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Distribution and habitat selection of elk in the north Garnet Mountains of western Montana

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DISTRIBUTION AND HABITAT SELECTION OF ELK IN THE NORTH GARNET MOUNTAINS OF WESTERN MONTANA

By

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ABSTRACT

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Elk movements and habitat selection were studied from May through November during 1977, 1978, and 1979. Thirty-one elk, equipped with radio-transmitter collars, were located 979 times from an airplane. Elk trapped at the Lindbergh and Potter traps primarily used an area of about 70 square miles (181 km^2), whereas elk trapped at Grace's Landing used an area of about 30 square miles (78 km^2). There was very little mingling of these 2 groups, and a remarkable fidelity to group home range boundaries was observed. Spring-fall use of the Core Study Area (CSA) was significantly greater than availability for all 3 years. During calving and summer seasons, most activity was in and near the north and west sides of the CSA. Elk ranged widely during the rutting season, generally dispersing from areas of summer use. Activity centers were grouped during the hunting season, mainly in areas about 2 miles (3.2 km) from the nearest hunter access point. Elevations from 5700 to 6200 feet (1740-1890 m) were consistently selected for. Ridgetops were selected for during 1978 and 1979, but use was greatest on upper and mid-slopes. Concave slope configurations were usually preferred. Northeast aspects were overall the most preferred aspect. Distance to water did not influence elk distribution; however, water and moist sites were readily available throughout the study area. Little preference was shown for canopy cover. Pole-young, mixed species stands were used the most, but only mature-old, mixed species stands were preferred. The ABLA/CACA habitat type was most preferred, followed by the ABLA/LIBO, ABLA/XETE-VAGL, PSME/CARU, and ABLA/MEFE types. Open roads were not avoided during the calving and summer seasons, but areas within 550 yards (500 m) and 1350 yards (1230 m) of open roads were avoided during the rutting and hunting seasons, respectively. Elk consistently avoided areas within 0.5 mile (800 m) of active logging and road building activities.

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I am particularly indebted to Dr. C. Les Marcum for his encouragement, assistance, and patient advice and support during all aspects of the study.

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CHAPTER I

INTRODUCTION

The elk (Cervus elaphus) is one of western North America's most prized animals. Hunters and nonhunters alike value the elk for its grace and beauty. By the turn of the century, this once abundant animal had been drastically reduced in number and range of occurrence throughout western North America. Through a combination of reintroductions and favorable habitat alterations caused by wildfire in the early part of the century, populations of elk increased to become abundant in the northern Rocky Mountains during the 1930's and 1940's (Lyon 1966, Marcum 1975). Since that time, however, forest successional trends have reduced the availability of high quality habitat for elk, hunting pressure has increased, and the demand for forest products has also increased. These factors caused concerned wildlife biologists to question the capability of forest lands to maintain viable elk populations.

Large wildfires were no longer an important factor for increasing elk habitat, but it was felt that logging would adequately mimic the action of fire in creating early successional stages beneficial to elk. However, many of the claimed beneficial aspects of logging were disputed by wildlife managers. It was concluded that there was too little information concerning the effects of timber harvest practices on elk (Marcum 1975). Lyon (1971) outlined a research program to study elk-logging relationships that was initiated in 1970 as the Montana Cooperative Elk-Logging Study. The goal of the Study was to assess the impact of logging practices and road building on the movements, habitat selection and use, and survival of elk in Montana. My study was part of the research program.

The main Chamberlain Creek drainage is the primary summer range for elk wintering in adjacent north and west drainages. The area is heavily forested, and has remained relatively untouched by logging and road building activities, mainly due to the small amount of merchantable timber occurring there. Planning for timber harvest and the predisturbance study of elk habitat selection was begun by Bureau of Land Management personnel during 1971 and continued through 1974. A contract was awarded to the University of Montana in 1975 to continue the study. Predisturbance results of pellet-count surveys in the main Chamberlain Creek drainage, or Core Study Area (CSA), were presented by Marcum and Scott (1977), Marcum et al. (1978, 1977), Scott (1978), and Marcum and Lehmkuhl (1980). The objectives of my study were to describe the spring through fall movements, habitat selection and use, and available habitat of elk that use the Chamberlain Creek drainage. My working hypothesis was that elk use of various environmental situations was in proportion to their availability.

It was intended that my study be the "disturbance phase" of the long-term study. However, road building and logging were delayed; consequently, more definitive results concerning the response of elk to active timber harvest activities should be available from subsequent studies in the area.

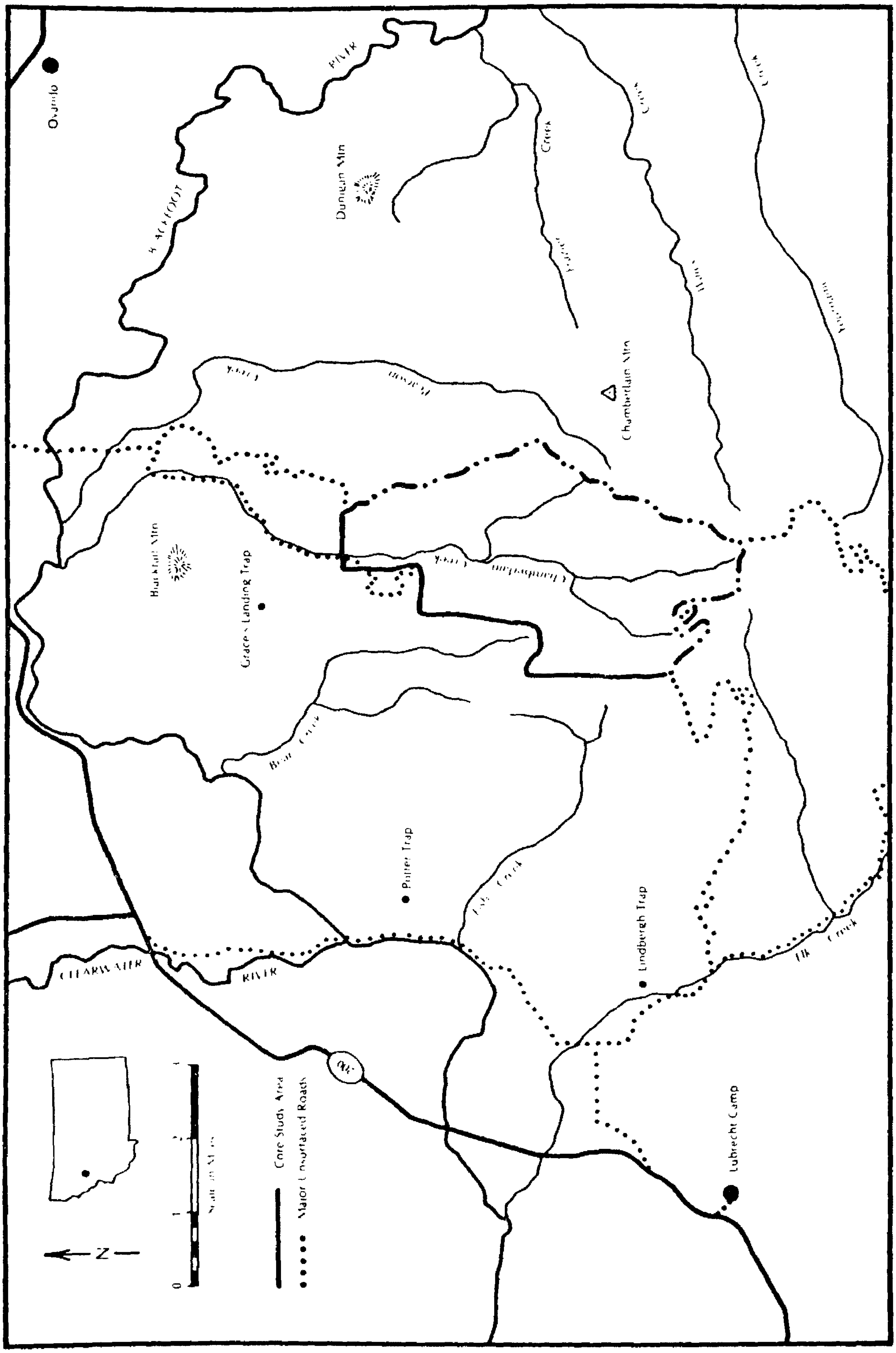
CHAPTER II

STUDY AREA

Location and Physiography

The study area was located in the north Garnet Mountains of western Montana, approximately 35 miles (56 km) east of Missoula, Montana, in northwestern Powell County and northeastern Missoula County. Elk radio-collared for the study used an area of about 80 square miles (207 km^2) that included the Chamberlain Creek, Bear Creek, Fish Creek, and Little Fish Creek drainages. Portions of the upper Pearson Creek and upper Wales Creek drainages, Lubrecht Experimental Forest, and the area west of the mouth of Bear Creek and south of Highway 200 were also used (Fig. 1).

Topography ranges from steep, high elevation, timbered basins in the upper Pearson Creek and upper Wales Creek drainages, to open level pastures and hayfields near the Potter Trap, along the south side of the Blackfoot River north of Blacktail Mountain, and adjacent to lower Elk Creek. Two north-south fourth-order ridges define the main fork Chamberlain Creek drainage, the CSA. The east ridge slopes to gentle undulating terrain east of the Grace's Landing Trap, whereas the west ridge terminates abruptly at the West Fork


Ovando
Chamberlain Mtn
Potter Trap
Lindbergh Trap
Lubrecht Camp
Elk Creek
Bear Creek
CLEARWATER
RIVER
Core Study Area
Major Unsurfaced Roads
N

Chamberlain Creek just south of the Trap. A third major ridge extends northwest from the head of Bear Creek, forming the western boundary of that drainage.

The CSA is composed of 2 topographically distinct portions. The upper (southern) third is characterized by moderate to gentle forested slopes of 20° or less, and several small wet meadows at the head of Chamberlain Creek. The lower two-thirds is composed of moderate to steep slopes (15-30°) with very steep to precipitous slopes and rocky outcrops along Chamberlain Creek.

Extending west from the southern half of the CSA are moderate to steep timbered ridges terminating in gently undulating forest. The latter extends north from the Lindbergh Trap, following the base of the hills to the Blackfoot River. Similar terrain is found west of Elk Creek, on Lubrecht Experimental Forest, in the Bear Creek drainage, and north of the Blackfoot River west from the mouth of Bear Creek. Steep to precipitous slopes occur north and west of the mouth of Bear Creek, adjacent to the Blackfoot River, and on the north side of Blacktail Mountain. The south side of Blacktail Mountain, essentially an east-west ridge, is a moderately steep, open-timbered slope leading to a series of shallow draws and ridges that terminate at the West Fork of Chamberlain Creek, where the Grace's Landing Trap is located. West of the Trap, gently undulating forest occurs. The entire study area is well-watered by numerous small streams.

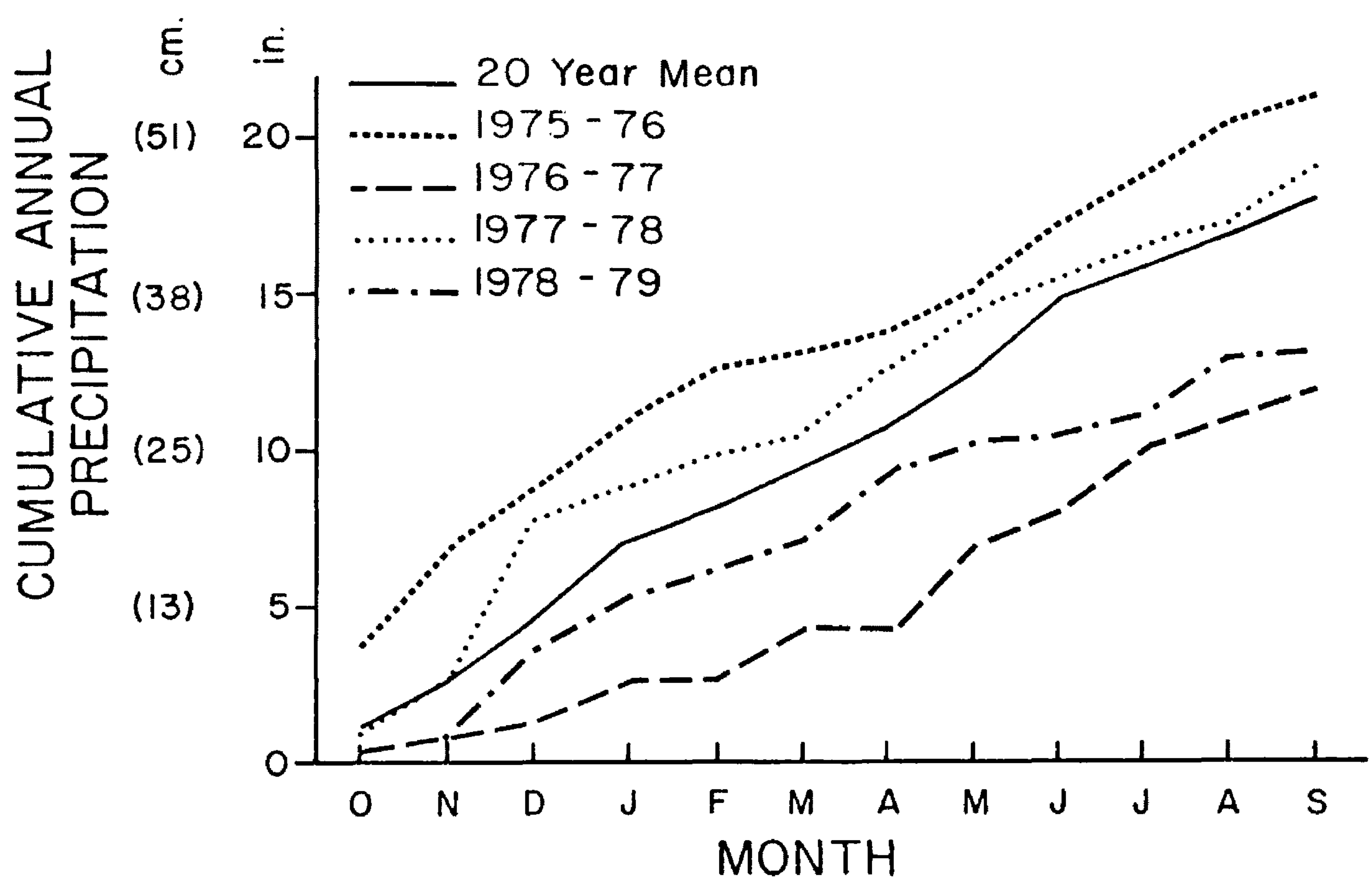
Elevations range from about 3800 feet (1160 m) along lower Elk Creek to approximately 6860 feet (2090 m) at Chamberlain Mountain on the southeast side of the study area.

Climate

The climate of the area is characterized by cool, moist winters and warm, dry summers. Weather data are collected at Lubrecht Experimental Forest (elevation 4100 feet [1250 m]) at the west side of the study area (Steele 1980). The 22-year mean monthly precipitation ranges from 0.95 inches (2.41 cm) in July, to 2.35 inches (5.97 cm) during January. The annual mean is 17.60 inches (44.70 cm). More than two-thirds of the annual precipitation occurs during winter and spring (December through June). The highest average monthly temperature (62.4°F) and highest average daily maximum temperature (82.3°F) occur during July. Average daily minimum temperature is lowest (7.5°F) in January. The climate of the study area at higher elevations is probably slightly cooler and more moist than that of Lubrecht Forest.

Fig. 2 shows cumulative precipitation for October through December for all the study years, and for the 22-year mean. Values for October through December are included with January through September values for the next year so that cumulative precipitation would more naturally coincide with the cycle of soil moisture accumulation and availability for plant growth.

Fig. 2. Cumulative annual precipitation at Lubrecht Experimental Forest.


CUMULATIVE ANNUAL PRECIPITATION
cm.
in.
(51)
(38)
(25)
(13)
20
15
10
5
0
20 Year Mean
1975 - 76
1976 - 77
1977 - 78
1978 - 79
O
N
D
J
F
M
A
M
J
J
A
S
MONTH

Cumulative precipitation for 1977 was 32% below normal. The October through April period was extremely dry, with precipitation 59% below average. However, rainfall was near normal from May through September. During 1978, total precipitation was slightly above the 22-year mean; precipitation was 43% higher than normal from October through December 1977, but 80% lower than normal during June. Precipitation during 1979 was intermediate between that of 1977 and 1978, and 25% below normal. Precipitation was only slightly below normal from October through April, but May through July rainfall was 62% below the mean. August was abnormally wet, but September was unusually dry.

Average daily maximum temperatures from May through November for all years of the study did not deviate greatly from the 22-year mean (Table 1). Generally, daily maximum temperatures were slightly higher during June and slightly lower during July and August than the mean. Fall 1978 was considerably cooler than usual, while October 1979 was warmer than normal.

Table 1. Average daily maximum temperature (F) by month at Lubrecht Experimental Forest (Steele 1980).

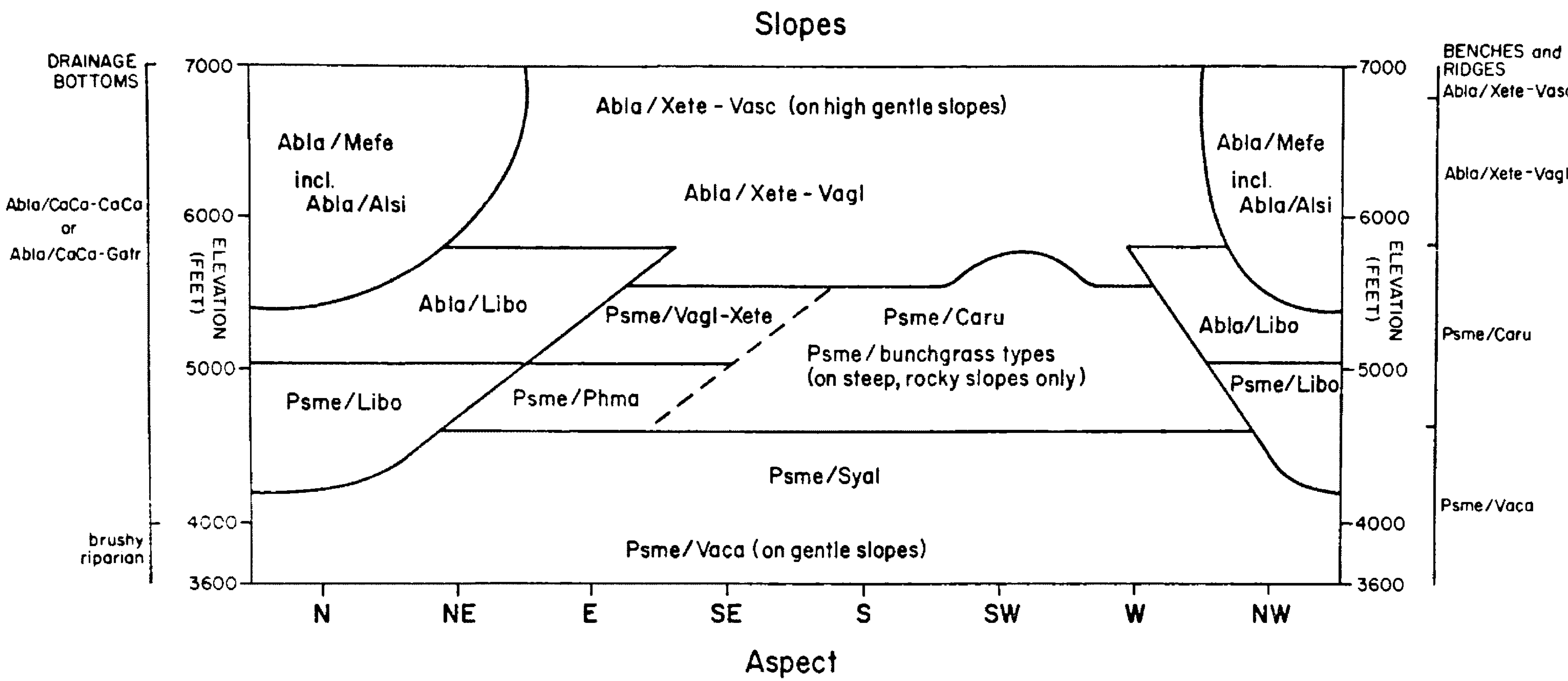
	May	Jun	Jul	Aug	Sep	Oct	Nov
1977	59.9	75.7	77.7	79.4	66.6	53.0	31.5
1978	53.4	71.0	77.8	76.1	54.4	50.3	30.3
1979	62.6	74.0	83.3	75.4	70.5	61.5	34.7
22-year mean	62.2	71.2	82.3	80.3	67.5	53.9	36.8

Vegetation

Approximately 85% of the study area is forested. Forested areas were classified by arbitrary types based on the dominant structural characteristics of the stand, and by habitat types (Pfister et al. 1977). Structural characteristics were chosen as the classification basis for the forest overstory because distinguishing tree species from aerial photos with complete accuracy was often difficult. Furthermore, elk probably respond more to structural characteristics of the forest than to overstory composition (Marcum 1975). Pfister et al. habitat types were determined with an elevation/aspect model developed from approximately 450 sampled sites (Fig. 3). Habitat type phases and minor habitat types were generally not differentiated by the model, and were grouped with similar, more common types. This system was used primarily to describe understory species composition because habitat types were originally described only in potential or near climax (about 70 years old or greater) plant communities. According to Pfister, climax understory species become established in early seral stages; hence, the system probably has greater value for describing understory rather than overstory species composition in areas comprised primarily of early to mid-seral communities.

As a result of extensive forest fires about 30, 60, and 90 years ago (Ellison 1972), the forest overstory is predominantly pole-size (4-10 inches [10-25 cm] dbh) lodgepole pine (*Pinus contorta*)

Fig. 3. Forest habitat type model for the study area.


Slopes
DRAINAGE BOTTOMS
Abla/CaCa-CaCa
or
Abla/CaCa-Gatr
brushy riparian
7000
6000
5000
4000
3600
ELEVATION (FEET)
Abla / Xete - Vasc (on high gentle slopes)
Abla / Mefe
incl.
Abla / Alsi
Abla / Xete - Vagl
Abla / Mefe
incl.
Abla / Alsi
Abla / Libo
Psme / Vagl - Xete
Psme / Caru
Abla / Libo
Psme / bunchgrass types
(on steep, rocky slopes only)
Psme / Libo
Psme / Phma
Psme / Libo
Psme / Syal
Psme / Vaca (on gentle slopes)
N
NE
E
SE
S
SW
W
NW
Aspect
BENCHES and RIDGES
Abla/Xete-Vasc
Abla/Xete-Vagl
Psme/Caru
Psme/Vaca

at elevations above 5600 feet (1700 m) on southerly aspects, and above 5100 feet (1550 m) on northerly aspects. Isolated stands of mature-old (greater than 15 inches [38 cm] dbh) subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmanii), and some western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) that escaped burning are also present above these elevations. The range of subalpine fir and Engelmann spruce, however, extends down to 4400 feet (1340 m) in stream bottoms. Both the seral lodgepole pine and the mature mixed-species stands are in the subalpine fir habitat type series.

At elevations below the subalpine fir zone, Douglas-fir occurs in almost pure stands on dry, west and south aspects. However, on north and east aspects and on locally moist sites, mixed Douglas-fir and western larch stands are found. Ponderosa pine (Pinus ponderosa) is a common seral codominant with Douglas-fir on dry sites at low elevations. Generally, Douglas-fir and ponderosa pine stands are pole-young size (4-15 inches [10-38 cm] dbh), whereas some mixed Douglas-fir/larch stands are mature-old, due to large larch that dominate the stands. Areas where subalpine fir is absent are in the Douglas-fir habitat type series.

Understory species distribution follows an elevational gradient similar to that of tree species. Understory composition is discussed below in reference to habitat types. Table 2 shows the percentage of the study area occupied by each type, and constancy and mean canopy

Table 2. Constancy[a] and average coverage (%) of important plants in forest habitat types and phases in the lower Blackfoot drainage. Data from Dr. Stephen Arno, USDA Forest Sciences Laboratory, Missoula, MT.

	Douglas-fir habitat types							Alpine fir habitat types				
	VACA	SYAL	LIBO	CARU	FEID[b]	PHMA	VAGL	XETE-VAGL	XETE-VASC	LIBO	MEFE	CACA[c]
Percent of study area[d]	13.0	18.0	10.7	8.7	5.7	2.3	1.3	6.7	0.3	4.3	11.3	2.7
Number of plots	5	8	8	14	19	30	9	16	7	9	14	
Alnus sinuata	...	...	...	...	...	...	...	1 (3)	1 (37)	3 (0)	3 (0)	
Menziesia ferruginea	...	...	...	...	...	...	...	3 (0)	1 (1)	8 (1)	10 (38)	
Physocarpus malvaceus	...	3 (2)	5 (2)	1 (2)	...	10 (44)	3 (1)	...	...	...	...	
Spirea betulifolia	10 (14)	6 (7)	10 (8)	8 (2)	...	7 (6)	7 (4)	8 (2)	7 (1)	5 (5)	1 (3)	
Symphoricarpos albus	8 (18)	10 (18)	9 (13)	5 (1)	1 (1)	9 (9)	2 (2)	1 (1)	...	1 (3)	...	
Vaccinium caespitosum	10 (15)	...	...	1 (0)	...	...	...	...	...	...	...	
Vaccinium globulare	2 (15)	...	8 (10)	1 (1)	...	1 (23)	9 (31)	10 (43)	7 (2)	10 (27)	9 (11)	
Vaccinium scoparium	...	...	1 (0)	...	...	...	2 (19)	6 (22)	9 (70)	5 (20)	7 (19)	
Arctostaphylos uva-ursi	10 (34)	3 (2)	5 (3)	4 (13)	...	2 (4)	2 (9)	1 (2)	...	5 (5)	1 (37)	
Linnaea borealis	6 (11)	1 (0)	10 (15)	1 (1)	...	2 (4)	2 (1)	1 (1)	...	10 (13)	2 (18)	
Agropyron spicatum	...	3 (19)	...	2 (1)	8 (15)	3 (9)	...	...	...	...	...	
Calamagrostis rubescens	10 (19)	8 (18)	10 (8)	10 (41)	2 (1)	9 (27)	9 (15)	6 (10)	3 (2)	8 (1)	1 (8)	
Carex geyeri	10 (17)	9 (8)	8 (7)	8 (15)	2 (6)	9 (22)	8 (8)	8 (8)	10 (1)	3 (1)	...	
Festuca idahoensis	...	...	...	2 (6)	10 (12)	1 (1)	...	...	...	...	...	
Arnica cordifolia	6 (1)	6 (14)	8 (15)	9 (14)	3 (1)	4 (11)	4 (14)	1 (1)	...	1 (1)	...	
Arnica latifolia	2 (3)	...	8 (8)	1 (9)	...	1 (5)	6 (21)	9 (8)	7 (4)	8 (18)	9 (17)	
Balsamorhiza sagittata	2 (1)	1 (3)	...	1 (1)	3 (10)	4 (3)	1 (3)	...	...	...	...	
Xerophyllum tenax	2 (3)	...	6 (4)	...	...	1 (2)	7 (28)	10 (46)	10 (13)	9 (28)	9 (15)	

[a]Code to constancy values:

+ = 0-5%	2 = 15-25%	4 = 35-45%	6 = 55-65%	8 = 75-85%	10 = 95-100%
1 = 5-15%	3 = 25-35%	5 = 45-55%	7 = 65-75%	9 = 85-95%	

[b]From Pfister et al. (1977).

[c]Data available only for habitat phase.

