen, riparian shrub, and *Pinus flexilis*/*Betula occidentalis*. Low-use zones had significantly more of the dense timber types than did winter ranges. Transition ranges differed from

Figure 6. Map of the East Front showing 3 low use zones, 2 transition areas, and Swanson Ridges that were vegetatively and topographically sampled during 1981.

Table 15. Chi-square analysis of availability of vegetative cover types among: low use zones and winter ranges; transition ranges and low use zones; and transition ranges and winter ranges^a.

Cover Type ^b	Low Use Zone	Winter Range	Transition Range	Low Use Zone	Transition Range	Winter Range
Pofr-Fesc	+	-	-	+	+	-
Pif1-FescI	-	+	-	+	-	+
Pif1-FescII	+	-	-	+	NS	
Pif1-FescIII	+	-	NS		+	-
Pif1-Aspen	+	-	NS		NS	
Aspen	NS		NS		NS	
Shrub Rip.	NS		-	+	-	+
Tree Rip.	+	-	-	+	NS	
Psme-Spbe			+	-	+	-
Psme-Syal	+	-	NS			
Hay	-	+				
Swamp	+	-				
Pif1-Beoc	NS					
Abla-Clps			+	-		
Pif1-Junip					+	-
Fesc-Agsp					-	+

^aNS = No significant difference.

- = Significant lower occurrence than the other unit in the test.

+ = Significant higher occurrence than the other unit in the test.

^bSee Appendix Table 21 for key to 4-letter plant species abbreviations.

both low-use zones and winter ranges by having higher percentages of *Pseudotsuga menziesii*/*Spirea betulifolia*, *Abies lasiocarpa*/*Clematis* sp., *Pinus flexilis*/*Juniperus* sp. and low density *Pinus flexilis*/*Festuca scabrella* types, and lower percentages of the riparian shrub and *Festuca scabrella*/*Agropyron spicatum* types. Aspen was the only type that occurred in similar proportions on all areas.

Winter ranges also differed from low-use zones in topographic characteristics. Winter ranges were consistently lower in elevation. They also had wider availability of aspect classes (Fig. 7) and greater percentages of area in moderate and steep slope categories (Fig. 8) than did low-use zones. Transition ranges differed from winter ranges and low-use zones in having the steepest slopes and the highest average elevations.

Mule Deer Habitat Use

Mule deer use of vegetation cover types (Table 16), slope (Fig. 9, Table 16), aspect (Fig. 10, Table 16), and elevation (Table 17) on the 5 major winter ranges during 1980-1981 was compared with availability of those components as determined by Kasworm (1981). Although use data doubtless were biased toward more open habitat configurations and diurnal periods, some selection for specific habitat attributes or configurations was evident.

The *Pinus flexilis*/*Festuca scabrella* type was heavily used on all areas (Table 16). Snowdrift shrub type (Kasworm 1981), when

WINTER RANGES

SCOFFIN BUTTE

DUPUYER CREEK

BLACKLEAF-TETON

EAR MOUNTAIN

CASTLE REEF

SWANSON RIDGES

LOW USE ZONES

UPPER MUDDY CK

VOLCANO REEF

UPPER DUPUYER CK

TRANSITION RANGES

UPPER CHICKEN
COULEE UPPER ANTELOPE
BUTTE

↑
AVERAGE
ASPECT

Figure 7. Aspect distribution (%) on 3 low use zones, 2 transition ranges, and 6 winter ranges for mule deer on the East Front during 1979-1981.

WINTER RANGES**A**-SCOFFIN BUTTE**B**-DUPUYER CREEK**C**-BLACKLEAF-TETON**D**-EAR MOUNTAIN**E**-CASTLE REEF**F**-SWANSON RIDGES**LOW DEER USE ZONES****G**-VOLCANO REEF**H**-UPPER DUPUYER CREEK**I**-UPPER MUDDY CREEK**TRANSITION RANGES****J**-UPPER ANTELOPE BUTTE**K**-UPPER CHICKEN COULEE

- 1 - LEVEL 0-1°
 2 - GENTLE 1-7°
 3 - MODERATE 7-16°
 4 - STEEP 16+°

Figure 8. Percentages of 4 slope categories found on 3 low deer use zones, 2 transition areas, and 6 winter ranges for mule deer on the East Front during 1979-1981.

Table 16. Summary of Chi-square (χ^2) analysis^a of observed deer use vs. availability for 3 environmental variables.

Environmental variable	Areas				
	Scoffin	Dupuyer	Blk-Teton	Ear	Castle
Slope					
Level 0-1°	-	-	-	+	NS
Gentle 1-7°	-	-	-	-	-
Moderate 7-16°	+	+	+	+	+
Steep 16+°	+	-	NS	+	-
Aspect					
NE	-	-	-	NS	NS
E	-	+	NS	+	+
SE	NS	+	NS	-	+
S	+	+	+	+	-
SW	NS	NS	-	-	-
W	-	-	NS	NS	NS
NW	-	-	-	-	-
N	+	-	NS	NS	-
Vegetation types ^b					
Fesc-Agsp	-	-	-	-	-
Pofr-Phpr	+	-	-	-	-
Pofr-Fesc	-	+	NS	NS	-
Pifl-FescI	-	-	+	NS	+
Pifl-FescII	-	+	+	+	NS
Pifl-FescIII	+	-	+	-	-
Riparian	-	-	-	NS	NS
Hay meadow	-	+	-	NS	-
Snowdrift shrub	-	+	-	-	-
Aspen	-	-	NS	NS	-
Pifl-Beoc	-	-	NS	-	-
Pifl-Aspen	-	-	NS	-	-
Artr-Fesc	-	-	-	NS	NS

^a - = Significant negative occurrence.

+ = Significant positive occurrence.

NS = No significant difference from expected.

^b See Appendix Table 21 for key to 4-letter plant species abbreviations.

Figure 9. Observed deer use (%) of 4 slope categories relative to availability on 5 winter ranges on the East Front during 1980-1981.

Figure 10. Percentages and average aspects that deer were observed occupying on 5 winter ranges during 1980-1981.

Table 17. Average elevations at 3 low use zones, 2 transition ranges, and 6 winter ranges. Average elevations (m) of deer observations on 5 winter ranges during 1980-1981.

	Average Elevations of Range Unit	Average elevations of observed deer use
Low use zones		
Volcano Reef	1,515	
Upper Dupuyer Creek	1,545	
Upper Muddy Creek	1,545	
Transition ranges		
Upper Antelope Butte	1,758	
Upper Chicken Coulee	1,818	
Winter ranges		
Swanson Ridges	1,515	
Blackleaf-Teton	1,515	1,545
Dupuyer Creek	1,455	1,515
Scoffin Butte	1,424	1,455
Castle Reef	1,424	1,485
Ear Mountain	1,545	1,576

available, also received greater than expected observed deer use.

Fewer deer than expected were seen on the *Agropyron spicatum*/*Festuca scabrella* and riparian shrub types.

