1976

Browse production and utilization on Spotted Bear Mountain winter range and seasonal movements of the Spotted Bear elk herd

Patricia R. Fuller
The University of Montana

BROWSE PRODUCTION AND UTILIZATION ON SPOTTED BEAR MOUNTAIN WINTER RANGE AND SEASONAL MOVEMENTS OF THE SPOTTED BEAR ELK HERD

By

Patricia R. Fuller

B.A., University of Colorado, Boulder, 1973

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1976

Approved by:

Robert R. Ream

Chairman, Board of Examiners

John M. Stewart

Dean, Graduate School

Dec. 9, 1976

Date

Fuller Patricia R., M.S., December 1976 Wildlife Biology

Browse Production and Utilization on the Spotted Bear Mountain Winter Range and Seasonal Movements of the Spotted Bear Elk Herd. (66pp.)

Director: Robert R. Ream RRR

Winter range characteristics, particularly browse production and utilization, on Spotted Bear Mountain and movements of the Spotted Bear elk (Cervus elaphus) herd were investigated from August 1975 to July 1976. The study area was located in northwestern Montana, south of Glacier National Park and west of the Continental Divide.

Annual production of Amelanchier alnifolia and Acer glabrum was sampled using the ranked-set method on 30 plots at 38 sites within four major habitat-type groups. Utilization was determined by post-browsing surveys of length and diameter measurements. A random sample of twigs of the two key species was collected to prepare regression equations. A sample of 121 elk locations was accumulated by radiotelemetry.

Production was low, ranging from 1.60 to 38.15 lbs/acre (1.79-42.76 kg/ha) in the relatively closed canopy forest of the winter range. Highest mean production, 31.23 lbs/acre (35.00 kg/ha) and 24.86 lbs/acre (27.86 kg/ha) occurred in the two warm, dry Pseudotsuga menziesii habitat-type groups 1 and 2, on more open, steep slopes of southwest aspect. Production was lowest, 13.71 lbs/acre (15.37 kg/ha) and 2.35 lbs/acre (2.63 kg/ha), in the two Abies lasiocarpa groups 6 and 4, particularly in the dense Pinus contorta stands of group 4. The Pseudotsuga menziesii groups comprised about 42 percent and the Abies lasiocarpa groups about 52 percent of the winter range. Overall utilization was moderate at 50.7 percent following the mild 1975-76 winter. Between the habitat-type groups, utilization varied from heavy, 67.16 and 64.64 percent on groups 1 and 2, to moderate, 46.49 percent on group 6, to light, 16.24 percent on group 4. Acer glabrum showed higher use than Amelanchier alnifolia. Elk exhibited a preference for long twigs and took more than the current annual growth for both browse species. Regression equations showed high correlation for twig length on diameter, weight on diameter, and weight on length for both species.

Elk locations were concentrated on three areas of winter range with wide spring dispersal. About 18 percent of migration occurred west into the Swan Range. The remaining elk migrated up the Spotted Bear River or into drainages of the Middle Fork of the Flathead River, with a small portion summering in other areas near the winter range. Longest summer dispersal movements were about 25 airline miles (40.3 km). Fidelity to former seasonal ranges was high.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to all individuals who helped me during this study. I am grateful to my committee chairman Dr. Robert Ream and committee member Dr. Earl Willard for their advice during the study and review of my thesis. Special thanks go to my final committee member Dr. Bart O'Gara for his suggestions and invaluable editorial assistance.

I thank the following people for their contributions: Richard Weckworth and James Cross of the Montana State Fish and Game Department and Robert Hensler and John Baglien of the Flathead National Forest Service for their assistance during the field period; Danny On of the Flathead National Forest Service for his help in habitat typing and mapping; Dean and Katie Biggins for introducing me to the area and study; the pilots of Stockhill Aviation for safe and successful flights; the personnel of Spotted Bear Ranger Station for cooperation and the use of their facilities; and Kay and Ken Meagher of Kalispell for their hospitality and friendship.

This study was funded and conducted under a cooperative agreement between the University of Montana, the Montana State Department of Fish and Game, and the U.S. Forest Service, Flathead National Forest.

Special thanks go to my fellow graduate students and friends for their advice and moral support. For laughter, companionship, and "Congo bars" the women of 707 Dickinson deserve my heartfelt gratitude. Without their friendship and understanding my graduate career would have been a far less rewarding experience.

Finally I would like to thank my family for their constant support and love throughout this and many other endeavors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

From August 1975 to July 1976 characteristics of the Spotted Bear Mountain elk (Cervus elaphus) winter range were investigated with emphasis on browse production and utilization. Movement patterns and seasonal ranges of the Spotted Bear elk herd were also studied.

This study follows two elk research projects in the Spotted Bear area. Simmons (1974) studied movements and migration patterns of the Spotted Bear elk herd by radiotelemetry from March 1973 to March 1974. Biggins (1975) researched seasonal habitat selection with secondary emphasis on movements from April 1974 to July 1975.

Elk habitat was given high priority in several critical management areas under the Spotted Bear Multiple Use Plan (Anon. 1974). Planned timber harvest and consequent construction of logging roads, which might interfere with migration routes or subject migrating elk to increased hunting pressure, provided impetus for the studies. Effects of timber harvest may be beneficial, increasing browse production (Rognrud and Janson 1971, Resler 1972), or harmful, interfering with normal elk activity and habitat use (Pengelly 1972, Lyon 1975, Marcum 1975). The Multiple Use Plan (Anon. 1974) states that "a Wildlife Management Plan will be made to determine the potential carrying capacity, browse quantity potential, and other management needs to optimize big game habitat." This study was implemented to provide quantitative baseline data on browse production and utilization on the Spotted Bear Mountain winter range before road construction and timber harvest begin.

In recent years elk movements and distribution have been studied in detail (Knight 1970, Craighead et al. 1972). Radiotelemetry systems have been used effectively to document seasonal ranges and migration routes (McLean 1972, Ream et al. 1972, Craighead et al. 1973). Radiotelemetry was used in this study to supplement movement information gathered in the two previous studies.

The specific objectives of this study were to:

1. quantitatively sample browse production on Spotted Bear Mountain winter range;

2. quantitatively sample browse utilization on the same area;

3. compare the production and utilization between different habitat types on the winter range;

4. continue monitoring of radio-collared elk to provide additional movement and seasonal range information.

A secondary objective developed during the study was to:

5. determine the most successful utilization sampling method in terms of accuracy and field time required.

CHAPTER II

STUDY AREA

Location

The study area is located on the Spotted Bear Ranger District, Flathead National Forest, in northwestern Montana (Fig. 1) and occupies a mountainous region south of Glacier National Park and generally west of the Continental Divide. Much of the area is in the Bob Marshall Wilderness or the proposed Great Bear Wilderness and only about 20 percent is roaded (Biggins 1975). Several new systems of logging roads will be constructed in 1976-77, including one on the Spotted Bear Mountain winter range. Access to this area during the course of the study was by trail from Spotted Bear Ranger Station.

Elk disperse over the entire study area, involving drainages of both the South and Middle Forks of the Flathead River, during summer and fall. Winter and early spring range is concentrated along the South Fork from Harrison Creek to Brush Creek on Hungry Horse Reservoir (Fig. 2). Habitat measurements for this study were taken on the Spotted Bear Mountain section of the winter range (Fig. 2).

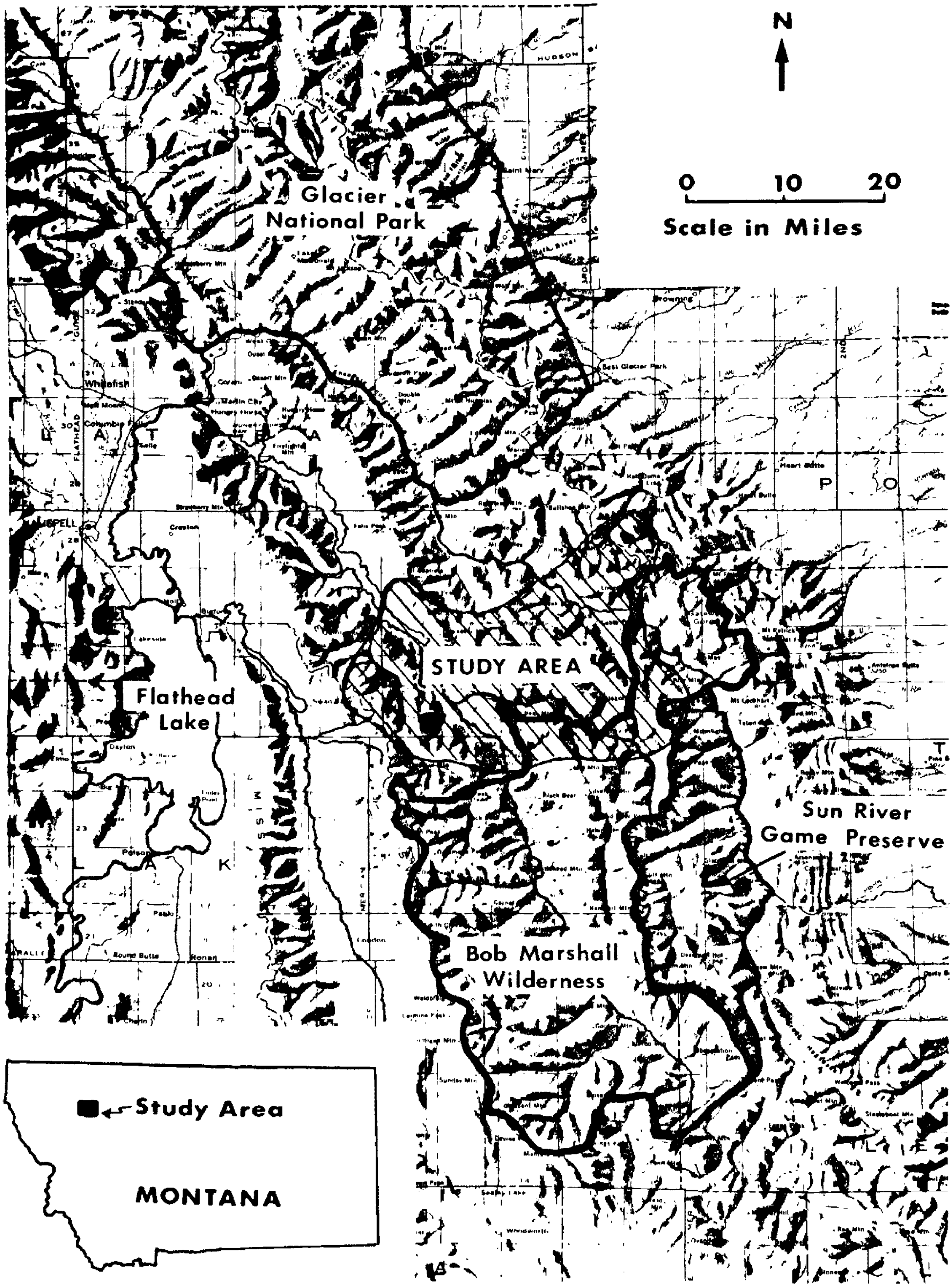

Fig. 1. Location of study area.