[d]Determined from this study, not by Arno.

coverages for understory species of habitat types found in the study area. The latter figures are based on habitat types sampled in the study area and in adjacent east Lolo National Forest lands. This information was kindly supplied by Dr. Stephen F. Arno, USDA Forest Sciences Laboratory, Missoula.

The Pseudotsuga menziesii/Vaccinium caespitosum (PSME/VACA) habitat type occurs at elevations below 4600 feet (1400 m) on east, south, and west aspects, and below 4200 feet (1280 m) on north aspects. It is also found on well-drained benches and ridgetops, and on gentle undulating terrain. Dominant species are white spirea (Spirea betulifolia), snowberry (Symphoricarpos albus), twinflower (Linnaea borealis), pinegrass (Calamagrostis rubescens), bearberry (Arctostaphylos uva-ursi), and elk sedge (Carex geyeri). Within the same elevation and aspect range, the Pseudotsuga menziesii/Symphoricarpos albus (PSME/SYAL) habitat type occurs on sites with moderate slope, and on dry, open ridgetops and slopes. The understory is usually dominated by snowberry. On dry sites, bluebunch wheatgrass (Agropyron spicatum) is well represented, whereas on more moist sites pinegrass and heart-leaf arnica (Arnica cordifolia) are common.

The Pseudotsuga menziesii/Linnaea borealis (PSME/LIBO) habitat type occurs on northerly aspects from about 4200 to 5100 feet (1280-1550 m) elevation. Vegetation is primarily twinflower, heart-leaf arnica, globe huckleberry (Vaccinium globulare), and snowberry.

Adjoining the PSME/LIBO habitat type on west slopes, the Pseudotsuga menziesii/Calamagrostis rubescens (PSME/CARU) habitat type extends along west and south slopes from 4600- to 5600-foot (1400- to 1700-m) elevations. Pinegrass often dominates this type, with heart-leaf arnica, elk sedge, and bearberry usually common. Within the PSME/CARU distribution, the Pseudotsuga menziesii bunchgrass habitat types, mainly the Idaho fescue (Festuca idahoensis) and bluebunch wheatgrass types, occur on steep and rocky, and open-timbered slopes.

The Pseudotsuga menziesii/Physocarpus malvaceus (PSME/PHMA) habitat type, dominated by ninebark (Physocarpus malvaceus) and pinegrass, is limited to east slopes from 4600 to 5000 feet (1400-1525 m) and on very steep and rocky west-facing slopes. The Pseudotsuga menziesii/Vaccinium globulare (PSME/VAGL) type extends to 5600 feet (1700 m) from the upper limit of the PSME/PHMA type on the same general aspects. Globe huckleberry, beargrass (Xerophyllum tenax), mountain arnica (Arnica latifolia), heart-leaf arnica, pinegrass, and grouse whortleberry (Vaccinium scoparium) are common.

The Abies lasiocarpa climax series habitat types occur above 5500 feet (1675 m) on northerly slopes, and 90° and 270° azimuths being convenient boundary lines to distinguish northerly and southerly aspects. The Abies lasiocarpa/Xerophyllum tenax (ABLA/XETE) habitat type, Vaccinium globulare (VAGL) phase, is found on southerly slopes and ridgetops bordering the low elevation PSME/CARU and PSME/VAGL types. Beargrass, globe huckleberry, and grouse whortleberry are well represented. The Vaccinium scoparium (VASC) phase is often found on benches on gentle slopes within this type's range. In some cases, a mosaic of VAGL and VASC phases, complicated by low coverage of VAGL, makes phase differentiation difficult. Extending from the upper, 5100-foot (1555-m), elevational boundary of the PSME/LIBO type to approximately 5800 feet (1770 m) on northerly slopes is the Abies lasiocarpa/Linnaea borealis (ABLA/LIBO) habitat type. Dominant species are beargrass, grouse whortleberry, twinflower, globe huckleberry, and mountain arnica. A dense growth of fool's huckleberry (Menziesia ferruginea) usually characterizes the Abies lasiocarpa/Menziesia ferruginea (ABLA/MEFE) habitat type. This type is found on north slopes above 5400 feet (1645 m). Low shrubs and forbs typical of the ABLA/XETE-VAGL habitat type are usually common. Inclusions of the ABLA/Alnus sinuata habitat type are common.

The habitat type in timbered stream bottoms is usually Abies lasiocarpa/Calamagrostis canadensis (ABLA/CACA). Understory varies with the horizontal configuration of the site. Broad, gently sloping bottoms are variously characterized by bluejoint (Calamagrostis canadensis), sedges (Carex spp.), wavy-leaved alder (Alnus sinuata), mountain alder (Alnus incana), and various forbs such as arrowleaf groundsel (Senecio triangularis) and twinflower. Narrow, steep-walled canyons are dominated by mountain alder, red-osier dogwood (Cornus stolonifera), and mountain maple (Acer glabrum). Wet meadows are mainly composed of sedges, bluejoint, and willow (Salix spp.).

Vegetation in dry meadows or natural openings varies with the moisture regime. Open ridgetops and slopes at low elevations are characterized mainly by bluebunch wheatgrass, Idaho fescue, and arrowleaf balsamroot (Balsamorhiza sagittata), with some prairie Junegrass (Koeleria cristata) and Sandberg's bluegrass (Poa sandbergii). At higher elevations and on moister sites, the forb component becomes more important with giant hysop (Agastache urticifolia) and arrowleaf balsamroot among the most common species. Hay meadows and pastures are variously vegetated with timothy (Phleum pratense), brome (Bromus spp.), Kentucky bluegrass (Poa pratensis), and alfalfa (Medicago sativa).

Vegetation in logged areas varies with elevation and aspect. High elevation, north-facing clearcuts in the south end of the CSA have a profuse growth of black elderberry (Sambucus racemosa), fireweed (Epilobium angustifolium), prickly current (Ribes lacustre), wild raspberry (Rubus ideaus), and lodgepole pine saplings 3-10 feet (0.9-3.0 m) tall. The surrounding forest is in the ABLA/MEFE habitat type. These cuts were completed in 1965. In contrast, the north-facing seed-tree cut and clearcut at lower elevations at the north end of the CSA are dominated by elk sedge and pinegrass. Douglas-fir habitat types are found in the surrounding area. These cuts were completed in 1968. Partially logged areas are mainly characterized by xeric species that were present in the understory before logging, and which are generally favored by open canopy conditions created by partial cutting methods.

Land-Use Practices

Logging has been, and continues to be, the predominant use of the study area. Approximately 60% of the area, mainly privately owned land outside the CSA, has been logged. Logging at the turn of the century was extensive on the flats and low undulating hills adjacent to the Blackfoot River. Logs were floated down the River to Bonner for milling during the spring high-water period. By 1950, extensive logging and associated road building had occurred throughout the north, northwest, and west portions of the area. Within the past 30 years, remnant and second-growth timber have been heavily logged throughout the Bear Creek, Little Fish Creek, and lower Chamberlain Creek drainages.

Approximately 53% of the area has been logged using some type of partial cutting method. The predominant cutting method prior to 1950 was overstory removal of the largest trees, usually greater than 18 inches dbh. Selection, shelterwood, and overstory removal methods have been used from 1950 to the present to harvest trees in a wider range of diameter classes. Even-age harvest methods have not been widely used; about 2.7% of the area has been logged in this manner, mainly by clearcutting but with some seed-tree logging. Clearcuts are located in the Bear Creek and Little Fish Creek drainages, at the south end of Chamberlain Creek, and at the north end of the CSA. A large seed-tree cut also occurs at the north end of the CSA.

About 30% of the area has not been logged, mainly the CSA and high elevation lands to the west of the CSA. Except for "jeep trails" for fire control, this area remained essentially unroaded until 1978, when the first roads of the planned CSA logging operation were built.

Cattle use areas north, west, and south of the CSA during the spring and summer, whereas horses are grazed in the Fish Creek and Bear Creek drainages. Because of its inaccessibility, the CSA received only light to moderate grazing before the western and northern boundaries were fenced in 1977. Since 1977, no livestock grazing has occurred in the CSA.

Hay fields occur along lower Elk Creek, between the Potter Trap and the Blackfoot River, and adjacent to the River north of Blacktail Mountain.

The majority of the approximately 51,000 acres (20,640 ha) in the study area is privately owned. About 39% is owned by the Champion

International Company, 8% by Burlington Northern Company, and 9% by ranchers. Natural Resource Lands, managed by the Bureau of Land Management, comprise about 20% of the area, with the remainder (24%) owned by the State of Montana.

Recreation

Recreational use of the study area is almost entirely limited to big game hunting in the fall. Most of the roads on private land are closed to public vehicular traffic year-round to limit trespassing and reduce interference with timber harvest activities. From 1 September to 30 November, the entire area is closed to public vehicular access. Administrative travel, such as routine road maintenance, is curtailed from 1 September to the beginning of the general big game hunting season in late October, after which logging and vehicles are not allowed in the area. These restrictions are the result of an agreement initiated in 1974 by area landowners and the Montana Department of Fish, Wildlife and Parks Commission to create the Blackfoot Special Management Area (BSMA). The study area comprises the majority of the BSMA.

The objectives of the road closures are to encourage elk use in areas that have been roaded or logged and security cover is limited; to provide a quality walk-in hunting area; to gain public hunting access privileges on previously closed private lands; and to prevent vehicular damage to soils and vegetation (McDaniel 1975).

Either-sex hunting for deer and elk is allowed in the area during the archery season, which generally occurs from the second week of September until the third week of October. Antlerless elk may be taken only by special permit during the general big game season which usually runs from the third week of October through the third week of November. During 1977 and 1978, 50 antlerless elk permits were allotted to hunting district 292. The study area comprises a major portion of the prime hunting area in this district. During 1979, 75 permits were allotted for the eastern part of hunting district 292 only. Table 3 shows elk harvest data for the study area and immediately adjacent areas as reported by Marcum et al. (1978, 1979) and Marcum and Lehmkuhl (1980), and hunter use of the general Blackfoot area tallied at the Bonner check station by Hartkorn (Montana Department of Fish, Wildlife and Parks, pers. comm. as reported by Marcum [ibid.]). Numbers of hunters and elk harvested have increased in recent years as well as hunter success (Firebaugh et al. 1979). Although the harvest of antlerless elk has increased over the past 3 years, aerial counts indicate that recent harvests have not been excessive.

Table 3. Estimated elk harvest in the Blackfoot Special Management Area from Marcum et al. (1978, 1979) and Marcum and Lehmkuhl (1980), and hunter use in the general Blackfoot area tallied at Bonner by Hartkorn (pers. comm. as reported in Marcum [ibid.]).

	Elk harvest					
	Total	Yearling males	Branch-antlered males	Females	Calves	Hunters
1977	38	17	10	9	2	2858
1978	50	27	10	8	5	4876[a]
1979	50	17	14	14	5	4879

[a]Portion of increase may be due to stricter enforcement of law requiring hunters to stop at check stations.

CHAPTER III

MATERIALS AND METHODS

Elk Marking and Observation

Three corral traps were constructed on the winter range (Fig. 1). Grass and alfalfa hay were used to bait traps. Trapping generally began in late December and continued until late March when elk were no longer attracted by the hay. Adult elk were collared with radio transmitters packaged in molded PVC pipe as described by Pederson (1977). Radio frequencies were in the 150-151 mHz range. Canvas web collars, color coded by trapsite, were attached to adult elk when the total number of radio collars in the field approached 20. Twenty radioed elk were considered the maximum number that could be located easily in 1 aerial tracking attempt. All calves were marked with web collars. Web collars were used primarily as marking devices for estimating spring population size by aerial counts. Population estimates from these counts were highly variable and will not be reported.

Extensive forest cover, absence of an extensive road network, and the lack of prominent ridges and points precluded reliable ground tracking on a regular basis. Therefore, light airplanes (Piper Super

Cub and Cessna 182) were used to locate radio-collared elk on a weekly basis from mid-May to early December. The receiving antenna system consisted of 2 "H" antennas (Telonics, Telemetry-Electronics Consultants, Mesa, AZ) mounted perpendicularly to the aircraft fuselage on wing struts. Aerial tracking methods were similar to those described by Denton (1973). Elk locations were marked on 1:12,000 scale color aerial photographs during the flight. Visual locations were accurately marked on the photo, whereas nonvisual locations were pinpointed in a 1-2 acre (0.4-0.8 ha) area.

Monitoring of 24-hour movements was done by ground tracking. Suitable locations from which to track elk were selected after elk had been located by weekly aerial tracking flights. Locations deemed suitable were: within 1.0 mile (1.6 km) of elk, preferably within 0.5 mile (0.8 km); on an open ridgetop to provide line-of-sight signal reception and eliminate topographic and vegetative signal bounce; and situated so that compass bearings taken on radio signals from 2 tracking locations would form approximately a 90° angle of intersection. The selected locations were used throughout the 24-hour tracking period, unless problems with signal reception were encountered. In that case, the questionable tracking station was relocated.

During 1978, tracking equipment consisted of a radio receiver and a hand-held "H" antenna at each station. Directional bearings on radio signals were taken with a hand-held Ranger compass. During

1979, an antenna-mast system was used to increase accuracy. An "H" antenna was mounted on an 8-12 foot (2.4-3.7 m) telescoping fiberglass pole that was placed in a 2-tiered aluminum base. The top plate of the base was inscribed with 360° compass bearings, and a pointer inserted into the mast indicated the antenna direction. Bearings on all radio-tagged elk that were within range of the receiving stations were recorded at hourly intervals for 24 hours. Communication between the stations, by means of walkie-talkies, enabled us to be certain that the same elk were being located from each station, and that there were no signal reception problems. Locations were later plotted in the office.

Elk Habitat Use and Movements

Locations for each radio-collared elk, as determined by aerial tracking, were plotted from aerial photos onto individual acetate sheets overlaid on a 1:24,000 scale, 7.5 min. USGS topographic base map. Topographic and vegetative characteristics of the location site (Table 4), and distance to roads and human activities were determined from the base map, map overlays, and aerial photos. Habitat types (Pfister et al. 1977) were determined from an elevation/aspect model that was based on approximately 450 sample sites in the study area (Fig. 3). Whenever possible, distance to active human disturbance was measured from elk locations to specific sites of human activity

Table 4. General habitat characteristics recorded for aerial elk locations.

Topography		
	Elevation	
	Slope	
	Aspect	
	Slope position	
	Topography Code I	
	Topography Code II	
	Horizontal configuration of slope	
	Distance to water	
Vegetation		
	Pfister et al. habitat type	
	Cover class	
	Successional stage	
	Proximity to ecotone	
	Diversity and interspersion	
Disturbance		
	Distance to:	Closed road
		Open road
		Nearest logged area
		Proposed logging roads and timber sales
		Nearest human disturbance
		New roads

as observed while tracking elk from the air. Otherwise, general areas of disturbance for discrete time periods were used.

Movements and home range statistics were determined with the aid of 2 computer programs developed by personnel of the Montana Department of Fish, Wildlife and Parks, and the Chamberlain Creek Elk Study. Both programs used Universal Transverse Mercator grid coordinates to describe each location. Home range area was calculated by the minimum area method of Mohr (1947). Standard diameters were calculated after Harrison (1958).

Habitat Availability

A sampling procedure developed by Marcum (1975) was used to provide estimates of habitat availability for comparison with elk habitat use. Initially, the area available to the elk was determined by connecting the perimeter points of all radio locations. The base map of this area was then overlaid with a grid on which randomly selected points were located. These points were also marked on aerial photographs. Each point was described in terms of topographic and vegetative characteristics and disturbance relationships as was done with elk locations. This procedure provided a percentage estimate of the occurrence of values for each habitat factor.

As opposed to elk locations, the random points had no temporal relationship, so it was necessary to take several samples for each season or year for habitat and disturbance factors that changed seasonally or yearly. Four hundred points were used initially in 1978; but, during 1979, 300 points were used after determining that this number would yield as good an estimate as 400 points. This decision was arrived at by plotting the percent occurrence of select habitat factors against sample size and noting when fluctuations in percent occurrence estimates leveled.

Tree Stand Type Description

Tree density and dbh size classes for stand types were determined on 0.1-acre (0.04-ha) circular plots. Plots were systematically placed on transects in stands of each type. Several stands were arbitrarily selected for sampling from aerial photographs as characteristic of each type. Mean tree density was calculated by pooling plots from all stand transects within a type.

Statistical Analysis

Data storage and analysis was done with the University of Montana DECSYSTEM-20 computer and a series of statistical programs, Statistical Package for the Social Sciences (SPSS, Nie et al. 1975). Significance testing of the difference between the proportion of elk use and the proportion of availability of some factor was determined by a z-test (Snedecor and Cochran 1967) following the procedure used by Marcum and Loftsgaarden (1980).

CHAPTER IV

RESULTS

Elk Marking and Observation

Table 5 shows, by age and sex, numbers of elk trapped and marked. A total of 64 elk, 52 females and 12 males, were trapped from 1976 through 1979. Thirty-one radio-transmitter collars were placed on 27 cows and 4 bulls. The numbers of radio collars put on cow elk were well distributed among the adult age classes, resulting in a representative sample of cow behavior. Calf elk were not equipped with radios, but this should not have biased the data because calves were not independent of their mothers, many of which were assumed to have been radio-collared.

Numbers of radio-collared elk that were tracked, and the number of aerial locations made by season are shown in Table 6. During 1978 and 1979, the number of elk tracked varied throughout the season for several reasons. Receiving equipment difficulties, transmitter failures, and both natural and human-caused mortality acted to vary the number of elk tracked. Generally, all the locations were used to determine distribution and movements, but a lesser number was used for habitat selection and use. Locations were not used if they

Table 5. Numbers of trapped elk listed by age and sex[a], with number of elk radio-collared in parentheses[b].

Age (years)	1976-1977		1977-1978		1978-1979		All years	
	♀	♂	♀	♂	♀	♂	♀	♂
0.5	1 (0)		4 (0)	4 (0)		4 (0)	5 (0)	8 (0)
1.5	4 (2)		5 (3)	1 (1)	1 (0)	1 (1)	10 (5)	2 (2)
2.5	4 (4)		6 (2)		5 (4)		15 (10)	
3.5	1 (1)		4 (3)	1 (1)	5 (1)		10 (5)	1 (1)
4.5			2 (1)	1 (1)	4 (3)		6 (4)	1 (1)
5.5			2 (1)				2 (1)	
6.5	1 (1)						1 (1)	
7.5	1 (1)						1 (1)	
8.5								
Unknown			1 (0)		1 (0)		2 (0)	
Total	12 (9)	0	24 (10)	7 (3)	16 (8)	5 (1)	52 (27)	12 (4)

[a]Includes 6 elk trapped twice.

[b]All elk not radio-collared were collared with canvas web collars.

Table 6. Numbers of radio-collared elk and number of aerial locations of these elk used for habitat utilization and disturbance relationships[a], and for distribution and movement statistics (in parentheses)[b].

Study year	Calving	Summer	Rut	Hunt	Total
1977 dates	5/15-6/20	6/21-8/31	9/1-10/22	10/23-11/27	5/15-11/27
N locations	27 (27)	45 (45)	72 (72)	36 (36)	180 (180)
N elk	9 (9)	9 (9)	9 (9)	9 (9)	9 (9)
1978 dates	5/15-6/15	6/16-8/31	9/1-10/21	10/22-11/26	5/15-11/26
N locations	53 (66)	148 (157)	103 (116)	48 (65)	352 (405)
N elk	15 (18)	14 (16)	14 (15)	12 (13)	12 (13)
1979 dates	5/15-6/15	6/16-8/31	9/1-10/20	10/21-11/28	5/15-11/28
N locations	43 (52)	164 (175)	91 (97)	63 (70)	361 (394)
N elk	12 (14)	15 (16)	14 (14)	14 (14)	14 (14)

[a]Cows only.

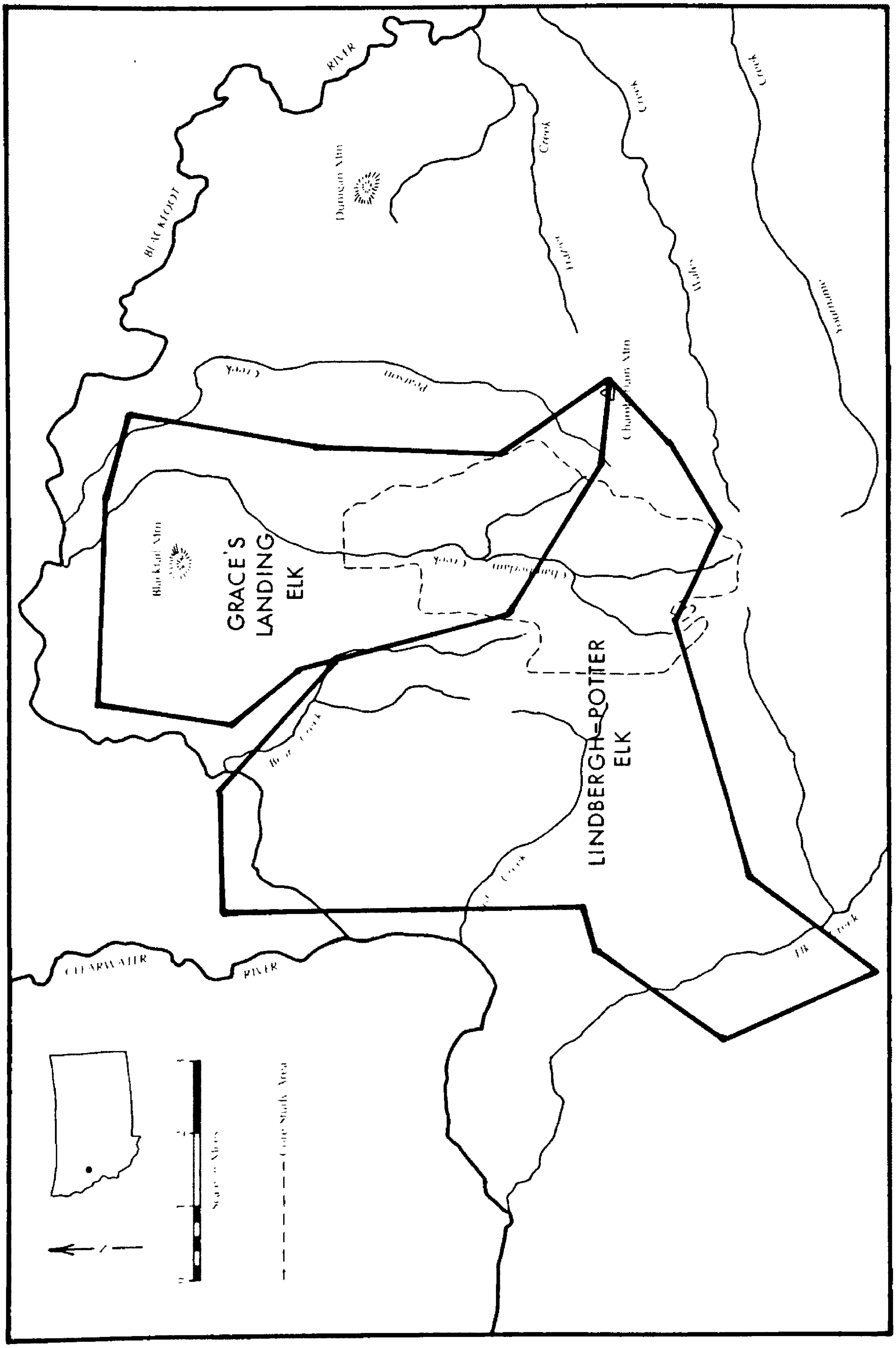
[b]Both sexes.

were rough approximations; fell far outside the study area, the only area for which habitat availability was measured; or were bull locations. The latter were not analyzed with regard to habitat use or detailed movements because the number of collared animals was small, the animals were most often outside the study area, and success was dismal with respect to collars remaining on the bulls and tracking an animal throughout the year in which it was collared. Consequently, the following results and discussion pertain only to cow elk unless otherwise specified.

Distribution and Movements

Fig. 4 shows the primary ranges of cow elk trapped at the Grace's Landing Trap and at the Lindbergh and Potter traps. Throughout the study, little overlap of those ranges was observed. Elk trapped at Grace's Landing ranged primarily in the area north of the CSA, in the Chamberlain Creek drainage, and in the northern half of the CSA. Occasionally, some of these elk were observed north and northeast of the study area, across the Blackfoot River, for short periods of time. Grace's Landing elk consistently used the CSA more than elk trapped at the Lindbergh and Potter traps during all 3 years. Elk trapped at the Lindbergh and Potter traps predominantly ranged west of the CSA in the Fish Creek and Bear Creek drainages, and in the southern half of the CSA. Areas to the east of the CSA, at the head

Fig. 4. Primary areas used by radio-collared elk from different traps.


BLACKFOOT
RIVER
GRACE'S LANDING ELK
LINDBERGH–POTTER ELK
CLEARWATER
RIVER
Creek
Creek
Creek

of Wales Creek, were occasionally used during the summer and rutting seasons. Lindbergh-Potter elk also ranged in areas to the west of Elk Creek, on Lubrecht Experimental Forest, and north of the Blackfoot River, west from the mouth of Bear Creek. One cow elk was a notable exception. Trapped during 1978 at the Lindbergh Trap, she moved south in the spring to the area between Union Creek and Interstate Highway 90, about 10 miles from the study area. She stayed in that area during the summer of 1978 and was shot by a hunter in the lower Union Creek drainage during that same year.

The importance of the CSA, which encompasses the majority of the high elevation summer range in the study area is shown in Fig. 5. Total use was significantly greater than availability for all 3 years. The year-to-year trend in total use appeared to be related to yearly differences in precipitation. Use was highest during 1977, an extremely dry year, and lowest during 1978, a moist year. Elk use during 1979 was intermediate to that of 1977 and 1978, but was closer to that of 1977. Precipitation followed a similar pattern. A regression of CSA elk use and cumulative precipitation yielded a high negative correlation ($r = -0.8$; Fig. 6). Some seasonal variation in CSA elk use can be similarly explained in relation to precipitation. Summer use was significantly greater than availability for all 3 years. However, use was greatest during 1977, decreased during 1978, and further decreased during 1979. If summer use was to follow the trend of total

Fig. 5. Percentages of availability and elk use by study area location.