The greater than expected numbers of deer observed on moderate slopes on all winter ranges indicated that type of terrain form was important to deer. Selection for aspect was less apparent, but deer generally were observed in less than expected numbers on northeast and northwest exposures and more frequently than expected, relative

to availability, on east and south exposures. In all cases, deer appeared to select higher-than-average elevations.

Rumen Analysis

Contents of 5 rumens collected on the study area in winter from 1980-1981 indicated that *Juniperus horizontalis* was heavily utilized (Table 18). Rumen contents consisted of 68% shrubs, 25% forbs, and 7% grasses.

Gas and Oil Impacts

Gas and oil drilling activity occurred exclusively in low deer use portions of the Blackleaf-Teton winter range during the winter of 1980-1981. As a result, too few deer were present for adequately testing the influence of the drill site on deer distribution. Efforts to conduct track counts were abandoned due to inadequate snow cover. Sightings of deer were limited to aerial transects and ground observations in the vicinity of the Blackleaf drill site. Three aerial transects were flown on January 2, January 23, and March 24, 1981 with 0, 7, and 6 mule deer counted, respectively, within 3 km² of the drilling operation.

Figure 11 presents drill site locations, proposed drill sites, and seismic lines on the study area. Surveillance of deer behavior in close proximity to seismic blasting was not possible because of problems encountered in learning where and when lines were to be run.

Table 18. Contents of 5 mule deer rumens (by percent volume) collected in the study area during 1980-1981.

Contents	Rumens ^a				
	1	2	3	4	5
Juho	7	61	17	60	71
Pifl	4				
Grass	12	9	Trace	9	4
Unid. Forb	71	20	35		
Unid. Shrub	5			8	
Artr		10	11		
Shca			5		10
Juco			14		
Aruv			9	18	4
Pico			9	5	8
<i>Sedum</i> sp.					1
Pogr					Trace
<i>Rosa</i> sp.					Trace
Mushroom					Trace
<i>Antenn.</i> sp.					Trace
<i>Douglasia</i> sp.					Trace
Psme					Trace

^a

	<u>#</u>	<u>Date</u>	<u>Location</u>	<u>Age</u>	<u>Case of death</u>
Rumen:		1-2/80	Castle Reef	Fawn	Eagle kill
		2-1/80	Castle Reef	Fawn	Eagle kill
		3-2/80	Ear Mountain	Fawn	Coyote kill
		4-2/80	Dupuyer	Adult	Unknown cause of death
		5-1/81	Ear Mountain	Adult	Road kill

However, observations on deer that were approximately 3 km away from the activity were made on one occasion. These deer looked up after blasts, assumed an alert posture, and then either ran a short distance or resumed feeding. Five radioed deer did not exhibit any noticeable long term changes in home range locations following seismic activity within their home ranges.

Figure 11. Gas well locations, proposed well locations, and seismic lines run on the East Front 1980-1981.

Winter home ranges of 4 radio-collared deer during 1979-1980 (prior to drilling activity) and 1980-1981 (during drilling activity) on the Blackleaf-Teton winter range are shown in Figure 12. Geographic activity centers were 1.8-4.1 km farther northeast or southwest in 1980-1981 than in 1979-1980. Geographic activity centers of 4 radio-collared deer on the Ear Mountain winter range, where no hydrocarbon exploration occurred, shifted 1.2-2.8 km in a northwesterly direction during the same time period.

▲ DRILL SITE

Figure 12. Home ranges of 4 radio-collared mule deer in winter 1979-1980 (prior to gas and oil activity at the Blackleaf-Teton winter range) and in winter 1980-1981 (during activity at the Blackleaf-Teton winter range).

DISCUSSION AND CONCLUSIONS

Seasonal Distribution , Movements, and Home Ranges

Although a great deal of emphasis in this study was placed on winter ranges, the status of a mule deer population is only partially determined by winter range conditions. Other seasonal ranges have been shown to be equally important (Wallmo et al. 1977, Mautz 1978, Julander et al. 1961, Edwards and Ritcey 1958).

Mackie et al. (1980) found that mule deer associated with a specific winter range could be characterized as a population unit associated with a definable yearlong herd range. Four of the 6 (possibly 7) winter ranges I recognized along the east slope of the Rocky Mountains between Birch Creek and the Sun River were represented by sufficient numbers of marked animals to tentatively delineate total herd ranges. Those 4 varied from 328 to 1056 km². They had lower densities (2-3 deer/km²) than herd ranges in the Bridger Mountains (6-25 deer/km²) (Rosgaard 1981). Very few deer (<100) winter west of the Continental Divide directly west of the study area (Jim Cross pers. comm.). This would indicate that 90% or more of all mule deer that summer in the portion of the Bob Marshall Wilderness north of the Sun River may winter on the East Front ranges.

The East Front winter ranges were concentrated into at least 6, and possibly 7, discrete units ranging in size from 10 to 81 km². Winter densities of deer in 1979-1980 and 1980-1981 varied from 5 to

80 deer/km² among these units. Other studies from mountain areas in Montana have reported densities on winter range of 10 to 150 deer/km² (Mackie et al. 1980).

Deer density was inversely related to the size of individual winter range units. Winter ranges with the highest densities (22 to 80 deer/km²) were 10-39 km² in size. Units with the lowest densities (5 to 10 deer/km²) varied from 44-80 km². A similar relationship has been reported by Mackie et al. (1978) for the Bridger Mountains of southwestern Montana.

The actual area occupied by East Front populations during winter, and consequently deer density, varied from year to year with differences in snow and weather conditions. Average winter conditions prevailed in 1979-1980, and mild conditions occurred in 1980-1981. Total winter range used by all populations units increased from 242 km² in 1979-1980 (Kasworm 1981) to 289 km² in 1980-1981. Information on deer distribution during a severe winter was limited to one helicopter survey in 1978-1979. Winter distribution within primary use areas was evidently similar in all 3 of the winters, but secondary range was used much more extensively in the 2 milder years.

Winter ranges on the study area were separated by areas of little or no deer use. These low use zones may support greater deer numbers as the population increases, or they may provide usable winter range only during abnormally mild winters as 1980-1981. Although I could not

determine which of these two situations applied to the study area, because winter severity decreased and population size increased during the 2-year study, a helicopter survey by Olson (pers. comm.) in January 1982 indicated that the Volcano Reef low use zone was not occupied by deer despite an apparent increase in deer numbers on the Blackleaf-Teton winter range.

Average individual winter home ranges of adult females increased in size from 4.6 km^2 in 1979-1980, to 6.0 km^2 in 1980-1981. This indicated an inverse relationship between size and winter severity. Youmans (1979) documented larger winter ranges for mule deer during a mild year in the Bridger Mountains. East Front home ranges were smaller than those reported for the east side of the Bridger Mountain Range (Nyberg 1980) but larger than those found on the west slope of that range (Youmans 1979, Steerey 1979).

Transition or holding areas were heavily used by deer in spring and fall. Transition range was characteristically located in the foothills adjacent to and west of winter ranges. The importance of transition ranges as staging or holding areas along mule deer migration routes has been noted in Utah (Robinette 1966) and California (Bertram and Remple 1977). Pac (1976) and Steerey (1979) delineated holding areas for mule deer in the Bridger Mountains.