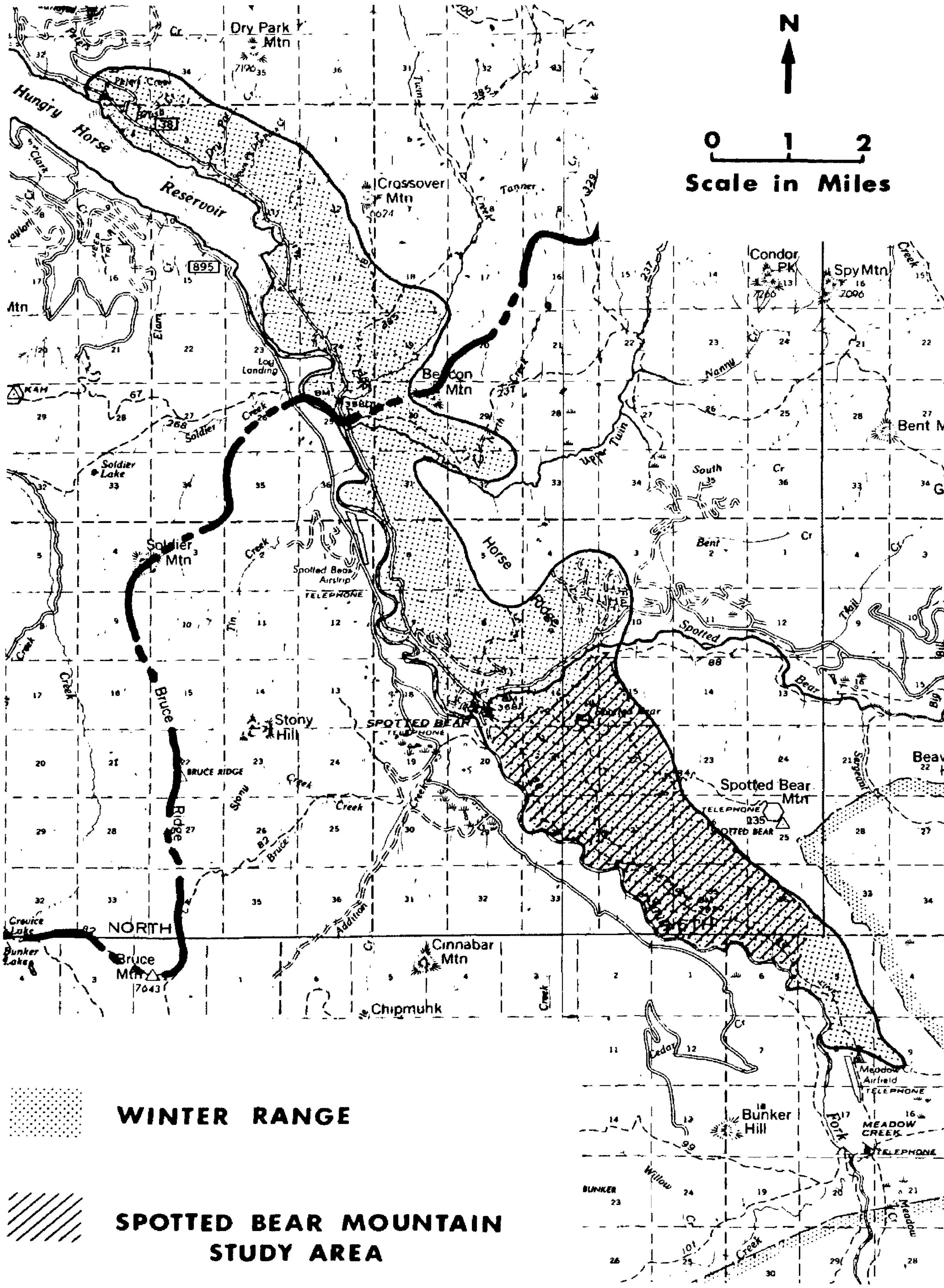

Fig. 2. Location of winter range and the Spotted Bear Mountain study area.

Physiography

The physiography of the area shows evidence of mountain glaciation. Johns (1970) described the geology, Simmons (1974) summarized the physiography, and Biggins (1975) described elevations and percent slopes.

On the Spotted Bear Mountain winter range, elevation varies from 3,700 to 5,000 feet (1,130-1,520 m) with most in the 3,800 to 4,600 foot (1,160-1,400 m) range. Bench and swale topography dominates the area and terminates in a line of cliffs along the entire mountain at an elevation of 4,600 to 5,000 feet (1,400-1,520 m). Martinson et al. (1973) describe the geomorphology of the lower part of this area [up to 4,500 feet (1,370 m)] as "Glacial fluvial deposits over thick glacial morainal deposited by the South Fork valley glacier" and the upper part [4,400 to 4,800 feet (1,340-1,460 m)] as a "Lateral moraine deposited by the South Fork valley glacier." Soils are described as "Loamy profiles developed in thick glacial till with a loess cap."

Aspect is generally southwest with considerable local variation. In comparison with other parts of the winter range percent slope is less but again with much local variation. Generally the lower part of the Spotted Bear Mountain winter range is less steep, with 0 to 40 percent slopes, than the upper part which has 40 to 70 percent slopes.

Several intermittent streams drain the area into the South Fork. A small shallow lake, Spotted Bear Lake, occurs on the northwest portion of the winter range.

Climate

The study area has an inland climate strongly modified by North Pacific Ocean air masses. This results in milder, more cloudy weather and precipitation more evenly distributed throughout the year (commonly with a July-August drought) than the continental climate prevalent east of the Continental Divide. Simmons (1974) reported average annual precipitation varying from 30 inches (76 cm) along the South Fork to 80 inches (203 cm) along the Continental Divide. Snow constitutes about 50 percent of the annual precipitation at lower elevations and 80 percent or more at higher elevations with maximum snow accumulation in late March (Martinson et al. 1973).

The nearest weather station is at Hungry Horse Dam, 50 miles (80 km) northwest of Spotted Bear Ranger Station. A summary of temperature and precipitation information was compiled from weather station data for the period August 1975 through July 1976. Table 1 presents this information in comparison to the 28-year means. Temperatures for the study area were probably slightly lower for all months than those recorded at Hungry Horse Dam. Simmons (1974) presented temperature records from Spotted Bear Ranger Station for

Table 1. Summary of weather data, Hungry Horse Dam, August 1975-July 1976.

Month	Ave. daily max. temp. (°F)	Ave. daily min. temp. (°F)	Ave. daily mean temp. (°F)	28-year ave. mean temp. (°F)	Ppt (inches)	28-year mean ppt (inches)
1975						
August	69.87	47.90	58.89	64.29	4.07	1.88
September	68.29	40.00	54.14	53.75	1.10	2.47
October	49.65	34.55	42.10	42.82	5.89	3.36
November	37.90	24.23	31.07	32.11	3.09	3.64
December	35.52	22.87	29.20	25.93	3.81	3.54
1976						
January	34.97	19.45	27.21	20.99	3.75	4.03
February	37.31	23.41	30.36	26.49	3.10	2.67
March	38.48	19.71	29.10	31.36	1.49	2.22
April	53.80	32.07	42.94	40.24	2.75	2.13
May	67.70	38.54	53.12	51.00	2.89	2.55
June	66.83	43.10	54.97	58.04	3.66	3.28
July	78.45	50.81	64.63	65.00	2.98	1.62

From: U.S. Climatological Records, U.S. Weather Bureau, Hungry Horse Dam, 1975-1976.

winter 1974 and Biggins (1975) described weather conditions from April 1974 to July 1975.

Beall (1974) found that elk behavior was directly influenced by local weather conditions. A general, if subjective, discussion of weather conditions is important in a study of habitat use and is included here as it was in Biggins (1975). Climatic severity in winter, the period of food scarcity, is an important factor affecting elk survival.

Late summer and fall 1975 were generally cooler and wetter than normal with prolonged periods of cloudy weather except for September which was warm and dry. December 1975 and January and February 1976 were significantly warmer than the 28-year mean with near average precipitation. March was slightly colder with less precipitation, and April and May were warmer and wetter than normal. June and July were cooler with more cloudy, rainy weather than average.

An index of winter severity was determined for the 1975-76 winter and compared to the 28-year average using the method described by Peek et al. (1976). The index was derived by subtracting the mean monthly temperature from 32°F (R), multiplying this by the corresponding monthly precipitation (T), and adding the products ($P = R \times T$) for the months December through March. The average index value was calculated in the same way using the 28-year mean figures. The index computed for the 1975-76 winter was 38.03 which was judged much less severe than the 28-year average index of 81.99. Peek et al. (1976) reported a 12-year average in northeastern Minnesota of 89.15. Severity indices of 182.15 and 45.76 were considered much more severe and much less severe, respectively, than the 12-year average. Indices that I calculated for the 1973-74 and 1974-75 winters were 97.12 and 92.68, respectively, which were slightly more severe than normal. Biggins (1975) felt that the 1974-75 winter was very severe for the Spotted Bear area.

Vegetation

Vegetation consisted of a diverse complex of plant communities resulting from topographic, climatic, edaphic, and disturbance (primarily fire and logging) factors. Plant communities of the entire elk-range study area and seasonal elk use were described in detail by Biggins (1975) using the classification system devised by Pfister et al. (1974). The basic unit of this system is the habitat type which is defined as "the aggregation of units of land capable of producing similar communities at climax. Since it is the end result of plant succession, the climax plant community reflects the most meaningful integration of the environmental factors affecting vegetation." On and Losensky (1975) developed a system of combining habitat types into ecoclass groups to provide a hierarchial approach to land planning.

This system was used with a habitat-type map prepared by On (1975) and field habitat typing to describe plant communities on the Spotted Bear Mountain winter range. Plant nomenclature follows Hitchcock and Cronquist (1973).

The winter range study area on Spotted Bear Mountain was approximately 4,200 acres (1,700 ha). Most of the area is forested with only a few small openings. Almost 95 percent of the vegetation was categorized into four habitat-type ecoclass groups. Table 2 gives a summary of the areas of each group.

Table 2. Areas of ecoclass groups on Spotted Bear Mountain winter range.

Group		Area (acres)	Area (hectares)	Percent of total area
1	"Warm and Dry"	440	180	11
2	"Moderately Warm and Dry"	1,330	540	32
4	"Cool and Moderately Dry"	550	220	13
6	"Cool and Moist"	1,630	660	39
Other		250	100	5
	Total	4,200	1,700	100

Pseudotsuga menziesii/Agropyron spicatum (DF/Agsp) was the major habitat type found in Group 1 "Warm and Dry" stands. Vegetation consisted of open growth ponderosa pine (Pinus ponderosa) or Douglas-fir (Pseudotsuga menziesii) with a bunchgrass dominated understory. These communities occurred on steep slopes (> 40 percent) of southwest aspect (200-240°) and 3,800 to 4,600 foot (1,160-1,400 m) elevation.

The Pseudotsuga menziesii/Symphoricarpus alba (DF/Syal) habitat type and Pseudotsuga menziesii/Symphoricarpus alba/ Calamagrostis rubescens (DF/Syal/Caru) habitat-type phase were most abundant on Group 2 "Moderately Warm and Dry" areas. Stands were relatively closed canopies of mixed ponderosa pine and Douglas-fir with a shrub dominated understory. Snowberry (Symphoricarpus alba) was the dominant shrub. Lodgepole pine (Pinus contorta) was a minor seral species on some sites. Stands occurred on slopes and benches. Slopes varied from 10 to 70 percent, aspect was south to west (190-270°), and elevation was generally above 4,200 feet (1,280 m).

Abies lasiocarpa/Vaccinium caespitosum/Vaccinium caespitosum (AF/Vaca/Vaca) predominated on Group 4 "Cool and Moderately Dry" areas. Stands consisted of almost pure lodgepole pine with an understory of beargrass (Xerophyllum tenax), dwarf huckleberry (Vaccinium caespitosum), grouse whortleberry (Vaccinium scoparium), and buffaloberry (Shepherdia canadensis). Elevation was generally low, 3,800 to 4,200 feet (1,160-1,280 m); slopes were relatively flat, with stands occurring on benches or in frost-pocket basins; and aspects were variable.

Group 6 "Cool and Moist" habitat types were the most varied and occurred on the most diverse areas. Phases of the Abies lasiocarpa/Clintonia uniflora (AF/Clun) habitat type, particularly the Clintonia uniflora (AF/Clun/Clun), Vaccinium caespitosum (AF/Clun/Vaca), and Xerophyllum tenax (AF/Clun/Xete) phases, predominated. Stands were often a mosaic of all three phases and AF/Vaca/Vaca. Vegetation was a mixed forest of Douglas-fir, lodgepole pine, larch (Larix occidentalis), subalpine fir (Abies lasiocarpa), and spruce (Picea englemanii and hybrids) in order of importance. Marked diversity in undergrowth was characteristic with queencup beadlilly (Clintonia uniflora) present throughout. Stands occurred on moist benches, north to northwest slopes, and stream bottoms. Slopes varied from 0 to 40 percent, aspect was variable through generally northwest to north (320-350°), and elevation varied from 3,900 to 5,000 feet (1,190-1,520 m) with most at 4,000 to 4,400 feet (1,220-1,340 m).