LEGEND

○ Habitat availability

▲ Calving season elk use

▼ Summer elk use

■ Rutting season elk use

◆ Hunting season elk use

● Total (Calving-Hunting season) elk use

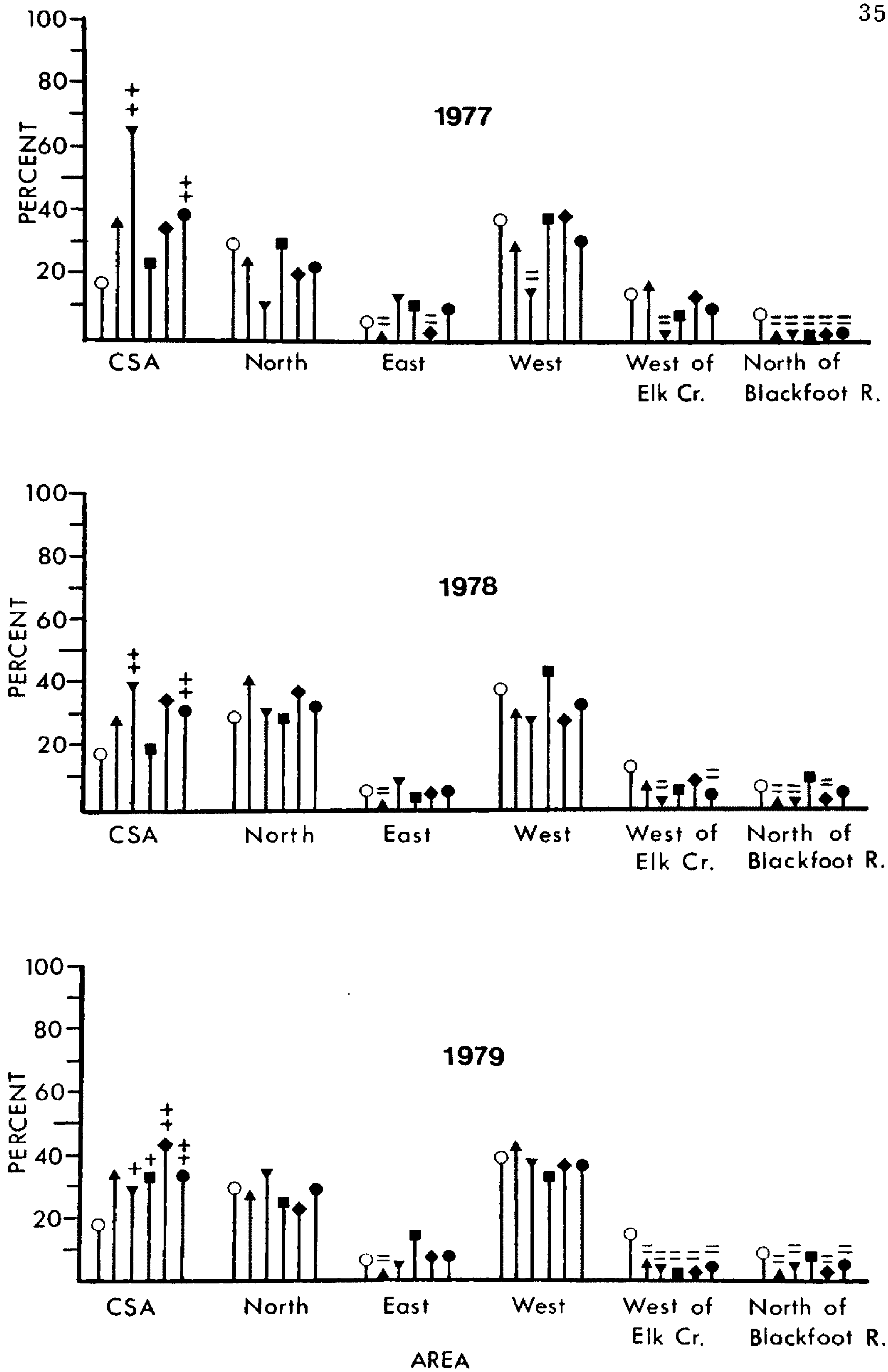
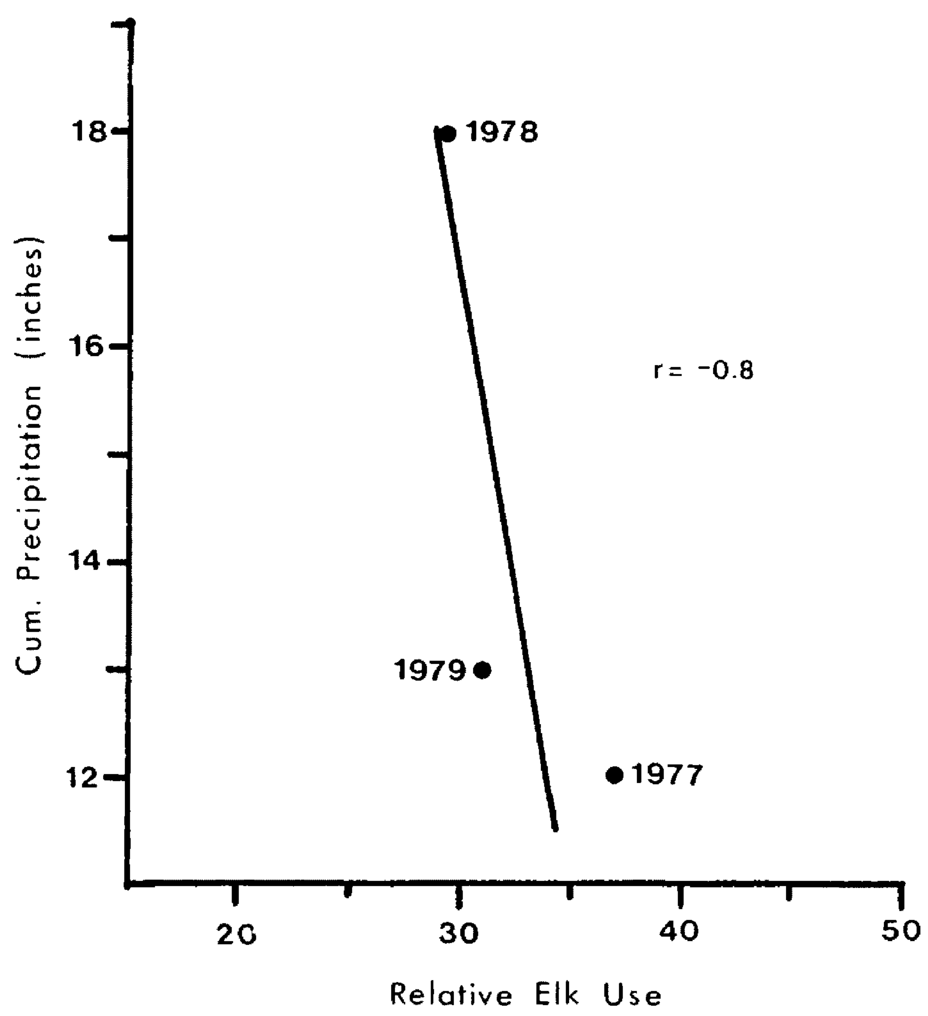

1977
1978
1979
PERCENT
100
80
60
40
20
CSA
North
East
West
West of Elk Cr.
North of Blackfoot R.
AREA

Fig. 6. Regression of CSA elk use by cumulative precipitation.


18
16
14
12
Cum. Precipitation (inches)
1978
1979
1977
r= -0.8
20
30
40
50
Relative Elk Use

use in relation to precipitation, use during 1979 should be greater than during 1978 and approximate that of 1977. Precipitation, however, was only slightly below normal through May 1979; whereas, during 1977 precipitation was well below normal for the same period. Consequently, sufficient moisture was available during 1979 for spring plant growth and to delay dessication of vegetation at low elevations outside the CSA, thus providing elk with relatively more suitable foraging areas during the summer of 1979. The decreased use of the CSA during the summer of 1979 can further be attributed to a greater use by elk trapped at the Lindbergh and Potter traps of mesic, high elevation areas to the west of the CSA than of similar areas within the CSA. Use of the CSA was similar during the rutting seasons of 1977 and 1978, but was substantially higher during the 1979 rut. The fact that the fall of 1979 was unusually hot and dry accounts for this pattern of use. Hunting season use followed a similar pattern. Greater use of the CSA during 1979 than during previous years was probably the result of elk remaining in areas used during the rutting season and hunter pressure forcing elk into areas of heavy cover that were least accessible.

Areas of seasonal importance are indicated by geographic centers of activity in Figs. 7-10. These point locations are the averages of the X and Y coordinates for seasonal locations of individual elk (after Hayne 1949), and are the center points for

Fig. 7. Geographic centers of activity during the calving season.

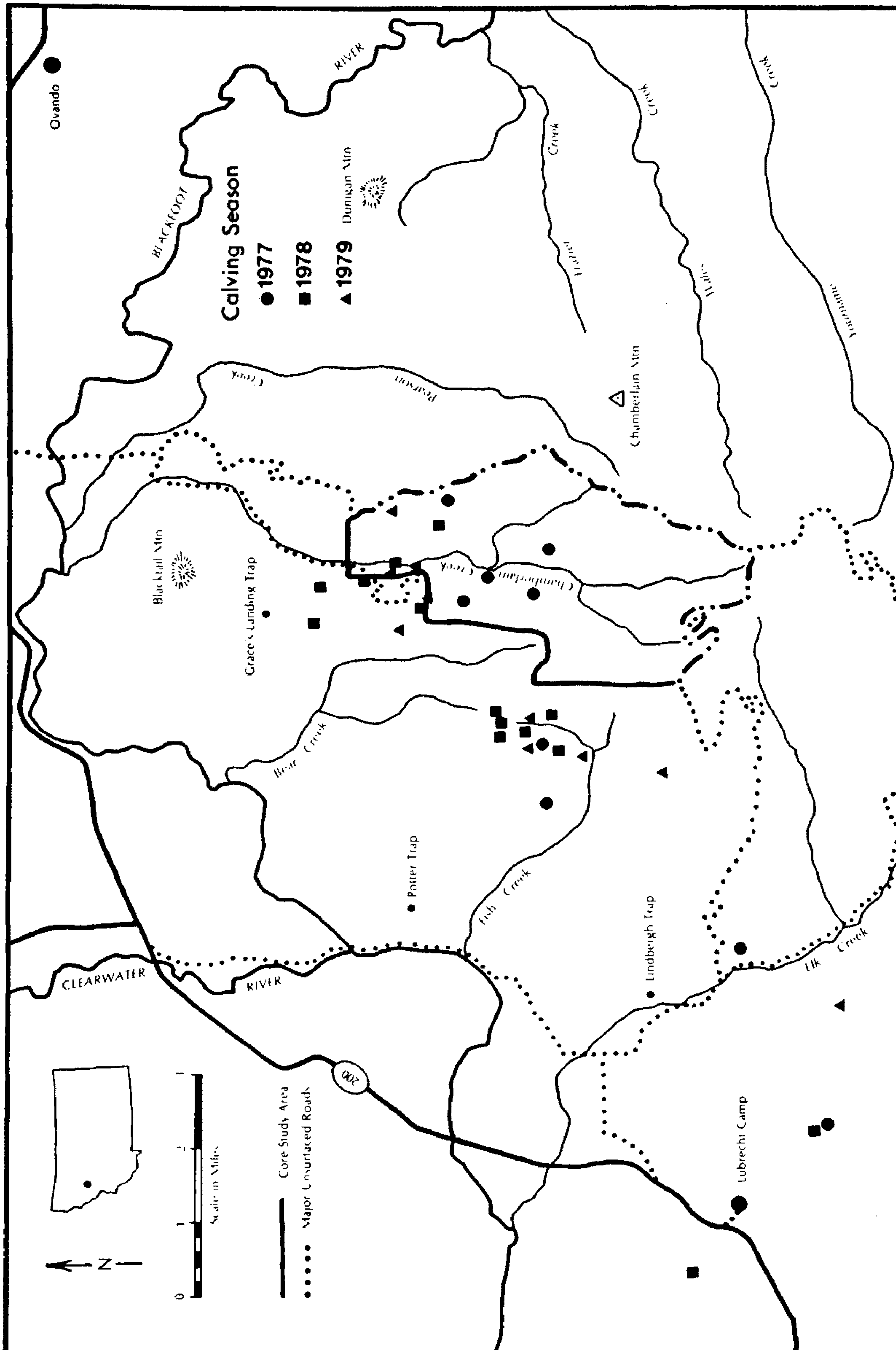

Ovando
BLACKFOOT
RIVER
Calving Season
1977
1978
1979
Dunigan Mtn
Creek
Chamberlain Mtn
Blacktail Mtn
Grace's Landing Trap
Bear Creek
Potter Trap
Fish Creek
Lindbergh Trap
Elk Creek
CLEARWATER
RIVER
200
Lubrecht Camp
N
Scale in Miles
0
1
2
Core Study Area
Major Unsurfaced Roads

Fig. 8. Geographic centers of activity during the summer.

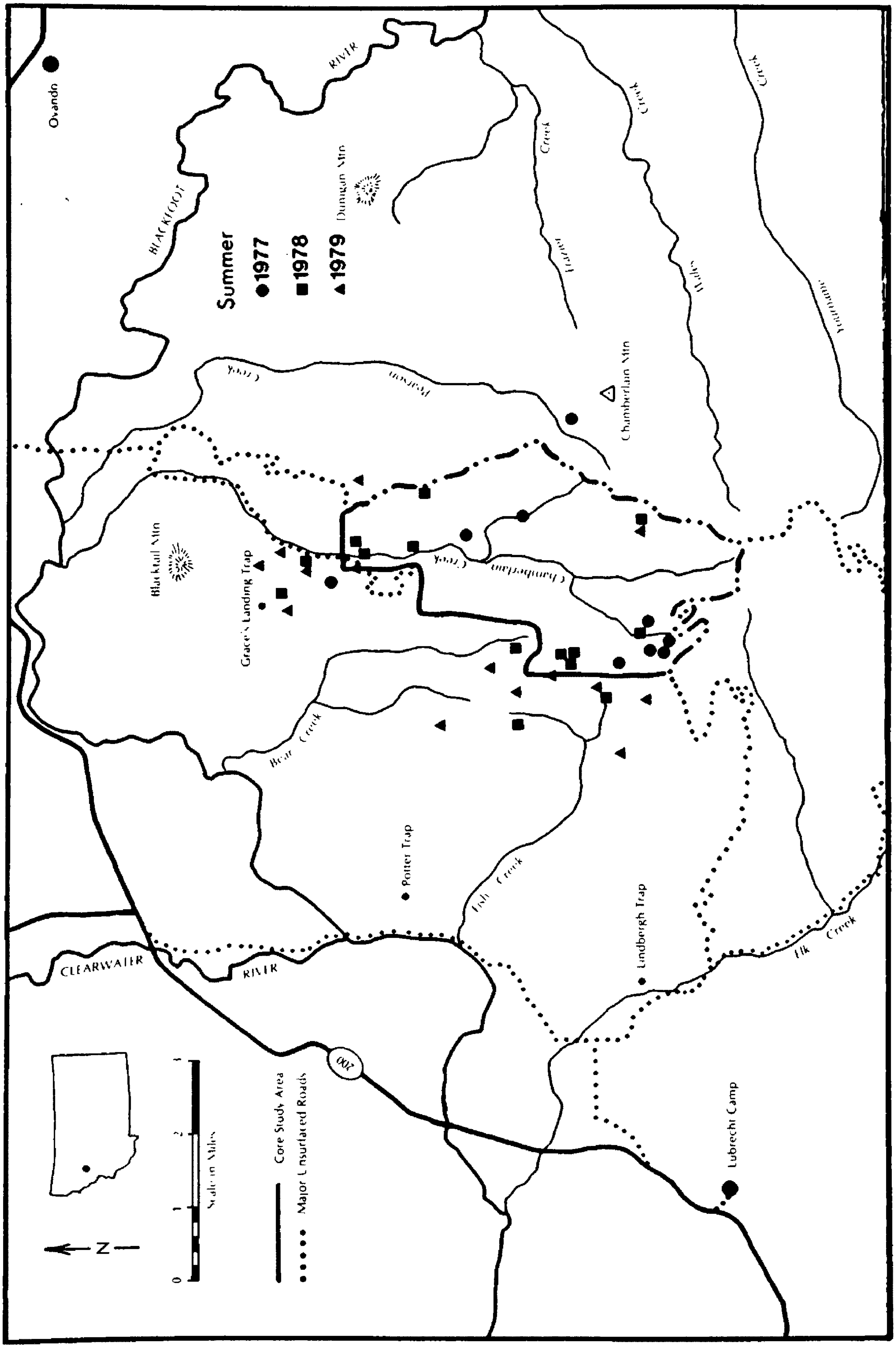

Ovando
BLACKFOOT
RIVER
Dunigan Mtn
Summer
●1977
■1978
▲1979
Chamberlain Mtn
Blacktail Mtn
Grace's Landing Trap
Chamberlain
Creek
Bear Creek
Potter Trap
Fish Creek
Lindbergh Trap
Elk Creek
CLEARWATER
RIVER
200
Lubrecht Camp
Core Study Area
Major Unsurfaced Roads
Scale in Miles
0
1
2
3
N

Fig. 9. Geographic centers of activity during the rutting season.

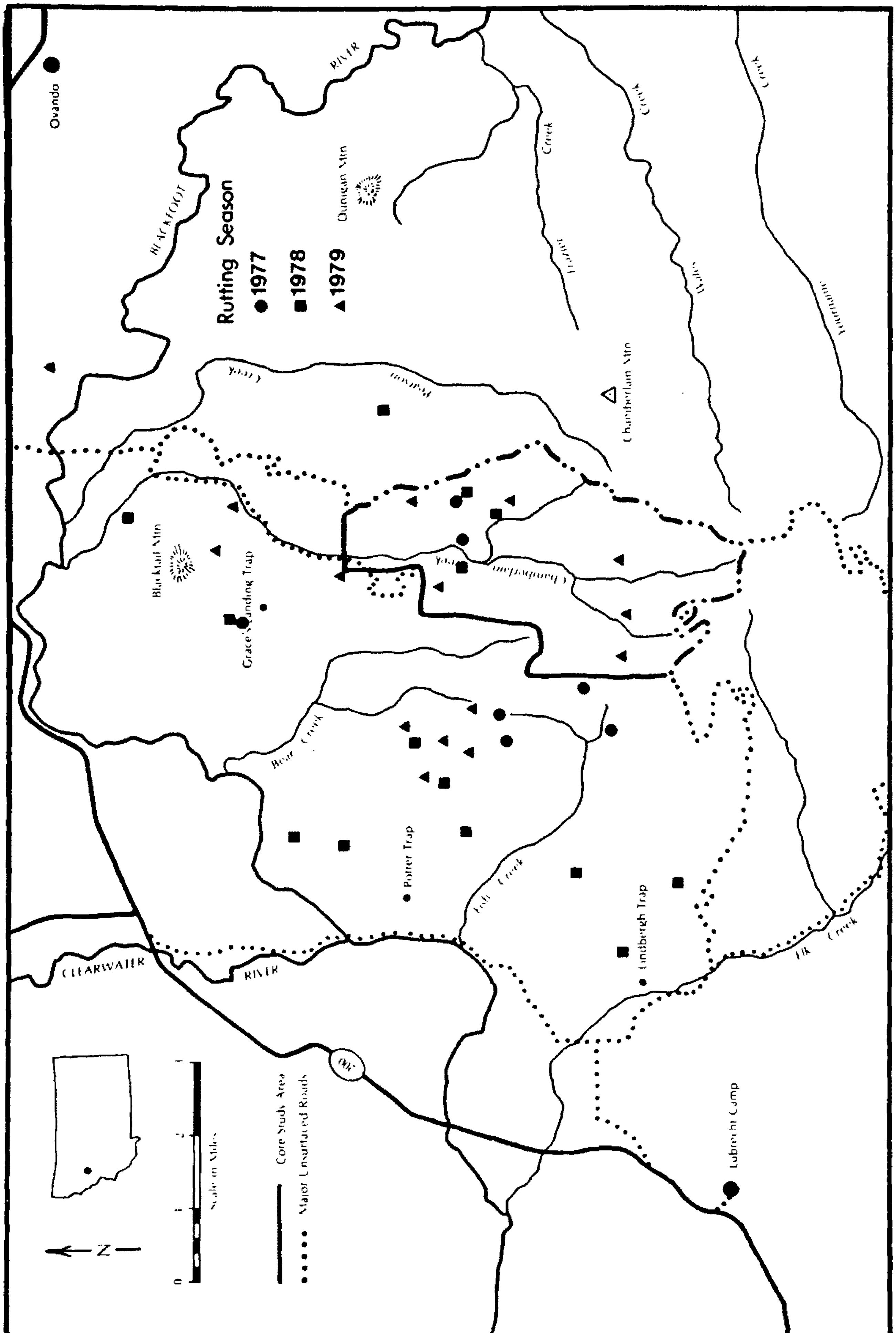
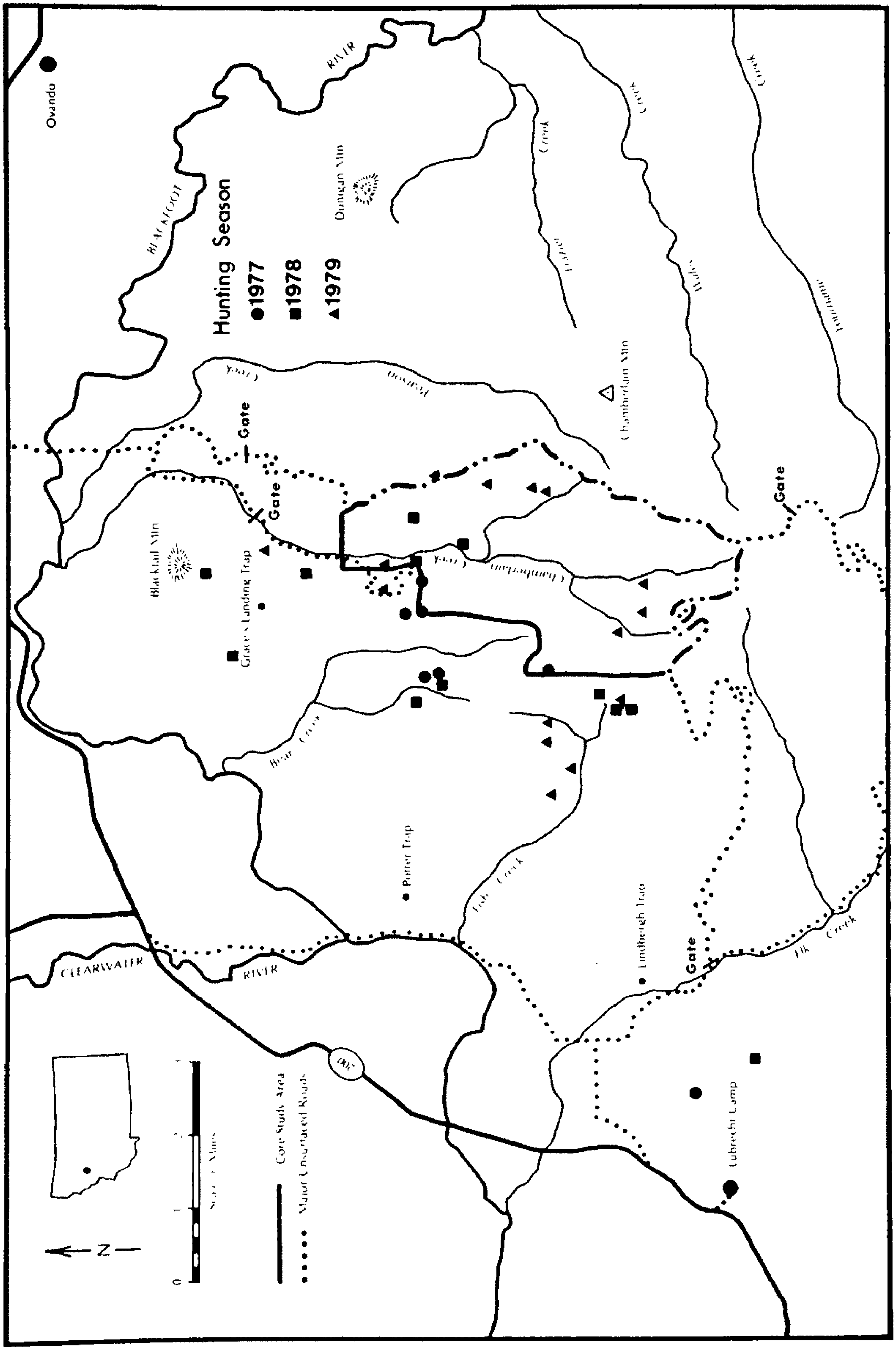

Rutting Season
1977
1978
1979
Ovando
BLACKFOOT
RIVER
Dunigan Mtn
Chamberlain Mtn
Blacktail Mtn
Grace's Landing Trap
Potter Trap
Lindbergh Trap
Lubrecht Camp
Bear Creek
Elk Creek
CLEARWATER
RIVER
Core Study Area
Major Unsurfaced Roads
Scale in Miles
N

Fig. 10. Geographic centers of activity during the hunting season.


Ovando
BLACKFOOT
RIVER
Hunting Season
1977
1978
1979
Dunigan Mtn
Chamberlain Mtn
Gate
Gate
Gate
Gate
Blacktail Mtn
Grace's Landing Trap
Bear Creek
Potter Trap
Fish Creek
Lindbergh Trap
Elk Creek
CLEARWATER
RIVER
Lubrecht Camp
Core Study Area
Major Unsurfaced Roads
N
0
1
2
3

standard diameters. The exact location of the point should not be taken as an actual place of heavy use; rather, the distribution of points for each year and for all years should be considered along with home range size to determine general areas of importance.

The importance of the upper Fish Creek drainage during the calving season was clearly indicated (Fig. 7). The combination of south-facing, partially logged, open slopes and adjacent heavy timber appeared to make this an attractive area for Lindbergh-Potter elk. The northern half of the CSA was important to Grace's Landing elk. During 1977, when conditions were dry and snowmelt early, these elk moved farther into the CSA than during the subsequent years when precipitation was closer to normal.

Centers of activity were more dispersed during the summer than during the calving season (Fig. 8). The west side of the CSA and the adjacent drainage heads of Fish and Bear creeks were heavily used. During 1977, use of the CSA's gentle and mesic terrain was highest. On the north side of the CSA, most activity was centered in the vicinity of Grace's Landing and near the northern border area of the CSA.

During the rutting season, elk ranged more widely than during the summer (Fig. 9). Lindbergh-Potter elk activity was more dispersed during 1978, the wettest year, than during the other years. However, for all years the Baldy Mountain-Bata Mountain area, between the Potter Trap and the west fork of Bear Creek, was heavily used. Grace's Landing elk were similarly widespread, with high use of the northeast part of the CSA and the Blacktail Mountain area.

Activity centers were more grouped during the hunting season than during the rut (Fig. 10). Lindbergh-Potter elk notably centered their activity in upper Fish Creek, upper Bear Creek, and upper Chamberlain Creek. The northwest and northeast parts of the CSA were important areas of activity for Grace's Landing elk. Most centers of activity for all elk were at least 2 miles (3.2 km) from the nearest hunter access point, and were in or near dense forest.

Information concerning the distribution and movements of the 4 radio-collared bull elk was sketchy. Generally, they ranged more widely than cow elk and did not use the same areas as cows trapped at the same site. A summary of the distribution and movements for each male follows.

Bull elk No. 49, trapped at Grace's Landing, was successfully tracked during 1978 and for most of 1979. During 1978, as a 2-year-old, he was found during the calving and summer seasons east of the CSA, and during the rutting and hunting seasons in or near the CSA. During 1979, the initial spring locations for this animal were north of the CSA. He then moved east to the Pearson Creek drainage, next to the head of Wales Creek, and was last located south of the Chamberlain Creek burn in late August. Two bull elk, 4 and 5 years old (No. 410 and No. 36, respectively), radio-collared at the Grace's Landing Trap during the winter of 1977-78 generally used the study area little. They ranged widely to the east of the CSA, using the Pearson Creek, Frazier Creek, and Wales Creek drainages. Elk No. 410 broke its collar off in late August 1978, and No. 36 died of unknown causes in early July 1978. A yearling bull, No. 36 (the collar from above mentioned elk No. 36 was reused) was radio-collared at the Lindbergh Trap during the winter of 1978-79. Before its transmitter failed in early June 1979, the bull was located in an area normally used by cow elk trapped at the same site. He was killed during the hunting season near Hungry Horse Reservoir, almost 100 airline miles north of the study area.

Mean values for seasonal distribution and movement statistics were quite variable from year to year. Total home range size for individual elk, or "area used," averaged 14.9 square miles (38.6 km^2) for all 3 years and ranged from 13.9 to 16.0 square miles (36.0-41.4 km^2) (Table 7). For the entire study period, the largest mean seasonal home range occurred during the rutting season, followed by summer, hunting season, and calving season. Mean home range size was similarly small for all 3 years during the calving season. Mean home range size during summer, however, was quite variable between years; however, values for 1978 and 1979 were similarly high, whereas the value for 1977 was extremely low, thus accounting for the variability. During the rutting season, mean home range size

Table 7. Mean seasonal and total home range areas for cow elk during 1977-1979.