Loveless (1967) felt that migratory movements were correlated with temperature and that snow accumulation forced deer to concentrate

on winter ranges. Along the Front, snow accumulation apparently influenced movements from transition and summer range during the 1978-1979 and 1979-1980 winters, but tradition evidently played a role in timing of movements from transition to winter range in 1980-1981. Snow depths were so low during this winter that deer had access to transition ranges throughout most of the winter, yet most deer moved onto the East Front winter ranges in December and January as they did the previous winter.

The moderate to heavily forested transition ranges along the East Front probably provide secure habitat for deer during the hunting season. I could not determine if hunting pressure forced deer into forested transition range or if security from hunters was a secondary outcome of autumn habitat preferences.

Spring movement to summer ranges was direct, rapid, and apparently influenced both by snow melt in higher passes and plant phenology. Migration routes were described by Kasworm (1981). The same major drainages were used as migration routes during spring and fall. One additional migration route through the Blackfoot Indian Reservation was documented. Timing of spring (May to early June) and fall migration was similar during 1979-1980 and 1980-1981. Fall movements of deer that summered west of the divide onto transition ranges occurred in middle October to early November of both years.

Three summer range segments were described by Kasworm (1981) and confirmed by my study. These included deer summering within or very close to the wintering area (RES), deer summering east of the Continental Divide (EOD), and deer summering west of the divide (WOD). Similar distributional patterns have been described by Harestad (1979) for black-tailed deer and Rosgaard (1981) for mule deer in other areas. The 22 radio-collared deer in the East Front population included 14% residents, 59% short-distance migrants (EOD), and 27% long-distance migrants (WOD). If this distribution approximated the actual summer dispersal pattern, the East Front population had fewer long-distance migrants than the Brackett Creek winter range in the Bridger Mountains where residents, short-distance migrants and long-distance migrants made up 5, 20, and 75% of the population, respectively (Rosgaard 1981).

Animals that summered near their winter ranges were more flexible in their movement patterns. They tended to make less use of transition range in fall than long distance migrants (WOD), remained on summer ranges later in fall, and returned to summer range earlier in spring. Individuals that crossed a major divide were inclined to move with the first severe snow storms of the fall season. These differences in movement patterns among summer range segments have also been documented in the Bridger Mountains (Steerey 1979, Nyberg 1980, Rosgaard 1981).

Average summer home range sizes for radio-collared females on the study area were 6.4 km^2 in 1979, 3.5 km^2 in 1980, and 1.4 km^2 in

1981. These compared to means of 3.7 km^2 in 1979 (Nyberg 1980), and 3.1 km^2 in 1980 (Rosgaard 1981) for mule deer ranging on the east side of the Bridger Mountains and a mean of 1.7 km^2 for those on the west side of that range (Mackie et al. 1980).

Fidelity to summer home ranges (21 of 22 radio-collared deer) was high in 1980 and 1981. Other studies have also documented high fidelity of mule deer to both summer and winter ranges (Leopold et al. 1951, Gruell and Papez 1963, Zalunardo 1965, Robinette 1966, Pac 1976, Steerey 1979, Rosgaard 1981, Mackie et al. 1979, 1980).

Individual seasonal home range used in 1 year indicates only a portion of the total seasonal home range needed and used over a mule deer's lifetime. Data are not available for lifetime seasonal home ranges, but data from this study indicated that radioed deer relocated for 3 summers had total seasonal home range that averaged 11.1 km^2 , a much greater area than was used in a single year. Average summer home ranges for EOD deer were smaller than those for WOD deer in all 3 years for which radio-telemetry data were available.

Three out of 78 marked animals were known to have dispersed (from one winter range to another) within the study area. All 3 deer that were known to change winter ranges were males; 2 of those were yearlings. Male mule deer are more likely to disperse than females (Pac 1976, Mackie et al. 1979, 1980), and yearlings have a higher affinity

for dispersal than do other classes (Robinette 1966). If the observed sample of aged deer were representative of the population, dispersal rates for the total and yearling segments were 4 and 9%, respectively. Rosgaard (1981) documented dispersal of similar magnitude along the east side of the Bridger Mountains during a period of higher than average deer density.

Population Dynamics

Helicopter surveys conducted in 1978-1980 (Kasworm 1981) indicated that the mule deer population wintering along the East Front was increasing. An additional increase of approximately 6% occurred between 1980 and 1981. Actual numbers observed in March 1981 were lower than in March 1980; however, the proportion of collared animals observed during the 1981 helicopter survey was lower due to milder winter conditions and a wider distribution of deer. During 1981, numbers of deer on national forest lands that serve as secondary winter range were greater than in 1980. The low percentage of marked deer observed during the April 1981 survey indicated that deer were beginning to move off the winter range onto forested transition ranges and precluded the use of that survey for a population estimate.

Fawn:adult ratios for mule deer on the Front were relatively high when compared to other mountain foothill areas (Mackie et al. 1980). Ratios observed on the study area were greater in the 1979-1980 winter

than in 1980-1981. This probably was due to an increased proportion of yearlings in the "adult" category rather than to decreased productivity. High yearling numbers will dilute fawn:adult ratios since yearlings generally are nonproductive in mule deer populations (Nellis 1968, Hamlin 1977). Mild conditions in 1979-1980 apparently resulted in abnormally low fawn mortality which led to high yearling recruitment for 1980-1981. A similar situation may occur during the 1981-1982 winter.

Limited data indicated a relatively young age structure for population units on the study area. A similarly young age distribution was reported by Nyberg (1980) and Rosgaard (1981) for mule deer on the east side of the Bridger Mountains; whereas on the west slope, an older age structure has been reported (Mackie et al. 1980).

The proportion of antlered to non-antlered (does and fawns) deer (19:100 in January 1981) on the study area was higher than in some other southwestern Montana mule deer populations (Pac et al. 1981, Rosgaard 1981). High proportions of males may be attributed to low harvest or to the general nature of the Front habitat characteristics.

Habitat Characteristics and Use

Deer wintering along the East Front were not uniformly distributed. Even in a mild winter, some sites held very few or no deer, others had low to moderate densities, and 4 areas (Scoffin Butte,

Dupuyer Creek, Long Ridge, and Castle Reef) had high densities. Kasworm (1981) noted an inverse correlation between deer densities on winter ranges in the study area and elevation, but he did not investigate differences between areas used by deer along the East Front and low deer use zones. I found that low deer use zones had significantly lower percentages of moderate to steep slope categories and a lower proportion of southerly aspects than core winter ranges. Observations of deer within core winter ranges indicated that these slope and aspect categories received greater use than expected if deer were selecting for aspect and slope steepness in proportion to availability. Loveless (1967) noted that southern aspects receive 9 times as much direct sunlight as northern aspects. He found that east and south slopes received greater use by mule deer on winter ranges in Colorado during periods of low temperature and that snow depths were lower on east and south than on north and west slopes.

Greater deer use was observed at elevations higher than average for the winter range. Loveless (1967) found that higher portions of slopes on the winter range were warmer than lower portions of slopes on the winter range.