CHAPTER III

MATERIALS AND METHODS

Browse Production

Browse production was sampled in fall, 1975 after annual growth was completed. A modified form of the ranked set method of Halls and Dell (1966) was used. One sampling site consisted of four transects, 10 chains (200 m) long and 1 chain (20 m) apart. Transects 1 to 3 were clipped for production and transect 4 was tagged for utilization (Fig. 3).

Sampling sites were located on the Spotted Bear Mountain winter range. Sites were stratified by habitat-type groups using On and Losensky's (1975) ecoclass identification groups. Locations were randomly selected with a random numbers grid and modified form of On's (1975) habitat-type group map. Site field locations were made by compass directions and flagging from the nearest trail. Thirty-eight sites in four habitat-type groups were sampled.

Transects 1 to 3 each contained 10 sampling plots at paced 1-chain (20 m) intervals. At each plot, three 3.1 foot (1 m) square wooden frames were placed on the ground (Fig. 4). The three quadrats (ranked set) were ranked high, medium, and low in weight

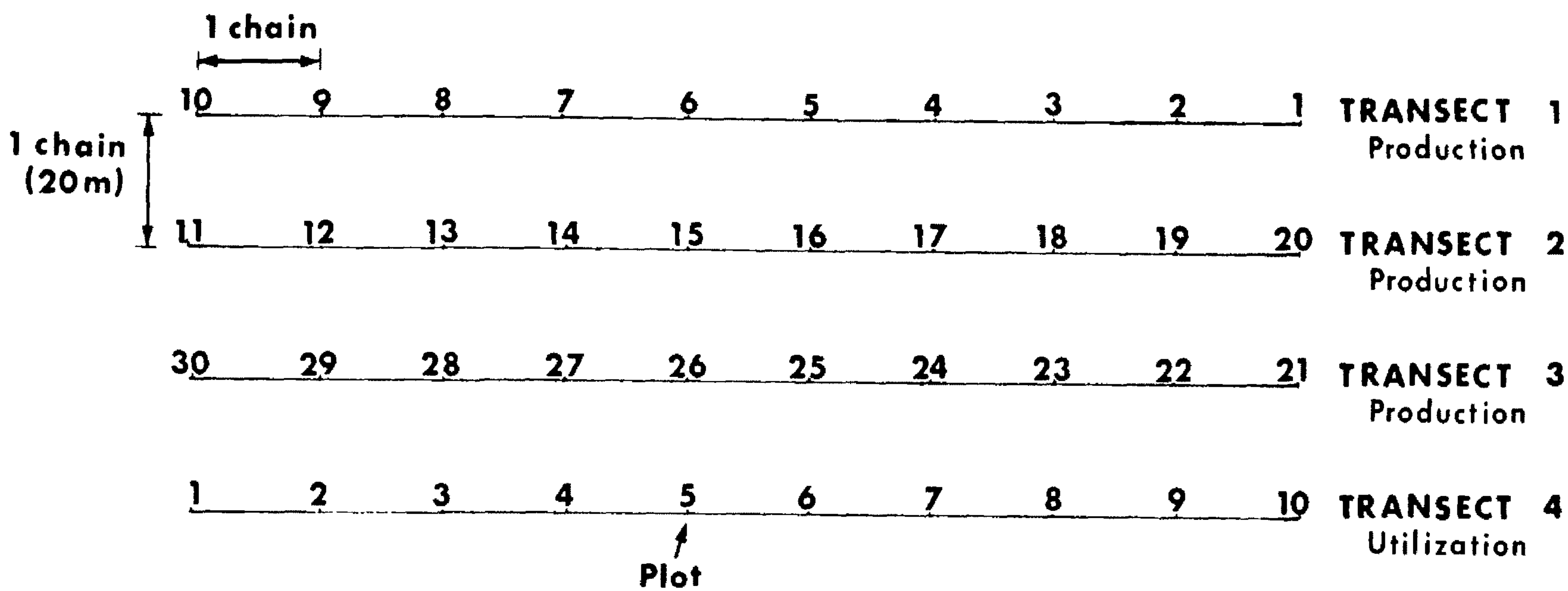

Fig. 3. Example of a production/utilization sampling site.

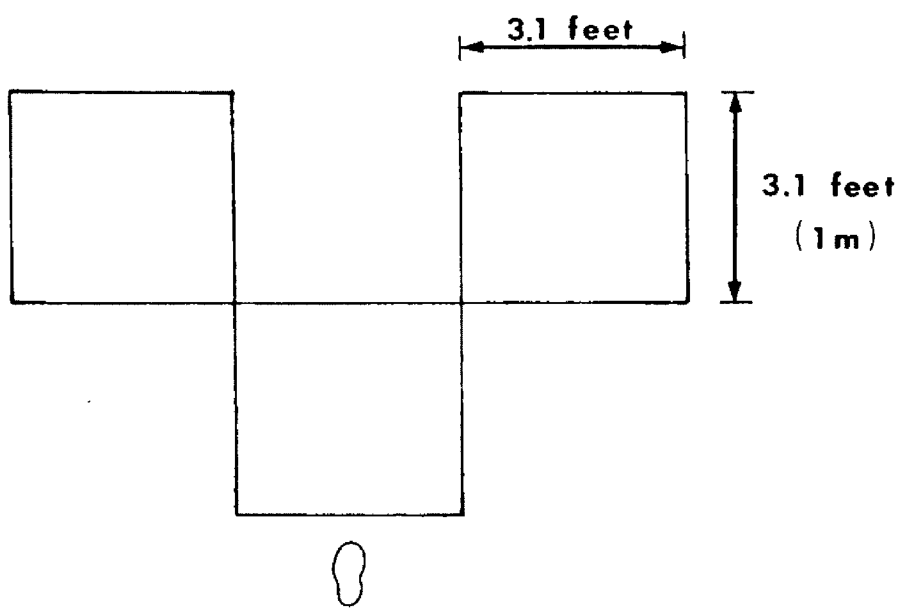

Fig. 4. Placement of sampling frames at a production sampling plot.

of browse. Rankings were based on ocular estimates of current annual twig growth, from ground level to approximately 6 feet (1.8 m), of browse plants whose stems were included within the frame. Browse included the two key species, serviceberry (Amelanchier alnifolia) and mountain maple (Acer glabrum), and small amounts of chokecherry (Prunus virginiana) and red-osier dogwood (Cornus stolonifera). Although snowfall reached average winter depths of 30 to 50 inches (76-127 cm), twigs within the 0 to 6 foot (0-1.8 m) zone were available during at least part of winter.

Quadrats were clipped in a predetermined order: 1-high, 2-medium, 3-low, 4-high, etc. All current annual twig growth within the selected quadrat was clipped and placed in paper sacks labeled for site, transect, plot, rank, and species. Sacks were stapled and stored for later laboratory analyses. Datum sheets were used to record date clipped, site identification, directions, habitat-type groups, habitat type, slope, aspect, elevation, and comments on elk use and general features for each sampling site. Elevation was taken from USGS topographic maps, aspect by compass, and slope with a clinometer.

Samples were dried to constant weight at 65°C for at least 72 hours and weighed to the nearest centigram on a Mettler balance. For each site, mean weight of production in grams was calculated for the high, medium, and low plots. Production in pounds/acre was calculated by multiplying the overall mean [1/3 (high plot mean + low plot mean)] by the conversion factor 10 (for a 3.1 foot square quadrat).

Browse Utilization

Transect 4 of the production/utilization sampling sites was used to sample winter utilization. Serviceberry and mountain maple were tagged in fall before the elk migrated onto the winter range and after plant growth was completed. At each of the 10 plots along the transect, all leaders of a main lateral branch of the nearest shrub were tagged with Rolex plastic marking tape. The selected branch was alternately chosen from the upper third, middle third, or lower third of the shrub. Species and twig lengths were recorded at each plot.

In spring, when elk began returning to summer ranges and before shrub dormancy was broken, tagged twigs were remeasured to determine length of utilization. To determine utilization by weight, a length-weight regression equation was prepared. Representative twigs of varying lengths of serviceberry and mountain maple were clipped at all sites during fall. After drying for 48 hours at 70°C, the leaders were cut into sections measuring 10 percent of the total length. Sections were weighed cumulatively, beginning with the section containing the terminal bud. Cumulative and respective weights were converted into percentages of the total weight. A regression equation was derived from the percentages of weights and lengths (Hemmer 1975). Separate regression equations were prepared for serviceberry and mountain maple. These were used to determine percent of weight utilized from percent of length browsed.

Utilization was also determined by postbrowsing surveys in spring 1976. Two procedures were used: (1) an estimate of percentage of current annual growth twigs (CAGT) browsed (Cole 1958, Stickney 1966); and (2) an estimate of length and weight removed (Basille and Hutchings 1966, Lyon 1970). Thirty-eight sites, roughly adjacent to the randomly selected production sites, were sampled. At each site, 15 to 20 shrubs (serviceberry or mountain maple) were measured. Plants were selected by the closest neighbor method (Cole 1958) along a compass line or by the nearest plant every 5 to 10 paces, depending upon relative shrub density. On each shrub, a major branch or stem [one with 10 to 20 current annual growth twigs within 6 feet (1.8 m) of the ground] was chosen as a twig cluster. In most instances no single stem had enough twigs to constitute a cluster so the nearest stem or stems were also measured. The stems collectively made up the twig cluster. Within the cluster, the number of browsed and unbrowsed twigs was recorded. Any CAGT that had the terminal bud or any portion below it missing constituted a browsed twig. Length of each browsed twig was measured from the leaf scar to the browsed end to the nearest 1/16 inch (.16 cm). Two diameter measurements at point of browsing were taken at right angles on each browsed twig and averaged to obtain mean diameter. Diameter was measured to the nearest 0.001 inch (0.025 mm) with a dial caliper. Utilization was determined by percentage of number browsed and percentage of length reduction within a twig cluster.

To prepare linear regression equations random CAG leaders of serviceberry and mountain maple were clipped at all sites. Twigs were selected to obtain a range of lengths with no twigs shorter than 0.5 inch (1 cm) clipped. On the day the twigs were clipped, diameter was measured 0.5 inch (1 cm) above the bud scar to the nearest 0.001 inch (0.025 mm). Two diameter measurements were taken at right angles and averaged. Twig lengths were measured to the nearest 1/16 inch (.16 cm) from the leaf scar to the tip of the terminal bud. Twigs were later oven-dried for 48 hours at 70°C and weighed to the nearest 0.01 gm. Coefficients were computed for the regression of length on diameter, weight on diameter, and weight on length.

Statistical and Computer Procedures

The Student's t-test and Scheffe's s-method (Chapman and Schaufele 1971, Hicks 1973) were used to test for significant differences between production and utilization in the four habitat-type groups.

Regression analyses on utilization data were performed with BMD polynomial linear regression program 5-R (Dixon 1974). A

Dec-10 digital computer system was used.

Radiotelemetry

Radiotelemetry was the primary means of collecting elk location data. Trapping and marking were concluded during the previous study (Biggins 1975) leaving 18 elk with operative radios and numerous collared elk. Fourteen elk with operative radio collars remained at the conclusion of this study.

Aerial tracking was used to locate instrumented elk. Flights were made with a 150 Super Cub with two, three-element Yagi antennas attached to the wings and tracking equipment as described by Denton (1973). Weather conditions limited the number and regularity of the flights. Nine flights were made during the study period, lasting from 2 to 4 hours each. Additional information on locations of radio-collared elk was obtained from researchers on the Border Grizzly Project (Joslin personal communication).

Locations of radioed elk were initially plotted on aerial photographs and later converted onto USGS topographic maps. For each location, general habitat type, slope position, time and weather conditions were recorded. If the radioed elk was sighted, sex, age, size of herd, and number of marked animals were recorded.