	Calving	Summer	Rut	Hunt	Total
1977	1.2[a] (1.19; 8)[b]	1.5 (2.14; 9)	6.9 (3.81; 9)	1.7 (0.59; 9)	16.0 (7.99; 9)
1978	0.7 (0.64; 15)	5.6 (2.81; 14)	5.0 (2.93; 14)	1.5 (1.26; 12)	14.7 (8.55; 12)
1979	1.1 (1.15; 11)	5.3 (2.51; 14)	4.1 (3.15; 14)	3.3 (2.79; 14)	13.9 (4.53; 10)
$\overset{\equiv}{X}$	1.0	4.1	5.3	2.2	14.9
$s_{\overset{\equiv}{X}}$	0.27	2.29	1.43	0.99	1.06
CV	27%	56%	27%	45%	0.7%

[a]Mean home range area in miles^2 (1 mile^2 = 2.6 km^2) calculated by minimum area method.

[b](Standard deviation; number of elk or N).

successively decreased each year from 1977. During the hunting season similar small home ranges were recorded for 1977 and 1978, whereas mean home range size almost doubled during 1979. Yearly and seasonal home range sizes varied considerably among individual elk as shown by the high standard deviations relative to the means.

Average distance moved between successive locations did not vary greatly among seasons or years (Table 8). Only a 0.3 mile (0.5 km) difference was noted in the range of mean seasonal values. The highest variability among yearly means occurred during the calving season, with the least variability during the rut.

Seasonal mean standard diameters for the 3 years followed a pattern similar to that of home range (Table 9). The highest value occurred during the rutting season, followed by summer and hunting season (equal values) and calving season. The range of seasonal means, however, was not so great as with home ranges. The pattern of yearly differences during the summer and rutting seasons was similar to that of home range.

24-Hour Tracking

Elk were located for 24-hour periods once in 1978, and 6 times in 1979. Only 1 day was spent tracking elk in 1978 because an assistant was not available for further tracking. Of the 6 tracking sessions during 1979, 5 were successful. Table 10 shows data and

Table 8. Seasonal and total mean distance moved between successive locations by cow elk during 1977-1979.

	Calving	Summer	Rut	Hunt	Total
1977	2.0[a] (1.21; 9)[b]	1.5 (1.01; 9)	1.9 (0.59; 9)	1.5 (0.37; 9)	1.8 (0.45; 9)
1978	1.0 (0.36; 15)	2.0 (0.60; 14)	1.8 (0.52; 14)	1.5 (0.52; 12)	1.8 (0.24; 12)
1979	1.4 (0.57; 12)	1.6 (0.40; 14)	1.8 (0.31; 14)	1.8 (0.59; 14)	1.7 (0.20; 14)
$\bar{\bar{X}}$	1.5	1.7	1.8	1.6	1.8
$s_{\bar{\bar{X}}}$	0.50	0.26	0.06	0.17	0.06
CV	33%	15%	3%	11%	3%

[a]Mean of average distances for individual elk in miles (1 mile = 1.6 km).

[b](Standard deviation; number of elk or N).

Table 9. Mean seasonal and total standard diameters for cow elk during 1978-1979.

	Calving	Summer	Rut	Hunt	Total
1977	2.7[a] (3.97; 9)[b]	2.0 (1.48; 9)	4.2 (1.35; 9)	2.4 (0.88; 9)	4.5 (1.53; 9)
1978	1.5 (0.43; 15)	3.5 (1.16; 14)	3.4 (0.77; 14)	2.9 (0.92; 12)	4.1 (1.14; 12)
1979	2.1 (0.56; 12)	3.0 (0.87; 14)	3.6 (1.03; 14)	3.0 (1.30; 14)	4.0 (0.63; 10)
$\bar{\bar{X}}$	2.1	2.8	3.7	2.8	4.2
$s_{\bar{\bar{X}}}$	0.60	0.76	0.42	0.32	0.26
CV	29%	27%	11%	11%	6%

[a]Mean standard diameter in miles (1 mile = 1.6 km).

[b](Standard deviation; number of elk or N).

Table 10. Data and statistics for 24-hour movements of elk during 1978 and 1979.

Date	Elk no.	Points plotted[a]	Points used	Hours[b]	Length (miles)[c]	Width (miles)[d]	Length/ width	Area (sq. miles)[e]
8-10-78	31	20	20	24	1.0	0.4	2.5	0.33
8-10-78	311	24	23	24	1.4	0.4	3.5	0.41
8-10-78	34	22	22	24	0.7	0.7	1.0	0.27
8-10-78	43	16	14	23	1.7	0.6	2.8	0.63
7- 4-79	31	5	0	15	...	...	...	...
7- 4-79	312	2	0	4	...	...	...	...
7-18-79	46	12	12	23	1.1	0.4	2.8	0.23
7-18-79	37	14	13	24	0.9	0.3	3.0	0.16
7-18-79	35	7	7	20	1.1	0.3	3.7	0.20
7-18-79	25	9	9	21	1.4	0.6	2.3	0.58
7-25-79	46	15	0	24	...	...	...	...
7-25-79	411	7	0	17	...	...	...	...
7-25-79	37	8	0	16	...	...	...	...
8- 1-79	37	19	9	24	1.3	1.1	1.2	0.73
8- 1-79	411	21	21	24	1.0	0.4	2.5	0.29
8- 9-79	211	12	12	24	1.3	1.0	1.3	0.81
8- 9-79	28	22	22	24	1.3	1.2	1.1	0.88
8- 9-79	33	7	0	15	...	...	...	...
8- 9-79	31	2	0	10	...	...	...	...
8- 9-79	39	5	0	13	...	...	...	...
8-25-79	25	13	12	20	1.0	0.2	5.0	0.18
$\bar{X}$					1.2	0.6	2.5	0.44
Standard deviation					0.26	0.33	1.17	0.25
Coefficient of variation					22%	55%	47%	58%

[a]Number of points plotted out of 24 possible locations.

[b]Hours between first and last location.

[c]Maximum length of area used (1 mile = 1.6 km).

[d]Maximum width of area used (1 mile = 1.6 km).

[e]Area used in square miles determined by minimum area method (1 mile^2 = 2.6 km^2).

statistics for 21 elk tracked during 1978 and 1979. Out of 504 possible locations of these elk, only 262 were plotted. Some locations were not plotted because of unreliable signal reception, or because compass bearings did not intersect. Other locations were eliminated if they seemed highly aberrant, that is, if they did not fit into the pattern of movements shown by previous locations. In addition, data for 8 elk were not used for 1 or more of the following reasons. Too few locations were made for some elk; for others, the number of hours tracked was less than 20, or indicated movements were highly erratic and widely spaced in a nonrealistic manner. As a result, only 187 locations for 13 elk, out of 262 plotted locations, were analyzed.

As indicated above, problems were encountered in trying to successfully and reliably locate elk for 24-hour periods. Suitable locations for tracking were few. Most of the area is heavily forested, resulting in problems with signal bounce and attenuation. Several test situations, where bearings were taken on radio transmitters of known position, indicated an error range of -15° to +22° from the actual bearing. Constantly moving receiving locations was not deemed feasible for several reasons. Often, the point initially selected was considered the best for signal reception based on previous tracking attempts. I felt that moving to different tracking locations would, therefore, probably be nonproductive and difficult in light of the limited road access and distance to desirable locations. The latter difficulty may have been reduced if radio locations were taken at longer intervals to provide more travel time. However, constantly moving the antenna system was not feasible, especially at night.

As a consequence of these problems, I felt that the only reliable types of information obtainable from the elk locations were geometric characteristics of the areas used (Table 10). Areas used were decidedly rectangular in shape. The average length was twice the average width. The former did not vary greatly among elk, but, width was twice as variable. Major differences in the width of areas used appeared to correspond to the topography of the area, which affected the ease with which elk were able to travel. Elk 211 and 28, located on 9 August 1979, were tracked in the south end of the CSA. This area is for the most part gently sloping forest. The shape of the areas used by these elk was more square than those of other elk located in more linear topography. The topography where the other elk were located is characterized by moderately steep, parallel ridges flanking Chamberlain Creek. The areas used by these elk were generally rectangular in shape, conforming to the linear arrangement of the topography. The size of the area used appeared to be also related to topography. Elk 211 and 28, located in gentle topography, used larger areas than elk located in steeper country.

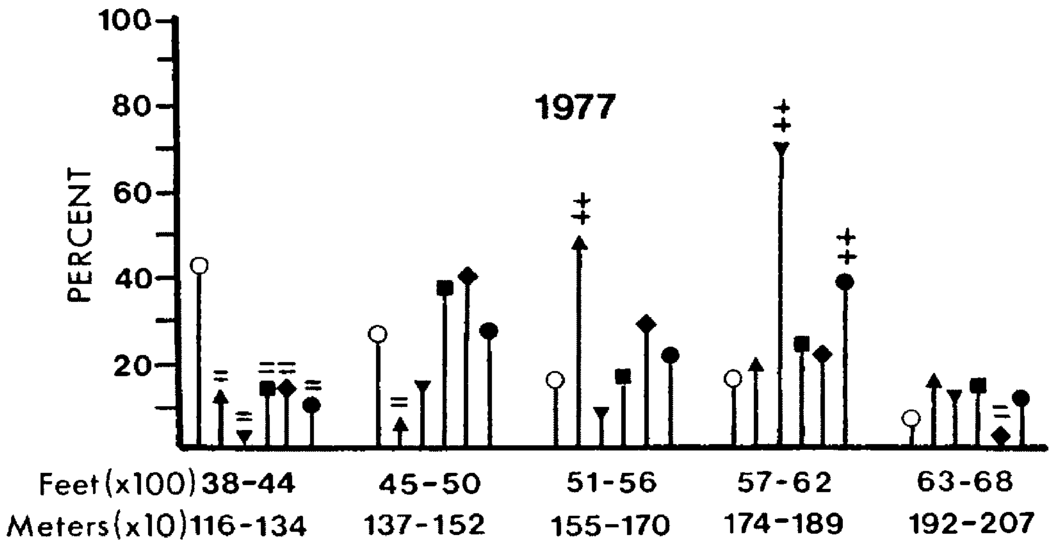
Habitat Selection and Use

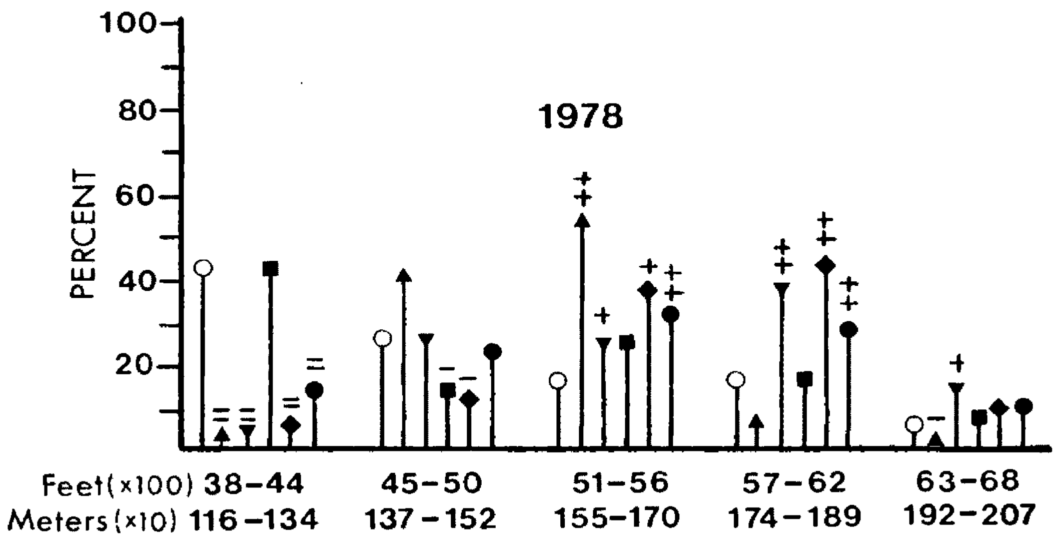
For clarity of definition when discussing habitat selection and use in the text, "favored" or "preferred" indicate elk use greater than availability for some factor. These words prefaced by "significantly" indicate statistical significance. The term "selected" will also denote a statistically significant, positive difference between elk use and availability of some habitat factor. For tables and figures, the following convention is used to denote a statistically significant difference: + or - indicate elk use significantly greater or less than availability, $p \leq 0.05$; ++ or -- indicates elk use significantly greater or less than availability, $p \leq 0.01$. Lack of a sign indicates no significant difference.

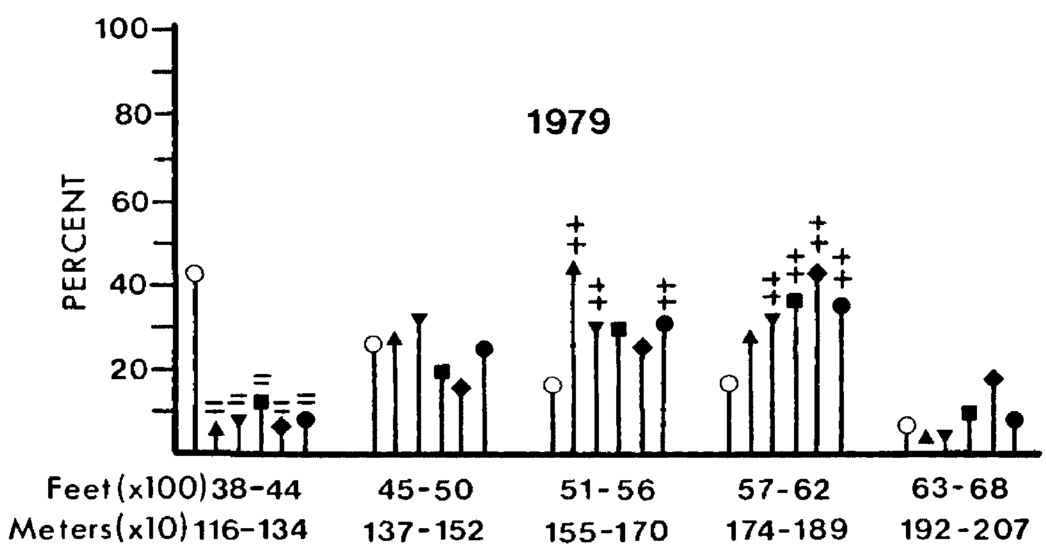
Topographic factors. Elevations from 4500 to 6200 feet (1370-1890 m) were used the most throughout the study; but, only the 5100-6200 foot (1550-1890 m) range was used in excess of availability (Fig. 11). Elk significantly preferred these elevations during 1978 and 1979, but during 1977, the driest year, elk selected for the narrower 5700-6200 foot (1740-1890 m) range. Elevations from 3800 to 4400 feet (1160-1340 m) were always used significantly less than availability.

During each calving season, elevations from 5100 to 5600 feet (1550-1700 m) were significantly preferred. Use of higher or

Fig. 11. Percentages of availability and elk use by elevation. (See Fig. 5, page 35, for legend.)


1977
PERCENT
100
80
60
40
20
Feet(x100) 38-44 45-50 51-56 57-62 63-68
Meters(x10) 116-134 137-152 155-170 174-189 192-207

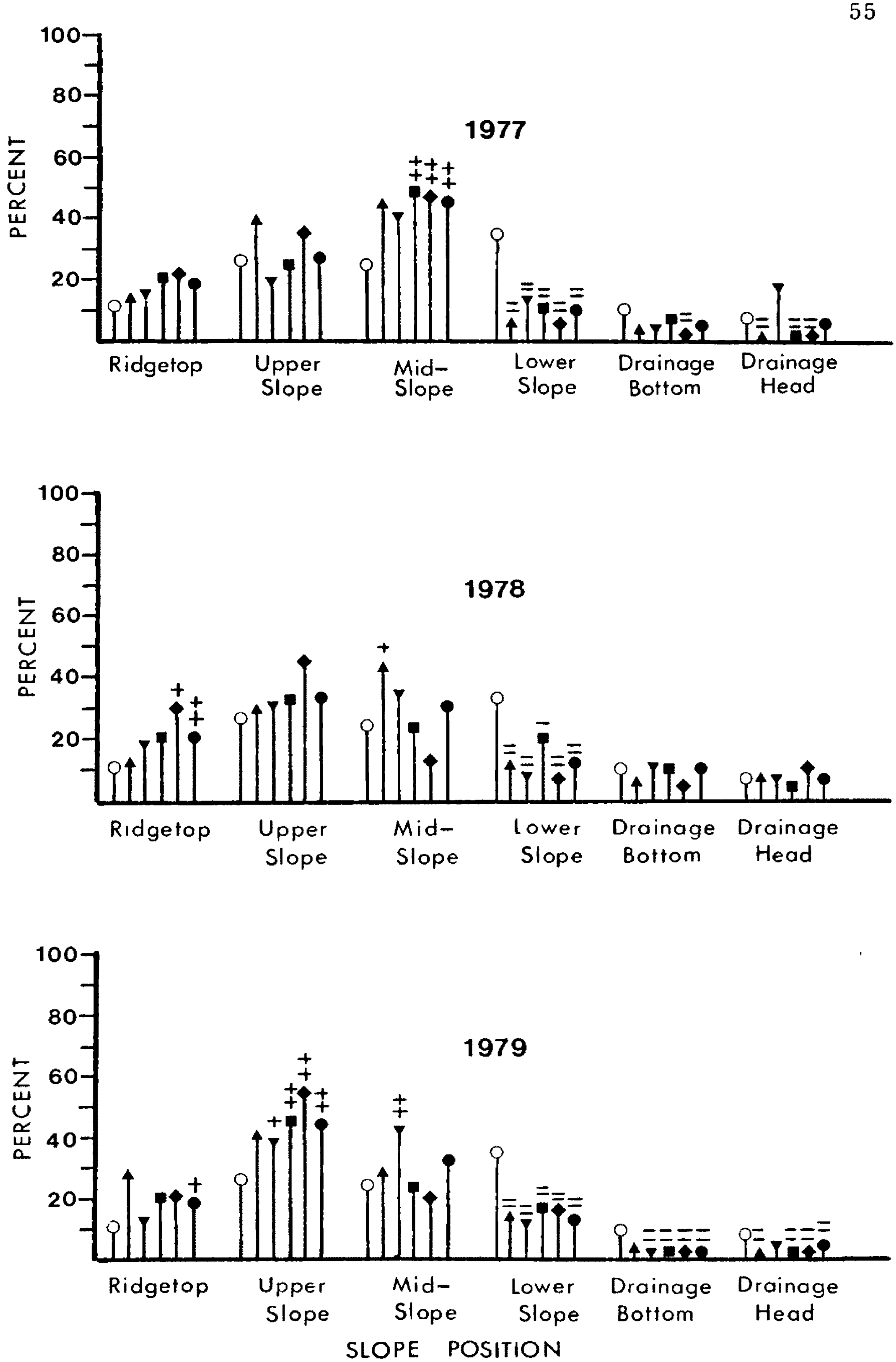

1978
PERCENT
100
80
60
40
20
Feet(x100) 38-44 45-50 51-56 57-62 63-68
Meters(x10) 116-134 137-152 155-170 174-189 192-207


1979
PERCENT
100
80
60
40
20
Feet(x100) 38-44 45-50 51-56 57-62 63-68
Meters(x10) 116-134 137-152 155-170 174-189 192-207
ELEVATION

lower elevations depended upon their availability as determined by snow conditions. During the dry summer of 1977, almost 70% of the elk use was in the 5700-6200 foot (1740-1890 m) range. This elevational range was also preferred during 1978 and 1979; but, elevations down to 4500 feet (1370 m) were also selected for during these moister years. No distinct elevational preference was noted during the rutting season. Low elevations (3800-4400 feet [1160-1340 m]) were favored during the cool moist year of 1978, and higher elevations (5100-6200 feet [1550-1890 m]) were preferred during the dry fall of 1979. During the hunting season, the pattern of yearly use showed a progressively greater preference for high elevations.

Fig. 12 shows elk use with respect to slope position. Notably, elk use of lower slopes was always significantly less than their availability. The greatest amount of use was on mid-slopes and upper slopes of first and second order ridges. Preference for these positions was variable among years. Ridgetops, mainly those of third and fourth order ridges, were significantly preferred during 1978 and 1979. No selection for drainage bottoms or drainage heads was evident. Seasonally, upper slopes of third and fourth order ridges and mid-slopes were favored during calving season, but ridgetops of third and fourth order ridges were also heavily favored during 1979. Cows favored the same upper and mid-slopes during the summer, rutting, and hunting seasons. During the summer of 1977,

Fig. 12. Percentages of availability and elk use by slope position. (See Fig. 5, page 35, for legend.)


1977
PERCENT
100
80
60
40
20
Ridgetop
Upper Slope
Mid-Slope
Lower Slope
Drainage Bottom
Drainage Head
1978
PERCENT
100
80
60
40
20
Ridgetop
Upper Slope
Mid-Slope
Lower Slope
Drainage Bottom
Drainage Head
1979
PERCENT
100
80
60
40
20
Ridgetop
Upper Slope
Mid-Slope
Lower Slope
Drainage Bottom
Drainage Head
SLOPE POSITION

drainage heads were also highly preferred. Ridgetops were used the most during the rutting and hunting seasons.

During each year, elk favored or selected for concave slope configurations (Fig. 13). Convex, straight, and undulating configurations were always used equal to or less than their occurrence. During calving season, cows did not particularly favor a single configuration, generally using each type as it occurred. Concave configurations were favored during the summer and rutting seasons, with little preference shown for other types. Slope configurations used during the hunting season varied.

With respect to slope steepness, elk exhibited little yearly or seasonal preference (Fig. 14). Gentle slopes (0-15°) were used the most, but generally not in excess of availability. Steep slopes (greater than 30°) were mainly used less than their occurrence.

The pattern of total use of different aspects did not vary much from year to year, and with few exceptions no particular aspects were consistently favored (Table 11). Northeast aspects were overall the most preferred, but east and south slopes were significantly favored during 1979 and 1978, respectively. Elk use was also high on west and northwest aspects. Areas with no aspect, or flats, were generally used less than their occurrence.

Cow elk did not exhibit a preference for areas close to water (Table 12). In fact, total use was significantly less than availability

Fig. 13. Percentages of availability and elk use by slope configuration. (See Fig. 5, page 35, for legend.)

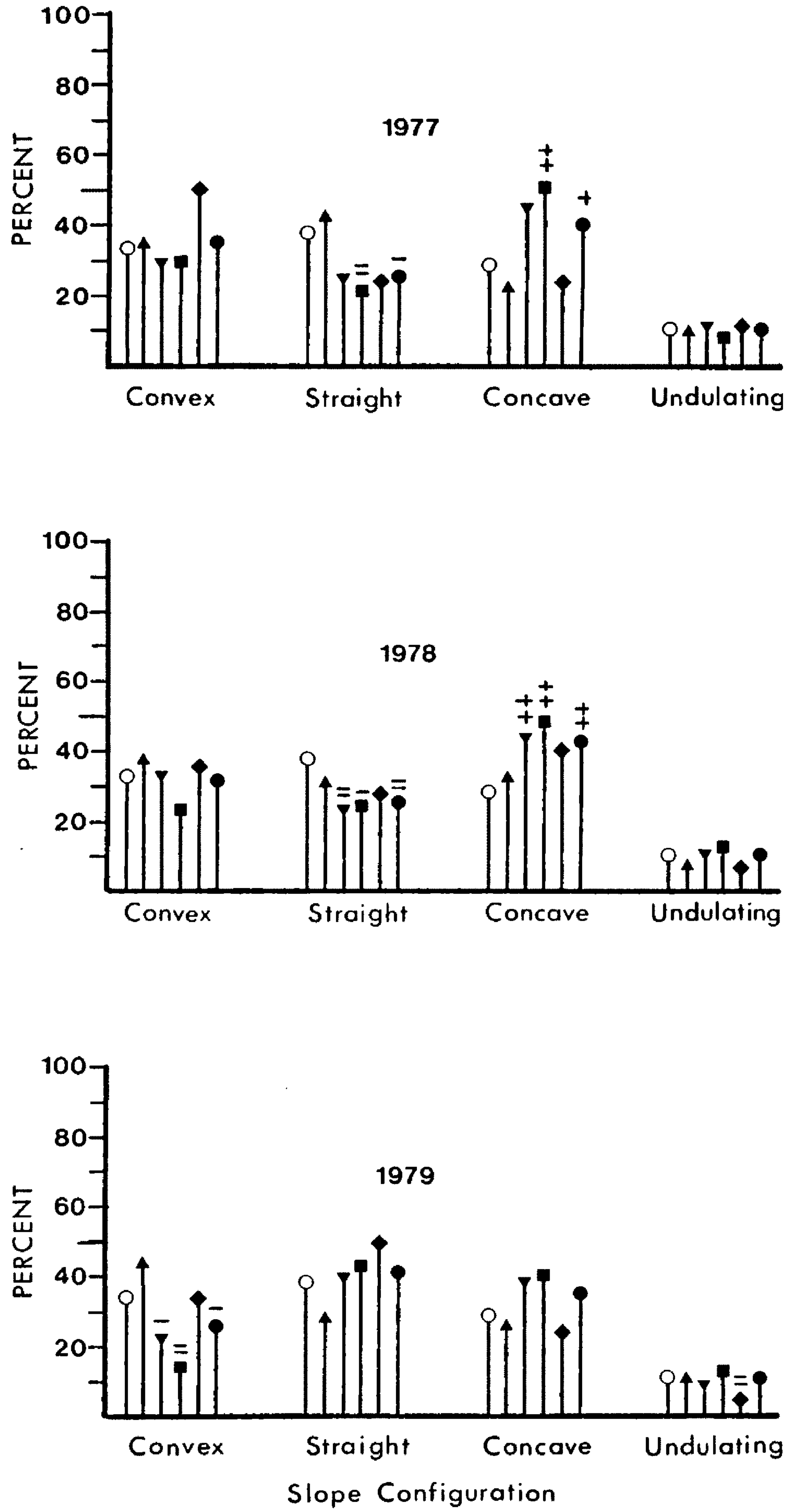

100
80
60
40
20
PERCENT
1977
Convex
Straight
Concave
Undulating
100
80
60
40
20
PERCENT
1978
Convex
Straight
Concave
Undulating
100
80
60
40
20
PERCENT
1979
Convex
Straight
Concave
Undulating
Slope Configuration

Fig. 14. Percentages of availability and elk use by slope steepness. (See Fig. 5, page 35, for legend.)