The vegetation on winter ranges was very different than that on low use zones, but a high degree of variability in occurrence of individual cover types among winter ranges and the low use zones made interpretation difficult. Deer favored the *Pinus flexilis*/*Festuca*

scabrella type on winter ranges, presumably because it represented a mixture of open slopes and patchy timber. Timber types have been reported to provide increased security, thermal cover, reduced snow depths, and protection from wind (Loveless 1967, Moen 1968, 1976, and Ozoga and Gysel 1972). Analysis of 5 rumens and studies of winter food habits of mule deer on the study area (McCarthy et al. 1978, Kasworm 1982 unpubl. report to BLM, Butte) have indicated that plant species abundant on open, exposed slopes comprised the bulk of mule deer diets. On the East Front, timber patches, moderate to steep slopes, and windward aspects at elevations low enough to be blown clear by chinook winds evidently are essential components in the environmental mosaic that enables mule deer to survive winter conditions.

Transition or holding areas along the Front were characterized by a high percentage of cover, higher elevations than winter ranges, eastern exposures, moderate slopes, and proximity to winter ranges. Transition ranges provided security during the hunting season and, presumably, preferable feeding conditions until snow accumulated or tradition forced deer onto winter ranges.

Hydrocarbon Exploration Impacts

Impacts of hydrocarbon exploration were difficult to assess due to the low intensity of activity during the study, the mild winter

conditions, and the low density of deer in the vicinity of the only active well sites on the area during the 1980-1981 field seasons. The limited data collected showed no obvious avoidance by deer of the well sites in the Blackleaf-Teton unit. The changes in geographic activity centers between 1980 and 1981 for 4 radio-collared mule deer in the vicinity of those drill sites were more likely due to differences in weather conditions between the 2 years than to gas exploration. However, as activity intensifies and a gas field is developed, the potential for impacts will increase.

Knight (1980) found that activity at the site of an oil well did not statistically influence elk movements or distribution. He attributed the lack of response to the adaptability of elk to predictable and stationary disturbances. Geist (1971) described this phenomena in other ungulate species. Since mule deer can be easily habituated to human activities (Geist 1981) and are difficult to force from their home ranges (Robinette 1966), the direct effects of gas/oil drilling at scattered sites for short periods of time may be negligible. Dense fields, however, may lead to physical habitat loss and increased access which could increase the risk of mortality to mule deer due to habitat deterioration, accidents, or poaching.

Seismic activity on the study area was extensive. The Lewis and Clark National Forest has sustained greater seismic activity than any other National Forest in western Montana during the past 2 years; 288

km of seismic lines were completed in 1981 alone (Great Falls Tribune Jan. 23, 1982). Radio-collared mule deer did not show any apparent long-term changes in seasonal home ranges as a result of seismic activity. I was unable to test short-term changes because of the reticence of seismic companies in divulging the exact timing of seismic operations and financial limitations on flight time. Limited ground observations indicated that deer 3 km away from seismic activity did run short distances and/or assumed alert postures.

Seismic operations on the East Front apparently influenced elk distribution (G. Olson pers. comm.) and led to short-term movements in mountain goats (G. Joslin pers. comm.). Seismic activity affected elk movements but not distribution in Michigan (Knight 1980). Knight felt that seismic activity had a greater potential for negatively impacting animals, through decreasing feeding efficiency, decreasing reproduction, and increasing energy expenditure, than did well drilling. Geist (1971) noted that disturbances are potentially more detrimental if unpredictable and frequent. Seismic activity along the Front in 1982 will reportedly be 4 times as great as in 1981 (L. Irby pers. comm.).

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

General Management Implications

Effective management or assessment of the potential influences of environmental factors on mule deer populations requires understanding of the spatial distribution and patterns of deer use in all seasonal habitats. Although individual seasonal ranges may be viewed separately for some management purposes, complete units are critical for the survival of viable populations. The three seasonally used segments identified within individual population-habitat units include: (1) winter range on which mule deer depend for survival from November-December through April-May, (2) summer range on which those animals are produced, and (3) transition range, which provides security during the hunting season and may also be important in determining the condition of deer as they move onto winter range.

The high percentages of successful does (i.e., does with fawns) and high fawn:doe ratios observed in early winter indicated that summer ranges were reasonably adequate. Because of this, management efforts relative to harvest and the influences of gas and oil development will most likely concern winter and transition ranges. Greatest opportunity for conflict occurs on winter ranges, large portions of which are privately owned and/or have privately-owned mineral rights. Deer populations on privately-owned surface areas are maintained primarily because landowners continue to tolerate the presence of deer and/or have

maintained land-use practices compatible with deer use. Regulation of the timing, type, and intensity of mineral development, extent of grazing, farming, hunting access, and housing developments on private land is beyond the control of state and federal wildlife and land management agencies.

The population apparently increased during the last few years, indicating a potential for greater harvest. The summer range segments, however, differ in their vulnerability to overharvest. The long distance migrants (WOD) seemed most vulnerable to hunting since they were hunted both on their summer ranges during early season hunts (mid-September through October) and on their transition or winter ranges during regular hunts (late October through November). Recovery by this segment following a serious reduction could take a long time because of the long distances to summer ranges and behavioral characteristics related to distribution. Similarly, loss of East Front winter ranges used by these deer would seriously impair their ability to occupy vast areas of wilderness summer ranges west of the Continental Divide.

More access might be desirable at current high population levels in order to increase harvest and to spread hunting pressure more widely and uniformly across transition range, but control of access is essential. Uncontrolled access, as a result of extensive road development, could be dangerous to the entire population, especially

the WOD segment. Restriction of access to the few drainages easily reached through public lands could concentrate hunting pressure to the extent that specific population units (the Blackleaf-Teton and Ear Mountain units under current land ownership patterns) could be jeopardized. Cooperation of private landowners is essential in gaining and controlling access.

Winter range sizes delineated in this study are tentative and could change with increasing population size. Similarly the 7 individual winter ranges varied widely in basic environmental features and the manner of deer use. Summer range characteristics are important in determining the size and quality of populations on winter ranges, but current data are insufficient to fully assess the influence of variation in summer range characteristics for mule deer along the East Front. Because of the changing status of the East Front population, the limited available data, and the unique characteristics associated with each winter-transition-summer range complex, each population unit should be considered individually. No single, rigid set of regulations governing development can be expected to apply to the entire East Front. Priorities for protection of winter ranges should be determined relative to the potential value of the range for development, livestock grazing, recreation, and wildlife habitat for mule deer and other species, but the regulation of impacts should be undertaken on a site by site basis.

Population units should be monitored closely to detect changes in population size, productivity, mortality, and distribution associated with changes in land use. Monitoring will be crucial in detecting, or possibly predicting, future deterioration in populations and in judging the success of management practices. Possible innovative management options could include deer easements on private winter range, trades of livestock grazing on noncritical range on public lands for wildlife grazing reservations on private critical range, road closures, year to year shifts in numbers of doe permits, alternative opening and closing of land access, and manipulation of timing and/or spacing of development on public land to compensate for activities on adjacent private land.