CHAPTER IV

RESULTS AND DISCUSSION

Vegetative Characteristics of the Winter Range

Habitat types and habitat type phases (where possible) present on the Spotted Bear Mountain winter range study area are listed by habitat type groups in Table 3. Percent area covered by the groups and the number of production/utilization sampling sites within the groups and in specific habitat types and phases are also listed. Fig. 5 is a map of the winter range study area showing the areas of each habitat type group and the predominant habitat types and phases (by abbreviations given in Table 3) within the group areas. Locations of production/utilization sampling sites are also shown.

Serviceberry and mountain maple were selected as the "key species," as defined by Julander (1937), because of their relative abundance and importance to wintering elk, as indicated by observation and the two previous studies (Simmons 1974, Biggins 1975). Both species were found on areas of all four habitat-type groups. Actual densities of serviceberry and mountain maple were not calculated. Both species were moderately abundant, at least in parts, on areas of groups 1, 2, and 6, but were much less abundant on group 4 areas

Table 3. Habitat types and phases on the Spotted Bear Mountain winter range. (Groups after On and Losensky 1975.)

Habitat type and phase	Abbreviations		Percent coverage	No. sampling site locations
Group 1 "Warm and Dry"			10	5
Pseudotsuga menziesii (DF) series				
DF/Agropyron spicatum	DF/Agsp	DA		1
DF/Symphoricarpus alba/Agropyron spicatum	DF/Syal/Agsp	DSA		4[1]
Group 2 "Moderately Warm and Dry"			32	11
Pseudotsuga menziesii (DF) series				
DF/Symphoricarpus alba	DF/Syal	DS		4
*DF/Symphoricarpus alba/Symphoricarpus alba	DF/Syal/Syal	DSS		1
DF/Symphoricarpus alba/Calamagrostis rubescens	DF/Syal/Caru	DSC		6[2]
*DF/Vaccinium caespitosum	DF/Vaca	DVc		
*DF/Spirea betulifolia	DF/Spbe	DSp		
Group 3 "Moderately Cool and Dry"			2	0
Abies lasiocarpa (AF) series				
*AF/Calamagrostis rubescens	AF/Caru	ACr		
Group 4 "Cool and Moderately Dry"			13	7
Abies lasiocarpa (AF) series				
AF/Vaccinium caespitosum/Vaccinium caespitosum	AF/Vaca/Vaca	AVV		7[3,4]
*AF/Xerophyllum tenax	AF/Xete	AX		
*AF/Xerophyllum tenax/Vaccinium globulare	AF/Xete/Vagl	AXVg		

Table 3. (continued)

Habitat type and phase	Abbreviations		Percent coverage	No. sampling site locations
Group 5 "Moderately Cool and Moist"			1	0
Picea (S) series				
*S/Vaccinium caespitosum	S/Vaca	SV		
*S/Clintonia uniflora	S/Clun	SC		
*S/Clintonia uniflora/Clintonia uniflora	S/Clun/Clun	SCC		
Group 6 "Cool and Moist"			39	15
Abies lasiocarpa (AF) series				
AF/Clintonia uniflora	AF/Clun	AC		1
AF/Clintonia uniflora/Clintonia uniflora	AF/Clun/Clun	ACC		8
AF/Clintonia uniflora/Vaccinium caespitosum	AF/Clun/Vaca	ACV		4
AF/Clintonia uniflora/Xerophyllum tenax	AF/Clun/Xete	ACX		2
*AF/Linnaeus borealis	AF/Libo	AL		

*Statistically small areas.

[1]Two sites classified as DSA-DSC.

[2]One site classified as DSC-DSA.

[3]One site classified as AVV-ACV.

[4]One site classified as AVV-DS.

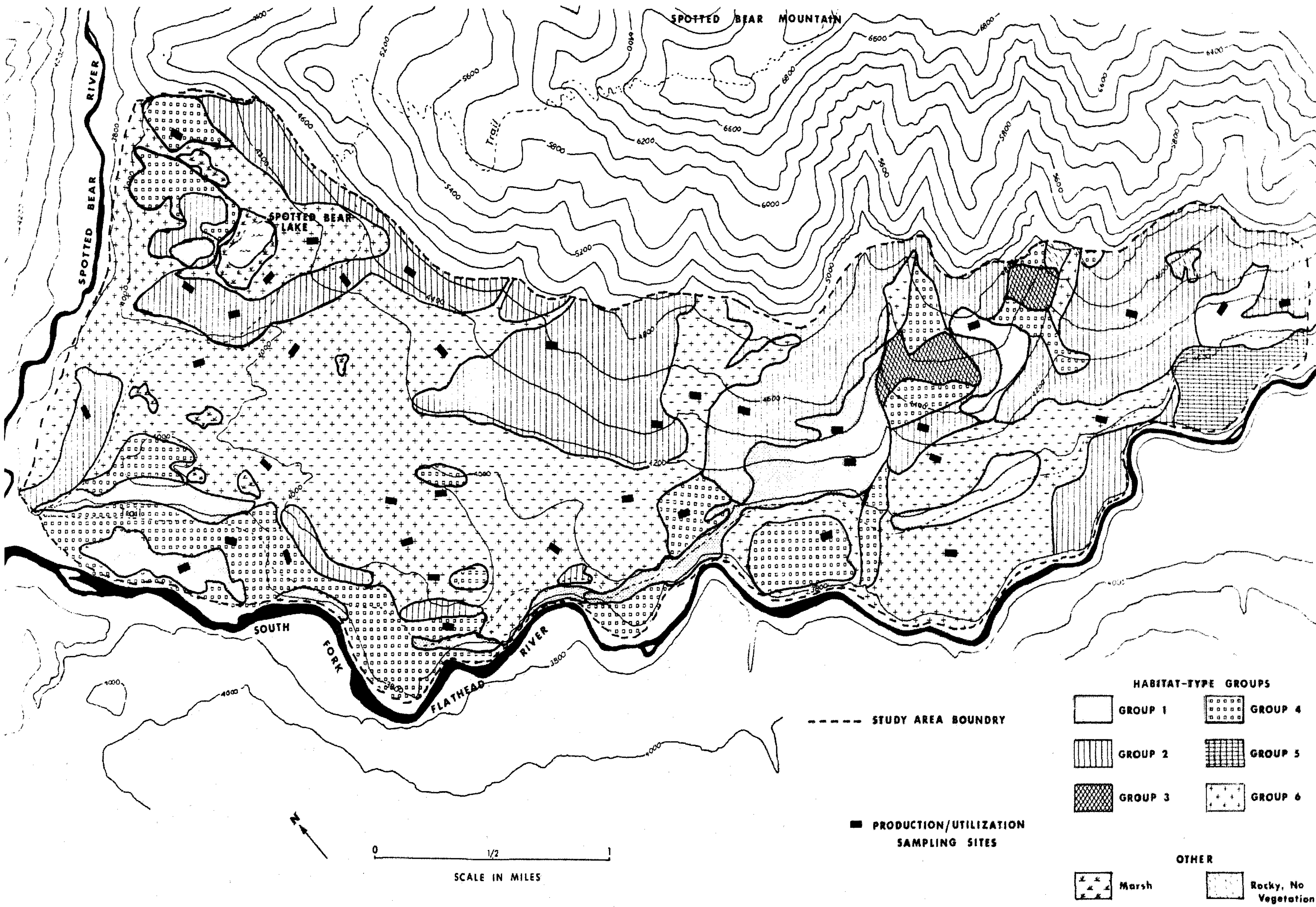

Fig. 5. Map of Spotted Bear Mountain winter range showing ecoclass groups and production/utilization sampling sites. (Map adapted from On 1975.)

where mountain maple was nearly absent. The relative occurrence of the two species in comparison to each other was calculated by the numbers of each species encountered on the utilization transects. On the average, serviceberry occurred more frequently than mountain maple on areas of all four habitat-type groups, although mountain maple was more abundant on individual sites within groups 2 (one site) and 4 (four sites). The two species were most evenly distributed on group 6 areas, occurring in a 1.9:1 ratio of serviceberry to mountain maple. Percent cover of serviceberry relative to mountain maple increased on the drier, warmer areas of groups 1 and 2, with ratios of 4.4:1 and 4.5:1 respectively. Serviceberry was much more abundant relative to mountain maple on group 4 areas, with a 79.9:1 ratio.

Overall vigor of both serviceberry and mountain maple was generally low throughout the range with most mountain maple under 4 feet (1.2 m) tall and most serviceberry under 3 feet (0.9 m). Exceptions occurred in intermittent stream bottoms (in group 6 habitat types) where most shrubs had grown beyond the reach of elk, possibly as a result of winter inaccessibility due to snow accumulation. Some tall overmature forms of both species were found on steep, relatively open (low canopy density) group 1 areas. Serviceberry demonstrated all five growth forms described by Hemmer (1975) but with few examples of the mat-forming and overmature forms. Most plants of both species were moderately to heavily clubbed (Cole 1958), particularly on areas of groups 1, 2, and 6.

Random Sampling Procedures

Production and utilization sampling sites were chosen by a random method in order to eliminate bias from site selection and to allow the procedures to be repeated without establishing permanent transects. In this way, data can be obtained by comparable production and utilization sampling methods during and after timber harvest which will alter the existing conditions. In addition, for production studies involving clipping, permanent transects could affect the physiology and vigor of the plants.

Browse Production

Forage production studies are used to determine potential carrying capacity of pastures and ranges. Sampling methods often involve clipping and weighing forage from small randomly located plots but plot yields may vary widely and the process is time consuming. Halls and Dell (1966) found that the ranked-set method of clipping proposed by McIntyre (1952) was considerably more effective than random sampling for estimating weight of browse in a pine-hardwood forest of east Texas. The increased efficiency and consequent accuracy saved time. The ranked-set method proved effective in sampling current annual production on Spotted Bear Mountain winter range. The area was too large for complete quantification and the randomly located, stratified ranked-sets provided an unbiased estimate of production. Local variation within habitat-type groups was the major sampling problem.

Current annual growth production for serviceberry and mountain maple (and small amounts of chokecherry and red-osier dogwood) was measured on 38 sample sites (1,140 plots) within areas of the four habitat-type groups. Production sampling sites are shown on Fig. 5. Table 4 summarizes production data by habitat-type group. Aspect, slope, and elevation given in Table 4 are representative averages for the sample sites within the habitat-type group.

Analyses using Scheffe's s-test showed highly significant differences in mean production between all four habitat-type groups at the 0.05 confidence level. Differences were also significant between all groups at the 0.01 confidence level, except between groups 1 and 2. Ranges of production data (Table 4) within these two groups show considerable overlap. Some overlap is probably caused by "blending" of the habitat types. Although sites were stratified by habitat-type groups, local variation within a site resulted in two or three classifications of habitat type phase within the site. Habitat blending also occurred within groups 4 and 6.

Production results were also analyzed by subpopulations based on aspect, slope, and elevation. Most of the gradients in production

Table 4. Summary of production data from ranked-set samples on Spotted Bear Mountain winter range.

	Habitat-type groups			
	1	2	4	6
Mean annual production				
lb/a	31.23	24.86	2.35	13.71
kg/ha	35.00	27.86	2.63	15.37
Range of annual production				
lb/a	24.80-37.66	14.12-38.15	1.60-3.13	8.27-18.96
kg/ha	27.80-42.21	15.83-42.76	1.79-3.51	9.27-21.25
Average aspect	210°	240°	variable	330°
(range)	(200°-240°)	(210°-270°)		(200°-40°)
Average percent slope	50	30	<10	20
(range)	(40-70)	(10-70)	(0-10)	(0-40)
Average elevation in feet	4,200	4,500	3,900	4,100
(range)	(3,900-4,400)	(4,000-4,700)	(3,700-4,100)	(3,900-4,400)
Average elevation in meters	1,280	1,370	1,190	1,250
(range)	(1,190-1,340)	(1,220-1,430)	(1,130-1,250)	(1,190-1,340)

revealed by these factors corresponded highly to the different habitat-type groups. Habitat types, by definition, describe the potential climax vegetation based on the sum of environmental factors, including aspect, slope, and elevation.