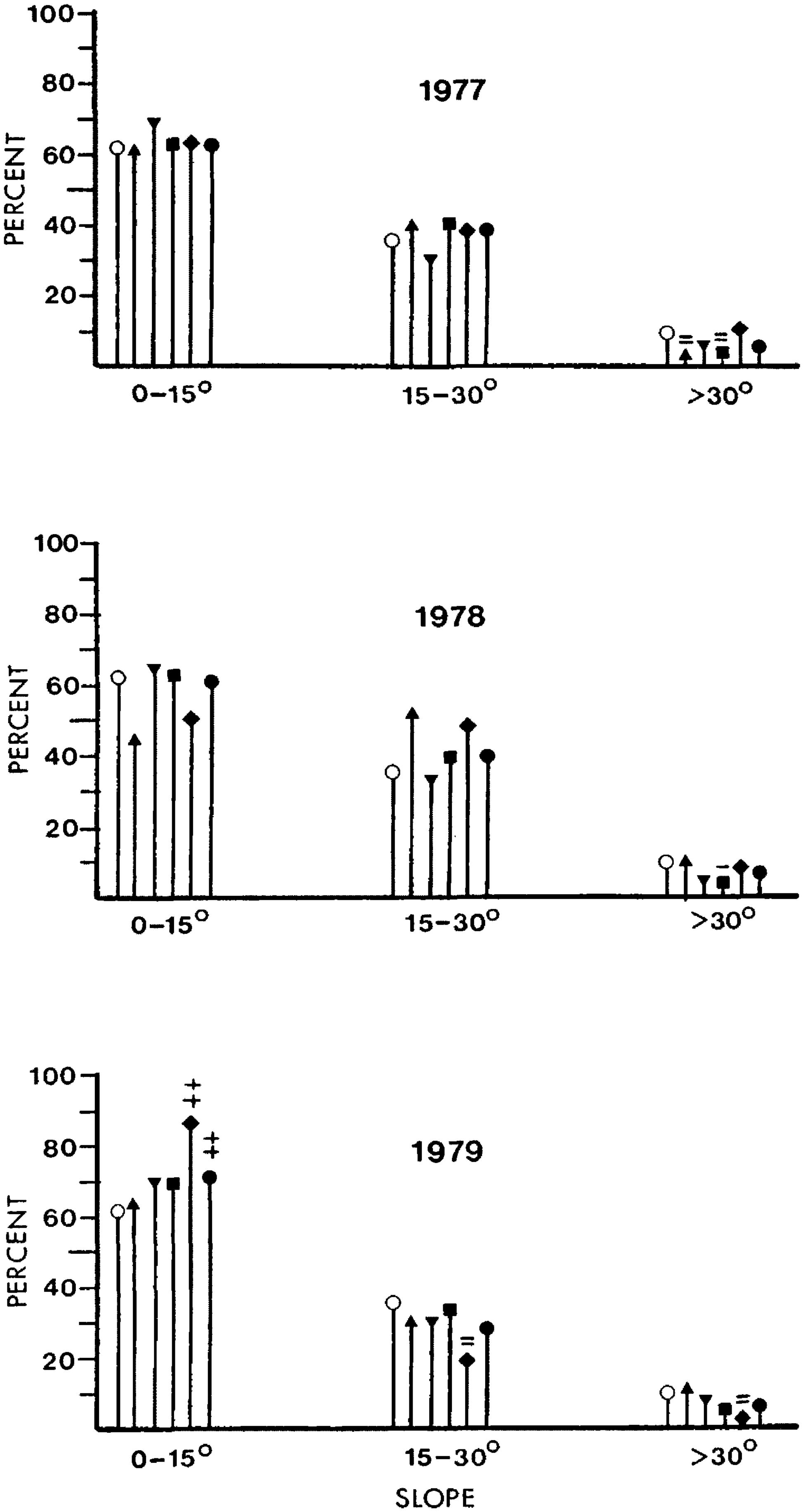

1977
1978
1979
PERCENT
100
80
60
40
20
0–15°
15–30°
>30°
SLOPE

Table 11. Percentages of availability and elk use by aspect.

	Aspect	% Availability N = 400	% Elk Use Calving N = 26	Summer N = 45	Rut N = 69	Hunt N = 33	Total N = 173
1977	N	16.8	15.4	-- 2.2	21.7	18.2	15.0
	NE	9.5	-- 0.0	++ 40.0	10.1	27.3	+ 19.7
	E	7.5	-- 0.0	2.2	7.2	3.0	4.0
	SE	4.8	-- 0.0	4.4	4.3	-- 0.0	2.9
	S	2.8	3.8	-- 0.0	2.9	6.1	2.9
	SW	9.8	19.2	4.4	2.9	-- 0.0	5.2
	W	13.5	30.8	17.8	15.9	24.2	20.2
	NW	15.8	26.9	15.6	23.2	-- 3.0	17.9
	Level	19.8	-- 3.8	13.3	11.6	18.2	12.1

	Aspect	% Availability N = 400	% Elk Use Calving N = 53	Summer N = 148	Rut N = 103	Hunt N = 48	Total N = 352
1978	N	16.8	24.5	12.2	15.5	18.8	15.9
	NE	9.5	18.9	10.8	8.7	8.3	11.1
	E	7.5	7.5	4.1	7.8	8.3	6.3
	SE	4.8	9.4	10.8	2.9	4.2	7.4
	S	2.8	5.7	+ 11.5	1.9	8.3	+ 7.4
	SW	9.8	9.4	12.2	5.8	- 2.1	8.5
	W	13.5	9.4	10.8	23.3	14.6	14.8
	NW	15.8	7.5	14.9	19.4	20.8	15.9
	Level	19.8	- 7.5	12.8	14.6	14.6	12.8

	Aspect	% Availability N = 400	% Elk Use Calving N = 43	Summer N = 164	Rut N = 91	Hunt N = 63	Total N = 361
1979	N	16.8	18.6	-- 7.3	9.9	11.1	10.0
	NE	9.5	16.3	16.5	14.3	19.0	+ 16.3
	E	7.5	14.0	14.0	17.6	9.5	+ 14.1
	SE	4.8	4.7	8.5	8.8	1.6	6.9
	S	2.8	2.3	5.5	-- 0.0	3.2	3.3
	SW	9.8	2.3	5.5	-- 1.1	3.2	-- 3.6
	W	13.5	20.9	12.8	13.2	19.0	15.0
	NW	15.8	16.3	18.9	12.1	25.4	18.0
	Level	19.8	-- 4.7	- 11.0	23.1	- 7.9	- 12.7

Table 12. Percentages of availability and elk use by distance to water.

1977

Distance to water yards (meters)	% Availability N = 400	% Elk Use Calving N = 26	Summer N = 45	Rut N = 66	Hunt N = 33	Total N = 170
0-50 (0-45)	16.0	7.7	17.8	16.7	15.2	15.3
50-150 (45-140)	23.0	- 7.7	17.8	-- 6.1	9.1	--10.0
150-250 (140-230)	24.0	15.4	28.9	22.7	++63.6	31.2
250-350 (230-320)	15.5	38.5	11.1	30.3	-- 3.0	21.2
350-450 (320-410)	12.5	19.2	11.1	12.1	-- 0.0	10.6
450-550 (410-500)	5.3	-- 0.0	8.9	6.1	9.1	6.5
>550 (>500)	3.8	11.5	4.4	6.1	-- 0.0	5.3

1978

Distance to water yards (meters)	% Availability N = 400	% Elk Use Calving N = 53	Summer N = 148	Rut N = 103	Hunt N = 48	Total N = 352
0-50 (0-45)	16.0	15.1	20.9	16.5	6.4	16.8
50-150 (45-140)	23.0	13.2	24.3	15.5	-- 8.5	17.9
150-250 (140-230)	24.0	30.2	19.6	- 12.6	29.8	20.5
250-350 (230-320)	15.5	13.2	11.5	18.4	27.7	16.0
350-450 (320-410)	12.5	15.1	8.8	13.6	6.4	10.8
450-550 (410-500)	5.3	5.7	5.4	8.7	4.3	6.3
>550 (>500)	3.8	7.5	9.5	+14.6	17.0	++11.7

1979

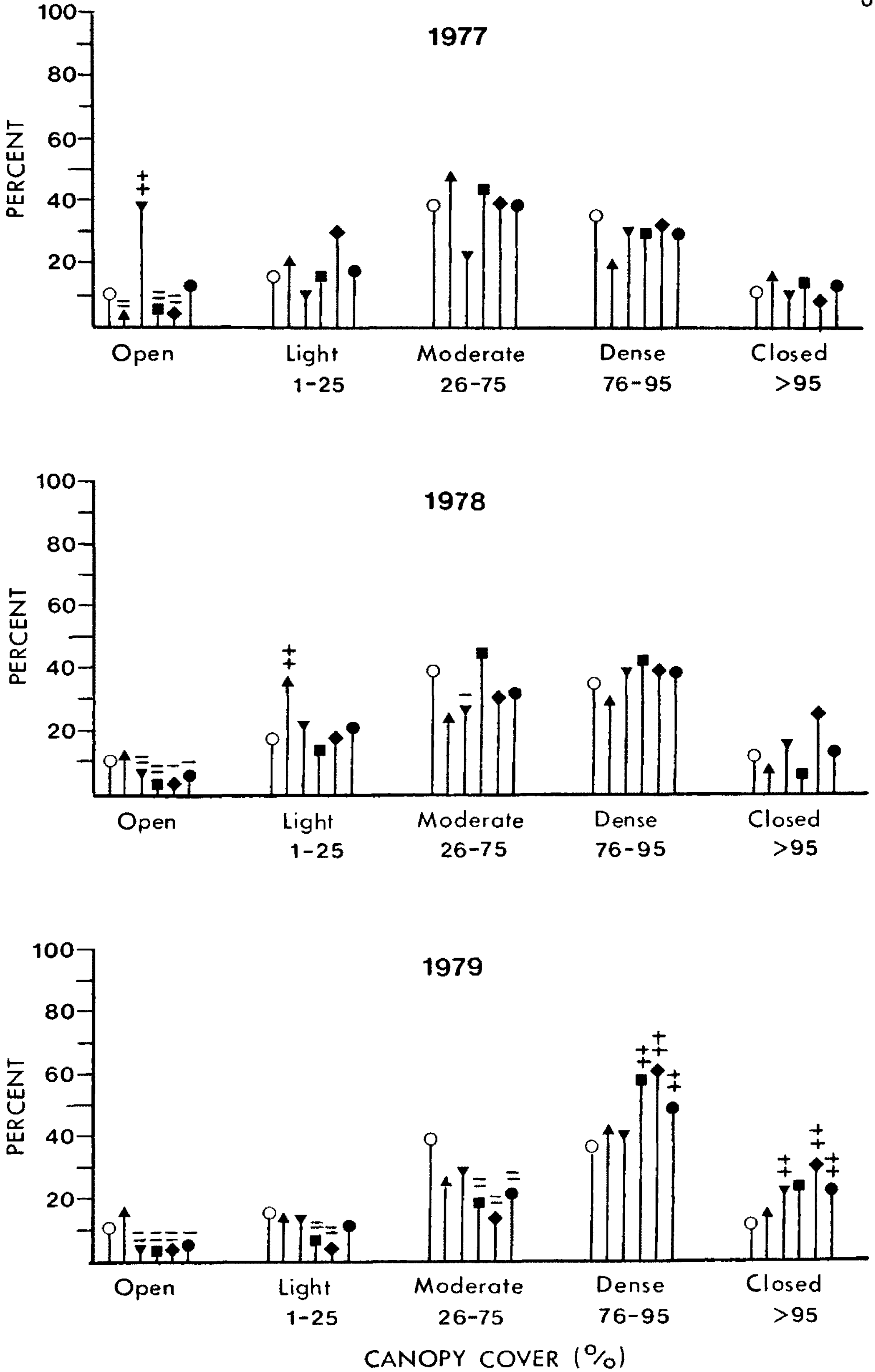
Distance to water yards (meters)	% Availability N = 400	% Elk Use Calving N = 43	Summer N = 164	Rut N = 91	Hunt N = 63	Total N = 361
0-50 (0-45)	16.0	- 4.7	15.9	14.3	-- 3.2	11.9
50-150 (45-140)	23.0	-- 7.0	20.7	- 11.0	-- 3.2	--13.9
150-250 (140-230)	24.0	27.9	24.4	-- 9.9	22.2	20.8
250-350 (230-320)	15.5	16.3	14.6	+29.7	31.7	21.6
350-450 (320-410)	12.5	20.9	13.4	18.7	19.0	16.6
450-550 (410-500)	5.3	11.6	3.7	7.7	3.2	5.5
>550 (>500)	3.8	11.6	7.3	8.8	+17.5	++10.0

for areas from 50 to 150 yards (45-140 m) of water during 1977 and 1979, and significantly greater than availability for areas greater than 550 yards (500 m) from water during 1978 and 1979. In general, total use was about equal to the availability of distance from water categories for all 3 years. Cows used areas close to water more during the summer than during other seasons.

Vegetative factors. Generally, elk did not favor a particular canopy coverage (Fig. 15). Cows were mainly found in forested areas with moderate (25-75%) to dense (75-95%) canopy coverage from spring through fall, but not more than expected with respect to availability. However, elk did select for dense and closed (> 95%) canopy stands during 1979. Open areas (areas with no trees and larger than or equal to 1 acre) were little used, and with the exception of 1977, when use slightly exceeded availability, elk use was significantly less than availability.

No consistent patterns of use were apparent during the calving and summer seasons. During the summer of 1977, open areas were notably selected for. Most of this use was in clearcuts at the south end of the CSA. In contrast, during 1978 and 1979, dense stands were used the most, with closed stands selected for during 1979. Elk use during the rutting seasons of 1977 and 1978 was about equal to the availability of different canopy coverages. Moderate and dense stands

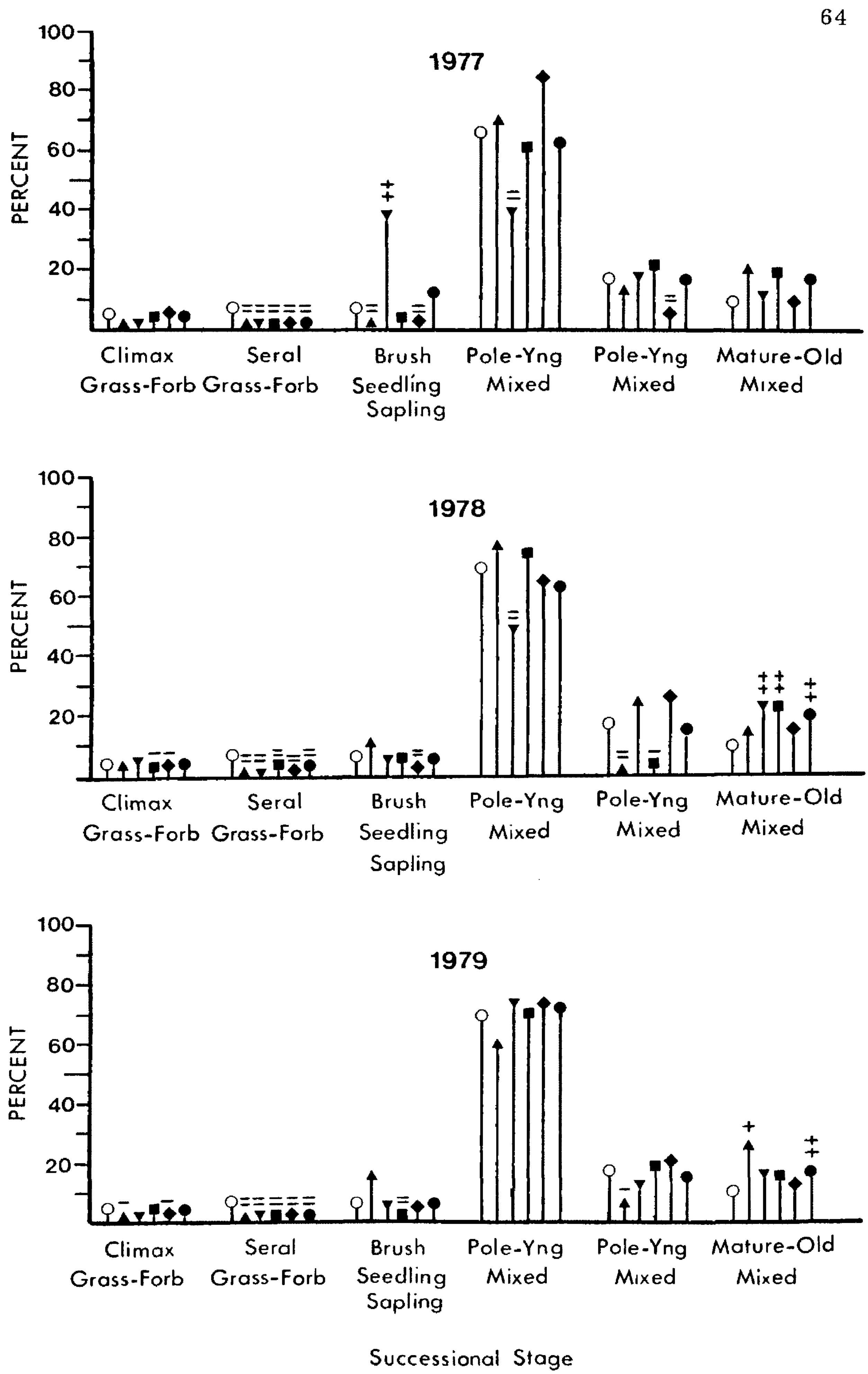
Fig. 15. Percentages of availability and elk use by canopy coverage. (See Fig. 5, page 35, for legend.)


1977
1978
1979
PERCENT
100
80
60
40
20
Open
Light
1-25
Moderate
26-75
Dense
76-95
Closed
>95
CANOPY COVER (%)

were used the most, with use of moderate canopy class greater than during the summer. During the hot, dry 1979 rut, elk significantly preferred dense stands and favored closed stands. Hunting season use showed a progressive yearly trend to use of greater canopy coverages. During 1977, elk use was almost evenly distributed among light, moderate, and dense canopy classes. Use of dense and closed stands increased during 1978, and further increased during 1979 to show a significant preference for these canopy coverages.

Elk use with respect to successional stage (estimated size and age of dominant vegetation) is shown in Fig. 16. Both climax and seral grass-forb sites were few in occurrence and little used. Brush-seedling-sapling areas, mainly clearcuts, were used about equal to their occurrence except during 1977, when high use of clearcuts during the summer caused total use to exceed availability. A preference for brush-seedling-sapling areas was also noted during the 1978 and 1979 calving seasons. Pole-young, mixed species stands received the greatest use, but not in excess of their availability. Pole-young lodgepole pine stands were neither consistently favored nor avoided. Total use of mature-old mixed species stands was always nearly twice the availability of these stands, and significantly exceeded availability during 1978 and 1979. Mature-old stands were generally favored during every season except the rut.

Fig. 16. Percentages of availability and elk use by successional stage. (See Fig. 5, page 35, for legend.)


1977
PERCENT
100
80
60
40
20
Climax Grass-Forb
Seral Grass-Forb
Brush Seedling Sapling
Pole-Yng Mixed
Pole-Yng Mixed
Mature-Old Mixed
1978
PERCENT
100
80
60
40
20
Climax Grass-Forb
Seral Grass-Forb
Brush Seedling Sapling
Pole-Yng Mixed
Pole-Yng Mixed
Mature-Old Mixed
1979
PERCENT
100
80
60
40
20
Climax Grass-Forb
Seral Grass-Forb
Brush Seedling Sapling
Pole-Yng Mixed
Pole-Yng Mixed
Mature-Old Mixed
Successional Stage

Seven arbitrary habitat types were developed by cross-tabulating cover classes and successional stages. Types that represented only a small portion of the study area were grouped, and 7 nonforest types were added. Table 13 shows the results of 265 one-tenth acre (0.04 ha) plots located in stands that were classified by these types from aerial photos. These plots were taken to describe the structural characteristics of the arbitrary types. Predictably, total stem density decreased as canopy cover decreased within each successional stage group. The density of trees in each diameter class also followed this pattern. Dense-closed lodgepole pine stands had the highest total stem density and were characterized by a lack of mature-old trees and a larger number of sapling and pole-young trees than other groups. Within the same canopy cover class, mature-old mixed species stands differed from pole-young mixed species stands by having a lower total stem density, a greater number of mature-old trees, and fewer pole-young and sapling size trees.

Mature-old stands achieved with fewer trees the same amount of canopy coverage as pole-young mixed stands because of the larger canopies of mature-old trees. Lodgepole pine stands attained canopy coverages comparable to other stand types, but with a higher density of pole-young and sapling trees. This was no doubt due to the sparser canopies of lodgepole pine trees relative to other conifers, and also because of the lack of mature-old trees.

Table 13. Mean number of trees per 0.1-acre circular plots. Listed by diameter class and stand type.

Stand type, canopy cover[a]	N	Diameter class (inches) Sapling 0-3	Pole-young 4-15	Mature-old >16	Sum
Mature-old mixed, light-moderate	38	3.6	4.1	1.7	9.4
Mature-old mixed, dense-closed	48	7.8	15.3	2.3	25.5
Pole-young lodgepole, moderate	13	10.9	18.8	0.1	29.8
Pole-young lodgepole, dense-closed	27	26.5	43.5	0.4	70.6
Pole-young mixed, light	48	2.5	4.8	0.5	7.9
Pole-young mixed, moderate	48	8.2	11.0	1.0	19.9
Pole-young mixed, dense-closed	43	8.6	18.3	1.6	28.1

[a]Canopy cover: light = <25%; moderate = 26-75%; dense-closed = > 75%.

The above discussion suggests fairly distinct structural types. However, plots on a transect within a particular stand were highly variable with respect to the frequency of tree diameter classes. This variability was clearly indicated when the data were analyzed by discriminant function analysis. The arbitrary stand types were not clearly distinctive on the basis of tree diameter-class densities. However, canopy coverage was not included as a variable in the analysis; therefore, the relationship between stem density and canopy coverage noted previously was not subject to discriminant analysis. Apparent differences do exist among stands when they are viewed from aerial photographs. These differences were probably not adequately described by tree size and density alone. Also, sample size might have been too small to adequately describe the stands. Considerable variability would be expected when dealing with such broad habitat categories. Clearly, description of stand structural characteristics requires more work.

Elk use and availability for these arbitrary types are shown in Table 14. Mature-old stands with dense canopy coverage were significantly preferred during 1978 and 1979, and usually received greater use than similar stands with light-moderate canopy coverage, relative to availability. For all 3 years, use of dense, mature-old stands was approximately 2.5 times greater than their occurrence.

Pole-young, mixed species stands with light canopy were

Table 14. Percentages of availability and elk use by structural characteristics of habitats.

	Age, spp., canopy cover[a]	% Availability N = 300	% Elk Use Calving N = 26	Summer N = 45	Rut N = 69	Hunt N = 33	Total N = 173
1977	Mature-old mixed, light-mod.	2.5	11.5	4.4	11.6	-- 0.0	7.5
	Mature-old mixed, dense	4.8	7.7	6.7	5.8	12.1	7.5
	Pole-young LPP, light-mod.	1.0	3.8	8.9	0.0	0.0	2.9
	Pole-young LPP, dense	13.7	7.7	6.7	20.3	- 3.0	11.6
	Pole-young mixed, light	7.3	15.4	6.7	7.2	24.2	11.6
	Pole-young mixed, mod.	31.3	34.6	-- 6.7	37.7	39.4	29.5
	Pole-young mixed, dense	23.3	19.2	24.4	15.9	21.2	19.7
	Brush-seedling-sapling	1.3	0.0	0.0	0.0	0.0	0.0
	Dry meadow	1.3	0.0	0.0	0.0	0.0	0.0
	Wet meadow	0.7	0.0	0.0	0.0	0.0	0.0
	Pasture-hayfield	6.3	-- 0.0	-- 0.0	-- 0.0	-- 0.0	-- 0.0
	North slope clearcut	2.7	0.0	++35.6	1.4	0.0	9.8
	Road	2.0	0.0	0.0	0.0	0.0	0.0
	Other[b]	2.0	0.0	0.0	0.0	0.0	0.0

	Age, spp., canopy cover[a]	% Availability N = 300	% Elk Use Calving N = 53	Summer N = 148	Rut N = 103	Hunt N = 48	Total N = 352
1978	Mature-old mixed, light-mod.	2.5	3.8	3.4	6.8	0.0	4.0
	Mature-old mixed, dense	4.8	9.4	++18.2	14.6	12.5	++15.1
	Pole-young LPP, light-mod.	1.0	0.0	3.4	1.0	0.0	1.7
	Pole-young LPP, dense	13.7	-- 0.0	19.6	-- 1.0	25.0	11.9
	Pole-young mixed, light	7.3	+28.3	13.5	3.9	14.6	13.1
	Pole-young mixed, mod.	31.3	17.0	- 18.2	35.0	27.1	24.1
	Pole-young mixed, dense	23.3	24.5	13.5	30.1	20.8	21.0
	Brush-seedling-sapling	1.3	0.0	3.4	3.9	0.0	2.6
	Dry meadow	1.3	0.0	0.7	0.0	0.0	0.3
	Wet meadow	0.7	0.0	2.7	0.0	0.0	1.1
	Pasture-hayfield	6.3	-- 0.0	-- 0.0	- 1.0	-- 0.0	-- 0.3
	North slope clearcut	2.7	7.5	0.7	1.0	0.0	1.7
	Road	2.0	7.5	2.7	1.9	0.0	2.8
	Other[b]	2.0	1.9	0.0	0.0	0.0	0.3

	Age, spp., canopy cover[a]	% Availability N = 300	% Elk Use Calving N = 43	Summer N = 162	Rut N = 91	Hunt N = 63	Total N = 359
1979	Mature-old mixed, light-mod.	2.5	4.7	1.2	2.2	0.0	1.7
	Mature-old mixed, dense	4.8	18.6	12.3	10.0	9.5	++12.0
	Pole-young LPP, light-mod.	1.0	0.0	0.0	1.1	0.0	0.3
	Pole-young LPP, dense	13.7	4.7	10.5	15.6	17.5	12.3
	Pole-young mixed, light	7.3	9.3	10.5	3.3	-- 0.0	6.7
	Pole-young mixed, mod.	31.3	18.6	22.8	-- 14.4	-- 11.1	-- 18.2
	Pole-young mixed, dense	23.3	30.2	35.8	++52.2	++60.3	++43.6
	Brush-seedling-sapling	1.3	0.0	1.9	0.0	1.6	1.1
	Dry meadow	1.3	0.0	0.0	1.1	0.0	0.3
	Wet meadow	0.7	0.0	0.0	0.0	0.0	0.0
	Pasture-hayfield	6.3	-- 0.0	-- 0.0	-- 0.0	-- 0.0	-- 0.0
	North slope clearcut	2.7	14.0	1.9	0.0	0.0	2.5
	Road	2.0	0.0	1.9	0.0	0.0	0.8
	Other[b]	2.0	0.0	1.2	0.0	0.0	0.6

[a]Canopy cover: light = <25%; moderate = 26-75%; dense >75%.

[b]Other: brushy riparian, water, scree, rock.

favored during 1977 and 1978. Use of moderately dense stands was less than availability all 3 years, significantly so during 1979. Dense pole-young mixed stands were used less than their occurrence during 1977 and 1978, but use during 1979 was almost twice as great as availability. Nonforest types made up a small part of the study area and were little used. Notably, pasture-hayfields were used significantly less than their occurrence every year. Use of clearcuts greatly exceeded availability during 1977, but, during other years, cows used clearcuts less than or equal to their occurrence.

During the calving season, pole-young mixed stands with light canopy were favored. Moderate and dense canopy stands were used less than or equal to their occurrence, respectively. Mature-old, mixed species stands were always preferred, especially stands with dense canopy coverage. Clearcuts were generally used the most during the calving season.

During the summer, pole-young, mixed species stands with light canopy were used in excess of availability. Mature-old, mixed stands with dense and closed canopies were favored, significantly so during 1978.

During the rutting season, use of pole-young mixed stands was higher than during the summer, with moderate and dense stands preferred. Both classes of mature-old mixed stands continued to be preferred as during the summer.

Use of pole-young mixed stands increased slightly during the hunting season, particularly in those stands with dense canopy cover. Mature-old stands with light-moderate canopies received no use, but use of similar stands with dense canopies remained high. Nonforest areas received practically no use.