Gas and Oil Impacts and Management Recommendations

Seismic activity- Seismic activity can potentially disrupt fawn rearing, rut activity, and winter resting. Deer can evidently tolerate low to moderate frequencies of seismic activity, but the potentially unlimited and loosely controlled activity permitted under present laws could surpass the tolerance range of deer rather easily. Roads built during seismic operations could potentially lead to a greater harvest of deer (legal and illegal), more road kills, and more harassment.

Drilling and production- The potential for deer to adapt to disturbances is much greater if the disturbance is predictable and

stationary. Therefore, short-term effects of drilling may be minimal, especially in low deer use areas. However, placement of drill sites on core winter ranges can have detrimental effects. The potential for damage will vary at each drill site depending on distribution of deer, condition of deer, condition of range, amount of new access created, permanence of the disturbance, and spatial or temporal relationships to disturbances on adjacent areas. Conflicts due to pipelines and sweetening plants will also vary between sites.

Timing and access- Timing of activity and regulation of access can minimize potential conflicts. Primary and secondary winter range should be avoided from December 15 to May 15, migration routes from May 15 to June 15, and transition areas from October 15 to December 31. Road locations, permanence, and extent of traffic should be carefully planned prior to construction. Helicopter travel during seismic operations should be limited to specific corridors.

Regulations- Compatibility of hydrocarbon development and mule deer would be enhanced if certain precautions, regulations, and cooperative agreements were formulated and enforced. Restriction of firearm, motorbike, and snowmobile use by personnel of gas and oil operations would minimize harassment. Modifications of laws to allow limits on frequency of exploration or sharing of information (i.e. pooled oil company exploration, or exploration financed by the Forest Service and

sold to interested parties) would greatly reduce stress placed on wildlife.

Consideration of cumulative impacts- When gas and oil development occurs in conjunction with other impacts, such as livestock grazing, presence of other wildlife species, housing development, recreation, and severe winters, the detrimental effects of hydrocarbon-related activity on mule deer may be accentuated. Consideration of these additional impacts when planning development is critical. Placement of pipelines, industrial plants, drill sites, and seismic lines on lands subject to public control should be carefully examined on a site by site basis to minimize conflicts with deer populations,

Coordination- Communication and cooperation between resource managers, private land owners, and the petroleum industry are critical to successful coexistence of mule deer populations and hydrocarbon development along the East Front. Communication and cooperation are also necessary among federal and state agencies assigned to manage resources. Specific suggestions that would facilitate cooperation include:

1. One person should be assigned responsibility for coordination, communication, and gaining cooperation between resource agencies, the gas and oil industry, and the public.
2. Advance notice of seismic proposals should be given to field biologists so that the effects can be monitored.

3. The detrimental effects of unplanned development should be communicated to land owners and resource users.
4. Development plans that are compatible with mule deer should be disseminated to land owners and resource users.
5. A system of shared responsibility and financial support should be developed for monitoring mule deer.

The management of wildlife and their habitat is directly related to the management of human impacts. The public must decide the balance between shorter term economic gains from gas and oil development and the much longer term economic and aesthetic benefits of large, healthy, and productive mule deer populations.

APPENDIX

[illegible]

^a See Appendix Table 21 for key to 4-letter plant species abbreviations.

Appendix Table 20. Descriptions of cover types not previously described by Kasworm (1981).

Psme/Syal^a

Upper stratum - *Pseudotsuga menziesii*, *Populus tremuloides*, *Pinus flexilis*

Mid-stratum - *Fibes* sp., *Potentilla fruticosa*

Lower stratum - *Symphoricarpos albus*, *Arnica cordifolia*, *Smilacina stellata*, *Galium boreale*

Pien/Smst

Upper stratum - *Picea engelmannii*, *Pinus flexilis*

Mid-stratum - *Juniperus* sp., *Shepherdia canadensis*, *Potentilla fruticosa*

Lower stratum - *Smilacina stellata*, *Arnica cordifolia*, *Fragaria virginiana*

Abla/Clps

Upper stratum - *Abies lasiocarpa*, *Pseudotsuga menziesii*, *Pinus flexilis*, *Picea engelmannii*

Mid-stratum - *Juniperus* sp., *Shepherdia canadensis*, *Potentilla fruticosa*, *Abies lasiocarpa*

Lower stratum - *Clematis pseudoalpina*, *Fragaria virginiana*, *Spiraea betulifolia*, *Galium boreale*, *Arnica cordifolia*

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^a See Appendix Table 21 for key to 4-letter plant species abbreviations.

Appendix Table 21. Key to 4-letter plant species abbreviations.

Abbreviation	Scientific name	Common name
Abla	<i>Abies lasiocarpa</i>	alpine fir
Agsp	<i>Agropyron spicatum</i>	bluebunch wheatgrass
Artr	<i>Artemisia tridentata</i>	big sagebrush
Beoc	<i>Betula occidentalis</i>	water birch
Clps	<i>Clematis pseudoalpina</i>	clematis
Fesc	<i>Festuca scabrella</i>	rough fescue
Junip	<i>Juniperus</i> sp.	juniper
Phpr	<i>Phleum pratense</i>	timothy
Pien	<i>Picea engelmannii</i>	Engelmann spruce
Pico	<i>Pinus contorta</i>	lodgepole pine
Pifl	<i>Pinus flexilis</i>	limber pine
Pofr	<i>Potentilla fruticosa</i>	shrubby cinquefoil
Psme	<i>Pseudotsuga menziesii</i>	Douglas fir
Smst	<i>Smilacina stellata</i>	false Solomon's Seal
Spbe	<i>Spiraea betulifolia</i>	white spiraea
Syal	<i>Symphoricarpos albus</i>	common snowberry

Appendix Table 22. Plants collected during 1980 and 1981 on the East Front study area.

Plantae

Embryobionta

Magnoliophyta

Liliopsida

Alismatidae

Najadales

Juncaginaceae

Triglochin L.

T. maritimum L.

Commelinidae

Cyperales

Cyperaceae

Carex L.

C. filifolia Nutt.

C. nebrascensis Dewey

C. xerantica Bailey

Poaceae

Agropyron

A. dasystachyum (Hook.) Scribn.

A. spicatum (Pursh) Scribn. & Smith

Bromus L.

B. carinatus Hook. & Arn.

B. inermis Leys.

B. tectorum L.

Deschampsia Beauv.

D. elongata (Hook.) Beauv.

Festuca L.

F. idahoensis Elmer

F. scabrella Torr.

Koeleria Pers.

K. cristata Pers.

Muhlenbergia Schreb.

M. cuspidata (Torr.) Rydb.

Phleum L.

P. pratense L.

Poa L.

P. cusickii Vasey

P. pratensis L.

P. sandbergii Vasey

Stipa L.

S. occidentalis Thurb. var. *minor* (Vasey) Hitchc.

S. viridula Trin.

Appendix Table 22. (Continued).