The number of sites on different habitat types and phases within the groups was too small to show significant differences ($p = 0.05$) between those habitat types and phases within one group. General trends were apparent. Within group 6 production on all AF/Clun/Clun habitat type phases was higher than on AF/Clun/Vaca phases. The AF/Clun/Vaca phases had the lowest production within the group. AF/Clun/Vaca is a distinct minor phase characterized by unusual undergrowth for AF/Clun habitat types (Pfister 1974). Characteristics (vegetation, slope, aspect, elevation) more nearly resembled AF/Vaca/Vaca areas of group 4, and the two often occupied small adjacent areas on the winter range. The highest production values were obtained for areas of DF/Syal/Agsp — DF/Syal/Caru (DSA-DSC, group 1) and DF/Syal/Caru — DF/Syal/Agsp (DSC-DSA, group 2) on moderate to steep (> 30 percent) slopes of southwest aspect (210-230°). Very poor production was found on all group 4 (AF/Vaca/Vaca) sites. Nearly all of the data for group 4 areas was based on production of serviceberry, which occurred sparsely and was usually of the spindly small-repressed growth form described by Hemmer (1975).

The weighted average of overall production on the winter range of Spotted Bear Mountain was 17.9 lbs/acre (20.1 kg/ha). This value was determined by multiplying the percentage of the study area occupied by each habitat-type group by the mean production of each group and adding the products. Percent area values were for the 95 percent of the entire range occupied by the four habitat-type groups, thus the overall value reflects production on 95 percent of the range.

The overall production value and mean group production values are relatively low in comparison to production capability for the area (On personal communication). Most sites, except those on group 1 areas, have high canopy cover and tree competition is a factor limiting production.

In a browse production study on control-uncut, clearcut-unburned, and clearcut-burned areas near St. Regis, Montana, Warner (1970) found production values in lbs/acre of 2.7, 20.8, and 48.4, respectively. Climax vegetation potential was Pseudotsuga menziesii/ Physocarpus malvaceus (DF/Phme). This habitat type fits in the ecoclass group 2 of this study. Comparison of data for different areas and browse species is difficult but Warner's (1970) data indicate increased production after timber harvest. Production will probably increase on the Spotted Bear Mountain range following timber harvest.

Browse Utilization

Utilization was measured by three methods. The first, involving measurements of marked twigs before and after the winter period along a transect adjacent to the production transects, was only attempted on part of the sample sites in the fall. Coupled with production clipping the process was too time-consuming. Additional time loss would have occurred while trying to relocate exact sites during spring. The method used for attaching the plastic marking tags resulted in loss of most of the tags by spring; thus, fall data were not used. Tags should have been stapled on to prevent loss.

Utilization was calculated by two means from postbrowsing measurements. Utilization by number of twigs browsed was determined by comparing the percent of browsed current annual growth twigs (CAGT) to the total CAGT available. Utilization by length removed was determined with diameter measurements and regression equations developed for length on diameter. Percent of average twig length utilized was calculated by the equation:

$$P = 100 \left(\frac{T - R}{T}\right).$$

P is the percent utilization by length, T the total length of twig computed with the diameter measurement and the regression equation, and R the length of the remaining portion (Basille and Hutchings 1966). To directly estimate utilization by weight, the portion of a twig remaining after browsing is clipped and weighed, and utilization is computed by substituting weight for length in the above formula. The regression equations developed in this study for weight on diameter for serviceberry and mountain maple (Table 5) could be used.

Table 5 presents the regression equations developed for regression of length on diameter, weight on diameter, and weight on length for serviceberry and mountain maple. Regression of percent weight on percent length is also given. Linear correlation between length and diameter of serviceberry and mountain maple was high, $r = 0.909$ and $r = 0.899$, respectively. Variation in diameter explained 82.6 percent of the variation in length for serviceberry and 80.9 percent for mountain maple. These high correlation values lend confidence to the method used to estimate length utilization from diameter measurements. Correlation was slightly better for length and diameter than weight and diameter.

Regression equations were calculated for the entire winter range study area with data from areas of all four habitat-type groups. Basille and Hutchings (1966) found significant differences in regression coefficients within and between sites for bitterbrush (Purshia tridentata). For field applications, Lyon (1970) reported that "utilization on twigs that are browsed will always be high enough to prevent gross errors in utilization estimates associated with site variability." In future studies on the Spotted Bear winter range,

Table 5. Summary of regression equations and correlation coefficients of length on diameter, weight on diameter, weight on length, and percent weight on percent length for serviceberry and mountain maple.

	Regression equation[1]			Correlation coefficient r
	intercept a	regression coefficient b	SE^2 of b	
Length (Y) on diameter (X)				
Serviceberry	-3.656	129.142	4.515	0.909
Mountain maple	-7.370	165.008	6.014	0.899
Weight (Y) on diameter (X)				
Serviceberry	-0.00198	0.0327	0.0013	0.882
Mountain maple	-0.00217	0.0320	0.0012	0.894
Weight (Y) on length (X)				
Serviceberry	-0.00089	0.00024	0.00001	0.902
Mountain maple	-0.00055	0.00017	0.00001	0.899
Percent weight (Y) on percent length (X)				
Serviceberry	-7.502	0.952	0.017	0.972
Mountain maple	-7.591	0.939	0.018	0.970

[1]Regression equation calculated by $Y = a + b(X)$; length and diameter in inches, weight in lbs.

[2]Standard error of regression coefficient.

separate regression equations could be developed for the four habitat-type groups to test this statement.

Table 6 summarizes utilization levels of serviceberry and mountain maple, calculated by the two postbrowsing methods, on the four habitat-type groups. I felt that the utilization levels determined by the percent length removed method most accurately reflected utilization on the Spotted Bear Mountain winter range. These data were used in making all the following comparisons and conclusions, unless otherwise stated.

Scheffe's s-test showed significant differences in mean utilization levels of both species between all combinations of habitat-type groups, except 1 and 2, at the 0.05 and 0.01 confidence levels. Utilization of both species was greatest on the warm, dry habitat-type groups 1 and 2. Within these two groups the highest values were calculated for steeper (aspect > 40 percent), southwest facing (210°-240°) slopes. Production values were also highest for these areas. Biggins (1975) found 53 percent habitat use of the drier habitat-type groups (groups 1-3) in January-February and 70 percent use in March-April when these slopes were the first to become snow-free. Significant amounts of utilization also occurred on areas of habitat-type group 6. Biggins (1975) found 60 percent habitat use of group 6 to 8 in late fall-early winter (November-December) and 40 percent use in March-April. Within group 6, utilization levels were highest on

Table 6. Average browse utilization on four ecoclass group areas as calculated by two methods.

	Habitat-type groups			
	1	2	4	6
1. Percent numbers removed:				
Serviceberry	53.72	54.28	8.48	28.68
Mountain maple	72.03	48.56	27.27	37.97
Total (weighted mean)	55.77	47.46	10.33	30.49
2. Percent length removed:				
Serviceberry				
mean	66.17	64.20	15.55	42.42
range	59.43-67.91	52.42-69.74	7.71-23.42	13.43-61.34
Mountain maple				
mean	70.87	75.76	37.50	56.53
range	62.03-77.12	52.42-78.98	31.37-43.63	39.36-69.28
Total (weighted mean)	67.16	64.64	16.24	46.49

AF/Clun/Clun habitat type phases which also had the highest production of group 6 areas. Utilization was low on group 4 areas which correlated with the less than 20 percent habitat use Biggins found on this group throughout the winter. These areas also had the lowest production values. Fig. 6 shows a relative comparison between production in pounds per acre and mean utilization of serviceberry and mountain maple by percent length on the four habitat-type groups.

Utilization on the entire Spotted Bear Mountain winter range varied from 7.71 to 69.74 percent for serviceberry and 31.37 to 78.61 percent for mountain maple. Mountain maple had higher mean utilization levels than serviceberry for all four habitat-type groups. In nearly all instances when both species were present on a sample site mountain maple showed greater utilization than serviceberry. Differential use could indicate greater preference for mountain maple by elk or it might reflect more favorable micro-habitat locations of mountain maple in the winter.

Between the habitat-type groups, mean utilization of serviceberry and mountain maple varied from 16.24 to 67.16 percent. Overall mean utilization on the winter range was 50.7 percent. This value was calculated by multiplying the mean utilization of each habitat-type group by the percent area occupied by the group and adding the products. Percent area was adjusted as in the calculation for overall production and thus, the utilization value refers to 95 percent of the

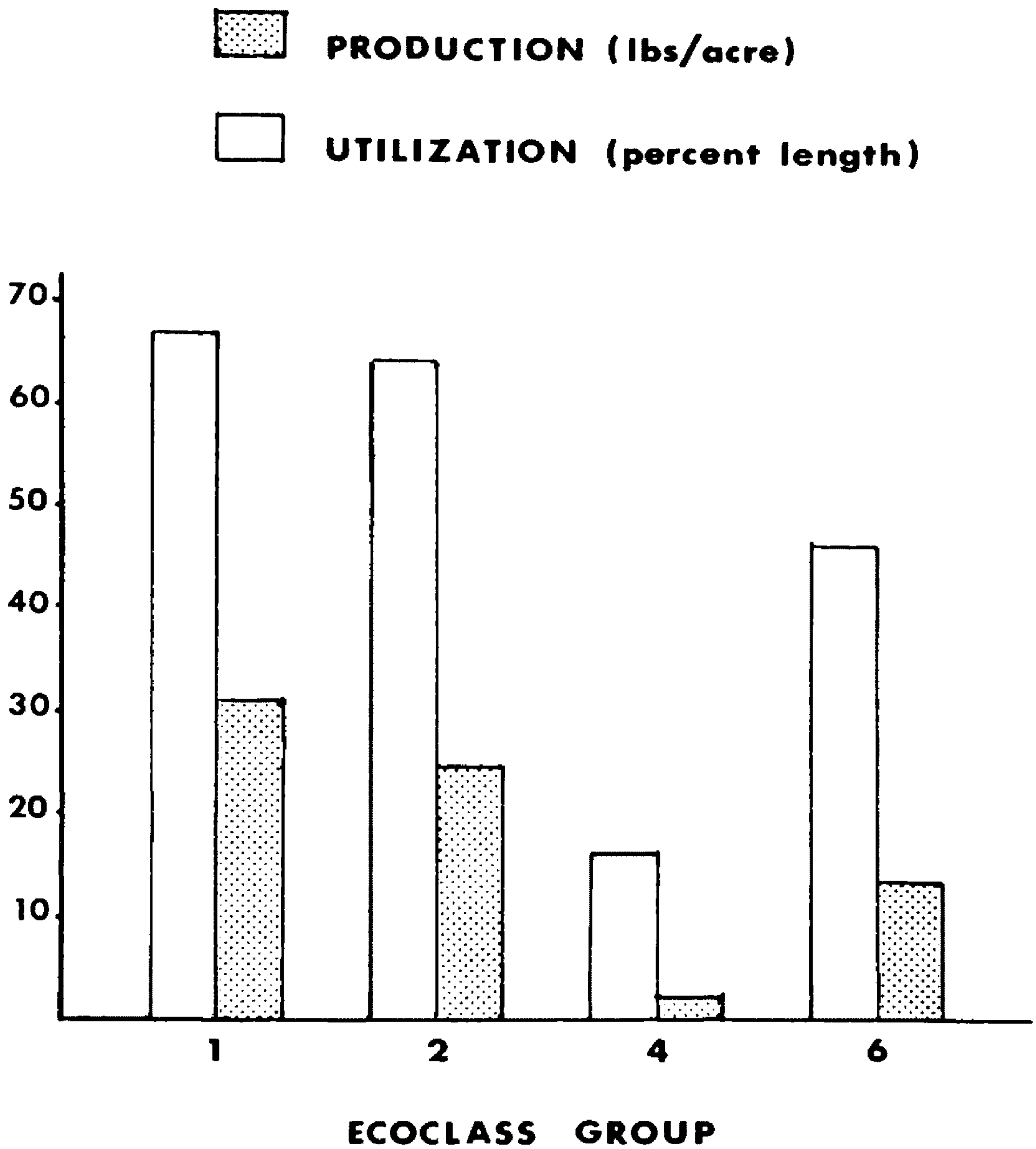

Fig. 6. Comparison of production in lbs/acre to percent utilization by length for serviceberry and mountain maple on four ecoclass groups.

winter range on Spotted Bear Mountain. If utilization levels over 60 percent are considered heavy (Anderson et al. 1972), overall utilization on Spotted Bear Mountain was moderate. Between the habitat-type groups utilization varied from light (group 4), to moderate (group 6), to heavy (groups 1 and 2).