Table 15 shows elk use in relation to Pfister et al. (1977) habitat types. Relative to availability, the ABLA/CACA habitat type was the most preferred, followed by the ABLA/LIBO and ABLA/XETE-VAGL types. The PSME/CARU and ABLA/MEFE types were also consistently favored, but to a lesser extent. The PSME/VACA and PSME/SYAL types were notably used much less than their occurrence. During the calving season, the PSME/CARU and ABLA/LIBO types were the most preferred. Elk used more habitat types during the summer with the ABLA/XETE-VAGL, ABLA/LIBO, ABLA/CACA, and PSME/CARU types generally favored. The greatest amount of use occurred in the ABLA/MEFE type, but relative to availability, it was not highly preferred. A slight shift to the more mesic ABLA/LIBO and ABLA/CACA types was observed during the rutting season, but, in general, habitat type use was similar to that of summer. The ABLA/MEFE and ABLA/XETE-VAGL types were used most during the 1978 and 1979 hunting seasons, whereas the PSME/CARU and ABLA/LIBO types were heavily used during 1977.

Table 15. Percentages of availability and elk use by Pfister's (1977) forest habitat types.

Year	Forest habitat types	% Availability N = 300	% Elk Use: Calving N = 26	Summer N = 45	Rut N = 69	Hunt N = 33	Total N = 173
1977	PSME/Bunchgrass	5.7	-- 0.0	2.2	1.4	6.1	2.3
	PSME/VACA	13.0	7.7	-- 0.0	7.2	-- 0.0	-- 4.0
	PSME/PHMA	2.3	0.0	0.0	2.9	0.0	1.2
	PSME/VAGL	1.3	0.0	0.0	0.0	0.0	0.0
	PSME/LIBO	10.7	7.7	-- 0.0	13.0	3.0	6.9
	PSME/SYAL	18.0	11.5	-- 4.4	8.7	9.1	- 8.1
	PSME/CARU	8.7	23.1	4.4	14.5	33.3	16.8
	ABLA/CACA	2.7	7.7	8.9	+17.4	6.1	+11.6
	ABLA/LIBO	4.3	15.4	6.7	7.2	+30.3	12.7
	ABLA/MEFE	11.3	15.4	20.0	10.1	- 0.0	11.6
	ABLA/XETE-VAGL	6.7	11.5	17.8	15.9	12.1	15.0
	ABLA/XETE-VASC	0.3	0.0	0.0	0.0	0.0	0.0
	Nonforest[a]	15.0	0.0	35.6	1.4	0.0	9.8

Year	Forest habitat types	% Availability N = 300	% Elk Use: Calving N = 53	Summer N = 148	Rut N = 103	Hunt N = 48	Total N = 352
1978	PSME/Bunchgrass	5.7	3.8	1.4	2.9	- 0.0	2.0
	PSME/VACA	13.0	-- 1.9	-- 0.0	26.2	-- 2.1	8.2
	PSME/PHMA	2.3	0.0	2.0	1.0	0.0	1.1
	PSME/VAGL	1.3	+18.9	0.0	1.0	4.2	3.7
	PSME/LIBO	10.7	15.1	6.1	8.7	8.3	8.5
	PSME/SYAL	18.0	-- 3.8	-- 7.4	9.7	-- 4.2	-- 7.1
	PSME/CARU	8.7	13.2	16.2	4.9	16.7	12.5
	ABLA/CACA	2.7	5.7	+12.2	9.7	8.3	++ 9.9
	ABLA/LIBO	4.3	13.2	10.8	+15.5	8.3	++12.2
	ABLA/MEFE	11.3	-- 1.9	16.2	7.8	20.8	12.2
	ABLA/XETE-VAGL	6.7	3.8	++20.3	6.8	25.0	++14.5
	ABLA/XETE-VASC	0.3	0.0	0.7	1.0	0.0	0.6
	Nonforest[a]	15.0	18.8	6.8	4.9	2.1	7.4

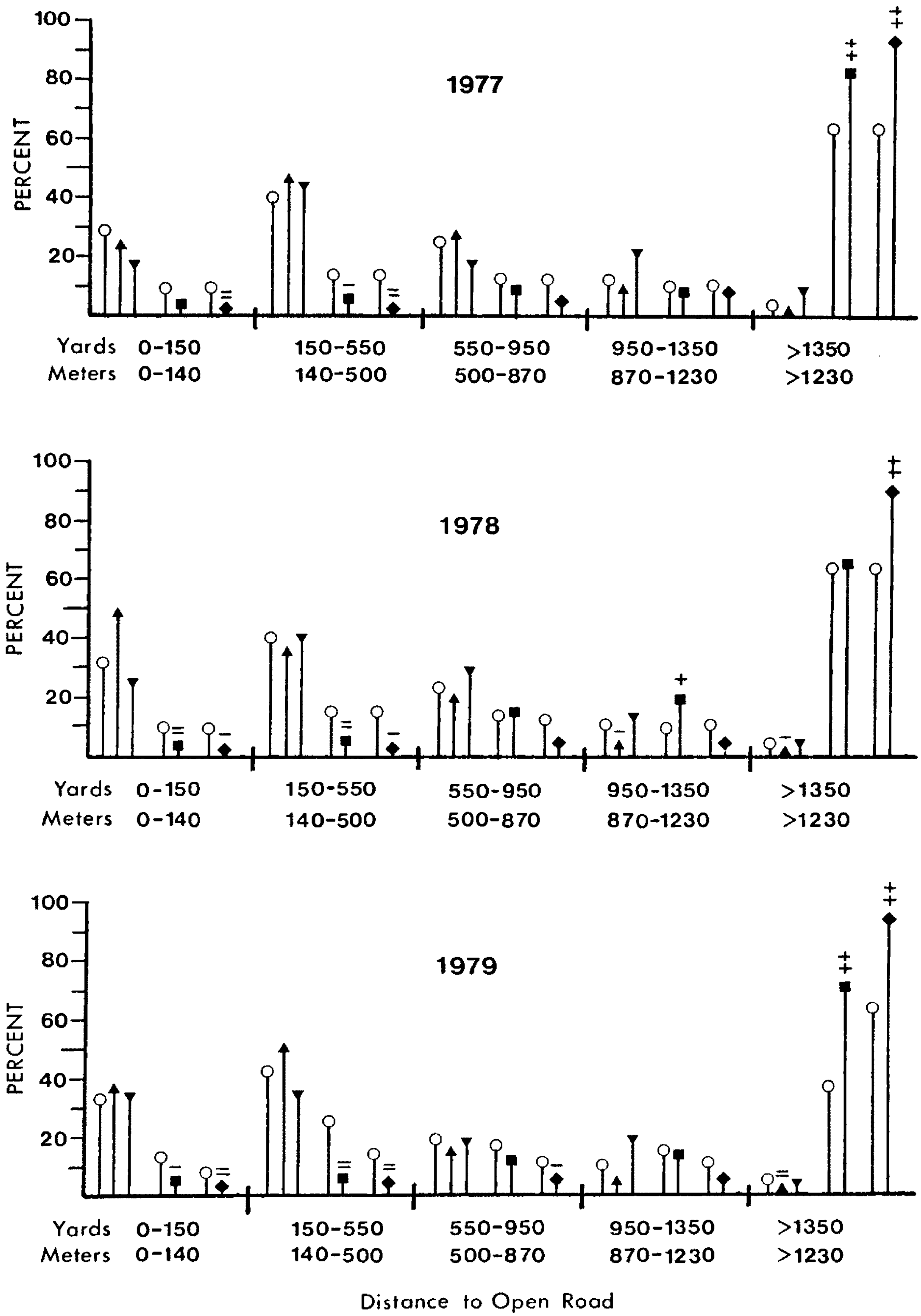
Year	Forest habitat types	% Availability N = 300	% Elk Use: Calving N = 43	Summer N = 164	Rut N = 91	Hunt N = 63	Total N = 361
1979	PSME/Bunchgrass	5.7	-- 0.0	2.4	1.1	1.6	1.7
	PSME/VACA	13.0	-- 2.3	-- 1.8	6.6	-- 1.6	-- 3.0
	PSME/PHMA	2.3	2.3	3.7	3.3	0.0	2.8
	PSME/VAGL	1.3	4.7	4.3	0.0	0.0	2.5
	PSME/LIBO	10.7	11.6	11.6	7.7	12.7	10.8
	PSME/SYAL	18.0	7.0	12.2	-- 5.5	-- 4.8	-- 8.6
	PSME/CARU	8.7	25.6	15.2	11.0	4.8	13.6
	ABLA/CACA	2.7	2.3	7.9	11.0	1.6	6.9
	ABLA/LIBO	4.3	14.0	9.8	12.1	14.3	++11.6
	ABLA/MEFE	11.3	4.7	15.2	17.6	++36.5	18.3
	ABLA/XETE-VAGL	6.7	11.6	11.0	+22.0	22.2	++15.8
	ABLA/XETE-VASC	0.3	0.0	0.0	1.1	0.0	0.3
	Nonforest[a]	15.0	14.0	4.8	1.1	0.0	4.2

[a]No significance test. See Table 13 (page 66) for breakdown of availability and elk use.

Relationships to roads and human disturbance. Vehicular use of areas near the study area was low during 1977, but substantially higher in surrounding areas such as the Elk Creek Road. During 1978, traffic in the study area was generally light (1 or fewer vehicle trips/day). Moderate to heavy traffic (2 to 9 vehicle trips/day) occurred in the lower and middle reaches of the main fork of Chamberlain Creek drainage throughout the season, and along the Cap Wallace Road to the head of Chamberlain Creek until 1 September. Vehicular use of the area was light to moderate (1 to 4 vehicle trips/day) during 1979. Heavy traffic (5 to 9 vehicle trips/day) occurred on the lower portions of the main Chamberlain Creek Road during the calving and hunting seasons. During the rut, traffic was heavy on all sections of the main Chamberlain Creek Road. (The upper section of road occurring from the north boundary of the CSA south to the fork in Chamberlain Creek was constructed in 1978.) The Cap Wallace Road, to the head of Chamberlain Creek, was moderately to heavily used throughout the season until 1 September.

Elk reaction to open roads was similar for all 3 years (Fig. 17). Elk did not avoid open roads during the calving and summer seasons. A crosstabulation of availability and elk use by distance to open roads and traffic volume for 1979, a year of high vehicle use, showed that during these seasons approximately 64% of the available habitat was closer to lightly traveled roads than to roads with higher

Fig. 17. Percentages of availability and elk use by distance to open roads. (See Fig. 5, page 35, for legend.)


1977
1978
1979
PERCENT
100
80
60
40
20
Yards 0-150 150-550 550-950 950-1350 >1350
Meters 0-140 140-500 500-870 870-1230 >1230
Distance to Open Road

traffic (Table 16). Elk use during the calving and summer seasons exceeded the availability of areas near lightly traveled roads, with about 85% and 91% of the seasonal use, respectively. Many roads were affected by the 1 September road closures so that the availability of areas close to open roads was greatly reduced during the rutting and hunting seasons. Most of the lightly traveled roads were closed so that the availability of areas near heavily and very heavily traveled roads increased substantially. Use of areas near lightly traveled roads during these seasons was less than availability, but sample size was small. Elk did not appear to avoid areas close to moderately traveled roads during the rut, but again sample size was small. However, areas less than 550 yards (500 m) from roads with heavy-very heavy traffic seem to have been avoided during the rut. When all open roads were considered, regardless of traffic volume, a significant avoidance of areas within 550 yards (500 m) of open roads was found. During the hunting season, an even greater negative response to all open roads was observed: approximately 90% of the elk use was in areas greater than 1350 yards (1230 m) from open roads. Broken down by traffic volume, the same pattern was shown--90% or more of the elk use was in areas greater than 1350 yards (1230 m) from open roads, regardless of traffic volume.

Rutting and hunting season use of areas near roads closed after 1 September was always less than availability for areas closer

Table 16. Percentages of availability and elk use by distance to open roads and traffic volume during 1979.

Traffic volume		Distance to road in yards (meters) 0-150 (0-140)	150-550 (140-500)	550-950 (500-870)	950-1350 (870-1230)	>1350 (>1230)	Total	N
Calving and Summer								
Light	Availability	34.0	40.3	15.2	7.9	2.6	63.7	191
	Calving	30.8	53.8	12.8	2.6	0.0	90.7	39
	Summer	37.4	32.4	12.2	16.5	1.4	84.8	139
Moderate	Availability	30.6	35.5	24.2	9.7	0.0	20.7	62
	Calving	100.0	0.0	0.0	0.0	0.0	7.0	3
	Summer	0.0	36.4	18.2	45.5	0.0	6.7	11
Heavy	Availability	25.0	45.8	25.0	4.2	0.0	8.0	24
	Calving	0.0	0.0	100.0	0.0	0.0	2.3	1
	Summer	9.1	36.4	54.5	0.0	0.0	6.7	11
Very heavy	Availability	8.7	34.8	13.0	21.7	21.7	7.7	23
	Calving	0.0	0.0	0.0	0.0	0.0	0.0	0
	Summer	0.0	0.0	66.7	33.3	0.0	1.8	3
Rutting Season								
Light	Availability	22.6	38.7	6.5	0.0	32.3	10.3	31
	Rut	0.0	0.0	0.0	0.0	100.0	13.2	12
Moderate	Availability	9.6	13.8	14.9	18.1	43.6	31.3	94
	Rut	11.1	22.2	0.0	0.0	66.7	9.9	9
Heavy	Availability	11.0	35.4	23.2	11.0	19.5	27.3	82
	Rut	3.6	3.6	21.4	14.3	57.1	30.8	28
Very heavy	Availability	7.5	20.4	12.9	17.2	41.9	31.0	93
	Rut	2.4	0.0	9.5	16.7	71.4	46.2	42
Hunting Season								
Light	Availability	29.2	50.0	12.5	0.0	8.3	8.0	24
	Hunt	0.0	0.0	0.0	0.0	100.0	7.9	5
Moderate	Availability	4.7	6.3	9.4	4.7	75.0	21.3	64
	Hunt	0.0	0.0	8.7	0.0	91.3	36.5	23
Heavy	Availability	3.9	10.1	13.2	12.4	60.5	43.0	129
	Hunt	0.0	4.0	0.0	4.0	92.0	39.7	25
Very heavy	Availability	2.4	11.0	4.9	11.0	70.7	27.3	82
	Hunt	0.0	0.0	0.0	10.0	90.0	15.9	10

than 150 yards (140 m) to those roads (Fig. 18). Generally, a greater negative response was observed during the hunting season than during the rutting season.

Elk use with respect to new roads built in the CSA is shown in Table 17. The distance from an elk location to a new road was not measured if the location was on the opposite side of a major ridge (third and fourth order ridges) from the road. These locations were placed in the "out of range" category. This procedure was followed because previous studies (Montana Cooperative Elk-Logging Study, 1980) have shown elk to be less affected by road activity when a major ridge separated elk from the road. Values for 1977 were considered a "control" as the roads were built during 1978 and 1979. For 1977 then, distances are to the proposed road site. Results indicated that elk were little affected by the few new roads in the CSA, when comparing use during 1977 with use during 1978 and 1979. Values for 1977 indicated that these areas were little used by elk even in the absence of roads.

The relationship of elk to areas of active human disturbance, such as road building and logging, was observed during 1978 and 1979. Road building activities during 1978 were concentrated in the lower and middle reaches of the main fork of Chamberlain Creek. This work involved upgrading the existing road. Right-of-way clearing and preliminary grading of the main-line haul road (Fig. 19) were completed

Fig. 18. Percentages of availability and elk use by distance to closed roads. (See Fig. 5, page 35, for legend.)

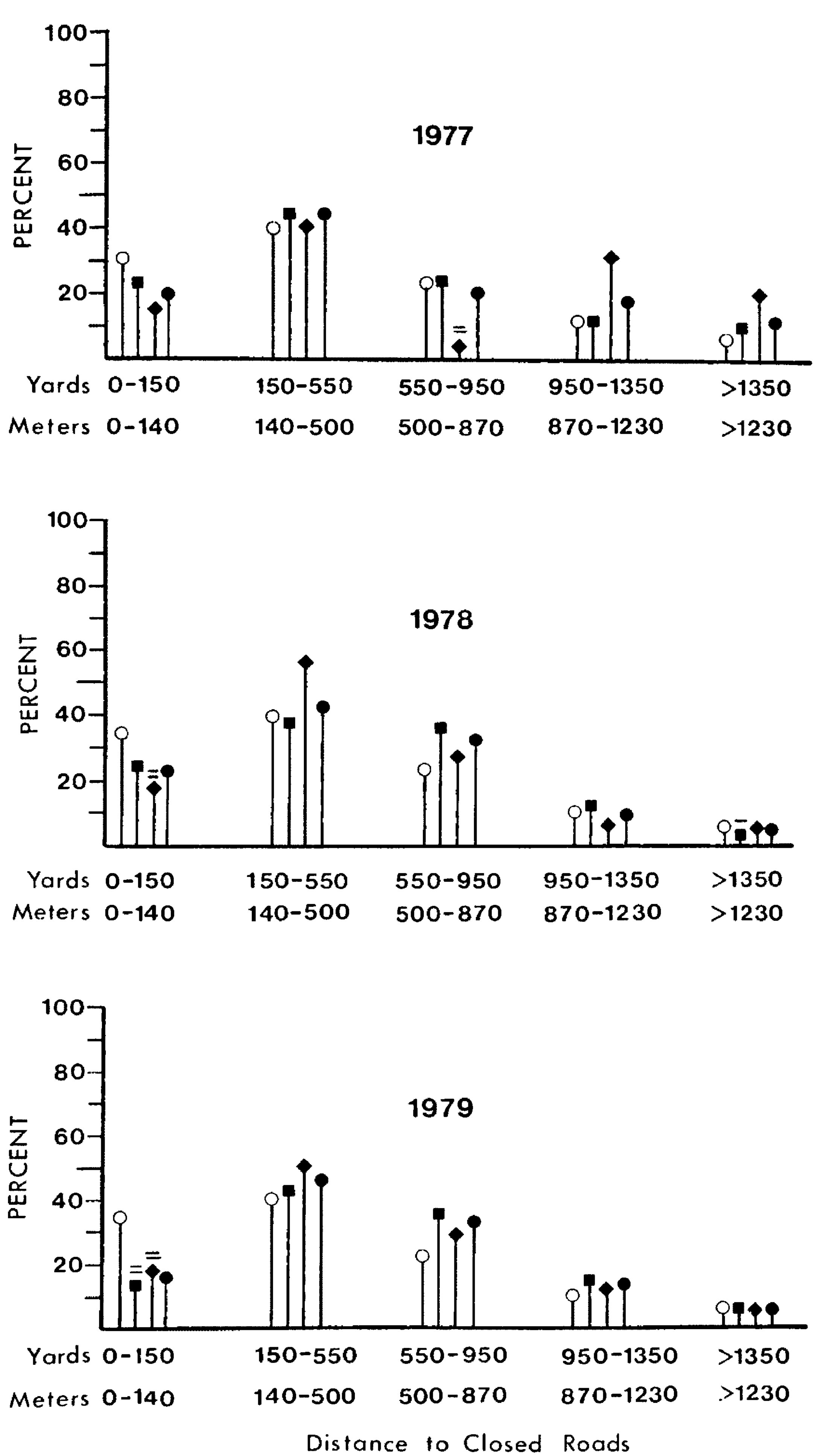

1977
PERCENT
100
80
60
40
20
Yards 0-150 150-550 550-950 950-1350 >1350
Meters 0-140 140-500 500-870 870-1230 >1230
1978
PERCENT
100
80
60
40
20
Yards 0-150 150-550 550-950 950-1350 >1350
Meters 0-140 140-500 500-870 870-1230 >1230
1979
PERCENT
100
80
60
40
20
Yards 0-150 150-550 550-950 950-1350 >1350
Meters 0-140 140-500 500-870 870-1230 >1230
Distance to Closed Roads

Table 17. Percentages of availability and elk use by distance to proposed new roads (1977) and new roads in the CSA (1978, 1979).

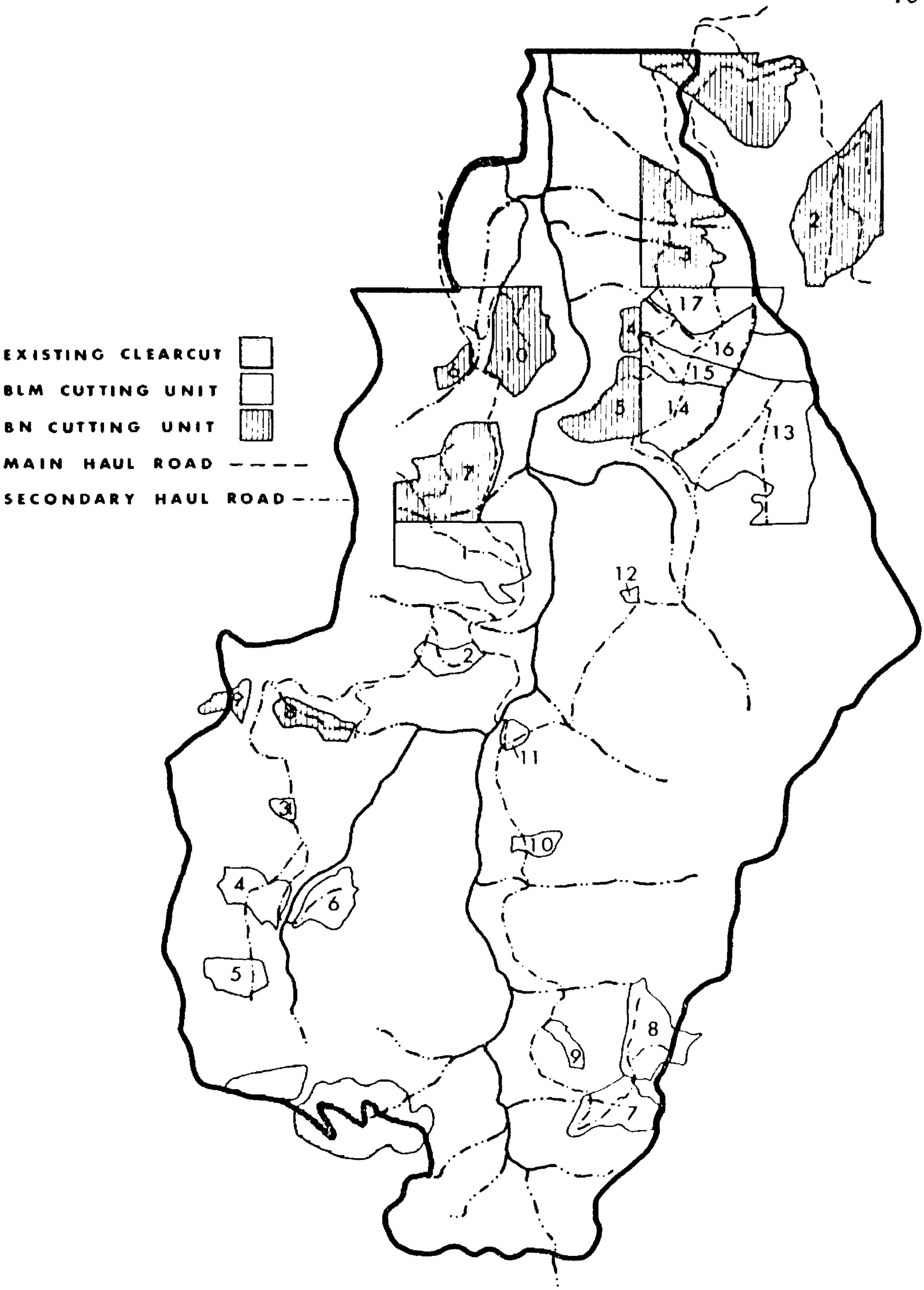
	Distance to new roads (proposed) in CSA yards	(meters)	% Availability N = 400	% Elk Use Calving N = 26	Summer N = 45	Rut N = 69	Hunt N = 33	Total N = 173
1977	0-150	(0-140)	1.5	0.0	0.0	1.4	3.0	1.2
	150-550	(140-500)	6.5	7.7	2.2	2.9	9.1	4.6
	550-950	(500-870)	4.0	-- 0.0	6.7	2.9	12.1	5.2
	950-1350	(870-1230)	3.8	11.5	2.2	7.2	9.1	6.9
	> 1350	(> 1230)	22.8	30.8	++57.8	24.6	36.4	++36.4
	Out of range[a]		61.5	50.0	--31.1	60.9	--30.3	--45.7

	Distance to new roads in CSA yards	(meters)	% Availability N = 400	% Elk Use Calving N = 53	Summer N = 148	Rut N = 103	Hunt N = 48	Total N = 352
1978	0-150	(0-140)	1.5	5.7	1.4	1.0	0.0	1.7
	150-550	(140-500)	6.5	5.7	-- 0.0	-- 0.0	2.1	-- 1.1
	550-950	(500-870)	4.0	17.0	3.4	4.9	10.4	6.8
	950-1350	(870-1230)	3.8	9.4	10.8	7.8	4.2	+ 8.8
	> 1350	(> 1230)	22.8	- 9.4	27.7	14.6	31.3	21.6
	Out of range[a]		61.5	52.8	56.8	71.8	52.1	59.9

	Distance to new roads in CSA yards	(meters)	% Availability N = 300	% Elk Use Calving N = 43	Summer N = 164	Rut N = 91	Hunt N = 63	Total N = 361
1979	0-150	(0-140)	1.7	0.0	1.2	3.3	0.0	1.4
	150-550	(140-500)	5.3	16.3	3.0	3.3	3.2	4.7
	550-950	(500-870)	3.7	14.0	7.9	4.4	6.3	7.5
	950-1350	(870-1230)	3.3	9.3	6.7	9.9	4.8	7.5
	> 1350	(> 1230)	19.7	11.6	28.0	20.9	30.2	24.7
	Out of range[a]		66.3	48.8	- 53.0	58.2	55.6	--54.3

[a]Separated from road by a 3rd or 4th order ridge.

Fig. 19. Proposed cutting unit and road locations in the CSA.


EXISTING CLEARCUT
BLM CUTTING UNIT
BN CUTTING UNIT
MAIN HAUL ROAD
SECONDARY HAUL ROAD
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

by mid-May. Subsequent work concentrated on improving the existing road north of the CSA. Construction of another road by the Burlington Northern Company in the northeast part of the study area began in mid-July 1978. This road was built from approximately the beginning of the "jeep trail" in the lower east fork of Chamberlain Creek through BN cut no. 3 to the northwest boundary of BLM cut no. 17. Construction of a secondary haul road in BN cut no. 1 was started in late September. Work on all roads ended by 20 October.