-
- Juncales
    - Juncaceae
      - Juncus* L.
        - J. longistylis* Torr.
  - Liliidae
    - Liliales
      - Iridaceae
        - Iris* L.
          - I. missouriensis* Nutt.
      - Liliaceae
        - Allium* L.
          - A. textile* Nels. & Macbr.
        - Lilium* L.
          - L. philadelphicum* L.
        - Smilacina* Desf.
          - S. racemosa* (L.) Desf.
        - Zigadenus* Michx.
          - Z. elegans* Pursh
          - Z. venenosus* Wats.
  - Magnoliopsida
    - Asteridae
      - Asterales
        - Asteraceae
          - Achillea* L.
            - A. millefolium* L. ssp. *lanulosa* (Nutt.) Piper
          - Agoseris*
            - A. glauca* (Pursh) Raf. var. *agrestis* (Osterh.) Q. Jones
          - Antennaria*
            - A. microphylla* Rydb. [incl. *A. rosea* (Eat.) Greene]
          - Arnica*
            - A. cordifolia*
          - Artemisia* L.
            - A. campestris* L.
            - A. cana* Pursh
            - A. frigida* Willd.
            - A. ludoviciana* Nutt.
            - A. tridentata* Nutt.
          - Balsamorhiza* Nutt.
            - B. sagittata* (Pursh) Nutt.
          - Carduus* L.
            - C. nutans* L.
          - Crepis* L.
            - C. occidentalis* Nutt.

Appendix Table 22. (Continued).

Asteraceae (Continued)

Erigeron L.*E. ochroleucus* Nutt.*E. speciosus* (Lindl.) DC.*Gaillardia* Foug.*G. aristata* Pursh*Gutierrezia* Lag.*G. sarothrae* (Pursh) Britt. & Rusby [= *Xanthocephalum sarothrae* (Pursh) Shinnery]*Heterotheca**H. villosa* (Pursh) Shinnery [= *Chrysopsis villosa* (Pursh) Nutt. ex DC.]*Hymenoxys* Cass.*H. acaulis* (Pursh) Parker*Liatris* Schreb.*L. punctata* Hook.*Senecio* L.*S. sp.**Solidago* L.*S. missouriensis* Nutt.*Taraxacum* Hall*T. officinale* Weber*Thelesperma* Less.*T. subnudum* Gray var. *marginatum* (Rydb.) Melchert*Trachypogon* L.*T. dubius* Scop.

Campanulales

Campanulaceae

Campanula L.*C. rotundifolia* L.

Dipsacales

Caprifoliaceae

Symphoricarpos DuRoi*S. albus* (L.) Blake*S. occidentalis* Hook.

Gentianales

Apocynaceae

Apocynum L.*A. medium* Greene

Lamiales

Boraginaceae

Cryptantha Lehm. ex G. Don*C. interrupta* (Greene) Payson

Appendix Table 22. (Continued).

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- Boraginaceae (Continued)
Eritrichium Schrad.
E. howardii (Gray) Rydb.
Lithospermum L.
L. ruderale Dougl. ex Lehm.
 Lamiaceae
Monarda L.
M. fistulosa L.
 Rubiales
 Rubiaceae
Galium L.
G. boreale L.
 Scrophulariales
 Scrophulariaceae
Besseyia Rydb.
B. wyomingensis (A.Nels.) Rydb.
Castilleja Mutis ex L.f.
C. lutescens (Greenm.) Rydb.
Collinsia Nutt.
C. parviflora Lindl.
Orthocarpus Nutt.
O. luteus Nutt.
Pedicularis L.
P. contorta Benth.
Penstemon Mitchell
P. albertinus Greene
P. confertus Dougl.
P. eriantherus Pursh
 Solanales
 Hydrophyllaceae
Phacelia Juss.
P. linearis (Pursh) Holz.
 Polemoniaceae
Collomia Nutt.
C. linearis Nutt.
Phlox L.
P. alyssifolia Greene
P. hoodii Rich.
 Caryophyllidae
 Caryophyllales
 Cactaceae
Opuntia Mill.
O. polyacantha Haw.

Appendix Table 22. (Continued).

-
- Caryophyllaceae
    - Arenaria* L.
      - A. congesta* Nutt.
    - Cerastium* L.
      - C. arvense* L.
    - Paronychia* P. Mill.
      - P. sessiliflora* Nutt.
  - Polygonales
    - Polygonaceae
      - Eriogonum* Michx.
        - E. flavum* Nutt.
      - Polygonum* L.
        - P. bistortoides* Pursh
  - Dilleniidae
    - Capparales
      - Brassicaceae
        - Alyssum* L.
          - A. alyssoides* (L.) L.
        - Descurainia* Webb. & Berth.
          - D. pinnata* (Walt.) Britt.
        - Draba* L.
          - D. reptans* (Lam.) Fern.
        - Lesquerella* Wats.
          - L. alpina* (Nutt.) Wats.
    - Ericales
      - Ericaceae
        - Arctostaphylos* Adans.
          - A. uva-ursi* (L.) Spreng.
    - Primulales
      - Primulaceae
        - Dodecatheon* L.
          - D. conjugens* Greene
        - Douglasia* Lindl.
          - D. montana* Gray
    - Salicales
      - Salicaceae
        - Populus* L.
          - P. tremuloides* Michx.
        - Salix* L.
          - S. bebbiana* Sarg.
    - Violales
      - Violaceae
        - Viola* L.
          - V. canadensis* L.

Appendix Table 22. (Continued).

Hamamelidaceae

Fagales

Betulaceae

Betula L.*B. occidentalis* Hook.

Magnoliaceae

Ranunculales

Berberidaceae

Mahonia Nutt.*M. repens* (Lindl.) G. Don [= *Berberis repens* Lindl.]

Ranunculaceae

Anemone L.*A. multifida* Poir.*A. nuttalliana* DC. [= *A. pratensis* L.]*Clematis* L.*C. hirsutissima* Pursh*C. pseudoalpina* (Kuntze) Nels.*Thalictrum* L.*T. occidentale* Gray

Rosaceae

Apiales

Apiaceae

Bupleurum L.*B. americanum* Coult. & Rose*Lomatium* Raf.*L. dissectum* (Nutt.) Math. & Const.*L. macrocarpum* (Hook. & Arn.) Coult. & Rose*Perideridia* Reichenb.*P. gairdneri* (Hook. & Arn.) Mathias

Fabales

Fabaceae

*Astragalus**A. adsurgens* Hook. [= *A. striatus* Nutt.]*A. bisulcatus* (Hook.) Gray*A. drummondii* Dougl. ex Hook.*A. gilviflorus* Sheldon*Hedysarum* L.*H. sulphurescens* Rydb.*Lupinus* L.*L. sericeus* Pursh*Melilotus* Mill.*M. officinalis* (L.) Lam.

Appendix Table 22. (Continued).

Fabaceae (Continued)

Oxytropis DC.*O. sericea* Nutt. ex T. & G.*O. splendens* Dougl. ex Hook.*O. viscida* Nutt. ex T. & G.*Petalostemon* Michx.*P. purpureum* (Vent.) Rydb.*Thermopsis* R.Br.*T. rhombifolia* Nutt.*Trifolium* L.*T. hybridum* L.*T. pratense* L.*T. repens* L.*Vicia* L.*V. americana* Muhl.

Geraniales

Geraniaceae

Geranium L.*G. viscosissimum* Fisch. & Mey.

Linales

Linaceae

Linum L.*L. perenne* L.