Utilization levels were generally lower than levels indicated for past years by clubbed growth forms of both species. The 1975-76 winter was significantly milder than the two previous winters and the 28-year mean. In a milder winter with less snow accumulation elk probably use larger areas (supported by location data in this study) and utilize shrubs and portions of shrubs not available during more severe winters. A greater proportion of grass species are probably also available, resulting in decreased browsing pressure on shrubs. Shifts in relative utilization levels on different habitat-type groups might occur between winters of differing severity. Greater utilization of the wetter, colder groups might occur in milder winters. Simmons (1974) reported a general figure of 80 percent utilization for the 1973-74 winter (relatively severe) based on visual estimates of leader use. Although this figure can not be compared directly to levels calculated in this study by different methods, it probably indicates that utilization is greater in local areas during a severe winter. Estimates of utilization by numbers browsed (roughly similar methods) calculated in this study show even greater differences.

On all sites, utilization as determined by percent length removed was greater than utilization determined by percent of twig numbers removed. In contrast, Beall (1974) found that utilization determined by percent numbers removed for five browse species on the Sapphire elk winter range was greater than that determined by length utilized. In a study of serviceberry in Montana, Hemmer (1975) found good correlation ($r = 0.97$ and $r = 0.93$ during 2 years) between percent number utilized and percent length utilized. Stickney (1966) reported that the twig count method is sensitive to utilization levels up to 60 percent and felt that beyond that most twigs would show some browsing. That method was not sensitive to utilization levels in this study. However in all habitat-type group areas the remaining unbrowsed twigs of both species were considerably shorter than the calculated lengths of the browsed twigs and than the mean twig lengths determined by the regression programs for both species. Elk preferred longer twigs on the Spotted Bear Mountain winter range. Perhaps in areas where browsing pressure is light and utilization levels low such as Beall (1974) found, elk take the ends of many twigs rather than the longer twigs. Taking the tips of many twigs would result in higher utilization by percent number while preference for longer twigs would result in greater utilization by percent length. In contrast, Hemmer (1975) found evidence for serviceberry that indicated a greater increase in percent number usage than percent length usage with higher utilization levels; this was the opposite of what he had expected.

Table 7 compares diameter at point of browsing (DPB) to diameter at proximal end of current growth (DCG) of browsed twigs for serviceberry and mountain maple on the four habitat-type group areas in percent DPB/DCG. Values were very similar for both species between the group areas and resulted in mean DPB/DCG values of 78 percent for serviceberry and 97 percent for mountain maple. Peek et al. (1971) made similar comparisons for 12 browse species in Minnesota and found an average value for all species combined of 115 percent for a moose (Alces alces) winter area and 78 percent for a deer (Odocoileus virginianus) winter yard. He suggested that the high values were probably caused by browsing of more than the current year's growth and preference for longer twigs. Observations during this study suggest that both factors are probably true for elk browsing on the Spotted Bear Mountain winter range.

The relation of DPB/DCG is important in estimating the effect of browsing intensity on browse production and plant physiology. Young and Payne (1948), Aldous (1952), Krefting et al. (1966), Shepherd (1971), and Mackie (1973) studied the effects of browsing (actual or simulated by clipping) on current annual growth. Browsing appears to stimulate growth by forcing the plant to channel energy into lateral bud growth rather than flowering and seed production.

Table 7. Comparison of diameter at point of browsing (DPB) to diameter at proximal end of current annual growth (DCG) in percentage DPB/DCG for serviceberry and mountain maple on four ecoclass groups.

Habitat-type group	Serviceberry DPB/DCG percentage		Mountain maple DPB/DCG percentage	
	Mean	Range	Mean	Range
1	79	75-83	96	88-103
2	78	71-86	97	92-101
4	77	63-75	—[1]	
6	79	74-90	97	93-109
Mean	79		97[2]	

[1]Not enough data to predict a statistically valid result.

[2]Value from habitat-type group 4 not used.

Young and Payne (1948) and Shepherd (1971) found that fall clipping increased serviceberry production the following year if it was done in levels under 80 percent. Aldous (1952) found 10 percent greater production after 6 years of 100 percent clipping of current annual growth of mountain maple. Krefting et al. (1966) found that sustained production by mountain maple (Acer spicatum) was maintained at the 80 percent level of utilization. Utilization levels on Spotted Bear Mountain were below the 80 percent level for serviceberry and mountain maple, although past levels after more severe winters were probably higher. Peek et al. (1971) stated that "100 percent utilization of twigs with a DPB that equals or exceeds the DCG has a more severe effect upon a plant than similar utilization of twigs with a DPB approximating 60-75 percent or less of the DCG." He maintained that this was particularly important where heavy utilization occurred on species that were tolerant to browsing. DPB/DCG values for mountain maple and serviceberry, species tolerant to browsing, in this study both show average values greater than 75 percent. Although utilization levels are below crucial levels on Spotted Bear Mountain the relatively high DPB/DCG values probably indicate a more severe effect of browsing on serviceberry and mountain maple growth.

Radiotelemetry

A maximum of 18 radio-collars operated simultaneously, and

14 elk with operative radios remained at the conclusion of this study. Radio transmitter performance is summarized in Fig. 7. Two radio-collars placed on cows F and H by Simmons (1974) were still transmitting at the end of this study, although signals from both were weak. The transmitters had been active for over 38 months.

Radiotelemetry work was of secondary importance in this study so flights were generally made on a monthly basis to monitor elk locations. Nine flights were made, resulting in 121 locations. All flights were made during the morning on days with "good" (calm and mostly clear) weather, which possibly introduced a bias in the locations. Because of the small sample size of locations, detailed descriptions of seasonal activity levels and habitat use are not possible. General descriptions of summer and winter areas and inferences on conclusions drawn by Simmons (1974) and Biggins (1975) are made.

Seasonal Elk Distribution

Summer-fall areas. General areas of summer-fall activity for the seven elk radio-collared during winter 1975 are shown in Fig. 8. In this study the summer-fall period was defined as June through November. Migration was completed during June so only locations on summer ranges were included for June. Summer-fall areas for the other elk monitored in the study were given by

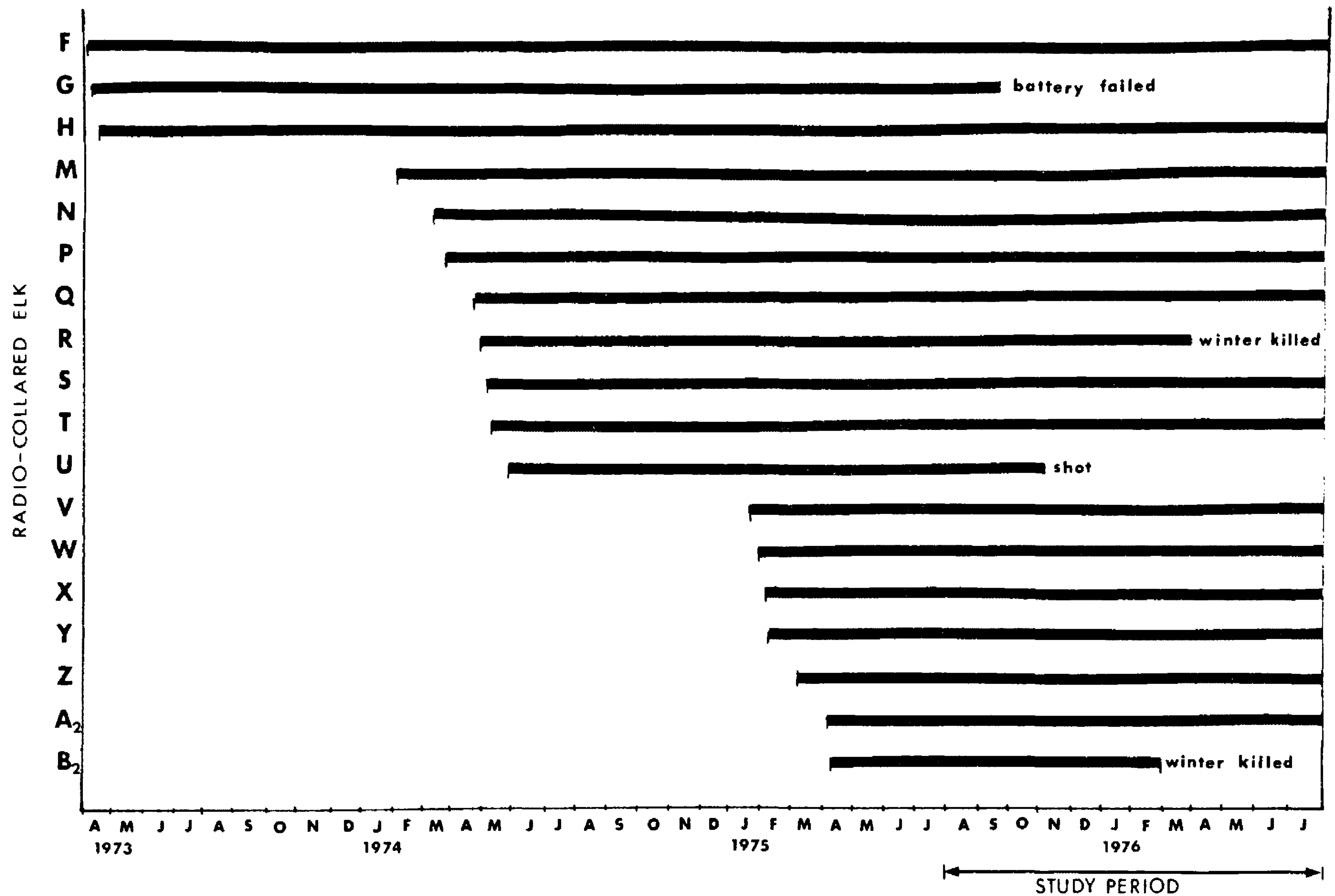

Fig. 7. Radio transmitter performance.