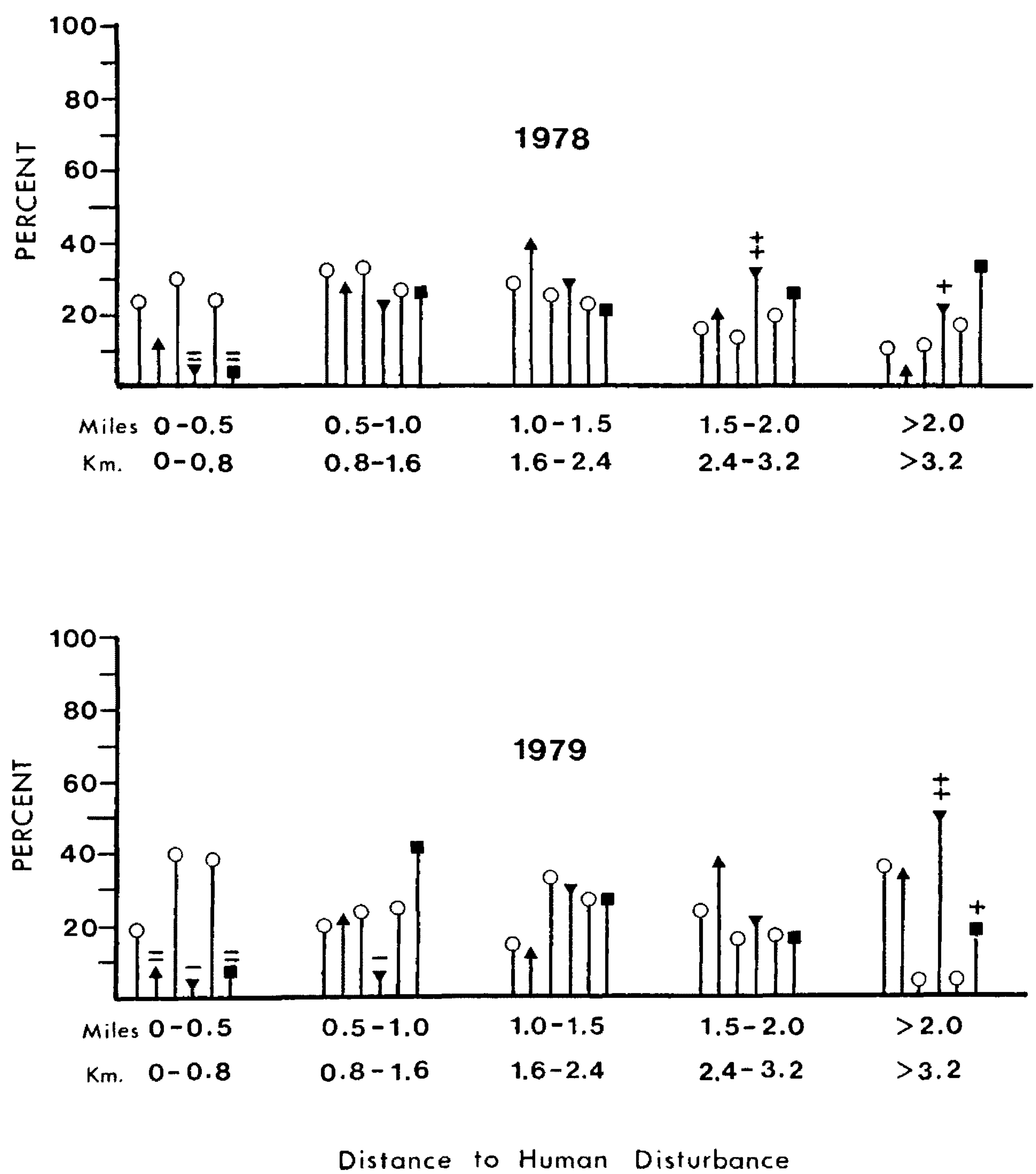
Logging occurred during June 1978 in the northeast corner of the study area east of lower Chamberlain Creek. Portions of the south side of the west fork of Chamberlain Creek drainage and the east side of the northern end of the Bear Creek-Chamberlain Creek divide were logged from mid-July through September. From late July to mid-September, logging took place at the upper end of Cap Wallace Gulch, along the Cap Wallace Road. In addition, road maintenance crews cleared slash windrows along sections of the Upper Cap Wallace Road, extending from the Cap Wallace-Little Fish Creek divide east into the CSA.

During the spring and summer of 1979, construction of secondary haul roads in and near BN cuts nos. 1 and 2 began. Work on the main line Chamberlain Creek haul road was confined to the first 2 weeks of July. After July, the main haul road was completed, and an east side spur road was extended from BN cut no. 3 into BN cut no. 5. As in 1978, this work stopped prior to the opening of the general hunting season on 20 October.

Logging occurred from late May through June 1979 on most of the westerly slopes of Blacktail Mountain, and on the lower portions of the adjacent southerly slope. From mid-July to early September, several small areas were logged at the head of the North Fork of Elk Creek and Cap Wallace Gulch. An area on the ridge separating the above drainages was also logged at this time. Two small areas were logged in lower Bear Creek from late August to late October. Limited logging took place from mid-October through the end of the study period in areas to the east of the study area, mainly in the Pearson Creek drainage and along the River Junction Road east of Pearson Creek. In addition, small precommercial thinning operations took place in the large clearcuts in Little Fish Creek drainage from mid-May through August, and in a small area southwest of the Grace's Landing Trap, at the west end of the West Fork Chamberlain Creek drainage, during late May. No logging was done inside the CSA during the study.

Fig. 20 shows the relationship between elk and distance to human disturbance. Elk locations that were closer to an open road with heavy or very heavy traffic than to a disturbance site were eliminated from the analysis. During both years, elk use was substantially less than availability for areas within 0.5 mile (0.8 km) of

Fig. 20. Percentages of availability and elk use by distance to active human disturbance. (See Fig. 5, page 35, for legend.)


1978
PERCENT
100
80
60
40
20
Miles 0-0.5
Km. 0-0.8
0.5-1.0
0.8-1.6
1.0-1.5
1.6-2.4
1.5-2.0
2.4-3.2
>2.0
>3.2
1979
PERCENT
100
80
60
40
20
Miles 0-0.5
Km. 0-0.8
0.5-1.0
0.8-1.6
1.0-1.5
1.6-2.4
1.5-2.0
2.4-3.2
>2.0
>3.2
Distance to Human Disturbance

disturbance, significantly so for all seasons except calving 1978. Areas from 0.5 mile to 1.5 miles (0.8-2.4 km) from disturbances were generally not avoided except during the summer of 1979 when use was significantly less than availability. During the summer of 1978, areas greater than 1.5 miles (2.4 km) from disturbances were significantly favored, while during 1979 areas greater than 2.0 miles (3.2 km) were significantly preferred, with almost 50% of the elk use in those areas. A finer breakdown of the distance categories into quarter-mile (0.4 km) intervals yielded similar results.

Fig. 21 shows elk use in logged and unlogged areas. Combining use and availability for both logged categories indicated that use was about equal to availability of logged areas during the calving season, was lowest of all seasons during the summer, slightly increased from summer during the rut, and exceeded availability during the hunting season, except during 1979. Unlogged areas were significantly favored for the entire season and during the summer for every year. Use of unlogged areas during other seasons was generally always greater than availability with varying degrees of significance.

Elk use, more finely broken down by age of the logged area, is shown in Fig. 22. Areas logged before 1949 were used significantly less than their occurrence each year. This was probably because such areas are generally at low elevations on the periphery of the study area, and elk use was previously shown to be limited at those elevations.

Fig. 21. Percentages of availability and elk use by general age of logged areas and by unlogged areas. (See Fig. 5, page 35, for legend.)

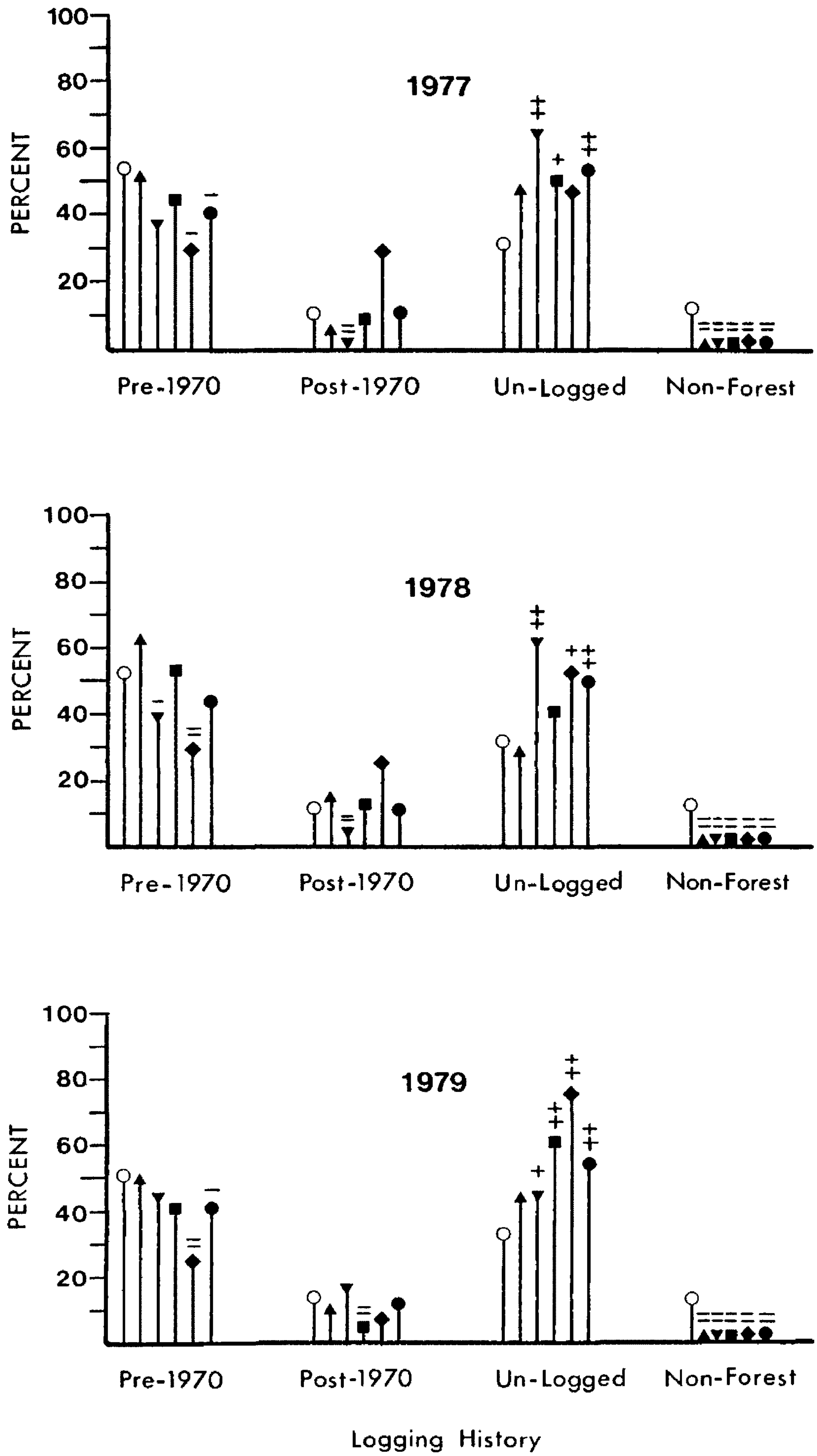
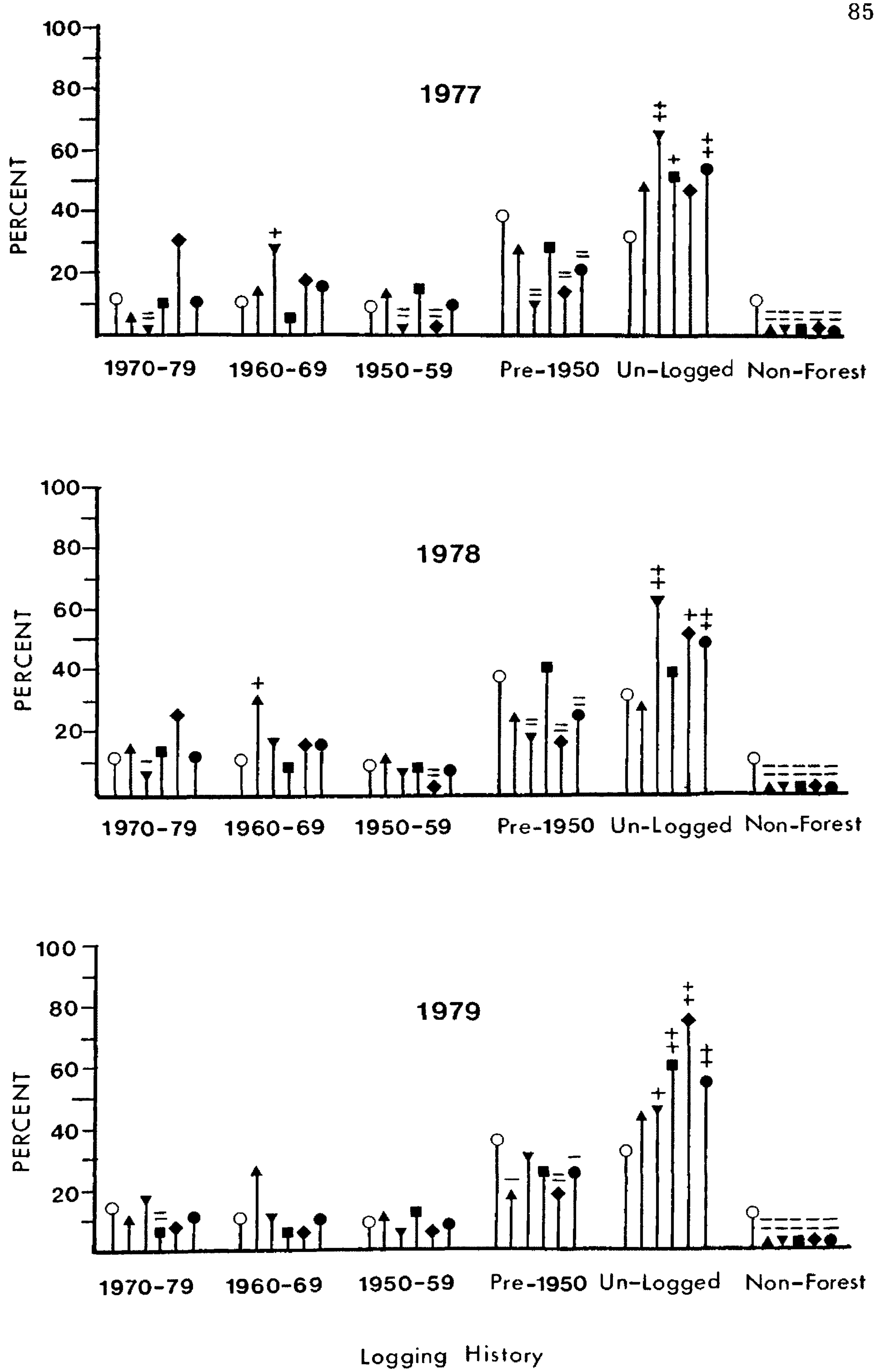

1977
1978
1979
PERCENT
100
80
60
40
20
Pre-1970
Post-1970
Un-Logged
Non-Forest
Logging History

Fig. 22. Percentages of availability and elk use by age of logged areas and by unlogged areas. (See Fig. 5, page 35, for legend.)


1977
1978
1979
PERCENT
100
80
60
40
20
1970-79
1960-69
1950-59
Pre-1950
Un-Logged
Non-Forest
Logging History

Use of areas logged from 1949 to the present was generally about equal to their occurrence. However, cuts made during 1970-79 were favored during the hunting seasons of 1977 and 1978. Also, areas cut during 1960-69 were highly preferred during the summer of 1977 and nominally favored during the calving seasons of 1978 and 1979. Most of this use can be ascribed to the use of clearcuts, most of which were logged during that decade.

CHAPTER V

DISCUSSION

Chamberlain elk used smaller areas than elk east of the Continental Divide in Montana. Both groups of Chamberlain elk used a total area of about 100 square miles (260 km^2). This area also included most of the winter range. Lindbergh-Potter elk had a larger range than Grace's Landing elk--about 70 square miles (181 km^2) versus about 30 square miles (78 km^2). Year-long home ranges for 30 radio-equipped elk studied by Lonner (1979) in the Long Tom area of southwestern Montana covered 675 square miles (1755 km^2). This figure is the composite range of 2 different groups of elk: 1 group had a range of 608 square miles (1575 km^2) and the other a range of 174 square miles (451 km^2). Cada (1978) reported year-long home ranges of 143 square miles (370 km^2) and 568 square miles (1471 km^2) for 3 elk from the Gallatin Valley and for 9 elk from the Madison Valley of southwestern Montana, respectively.

Elk studied by Lonner (1979) and Cada (1978) also migrated greater distances between summer and winter ranges than did Chamberlain elk. Lonner located most elk within 10 miles (16 km) of their winter ranges. Other studies reported spring migrations up to

25 miles (40 km) to summer range, but a general range was 8-15 miles (13-24 km) (Brazda 1953, Dalke et al. 1965, Knight 1970, and Smith 1978 among others). Ream et al. (1972) and Simmons (1974), however, noted the presence of "resident" groups that ranged within 4-5 miles (6-8 km) of their winter ranges. This situation closely matches the behavior of Chamberlain elk. Chamberlain elk had only to travel 5-6 miles (8-10 km) to reach the point in their ranges farthest from the winter range. This distance, however, was never traveled at once in what could be called a migration. Rather, the move to summer range was more of a "dispersal" as described by Ream et al. (1972) and Zahn (1974), whereby no group movements from one area to another were observed, and movements of individuals were independent in time and space. This "dispersal" of Chamberlain elk to summer range was affected by the yearly precipitation pattern: during moist years elk remained in areas used during the calving season longer than during dry years. Similar behavior was also noted by Ream et al. (1972).

Differences in home range size and the distance required to traverse it during migration appear to be related to the availability of acceptable seasonal habitat. No doubt the physiognomy of elk range has a bearing on the productivity and types of habitat available for use by elk, and thus an indirect impact on their range of movements. Murie (1951) noted that where needed resources are available in a small area migrations would be short. This is the case with Chamberlain elk.

Along with physiognomic factors that influence plant community composition, structure, and productivity, we must consider the migratory tradition (Murie 1951) as important when speaking of factors influencing elk movements. With few exceptions, Chamberlain cow elk were remarkably consistent in the area they used throughout the year. This is not to say that for each season they used the same sites, rather that their range of movements stayed within predictable boundaries. That elk from the 2 groups had mutually exclusive spring-fall ranges adjoining each other was particularly interesting. No major topographic barriers existed to hinder mingling of groups. In fact, group home range boundaries adjoined on a low ridge and on broad forested slopes. Only 2 cows were observed with other elk groups during the study, and these groups ranged outside the study area to the northeast and south. Fidelity to summer range has been noted by almost every elk researcher (Knight 1970, Craighead et al. 1972, Simmons 1974, Shoesmith 1979, and Lonner 1979 among others). However, elk groups with adjoining ranges were observed to mingle slightly on the boundaries of their summer ranges, and erratic movements by a few elk outside the normal range were also noted. Mixing of groups on the winter range was more common than on the summer range, as may be expected considering the lower availability of winter range relative to summer range.

Knight (1970) determined for the Sun River elk in Montana that use of a particular summer range was independent of the winter range used, but that elk yearly returned to the same summer range. Mixing of elk groups on winter range in the Chamberlain Creek area was noted for Grace's Landing elk, which mixed with elk that summered east of Chamberlain Creek. One Lindbergh-Potter elk mingled with elk that summered south of the study area. Grace's Landing and Lindbergh-Potter elk were not observed to mingle with each other during the winter. Winter ranges for these groups were topographically separated by the steep slopes of the lower Bear Creek drainage.

Patterns of elk distribution on seasonal ranges were different for the 2 groups of Chamberlain elk. Grace's Landing elk generally used their entire spring-fall range to some extent during every season. Lindbergh-Potter elk, however, showed more distinct seasonal ranges within their larger total home range. During the calving season, Lindbergh-Potter elk showed a definite preference for the upper Fish Creek drainage, which was about 2 miles (3.2 km) from their winter range. But a few elk calved southwest of Fish Creek adjacent to the winter range. In contrast, Grace's Landing elk did not show a preference for a specific calving area. The northern part of the CSA was of general importance, but the choice of calving areas seemed to be related to the timing of snowmelt. During 1977, a dry year with early snowmelt, centers of activity were located farther into the CSA than during subsequent years when snowmelt was later. The average standard diameter was largest during 1977 indicating a wider range of movements than during the subsequent wetter years. Ream et al. (1972) and Simmons (1974) also noted a wider range of movements during snow-free springs.

Zahn (1974), Lemke (1975), and Smith (1978) observed a similar relationship concerning calving areas and the timing of snowmelt: calving areas were not traditional but as snow conditions permitted. Nevertheless, calving areas were specifically described on winter range by Johnson (1951), Brazda (1953), Bohne (1974), and Biggins (1975); on summer range by Picton (1960), and Simmons (1974); and on the migration route by Grkovic (1974), Bohne (1974), and Zahn (1974). The latter would be similar to a variable calving area in that snow conditions would affect the timing of migration and hence the location of calving. Possibly, those studies describing calving on a specific range did not observe calving under varying weather conditions, and thus did not observe calving on different ranges. However, both traditional and variable calving areas seem possible.

The consistent use of the upper Fish Creek drainage would allow us to call this a traditional calving area. Preference for this area can probably be ascribed to its mosaic of young to mature timber stands and south-facing, partially logged, open slopes. This area is also easily accessible during the spring by open west-facing slopes leading up to it from the winter range. Conversely, calving areas for Grace's Landing elk are more densely timbered and less exposed to warming sun during the spring; thus the available area for calving is more subject to ambient temperature and snow conditions.

The summer distributions of the 2 elk groups as shown by centers of activity were dissimilar in direction of movement toward the CSA, but similar with regard to the yearly availability of moisture. Lindbergh-Potter elk generally moved east from the calving grounds into and adjacent to the CSA. Grace's Landing elk remained in the vicinity of calving areas or shifted their activity to the north of the CSA, between the calving and winter areas. With respect to cumulative precipitation, however, both groups showed a greater amount of activity at high elevations in the CSA during the dry year of 1977 than during the moister years of 1978 and 1979. This is not to say that during years of high moisture elk did not frequent the same areas used during the dry years. During 1977, standard diameter and home range sizes were smaller than during the subsequent moist years, indicating a smaller range of activity. The larger standard diameters and home ranges during 1978 and 1979 indicated a wider range of movements that can be attributed to the high availability of succulent forage over a broader area. Therefore, many of the same areas were probably used during every year even though activity was centered in different locations, i.e., during moist years the range of activity included those areas used during dry years. The distribution of all seasonal centers of activity, then, probably indicates the entire range of seasonal movements.

The relationship between available moisture and the range of activity makes comparisons with other studies difficult, especially when their data were collected during only 1 year. Ream et al. (1972) and Lonner (1979) noted larger average summer home ranges than Chamberlain elk, but Simmons (1974) reported smaller home ranges. Summer standard diameters for elk studied by Hash (1973), Smith (1978), and Lonner (1979) were higher than those of Chamberlain elk, but Knight (1970) and McLean (1972) noted smaller standard diameters. In addition to variation attributed to available moisture, differences in range of activity statistics for different elk herds may result from differences in habitat, sample sizes, methods for including locations in the calculations, or other factors. Differences in habitat topography, productivity, and availability are the most difficult factors to reconcile when making such comparisons. These differences often make the proper application and comparison of indices of home range difficult. To find a versatile index of home range size is a longstanding problem in population biology (Metzgar and Sheldon 1974).

A general dispersal or scattering of elk from the more concentrated activity of the summer occurred during the rutting season. This dispersal was much more pronounced with Lindbergh-Potter elk than with Grace's Landing elk. As during the summer, the extent of movements appeared to be related to weather conditions. During 1978, a moist year, Lindbergh-Potter elk were much more widely distributed at low elevations than during other years. During the dry falls of 1977 and 1979, the pattern of distribution was similar, most activity was at higher elevations than during 1978. Grace's Landing elk activity was oddly bipolar in distribution. During all years, some activity was in moderate elevation, mesic areas in the CSA south of the main summer activity area, but some animals moved north to the vicinity of the Blacktail Mountain winter range. Home range sizes and standard diameters were the largest of any season during each year indicating considerable activity.

A similar scattering of elk during the rutting season was observed by Murie (1951), Altmann (1956), Simmons (1974), Zahn (1974), and Smith (1978), but not by Bohne (1974).

After the opening day of hunting season, most elk were back in areas used during the summer. Locations taken immediately before and after the opening day of hunting season showed movements of up to 6 miles (10 km) during that weekend. A few days after opening weekend, elk would often move down to areas used before the weekend, to be later pushed back into less accessible areas during the next weekend. Concentrations of activity centers indicated that most of the elk activity was centered around densely timbered areas that were usually about 2 miles (3.2 km) from hunter access points and camping areas. Some activity centers were in easily accessible areas, but were usually adjacent to extensive areas of dense escape cover. Distance of activity centers from access points seemed to be negatively correlated with yearly snow depths: the distance of activity centers from access points increased as snow depth decreased.

Chamberlain Creek elk used virtually all available habitats at some time during spring through fall. A similar wide range of habitat use in the CSA was noted for Chamberlain Creek elk by Scott (1978) and Marcum and Lehmkuhl (1980), and for other elk herds by Murie (1951), Julander and Jeffrey (1964), Biggins (1975), and Marcum (1975). Scott (1978) said that elk appeared to become much more selective during periods of stress, and noted that, although partially a function of sample size, 46 habitat attributes were used significantly different than their availability during the summer of 1977, a dry year. In contrast, he found only 12 such differences during the summer of 1976, a moist year. This relationship did not seem to hold true during my study: 13 significant differences were noted for the summer of 1977, and 15 and 14 significant differences were tallied for the wetter summers of 1978 and 1979. However, as Scott found, the significance of a difference between availability and elk use was partially a function of sample size. The sample size during the summer of 1977 was almost one-third the sample sizes of subsequent years, resulting in a lower probability of observing a significant difference.

To confound the matter of comparing significant differences further, 7, 11, and 17 significant differences were tallied for total use during 1977, 1978, and 1979, respectively. This pattern clearly does not show a negative correlation between habitat selectivity and cumulative precipitation. With few exceptions, patterns of elk use did not markedly change from year to year.

An important point to recognize now and for later discussion is that Scott's data are not directly comparable to mine because the methods differed (he used pellet-group counts), and his study area was only the CSA, which is less than 15% of my study area.

Elk used a wide range of habitats; nevertheless, certain environmental situations were consistently avoided. During each year, elevations from 3800 feet to 4400 feet (1160-1340 m), lower slope positions, seral grass-forb types and pastures-hayfields, and PSME/VACA and PSME/SYAL habitat types were used significantly less than their occurrence. However, not all these situations were independent. For example, seral grass-forb areas, pastures-hayfields, and the habitat types were usually found at 3800-4400 foot elevations (1160-1340 m). These elevations were found mainly on the winter range, which was little used from spring through fall. Although yearly patterns of total habitat use were not markedly different, seasonal habitat use did vary and appeared to be influenced mainly by vegetation structure, composition, and phenology (Scott 1978).

Elevations from 5700 to 6200 feet (1740-1890 m) were significantly preferred during all years. During the dry year of 1977, this elevational range was used the most. During the moister years of 1978 and 1979, 5100-5600 foot (1550-1700 m) elevations were also selected for, with use about equal to that of the higher range. This pattern of yearly use no doubt reflects the availability of succulent forage as determined by precipitation. Elk consistently preferred 5100-5600 foot (1550-1700 m) elevations during the calving season. Use of other elevations in relation to this modal range was correlated with snow conditions. During 1977, the dry year, elk avoided lower elevations, probably because of the paucity of succulent forage, and used higher elevations that were snow-free. At the opposite extreme, during the moist year of 1978, elk were more restricted so that most of the elk were at or below the modal elevation. Precipitation was intermediate during 1979, and the distribution of elk use showed an intermediate pattern with elevations both lower and higher than the mode used. An opposite pattern of use in relation to precipitation was noted during the summer. Elevations from 5700 to 6200 feet (1740-1890 m) were selected for and used the most during each year.

However, the distribution of elk use around this mode was such that during the driest year, elk were primarily restricted to the modal range; but during 1978 and 1979, lower elevations were also preferred.