Myrtales

Onagraceae

Gaura L.*G. coccinea* (Nutt.) Pursh

Proteales

Elaeagnaceae

Eleagnus L.*E. commutata* Bernh.*Shepherdia* Nutt.*S. canadensis* (L.) Nutt.

Rosales

Crassulaceae

Sedum L.*S. lanceolatum* Torr.

Grossulariaceae

Ribes L.*R. cereum* Dougl.*R. inerme* Rydb.

Appendix Table 22. (Continued).

-
- Rosales (Continued)
- Rosaceae
- Amelanchier* Medic.
- A. alnifolia* Nutt.
- Fragaria* L.
- F. virginiana* Duchesne
- Geum* L.
- G. triflorum* Pursh
- Potentilla* L.
- P. fruticosa* L.
- P. gracilis* Dougl.
- P. hippiana* Lehm.
- Prunus* L.
- P. virginiana* L.
- Rosa* L.
- R. arkansana* Porter
- R. woodsii* Lindl.
- Spiraea* L.
- S. betulifolia* Pall.
- Saxifragaceae
- Heuchera* L.
- H. cylindrica* Dougl. ex Hook.
- Santalales
- Santalaceae
- Comandra* Nutt.
- C. umbellata* (L.) Nutt.
- Sapindales
- Anacardiaceae
- Rhus* L.
- R. trilobata* Nutt.
- Pinophyta
- Pinopsida
- Pinidae
- Pinales
- Cupressaceae
- Juniperus* L.
- J. communis* L.
- J. horizontalis* Moench
- J. scopulorum* Sarg.
- Pinaceae
- Picea* A. Dietr.
- P. engelmannii* Parry

Appendix Table 22. (Continued).

Pinaceae (Continued)

Pinus L.

P. contorta Dougl. ex Loud. var. *latifolia* Engelm. ex
S.Wats.

P. flexilis James

Pseudotsuga Carr.

P. menziesii (Mirbel) Franco

LITERATURE CITED

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- Aune, K. 1981. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dept. Fish, Wildl. Parks, Helena. 50 pp.
- Beasom, S. L., W. Evans, and L. Temple. 1980. The drive net for capturing western big game. J. Wildl. Manage. 44(2):478-480.
- Bertram, R. C. and R. D. Rempel. 1977. Migration of the North Kings deer herd. Cal. Fish and Game. 63(3):157-179.
- Deiss, C. F. 1943. Structure of the central part of the Sawtooth Range, Montana. Bull. Geol. Soc. 54(3):1123-1168.
- Edwards, R. Y. and R. W. Ritcey. 1958. Reproduction in a moose population. J. Wildl. Manage. 22(3):261-268.
- Erickson, G. L. 1972. The ecology of Rocky Mountain bighorn sheep in the Sun River area of Montana with special reference to summer food habits and range movements. M.S. Thesis. Mont. State Univ., Bozeman. 50 pp.
- Frisina, M. R. 1974. Ecology of bighorn sheep in the Sun River area of Montana during fall and spring. M.S. Thesis. Mont. State Univ., Bozeman. 68 pp.
- Geist, V. 1971. A behavioral approach to the management of wild ungulates. *In: The scientific management of animal and plant communities for conservation*, ed. E. Duffey and A. S. Watt, pp. 413-424. The 11th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. 652 pp.
- _____. 1981. Behavior: Adaptive strategies in mule deer. *In: Mule and blacktail deer of North America*, ed. O. C. Walmo, pp. 157-224. Univ. of Nebraska Press. 605 pp.
- Giesecker, L. F. 1937. Soils of Teton County. Bull. 332, Mont. State College, Agricultural Experiment Station, Bozeman. 63 pp.
- Great Falls Tribune. January 23, 1982. Overthrust Belt's potential assessed.
- Gruell, G. E. and N. J. Papez. 1963. Movements of mule deer in northwestern Nevada. J. Wildl. Manage 27(3):414-422.

- Hamlin, K. L. and M. R. Frisina. 1975. Special grizzly bear survey. Job progress report W-130-R-6, 1-1, 1-4, Mont. Dept. of Fish and Game, Helena. 64 pp.
- _____. 1977. Mule deer population ecology, habitat relationships, and relations to livestock grazing management and elk in the Missouri River Breaks, Mont. *In*: Montana Deer Studies. Job Prog. Rept., Proj. W-120-R-8. Job. 3. pp. 84-104.
- Harestad, A. S. 1979. Seasonal movements of black-tailed deer on northern Vancouver Island. PhD Thesis. University of British Columbia, Vancouver, Canada. 98 pp.
- Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. U. Wash. Press, Seattle. 730 pp.
- Johns, W. M. 1970. Geology and mineral deposits of Lincoln and Flathead Counties, Montana. Bull. 79, Montana Bureau of Mines. 182 pp.
- Jonkel, C. 1976. Annual report No. 1, Border Grizzly Project, Univ. of Mont., Missoula. 111 pp.
- _____. 1977. Annual report No. 2, Border Grizzly Project, Univ. of Mont., Missoula. 134 pp.
- Julander, O., W. L. Robinette, and D. A. Jones. 1961. Relations of summer range condition to mule deer herd productivity. *J. Wildl. Manage.* 25(1):54-60.
- Kasworm, W. F. 1981. Distribution and population characteristics of mule deer along the East Front, Northcentral Montana. M.S. Thesis. Mont. State Univ., Bozeman. 73 pp.
- _____. 1982. Dietary relations of mule deer, bighorn sheep, elk, and cattle along the East Front, Northcentral Montana. Unpubl. report to B.L.M. 13 pp.
- Knight, J. E., Jr. 1980. Effect of hydrocarbon development on elk movements and distribution in northern Michigan. Ph.D. Thesis. Univ. of Michigan, Ann Arbor. 79 pp.
- Knight, R. R. 1970. The Sun River elk herd. *Wildl. Manage.* No. 23. 66 pp.

- Leopold, A. S., T. Riney, R. McCain, and L. Tevis, Jr. 1951. The Jawbone deer herd. California Division of Fish and Game. Game Bull. 4. 139 pp.
- Lightfoot, W. C. and V. Maw. 1963. Trapping and marking mule deer. Proc. Western Assoc. Game and Fish Comm. 43:138-142.
- Lonner, T. N. 1981. Long Tom Creek - Elk Logging Study. *In*: Annual Prog. Rep. Mont. Coop. Elk Study. Job Prog. Rept., MDFWP Job IIB. pp. 4-18.
- Loveless, C. M. 1967. Ecological characteristics of a mule deer winter range. Colorado Div. Game, Fish and Parks. Tech. Publ. 20. 124 pp.
- Mackie, R. J., D. F. Pac, and H. E. Jorgensen. 1978. Population ecology and habitat relationships of mule deer in the Bridger Mountains, Montana. *In*: Montana Deer Studies. Job Prog. Rept., Fed. Aid Proj. W-120-R-9. pp.81-128.
- _____, _____, and _____. 1979. Population ecology and habitat relationships of mule deer in the Bridger Mountains, Montana. *In*: Montana Deer Studies. Job Prog. Rept., Fed. Aid Proj. W-120-R-10. pp. 69-118.
- _____, _____, and _____. 1980. Population ecology and habitat relationships of mule deer in the Bridger Mountains, Montana. *In*: Montana Deer Studies. Job Prog. Rept., Fed. Aid Proj. W-120-R-11. pp. 96-139.
- Marcum, L. C. and D. O. Loftsgaarden. 1980. A non-mapping technique for studying habitat preferences. J. Wildl. Manage. 44(4):963-968.
- Mautz, W. W. 1978. Nutrition and carrying capacity. *In*: Big game of North America: Ecology and Management, ed. J. L. Schmidt and D. L. Gilbert, pp. 321-348. Harrisburg, Pa. Stackpole Books. 494 pp.
- McCarthy, J., C. Watts, F. Feist, G. Erickson, and R. Buscus. 1978. Deer Surveys. *In*: Big Game Survey and Inventory - District Four. Unpubl. P-R Job Prog. Rept., Proj. W-130-R-8, Job 1-4. 51 pp.