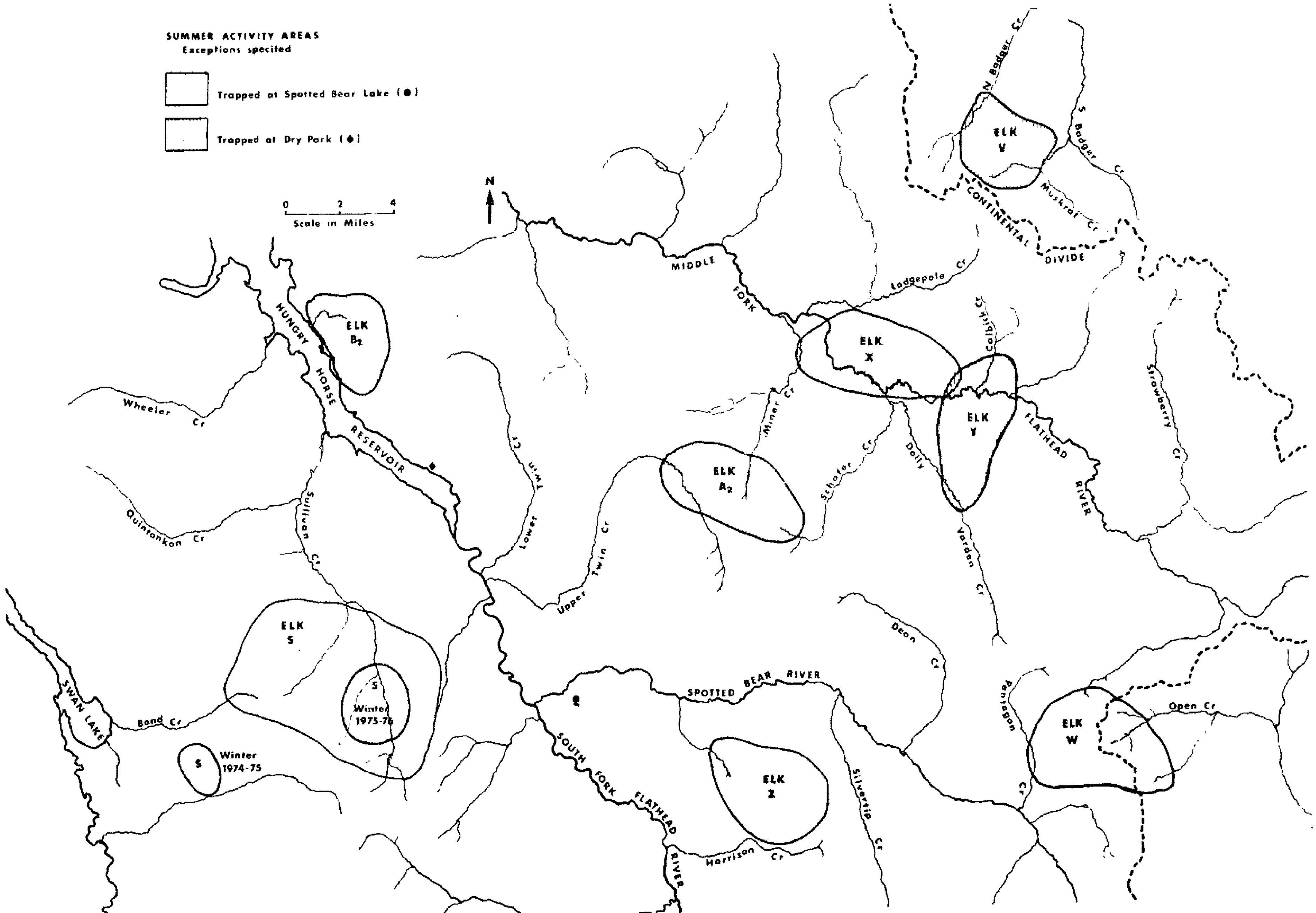

Fig. 8. Summer-fall activity areas of radio-collared elk of the Spotted Bear herd.

Biggins (1975). All locations were within the areas he delineated.

Locations within the summer-fall (and winter) areas were not evenly distributed but were clustered in small preferred areas as Biggins (1975) reported. Craighead et al. (1972) found similar patterns in a Yellowstone elk herd and termed the areas "centers of activity."

The distribution of the summer-fall areas provides an estimate of the proportions of the Spotted Bear elk herd which moves east and west from the winter range. Biggins (1975) found that 18.8 percent of the sightings of neckbanded elk were on the west side of the South Fork of the Flathead River and the remaining 81.2 percent were on the east side. All seven radioed elk in this study moved to the east. Combining the radio-collared elk of this study with those of Simmons (1974) and Biggins (1975) gives an estimate of 17.9 percent westerly migration and 82.1 percent easterly migration. Two patterns proposed by Simmons (1974) accounted for most of the westerly movements in my study. Elk W and Z, trapped at Spotted Bear Lake, followed the route up the Spotted Bear River into drainages of the Spotted Bear River. Elk W occupied a summer range spanning the Continental Divide, which included drainages of the Spotted Bear River and the North Fork of the Sun River. Migration into drainages of the Middle Fork of the Flathead River and beyond was shown by elk V, X, Y, and A_2. All were trapped at Dry Park. Elk B_2, trapped at Dry Park, remained on the east side of the South Fork but moved in a northerly direction along Hungry Horse Reservoir. Elk V crossed the Continental Divide, moving beyond the drainages of the Middle Fork as did elk D and E of Simmons' study (1974). All three of these elk moved over 25 air miles (40.3 km), the longest documented movement by radioed elk during the three studies.

Winter range. The Spotted Bear winter range is shown in Fig. 2. Table 8 gives the distribution of radio-collared elk on the three winter range segments which are separated by Spotted Bear River and Upper Twin Creek. These are not real physical barriers but are useful for management. Biggins (1975) found evidence of mixing among the segments, particularly on peripheral portions of adjacent segments. Mixing was also evident during winter of 1975-76. Greater movement along portions of the winter range than that reported by Biggins (1975) was demonstrated by several radio-collared elk. Elk W, trapped at Spotted Bear Lake, which spent the previous winter on the "southern" and "middle" section of winter range (Spotted Bear Mountain and Horse Ridge) spent the 1975-76 winter on the "middle" and "northern" sections (Horse Ridge and Crossover Mountain). Elk Z, a bull, wintered on Horse Ridge as he did the previous winter but was also located on the "back" (eastern) side of Horse Ridge. Elk S, a bull, trapped at Spotted Bear Lake in the

Table 8. Winter range distribution of radio-collared elk (excluding S) of the Spotted Bear herd.

	Winter range segment		
	"Northern"	"Middle"	"Southern"
	Beacon Mountain Crossover Mountain Dry Park	Horse Ridge	Spotted Bear Mountain
	R	F	N
	T	H	P
	V	Z	
	M[1]		
Elk	W[1]		
	X		
	Y		
	A_2		
	B_2		

[1]Used both "Northern" and "Middle" sections.

winter of 1973-74, spent the 1974-75 winter near Swan Lake (Biggins 1975). During most of the 1975-76 winter, he was located in the Sullivan Creek drainage (Fig. 8) within his summer area but had moved to the Swan winter area in late April.

The winter of 1975-76 was relatively mild with less snow accumulation than the previous winter. The mild winter could be a factor in the increased movement on the winter range. Hash (1973) found increased movements of the Lochsa elk herd in Idaho during a mild winter. Early snow accumulation in October might have blocked movement of Elk S to the Swan winter range. The mild winter might then have influenced him to remain on part of the summer range.

Migrations. Several studies (Simmons 1974, Zahn 1974, Lemke 1975, Grkovic 1976) found that spring migration to summer ranges was fairly abrupt, with long movements occurring over relatively short periods. Although locations were not made frequently enough to determine exact timing of migrations, the Spotted Bear elk herd seemed to exhibit the same pattern of spring migration during this study. After a mild winter, some radioed elk began moving in May 1976, the same as Simmons (1974) reported. Nearly all radioed elk reached their summer ranges by 6 June 1976. Simmons (1974) found spring migration completed by 1 June 1973, also after a mild winter. Biggins (1975) found peak movement from 2 to 10 June in both

1974 and 1975 after two, more severe winters. Variation in winter severity and snow accumulation seems to cause year-to-year variation in the timing of spring migration. Zahn (1974) and Lemke (1975) also found year-to-year variation in timing of migration in the Burdette Creek elk herd.

As reported by Simmons (1974) and Biggins (1975), movement to the winter range in the fall was accomplished more gradually in a series of short movements. Heavy snow accumulation on summer-fall ranges reduces forage availability and probably initiates movement to winter range. Several radio-collared elk had begun moving in early November after a cool, snowy October and more had begun moving by late November. No flights were made from December until early February, at which time all but Elk S were on the winter range.

Migration routes followed those described by Simmons (1974) with the exception specified by Biggins (1975).

Fidelity to Seasonal Areas

Movement data from radio-collared elk, for periods up to 4 years, provided information on repeated use of seasonal areas. Fidelity to former areas of summer and/or winter use was generally high as reported by others (Picton 1960, Judd 1971, Craighead et al. 1972, Ream et al. 1972, Simmons 1974, Zahn 1974, Biggins 1975, Lemke 1975). All radio-collared elk with known summering areas returned to those areas in 1975 (12 elk) and 1976 (14 elk). Elk F and H used the same summer areas during four successive summers.

Of the 16 elk with operative radio-collars, 15 returned to the Spotted Bear winter range. Areas of concentrated use on the winter range varied somewhat and were generally larger than during the previous year, possibly due to the mild winter. Knight (1970) and Hash (1973) also reported that habitual use of winter range was affected by the severity of the winter.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The Spotted Bear winter range supports the largest wintering population of elk along the lower South Fork of the Flathead River. The segment of winter range on Spotted Bear Mountain consists of a closed canopy forest and supports the smallest number of wintering elk in contrast to the other segments which have large open areas interspersed with stands of timber. Results of this study on Spotted Bear Mountain, indicate relatively low production and moderate utilization of serviceberry and mountain maple. Utilization was below critical levels following the mild 1975-76 winter but plant growth forms indicated more severe use in the past.

From his study on habitat use by elk, Biggins (1975) concluded that the greatest potential for habitat improvement was on January-June ranges. The low production levels and moderate utilization levels found in this study indicate potential winter range improvement on Spotted Bear Mountain with the timber harvest planned for the area. However, cover is also very important for wintering elk (Beall 1974, Simmons 1974). Winter fieldwork by Biggins indicated that elk use timbered areas more extensively than open areas during winters of deep and crusted snow. Therefore maintenance of timber stands with good browse understories is also important for the area.

Production and utilization were highest on the warm, dry Douglas-fir habitat types and phases of ecoclass groups 1 and 2, which comprised 42 percent of the range. Areas of group 1 showed the highest production and utilization. While production levels are relatively low, these areas were already relatively open (low canopy density) and range improvement would best be accomplished by a controlled burning program. Areas of habitat-type group 2, primarily DF/Syal, have great potential for increased browse production. A good mixed-browse understory currently exists and low plant vigor and production would be enhanced by timber removal and slash burning. Cuts on steep areas of southwest aspect may provide increased range, particularly late winter-early spring, where snow melt occurs first. Cuts should be interspersed with uncut stands to provide range for times of crusted snow.

Areas of ecoclass group 6, primarily AF/Clun habitat types, also have good potential for habitat improvement. These areas occurred mostly on the lower, flatter slopes of Spotted Bear Mountain. A reasonably good mixed browse understory exists at present, particularly on AF/Clun/Clun, and shrub density, vigor, and production could be increased by timber removal and slash burning. These areas would provide increased early winter and late spring range.

Densely timbered areas of AF/Vaca/Vaca show very low production and low utilization. These areas probably have the least potential for habitat improvement. Browse understory was poor; serviceberry occurred as small-repressed growth forms in low density and mountain maple was rarely present. Although timber removal and burning might increase browse density and production, habitat use by elk would probably remain low.

Data from radio-collared elk in this study supported the conclusions and recommendations made by Simmons (1974) and Biggins (1975) on seasonal ranges and migration routes. Further conclusions on management boundries should be made when the results of the study, currently in progress, on movements and ranges of the Middle Fork elk herd are available.

This study provided quantitative baseline data on production and utilization for the winter range on Spotted Bear Mountain. Measurements of both should be made after timber harvest and continued on a yearly basis to assess the effects of timber removal, slash removal/burning, and vegetational changes resulting from succession on overall browse production, browse species composition, and utilization by elk.

I feel that the ranked-set method of sampling production, while more time-consuming than methods which do not involve clipping, provides more accurate results. The same method should be used at regular intervals after timber harvest to sample changes in production. Division by ecoclass groups was a valid means of stratification in this study and could be used in future studies. If representative sampling by habitat types present on the range is desired, sites should be determined initially by random means. Some modification might be desirable to sample adjacent cut and uncut areas. A second sampling site could be located in the nearest cut (or uncut) area of similar type. Permanent transects, which would be easier to relocate with better accessibility resulting from logging and road construction, might be desirable to measure changes during successional vegetation stages. Field time could be decreased by sampling with a two-person crew.

Two methods were used in this study to determine utilization, while a third was attempted but not successful. The same considerations listed above for production sampling should be used in determination of utilization sampling locations for future studies. The attempted method, based on length measurements before and after browsing, is feasible for future studies. The easier accessibility of the area which will result after timber harvest would make relocation of sites less difficult and time-consuming.