- McCarthy, J., C. Watts, F. Feist, G. Olson, and R. Buscis. 1978. Deer Surveys. *In*: Big Game Survey and Inventory - District Four. Unpubl. P-R Job Prog. Rept., Proj. W-130-R-9, Job 1-4. 71 pp.
- _____, _____, _____, _____, and _____. 1979. Deer Surveys. *In*: Big Game Survey and Inventory - District Four. Unpubl. P-R Job Prog. Rept., Proj. W-130-R-10, Job 1-4. 59 pp.
- _____, _____, _____, _____, and _____. 1980. Deer Surveys. *In*: Big Game Survey and Inventory - District Four. Unpubl. P-R Job Prog. Rept., Proj. W-130-R-11, Job 1-4. 34 pp.
- Moen, A. N. 1968. The critical thermal environment: a new look at an old concept. *Bioscience* 18(11):1041-1043.
- _____. 1976. Energy conservation by white-tailed deer in the winter. *Ecology* 57(1):192-198.
- Mueggler, W. F. and W. L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA For. Ser. Gen. Tech. Rep. INT-66, Intermountain Forest and Range Experiment Station. Ogden, Utah. 154 pp.
- Nellis, C. H. 1968. Productivity of mule deer on the National Bison Range, Montana. *J. Wildl. Manage.* 32:344-349.
- Nyberg, H. E. 1980. Distribution, movements, and habitat use of mule deer associated with the Brackett Creek winter range. Bridger Mountains, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 104 pp.
- Overton, W. S. and D. E. Davis. 1969. Estimating the numbers of animals in wildlife populations. *In*: R. H. Giles (ed.) *Wildlife Management Techniques*. 3rd Edition. Printed for the Wildlife Society by Edwards Brothers, Inc., Ann Arbor, Michigan. 623 pp.
- Ozoga, J. J. and L. W. Gysel. 1972. Response of white-tailed deer to winter weather. *J. Wildl. Manage.* 36(3):892-896.
- Pac, D. F. 1976. Distribution, movements, and habitat use during spring, summer, and fall by mule deer associated with the Armstrong winter range, Bridger Mountains, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 120 pp.

- Pac, D. F., H. E. Jorgensen, and R. J. Mackie. 1981. Population ecology and habitat relationships of mule deer in the Bridger Mountains, Montana. *In: Montana Deer Studies. Job Prog. Rept., Fed. Aid Proj. W-120-R-12.* pp. 7-20.
- Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. USDA For. Ser. Gen. Tech. Rep. INT-34, Intermountain Forest and Range Experiment Station. Ogden, Utah. 174 pp.
- Picton, H. D. 1960. Migration patterns of the Sun River elk herd, Montana. *J. Wildl. Manage.* 24(3):279-290.
- _____ and I. E. Picton. 1975. Saga of the Sun. Montana Dept. of Fish, Wildlife and Parks. Helena, Montana. 55 pp.
- Robinette, W. L., D. A. Jones, G. Rogers, and J. S. Gashwiler. 1957. Notes of tooth development and wear for Rocky Mountain mule deer. *J. Wildl. Manage.* 21(2):134-153.
- _____. 1966. Mule deer home range and dispersal in Utah. *J. Wildl. Manage.* 30:335-349.
- Rosgaard, A. I. 1981. Ecology of mule deer associated with the Brackett Creek winter range, Bridger Mountains, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 76 pp.
- Schallenberger, A. D. 1966. Food habits, range use and interspecific relationships of bighorn sheep in the Sun River area, west-central Montana. M.S. Thesis. Mont. State Univ., Bozeman. 44 pp.
- _____. 1974. Reconnaissance survey of grizzly bear habitat Rocky Mountain Division, Lewis and Clark National Forest, USFS, Great Falls, MT. 46 pp.
- _____. 1976. Grizzly bear habitat survey Badger Creek-South Fork Two Medicine Management Unit, Lewis and Clark National Forest, USFS, Great Falls, MT. 70 pp.
- _____ and C. J. Jonkel. 1978. Rocky Mountain East Front studies, 1977. Border Grizzly Project Spec. Rep. No. 18. Univ. of Montana, Missoula. 69 pp.

- Schallenger, A. D. and C. J. Jonkel. 1979. Rocky Mountain East Front grizzly studies, 1978. Border Grizzly Project Spec. Rep. No. 27. Univ. of Montana, Missoula. 115 pp.
- _____ and _____. 1980. Rocky Mountain East Front grizzly studies. 1979. Border Grizzly Project Spec. Rep. No. 39. Univ. of Montana, Missoula. 207 pp.
- Snedecor, G. W. and W. G. Cochran. 1980. Statistical Methods. 7th Edition. Iowa State Univ. Press, Ames. 593 pp.
- Steerey, W. 1979. Distribution, range use, and population characteristics of mule deer associated with the Schafer Creek winter range, Bridger Mountains, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 119 pp.
- Sumner, J. and J. J. Craighead. 1973. Grizzly bear habitat survey in the Scapegoat Wilderness, Montana. Mont. Coop. Wildl. Res. Unit. Univ. of Mont., Missoula. 49 pp.
- Thompson, M. J. 1981. Mountain goat distribution, population characteristics and habitat use in the Sawtooth Range, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 80 pp.
- U.S. Dept. of Commerce. 1980-1981. Climatological data for Montana. National Oceanic and Atmospheric Administration. Environmental Data Service. Asheville, N.C. Vols. 83-84.
- Wallmo, O. C., L. H. Carpenter, W. L. Regelin, R. B. Gill, and D. L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. J. Range Mgmt. 30(2):122-127.
- Wilkins, B. T. 1957. Range use, food habits, and agricultural relationships of the mule deer, Bridger Mountains, Mt. J. Wildl. Manage. 21(2):159-169.
- Youmans, H. B. 1979. Habitat use by mule deer of the Armstrong winter range, Bridger Mountains, Montana. M.S. Thesis. Mont. State Univ., Bozeman. 66 pp.
- Zalunardo, R. A. 1965. The seasonal distribution of a migratory mule deer herd. J. Wildl. Manage. 29(2):345-351.