Utilization determined by percent-number browsed lacks desirable accuracy and, for this study, probably underestimated utilization levels. I feel that utilization by percent length, determined by diameter measurements and regression of length on diameter, provided the most accurate estimate of utilization on the winter range and recommend using this method for future studies. Regression equations developed in this study indicated a higher correlation of length and diameter than weight and diameter. If direct determination of utilization by weight is desirable, the correlation coefficient does indicate that this would also be a feasible method. The regression equations from this study (Table 5) are applicable to future utilization studies on the winter range. However, if increased production and/or a shift in key species composition are found after timber harvest or during succession, new regression equations should be determined to reflect these changes.

CHAPTER VI

SUMMARY

Characteristics of the Spotted Bear Mountain elk winter range, particularly browse production and utilization, and movements of the Spotted Bear elk herd were studied from August 1975 to July 1976.

Vegetation on the winter range was classified by habitat types and phases into four ecoclass groups. The warm dry groups 1 and 2 covered 11 and 32 percent of the winter range, respectively, and included *Pseudotsuga menziesii* habitat types. The cool and moderately dry group 4 covered 13 percent of the range and the cool and moist group 6 covered 39 percent. Both cool groups consisted of *Abies lasiocarpa* habitat types. Serviceberry and mountain maple were the key browse species.

Using the ranked-set method, 30 plots on 38 sites in the four habitat-type groups were sampled for production. Annual production was highest on group 1 areas with a mean of 31.23 lbs/acre (35.00 kg/ha) and a range of 24.80 to 37.66 lbs/acre (27.80-42.21 kg/ha). Group 2 showed mean production of 24.86 lbs/acre (27.86 kg/ha) with a range of 14.12 to 38.15 lbs/acre (15.83-42.76 kg/ha) and group 6

areas showed mean production of 13.71 lbs/acre (15.37 kg/ha) with a range of 8.27 to 18.96 lbs/acre (9.27-21.25 kg/ha). Production was lowest in the dense lodgepole pine stands of group 4 with a mean of 2.35 lbs/acre (2.63 kg/ha) and a range of 1.60 to 3.13 lbs/acre (1.79-3.51 kg/ha). Significant differences in production existed between all groups except 1 and 2 at the 0.01 confidence level. Overlap of production values was related to habitat blending.

Trends were evident between different habitat type phases within the groups. DF/Caru — DF/Syal (DSA-DSC) of group 1 and DSC-DSA of group 2 showed the highest production. Within group 6, the highest production was found on AF/Clun/Clun. Lowest production occurred on AF/Vaca/Vaca of group 4. Greater production was found on slopes of south to west aspects.

Overall production was 17.9 lbs/acre (20.1 kg/ha) for the winter range and was much lower than the capability of the area.

Utilization values were obtained by two methods. Percent numbers underestimated utilization. Percent length, determined from postbrowsing measurements and a regression equation of length on diameter for serviceberry and mountain maple, showed high correlation of length and diameter ($r = 0.909$ and $r = 0.899$).

Serviceberry utilization varied from 7.71 to 69.74 percent. Utilization of mountain maple varied from 31.31 to 78.61 percent and was always greater than serviceberry use on sites where the two occurred together.

The highest mean utilization of both species was on areas of groups 1 and 2. Utilization was 67.16 percent on group 1 and 64.64 percent on group 2. Group 6 showed moderate utilization of 46.49 percent. Utilization on group 4 areas was light at 16.24 percent.

Overall mean utilization on the winter range was 50.7 percent which was below critical levels; however, clubbed growth forms showed higher past use. The 1975-76 winter was milder and more range was available than normal.

Elk exhibited a preference for long twigs and took more than the current years growth.

Approximately 18 percent of the Spotted Bear elk herd moved west and used the Swan Range during summer and fall. Most of the remaining elk moved east into drainages of the Spotted Bear or Middle Fork of the Flathead rivers. A small portion remained on or near the winter range during summer and fall or moved north a short distance along Hungry Horse Reservoir.

Spring migration of most radio-collared elk was completed by 6 June 1976. The longest dispersal movements were near 25 airline miles (40.3 km).

Fidelity to summer and winter ranges was high. Two radio-collared elk used the same summer ranges for 4 consecutive years. Fifteen of 16 elk returned to the Spotted Bear winter range. Different segments of the winter range were used by three elk in consecutive winters.

The ranked-set production sampling method and length-diameter utilization methods were recommended for future use.

Greatest potential for winter range improvement on Spotted Bear Mountain was found on areas of groups 2 and 6. Proposed timber harvest and slash burning could increase late winter and early spring range on areas of group 2 and early winter and late spring range on group 6. Maintenance of timber stands with good browse understory in these two groups is also important for cover and use during years of crusted snow.

REFERENCES CITED

Anderson, A. F., D. E. Medin, and D. C. Bowden. 1972. Mule deer numbers and shrub yield utilization on winter range. J. Wildl. Manage. 36(2):571-578.

Aldous, S. F. 1952. Deer browse clipping study in the Lake States region. J. Wildl. Manage. 16(4):401-409.

Anonymous. 1974. Multiple use plan, Spotted Bear planning unit, final environmental statement. Rep. No. USDA-FS-FES (Adm) R1-74-9. Flathead Nat. For., Kalispell, MT. 52pp.

Basille, J. V., and S. S. Hutchings. 1966. Twig diameter-length-weight relations of bitterbrush. J. Range Manage. 19(1):34-38.

Beall, R. C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph.D. Thesis, Univ. of MT, Missoula. 197pp.

Biggins, D. E. 1975. Seasonal habitat selection and movements of the Spotted Bear elk herd. Job Final Rep. W-120-R-6 and 7. MT Fish Game Dept., Helena. 90pp.

Chapman, D. G., and R. A. Schaufele. 1971. Elementary probability models and statistical inference. Xerox College Pub. Co., Waltham, MA. 358pp.

Cole, G. F. 1958. Range survey guide. Job Final Rep. W-37-R. MT Fish Game Dept., Helena. 18pp.

Craighead, J. J., G. Atwell, and B. W. O'Gara. 1972. Elk migrations in and near Yellowstone National Park. Wildl. Mono. No. 29. 48pp.

________, F. C. Craighead, Jr., R. L. Ruff, and B. W. O'Gara. 1973. Home ranges and activity patterns of nonmigratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Mono. No. 33. 50pp.

Denton, J. W. 1973. A radiotelemetry system for elk: its use and efficiency. M.S. Thesis, Univ. of MT, Missoula. 77pp.

Dixon, W. J., ed. 1974. Biomedical computer programs. Univ. of CA Press, Berkeley and Los Angeles. pp.365-372.

Grkovic, N. 1976. Montana-Idaho elk migrations and key-use area study, Salmon, Beaverhead, and Bitterroot National Forests. M.S. Thesis, Univ. of MT, Missoula. 128pp.

Halls, L. K., and T. R. Dell. 1966. Trials of ranked-set sampling for forage yields. For. Sci. 12(1):22-26.

Hash, H. S. 1973. Movements and food habits of the Lochsa elk herd. M.S. Thesis, Univ. of ID, Moscow. 76pp.

Hemmer, D. 1975. Serviceberry: ecology, distribution, and relationships to big game. M.S. Thesis, Univ. of MT, Missoula. 76pp.

Hicks, C. R. 1973. Fundamental concepts in the design of experiments. Holt, Rinehart and Winston, Inc., NY. 349pp.

Hitchcock, C. L., and A. Cronquist. 1973. Flora of the Pacific Northwest. Univ. of WA Press, Seattle and London. 730pp.

Johns, W. M. 1970. Geology and mineral deposits of Lincoln and Flathead Counties, Montana. Bull. 79, MT Bur. of Mines, Helena. 182pp.

Judd, S. L. 1971. Movements and migrations of the Lochsa elk. M.S. Thesis, Univ. of ID, Moscow. 42pp.

Julander, O. 1937. Utilization of browse by wildlife. Trans. N. Am. Wildl. Conf. 2:276-287.

Knight, R. R. 1970. The Sun River elk herd. Wildl. Mono. No. 23. 63pp.

Krefting, L. W., M. H. Stenlund, and R. K. Seemel. 1966. Effects of simulated and natural deer browsing on mountain maple. J. Wildl. Manage. 30(3):481-488.

Lemke, T. O. 1975. Movements and seasonal ranges of the Burdette Creek elk herd, and an investigation of hunting. Job Final Rep. W-120-R-6. MT Fish Game Dept., Helena. 127pp.

Lyon, L. J. 1970. Length and weight-diameter relations of serviceberry twigs. J. Wildl. Manage. 34(2):456-460.

_________. 1975. Elk use of disturbed areas. In Montana cooperative elk-logging study, Ann. Prog. Rep. For. Sci. Lab., Univ. of MT, Missoula. pp. 121-127.

McIntyre, G. A. 1952. A method for unbiased selective sampling using ranked sets. Austral. J. Agric. Res. 3:385-390.

McLean, L. S. 1972. Movements and migrations of the Lochsa elk herd. M.S. Thesis, Univ. of ID, Moscow. 65pp.

Mackie, R. J. 1973. Evaluation of range survey methods, concepts and criteria (responses if four browse species to protection on big game winter range in western Montana). Job Final Rep. W-120-R-3. MT Fish Game Dept., Helena. 30pp.

Marcum, C. L. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph.D. Thesis, Univ. of MT, Missoula. 188pp.

Martinson, A. H., R. Delk, and D. Venturini. 1973. Spotted Bear Country. USDA For. Ser. Pub. No. R1-73-010, Flathead Nat. For., Kalispell, MT. 150pp.

On, D. 1975. Habitat-type group map--Spotted Bear Mountain. U.S. For. Ser., Flathead Nat. For., Kalispell, MT. (mimeo).

_________, and B. J. Losensky. 1975. Ecoclass identification for Region One. U.S. For. Ser., Flathead Nat. For., Kalispell, MT. 11pp. (mimeo).

Peek, J. M., L. W. Krefting, and J. C. Tappeiner. 1971. Variation in twig diameter-weight relationships in northern Minnesota. J. Wildl. Manage. 35(3):501-507.

_________, D. L. Urich, and R. J. Mackie. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildl. Mono. No. 48. 65pp.

Pengelly, W. L. 1972. Clearcutting: detrimental aspects for wildlife resources. J. Soil Water Cons. 27(6):255-258.

Picton, H. D. 1960. Migration patterns of the Sun River elk herd, Montana. J. Wildl. Manage. 24(3):279-290.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1974. Forest habitat types of Montana. Intermountain For. and Range Exp. Sta. and N. Region, USFS, Missoula, MT. 213pp.

Ream, R. R., R. C. Beall, and C. L. Marcum. 1972. Sapphire Range elk ecology study--elk, logging, roads, and people. Second Ann. Rep. School of For., Univ. of MT, Missoula. 54pp.

Resler, R. A. 1972. Clearcutting: beneficial aspects for wildlife resources. J. Soil Water Cons. 27(6):250-254.

Rognrud, M., and R. Janson. 1971. Elk. In Game management in Montana. T. Mussehl and F. Howell, eds. Fed. Aid Proj. W-3-C. MT Fish Game Dept., Helena. 237pp.

Shepherd, H. R. 1971. Effects of clipping on key browse species in southwestern Colorado. Tech. Pub. 28. CO Div. Game, Fish, Parks, Denver. 104pp.

Simmons, C. A. 1974. Seasonal movements and migrations of the Spotted Bear elk herd. Job Final Rep. W-120-R-5. MT Fish Game Dept., Helena. 99pp.

Stickney, P. F. 1966. Browse utilization based on percentage of twig numbers browsed. J. Wildl. Manage. 33(4):917-921.

Warner, R. 1970. Some aspects of browse production in relation to timber harvest methods and succession in western Montana. Job Final Rep. W-98-R-9. MT Fish Game Dept., Helena. 74pp.

Young, V. A., and G. F. Payne. 1948. Utilization of key browse species in relation to proper grazing practices in cutover western white pine lands in northern Idaho. J. For. 46(1):35-40.

Zahn, H. M. 1974. Seasonal movements of the Burdette Creek elk herd. Job Final Rep. W-120-R-4, 5. MT Fish Game Dept., Helena. 71pp.