Spring-fall elk use was mainly on upper and mid-slopes, but neither were consistently preferred. Upper slopes of secondary ridges were primarily used. Scott (1978) found that elk in the CSA favored secondary upper slopes, and used mid-slopes about equal to their availability. Marcum (1975) found elk significantly preferred upper slopes and avoided mid-slopes. But, as Scott noted, upper slopes in Marcum's study area tended to be more gentle than the steep mid-slopes, which probably influenced elk distribution. Elk studied by Smith (1978) favored upper slopes during the summer and mid-slopes during the rutting and hunting seasons. Average use of upper and mid-slopes was found by Lonner (1975), whereas Biggins (1975) found upper slopes to be used less than their availability and mid-slopes to be used the most but not preferred. Low use of lower slopes was noted by Biggins (1975), Marcum (1975), Scott (1978), and Smith (1978). Chamberlain elk consistently avoided lower slopes. Use on ridgetops was lower than on upper or mid-slopes, but ridgetops were favored each year, especially during the fall. Primary ridgetops were mainly preferred. Scott (1978) reported a preference for ridgetops, but for secondary ridgetops. Marcum (1975) and Lonner (1975) did not find a preference for ridgetops.

On the basis of studies by Marcum (1975), Lonner (1975), and others, drainage bottoms and moist sites were recommended for protection by the Montana Cooperative Elk-Logging Study (1980). Zahn (1974) and Marcum (1975) found drainage bottoms preferred during spring through fall. Biggins (1975) and Smith (1978) reported them as important during the spring, and Lemke (1975) noted their importance during the summer. During my study, drainage bottoms were always used less than or equal to their availability, thus exerting little influence on elk distribution. Scott (1978) noted similar use of drainage bottoms in the CSA and said, ". . . the attractiveness of drainage bottoms appears to reflect the relative abundance of preferred forage species compared to surrounding areas, the accessibility of the drainage bottoms, and perhaps the presence or absence of cattle." Regarding the latter, Lonner (1975) found elk use of drainage bottoms to be below average in a drainage bottom where cattle grazed and where succulent forage was available in nearby wet meadows.

Chamberlain elk did not even show a preference for areas close to permanent and intermittent sources of water. Areas within 50 yards (45 m) of water or moist sites were used about equal to their occurrence, and areas from 50 to 150 yards (45-140 m) were used much less than their availability. Most elk were within 150-350 yards (140-320 m) of water. Scott (1978) reported a slight preference for areas in the CSA within 50 yards (45 m) of water and low use in the

50-150 yards (45-140 m) category.

However, water is abundant in the Chamberlain area; about 90% of the study area is within $\frac{1}{4}$ mile (400 m) of water, and about 40% is within 150 yards (140 m). Julander and Jeffrey (1964) and Lyon (1974) found little relationship between elk distribution and distance to water where water was abundant. Where water was less abundant, however, elk use was depressed in areas far from water (Mackie 1970, Marcum 1975). For comparison, Marcum found elk use of areas within 150 yards (140 m) of water to significantly exceed availability. Only about 16% of his study area was within 150 yards (140 m) of water. Thus, the availability of permanent and intermittent sources of water, and the succulent forage associated with them, will determine the importance of these sites for elk in a particular area.

Although no preference was observed for drainage bottoms or areas close to water, Chamberlain elk did prefer concave slope configurations, which are generally moister than the surrounding area, during the summer and fall. Drainage bottoms were one type of concave configuration, but swales were also included in this category. Swales are a concave configuration that Scott (1978) found preferred during July and August for their more succulent vegetation than surrounding areas. Lonner (1975) found significant use of swales and benches during the summer, but not in the fall. Elk preference for moist sites was also indicated by preference for the ABLA/CACA habitat type, which is typical of moist sites. We can say, then, that moist situations were preferred, but that watercourses were not the most important nor the only environmental situation that provided moist areas where succulent forage was available.

Elk were least selective with regard to aspect during 1978, more selective during 1979, and most selective during 1977. The year-to-year trend of cumulative precipitation was from highest to lowest during those years. The same aspects, however, were generally favored each year--only the magnitude of use changed. West, northwest, north, and northeast aspects were the most used and preferred aspects. Northeast aspects were significantly preferred during 1977 and 1979, but, during 1978, south aspects were selected for. Biggins (1975) reported preferences for southeast, south, north, and northeast aspects. During the calving season, Chamberlain elk favored northerly exposures, whereas Bohne (1974), Simmons (1974), Marcum (1975), and Lemke (1975) found their elk mainly on southwesterly exposures during calving season.

Chamberlain elk showed little preference for different canopy coverages. Spring-fall use was about equal to the availability of different canopy cover classes with exceptions. Open areas were avoided during 1978 and 1979, but were significantly preferred during 1977. The latter was a result of high use of clearcuts at the south end of the CSA during the summer. Scott (1978) observed elk in these clearcuts during August 1977 during 13 of 14 early morning and evening visits. Marcum (1975) found elk to avoid openings, but noted that 1-25% cover was preferred during wet years. He also found 1-25% cover to be important for feeding, whereas denser cover was chosen for resting.

Another exception from equal use and availability was the significant preference for dense and closed canopies during 1979, mainly during the rutting and hunting seasons. Although the fall of 1979 was no drier than 1977, the driest year, average daily maximum temperatures were higher than in previous years. Thus, elk may have sought cooler temperatures under dense canopies. A point in favor of this was the greater preference for higher elevations during the 1979 rutting season than during previous years. Most observers have reported a general increase in use of heavily timbered areas during the rut (Altmann 1956, Hash 1973, Bohne 1974, Simmons 1974, Biggins 1975, Lemke 1975, Lonner 1975, Smith 1978). This behavior was variously attributed to the need for denser security cover for rutting activities or the search for succulent forbs. If we discount the affect of weather during 1979, no such pattern was found with Chamberlain elk. In fact, moderate cover was used more during the rut than during the summer. Marcum (1975) and Scott (1978) also did not observe a shift in use to greater canopy coverages during the rut. Whether elk do or do not use greater cover during the rut is probably a function of its availability at elevations lower than those used during the summer. As discussed previously, elk generally used lower elevations more during the rut than during the summer. Where summer range consists of high elevation open parks, lower elevations would typically be more densely forested. In the Chamberlain Creek area the opposite situation occurs.

Scott (1978) found stands of medium to large size (4-8 inch [10-20 cm] dbh) lodgepole pine the most highly preferred tree stand type in the CSA during the summer. Stands of small to medium (less than 4 inch [10 cm] dbh) lodgepole pine were avoided at all times. My results did not indicate a consistent preference or avoidance of lodgepole pine. These stands were avoided during the spring, and summer and fall use was variable but not much different than availability. This discrepancy between Scott's and my data may be due to my lumping all lodgepole pine stands into one group, a necessary procedure because differences of 4 inches (10 cm) dbh were not detectable from aerial photographs.

I found mature-old, mixed species tree stands highly preferred. Yearly seasonal values were variable, but use always exceeded availability, except during the rut. Scott's (1978) results were quite different: mature stands were used less than their occurrence and old stands were preferred only during the spring and winter. His old successional stage consisted of primarily open stands of Douglas-fir. He attributed low use of mature stands to the low sight distance (less than 50 yards [45 m]) caused by dense tree regeneration and/or high shrub density in mature spruce-fir stands on the summer range. Lemke (1975) and Lonner (1975) reported similar results with respect to use of mature and old stands. Biggins (1975), however, found the greatest number of elk locations in open, mature and old (greater than 18 inch [45 cm] dbh) subalpine stands during the summer and fall. I found stands with both light-moderate and dense canopy cover preferred. Understory density, however, was not determined. The discrepancy between Scott's data and mine could be attributed to differences in the method of classification, or that his study area was restricted to the CSA, which did not include the entire range of elk in the Chamberlain area.

Scott (1978) also found young stands highly preferred during the summer. Preference was mainly for pole-size lodgepole pine stands, which he lumped with young mixed-species stands. I found use to about equal availability of pole-young stands, even if lodgepole pine stands and mixed species stands were combined.

Elk were consistent in their preference for mesic habitat types during each year. The ABLA/CACA type was the most preferred type, followed by ABLA/LIBO and ABLA/XETE-VAGL. PSME/CARU and ABLA/MEFE types were also preferred, but to a lesser degree. Marcum (1975) similarly found the mesic ABLA/GATR type (similar to ABLA/CACA) the most preferred habitat type in the Sapphire Mountains. Other studies have also found mesic habitat types to be the most preferred (Zahn 1974, Biggins 1975, Lonner 1975, Smith 1978). Scott (1978) observed no selection for habitat types in the CSA during a normal precipitation year, but during the dry year of 1977 he found that elk favored the mesic ABLA/CACA, ABLA/CLUN, and ABLA/MEFE types. During 1977, I found the ABLA/CACA type preferred, but not the ABLA/MEFE type. Marcum (1975) also found a greater selection for mesic habitat types during a dry year than during moist years. There was little evidence for such a pattern in my study; preferred types were favored nearly equally each year.

Chamberlain elk did not avoid open roads during the calving and summer seasons. However, most open roads during those seasons were only lightly traveled or not used at all, and the primary calving and summer ranges were not located in areas of heavy traffic. Lemke (1975) and Marcum (1975) also reported no avoidance of lightly traveled secondary and spur roads. Other studies, however, found elk to avoid areas within 0.25-0.5 mile (400-800 m) of all roads, including secondary and primitive roads (Hershey and Leege 1976, Perry and Overly 1976). Scott (1978) reported an avoidance of areas within 150 yards (140 m) of roads in the CSA, but noted that these roads were generally little used and were adjacent to dense cover that was avoided in unroaded parts of the CSA. During the rutting season, I found elk avoiding areas within 550 yards (500 m) of open roads. Most lightly traveled roads were closed after 1 September so that traffic was generally greater during that season on roads that were open. Elk did not appear to avoid the few open roads with light-moderate traffic; but, they avoided areas within 500 yards (500 m) of roads with heavy and very heavy traffic. The greatest negative response was observed during the hunting season when nearly 90% of the elk use was in areas farther than 1350 yards (1230 m) from all open roads. Roads closed during the fall were avoided, particularly during the hunting season. Avoidance of roads during the hunting season may have been due to hunters walking on roads. In contrast, Marcum (1975) reported a selection for closed roads.

Several studies have found that areas 220-440 yards (200-400 m) or more from open roads were avoided by elk (Perry and Overly 1976, Hershey and Leege 1976, Rost and Bailey 1979). Lemke (1975), however, reported no avoidance of open roads and found elk use within 0.5 mile (800 m) of primary roads to exceed availability. Ward (1976) found that logging and recreational roads had little affect on elk past 400 m, but even within 400 m elk became accustomed to constant traffic if passengers did not leave the vehicle. Nevertheless, he found elk reluctant to feed in meadows unless they were separated from the road by 100 m of dense timber. Highway traffic was found by Burbridge and Neff (1976) to have little affect on elk use of adjacent habitat; rather, they felt that slow moving vehicles on primitive roads would be a greater disturbance. Lyon (1979a) found a negative correlation between canopy cover adjacent to roads and the distance from roads in which elk use was depressed. From the available evidence it seems that elk use of areas near roads is a function of several factors: traffic volume, regularity, and speed; passenger behavior; density of cover adjacent to the road; length and type of experience with roads; and previous use of area by elk before roads were built.

Areas within 0.5 mile (800 m) of active logging and road building activities were consistently avoided by Chamberlain elk. Lyon (1979b) also found elk use depressed in areas of active logging activities, with elk retreating across topographic barriers. Undisturbed forest and long spans across undisturbed drainages were not as effective in reducing distances moved as were ridges. Nevertheless, Lyon also reported a return movement to logged areas on summer range once work was completely finished at the site, but said that the rate of return was adversely affected by the duration of logging and post-logging disturbance, and the distribution of active sites. Ward (1976) indicated a similar avoidance of logging operations, but also found elk moving back into the disturbed area 3 weeks after the logging was completed. Beall (1976) reported one group of elk returning after 3 weeks to an area of active logging on the winter range after the initial displacement. Marcum (1975), however, noted that these elk were not able to move long distances as snow was fairly deep, and that during the summer and fall elk were displaced by road building and logging at high elevations in major drainages. In contrast, Hershey and Leege (1976) reported no avoidance of a low intensity, short-term logging operation.

Although my results indicated an avoidance of human activity, much of the area remained undisturbed, particularly within the range of Lindbergh-Potter elk. Disturbance also could have been in areas that were normally not used much, thus elk use could have appeared depressed in adjacent areas. For example, the area where the new main-line road in the CSA was built was little used by elk before construction began, and the pattern of use did not change during construction.

Use of recently logged areas was substantiated. Most of those areas were well scattered, the duration of logging was usually short, and sites were generally interspersed with older, denser stands. Elk were often observed in these areas during the winter, calving season, and late fall.

Unlogged areas were preferred over logged areas, most of which were partial cuts, by Chamberlain elk during every season. This pattern of use, however, was probably a result of elk preferring mesic, high elevations that happened to be unlogged, rather than an avoidance of logged areas, which were mostly at low elevations. Evidence for this was shown by seasonal use of logged areas. During the calving season, when elk were at low elevations, use of logged and unlogged areas was nearly equal to availability. Use of logged areas decreased during the summer when elk sought high elevations, but then increased during the rutting season when elk dispersed from the main summer areas to moderate elevations. Later, during the hunting season, elk use increased in unlogged areas, probably in response to hunting pressure. Marcum (1975) found elk use of partial cuts on the spring-fall range to equal or exceed their availability.

Clearcuts were very highly preferred during the summer of 1977, but, during subsequent years use was about equal to availability. Elk favored clearcuts during the calving seasons of 1978 and 1979. They were observed to both feed and bed in the cuts at that time. Total spring-fall use of clearcuts, however, was about equal to availability. Recent studies have found an avoidance of clearcuts by elk (Biggins 1975, Marcum 1975, Hershey and Leege 1976). But, Edgerton (1972) and Day (1973) reported heavy use in clearcuts that produced a high volume of preferred forbs and shrubs or that were close to heavy timber cover, natural openings or mesic sites. Lyon (1975) said that the most important factor determining elk use in a clearcut was the level of use in surrounding areas. Lyon and Jenson (1980) noted that elk will use clearcuts because of their usually better forage, but their willingness to use clearcuts is tempered by feeding security, past experience in the area, size of opening, and slash depths.

Thus, particular clearcuts may be favored, depending on their location within the elk's seasonal range and the vegetation on them, while other cuts appear to be avoided. Chamberlain elk used clearcuts in the upper Fish Creek and upper Chamberlain Creek drainages more than clearcuts in lower Chamberlain Creek and Little Fish Creek. Scott (1978) observed little use in the clearcut in lower Chamberlain Creek and in the surrounding area as well. This cut did not produce abundant succulent forage as did the cuts at the upper end of the drainage. Scott summarized the evidence for elk use of clearcuts nicely: "clearcuts located within the normal summer range of elk, near heavy cover, and on moist sites apt to produce abundant succulent forage, are most likely to receive summer elk use, particularly if human access and slash depths are not excessive."

The importance of proper interspersion of cover and forage areas on summer range was stressed by Thomas (1979) in formulating guidelines for maintaining or increasing elk use in managed forests. Improper interspersion of forage areas, created by logging, and cover may be the reason Chamberlain elk did not use the Bear Creek drainage much. The majority of this drainage has been extensively logged by partial, seed tree, and clearcut methods so that few large stands of dense timber remain for cover. Elk were seldom seen in the main part of the drainage, but used partially logged areas on the drainage periphery, next to denser unlogged areas or old, regenerated cuts.

CHAPTER VI

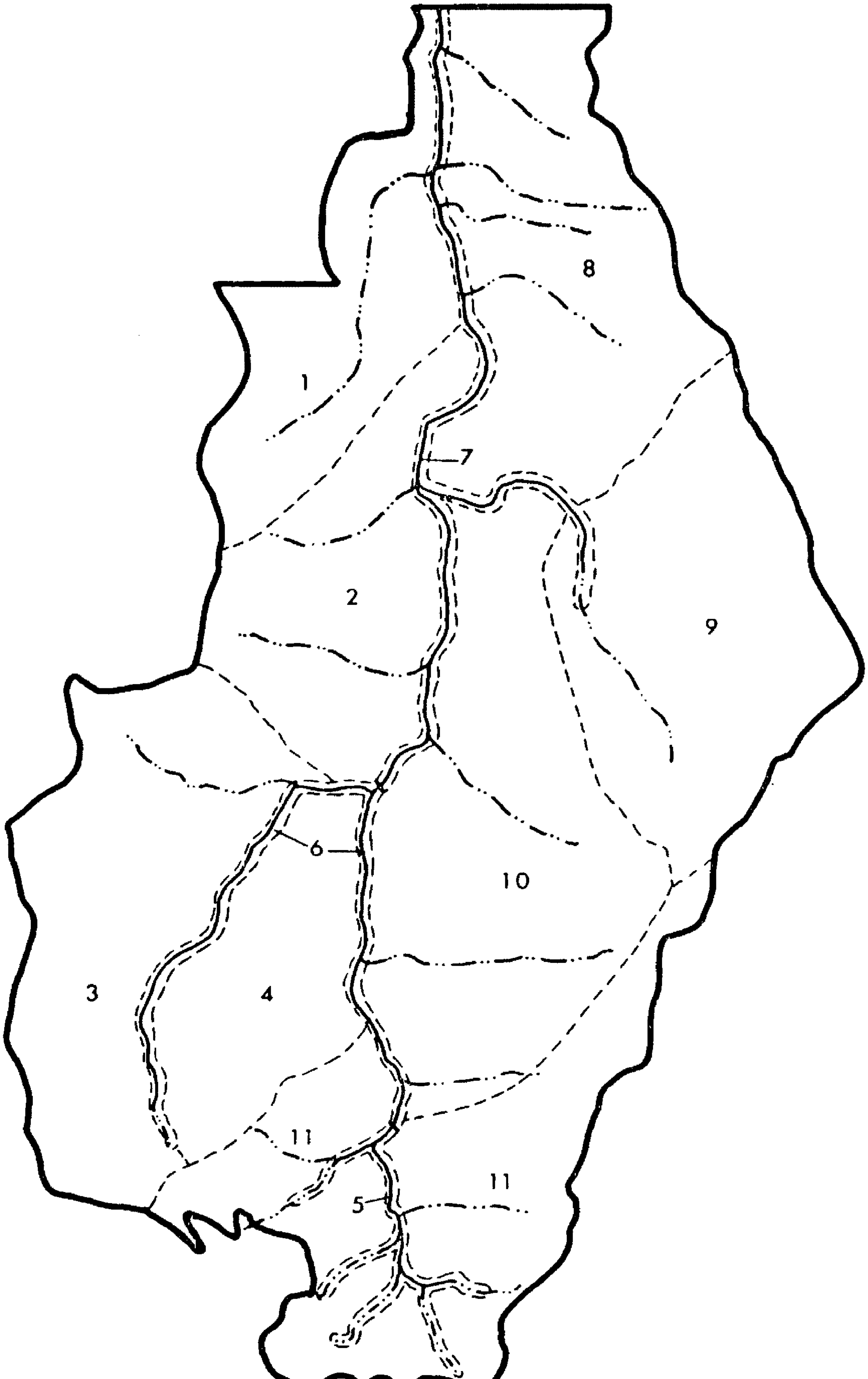
MANAGEMENT RECOMMENDATIONS

Scott (1978) provided a good analysis of the probable effects of the planned logging activities in the CSA based on his pellet-count surveys. He discussed the affect of both habitat change and disturbance on elk use.

The CSA was the center of spring-fall activity for the majority of Grace's Landing elk, whereas Lindbergh-Potter elk activity was centered more to the west of the CSA. Consequently, Grace's Landing elk will be more affected by the planned logging in the CSA than will Lindbergh-Potter elk. Pellet counts reported by Marcum and Lehmkuhl (1980) and my radio locations both indicated greater use of the CSA by all elk during dry years than during moist years. Also, elk were restricted in their summer movements to a smaller elevational and size range during dry years. Thus, elk are more likely to be affected by logging activities during a dry year such as 1977 than during a moist year.

Logging in Subunit 8 will have a greater impact on Grace's Landing elk than will logging in Subunits 1 or 9 (Fig. 23). Subunit 8 has considerable habitat diversity, with good interspersion of cover

Fig. 23. Map of CSA subunits.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and forage. Logging will not improve this situation. The location of centers of activity show that this area is particularly important during the rutting season, followed by calving season and summer. But, even though few activity centers were located in proposed cutting units during the summer, the range of elk activity was large enough to include most of these areas.

Elk use in Subunit 8 will no doubt be depressed during logging and for some time in the future. Grace's Landing elk will probably make greater use of Subunit 9 during and after logging, and possibly areas to the north and west of Blacktail Mountain. These areas should, therefore, be protected from disturbance. Subunit 1 was the most important area during the calving season. For this reason, I suggest that logging be delayed there until after June 15. Elk use may increase in this area during the summer if it is not logged concurrently with Subunit 8. Marcum and Lehmkuhl (1980) found this area to be little used, so it will be interesting to see if elk use it more during and after logging than before.

Lindbergh-Potter elk predominantly used the CSA during the summer. Calving activity was concentrated in the upper Fish Creek drainage, and summer activity was centered in Subunit 3. The northern part of this subunit's western boundary lies along several major crossing points for elk moving into and out of the CSA. Antici-pated logging and road traffic will likely preclude normal use of these passes and affect elk distribution during the late spring and summer. Habitat changes from logging, however, will probably not be detrimental in the long run. Logging will break up the extensive, dense forest cover and provide for better interspersion of cover and forage. Results of my study showed mature-old, mixed species stands preferred, and several mature-old stands will be cut in Subunit 3. However, Scott (1978) found this type of stand to be used less than its availability because of a dense understory. Logging activity will clear some of this understory and make the area more accessible. Also, use of mature-old stands was not so high that the loss of some stands could not be compensated for by better cover/forage interspersion and protection of nearby mature-old stands.

Elk will probably use the area west and southwest of Subunit 3 if logging occurs during the summer. Summer activity in the eastern part of Subunit 11 will likely affect movements of Lindbergh-Potter elk that use the head of Wales Creek, as Cutting Unit 8 is situated on the crossing point for these animals.

The overall impact of logging in the CSA should not be particularly detrimental to elk if the previous scheduling recommendations are followed, logging activity is completed as quickly as possible and roads are subsequently blocked, road-building and logging slash is adequately disposed of, cattle are excluded from the area, and no logging is allowed during the hunting season. In addition to recommendations of the Montana Cooperative Elk-Logging Study (1980), an effort should be made to avoid placing roads or cutting units on benches (particularly moist benches), swales, and ridgelines of "finger" (1st order) ridges (Scott 1978).

CHAPTER VII

SUMMARY

Elk movements and habitat selection were studied from May through November during 1977, 1978, and 1979. Thirty-one elk, equipped with radio-transmitter collars, were located a total of 979 times from an airplane. Seasonal and total home range areas, average distance moved between successive locations, and standard diameters were calculated for cows. Cows were also radiotracked from the ground for 7 24-hour periods to determine diel movements and areas used. Seasonal habitat use and relationships to timber harvest activities were determined by analyzing elk locations from topographic maps, aerial photographs, and field observations. Habitat selection was determined by statistically comparing proportions of elk use with proportions of habitat availability. Habitat availability was measured by analyzing habitat features of randomly selected locations in the study area in a manner similar to that of elk locations.

Two distinct groups of elk used the study area. Elk trapped at the Lindbergh and Potter traps used an area of about 70 square miles (181 km^2). These elk ranged primarily in the southern part of the Chamberlain Creek Core Study Area (CSA), in the Fish Creek, Little Fish Creek, and Bear Creek drainages, and on the Lubrecht Experimental Forest. Elk trapped at the Grace's Landing Trap predominantly ranged in the area north of the CSA, in the Chamberlain Creek drainage, and in the northern half of the CSA. Their total home range was about 30 square miles (78 km^2). Very little mingling of elk from the 2 groups was noted, and, with few exceptions, a remarkable fidelity to group home range boundaries was observed.

The CSA was of significant importance to Chamberlain elk. Spring-fall use was significantly greater than availability during all 3 years. The year-to-year trend in total use appeared to be related to yearly differences in cumulative precipitation and its influence on plant phenology. Use of the CSA was highest during 1977, an extremely dry year, and lowest during 1978, the wettest year. Elk use during 1979 was intermediate to that of 1977 and 1978, as was precipitation. Some seasonal variation in CSA elk use was similarly explained in relation to precipitation. Summer use was significantly greater than availability for all 3 years, and followed a year-to-year pattern similar to that of total use in relation to precipitation. However, use during 1979 was lower than during 1978. This divergence from the expected pattern was the result of near-normal precipitation until early summer during 1979.

The distribution of centers of activity indicated the seasonal importance of several locations. The upper Fish Creek drainage was the center of calving activity for Lindbergh-Potter elk. The combination of south-facing, partially logged, open slopes and adjacent heavy timber seemed to make this an attractive area. The northern half of the CSA was important to Grace's Landing elk during the calving season. During 1977, when conditions were dry and snowmelt early, these elk moved farther into the CSA than during subsequent years when cumulative precipitation during the calving season was closer to normal.

The distribution of centers of activity was more dispersed during the summer than during the calving season. The west side of the CSA and the adjacent drainage heads of Fish and Bear creeks were heavily used. On the north side of the CSA, most activity was centered in the vicinity of Grace's Landing and near the northern border of the CSA.

During the rutting season elk ranged widely, generally dispersing from areas of summer use. The Baldy Mountain-Bata Mountain area, the northeast part of the CSA, and the Blacktail Mountain area were general areas of concentration.

Activity centers were more grouped during the hunting season than during the rut. The upper Fish Creek, Bear Creek, and Chamberlain Creek drainages, and the northwest and northeast parts of the CSA were important areas. Most activity centers were at least 2 miles (3.2 km) from the nearest hunter access point, and were in or near dense forest.

Bull elk were not monitored closely because they ranged far to the east of the study area. Also, success was dismal with respect to locating bulls for an entire season because of natural and human-caused mortality, erratic movements, or radio transmitter failures.

The average total home range size for individual elk averaged 14.9 square miles (38.6 km^2). The largest mean home range occurred during the rutting season, followed by summer, hunting season, and calving season. Seasonal home range sizes varied considerably among individual elk. Average distance moved between successive locations did not vary greatly from year-to-year or seasonally. The mean value for all 3 years was 1.8 miles (2.9 km). The overall mean standard diameter was 4.2 miles (6.7 km). The highest value occurred during the rutting season, followed by summer and hunting season (equal values), and calving season.

Radiotracking for 24-hour periods was of limited success because of problems with signal bounce and lack of suitable tracking locations. The area used during a 24-hour period averaged 0.44 square miles (1.1 km^2). The shape of the area used was related to the topography of the area. Movements were confined to rectangular areas where topography had a linear quality, e.g., moderately steep, parallel ridges flanking a drainage bottom. Areas used were more square where topography was gently undulating.

Chamberlain elk used virtually all available habitats at some time during spring through fall. Certain environmental situations, however, were consistently avoided. During each year, elevations from 3800 to 4400 feet (1160-1340 m), lower slope positions, seral grass-forb types, pastures-hayfields, and PSME/VACA and PSME/SYAL habitat types were used significantly less than their occurrence. However, not all these situations were independent, as seral grass-forb types, pastures-hayfields, and the habitat types were usually found at 3800-4400 foot (1160-1340 m) elevations. This elevational range occurred on the winter range, which was little used during spring-fall.

During spring-fall, elk consistently preferred 5700-6200 foot (1740-1890 m) elevations. Elk were mainly found at this range of elevation during the dry year of 1977; whereas, during the subsequent wetter years, 5100-5600 foot (1550-1700 m) elevations were also preferred. During the calving season, 5100-5600 foot (1550-1700 m) elevations were consistently selected for. Ridgetops were significantly preferred during 1978 and 1979, but most of the use during all years was on upper and mid-slopes. Drainage bottoms were not selected for. Concave slope configurations along the contour were usually preferred. Most elk were located on gentle slopes, but no selection for slope steepness was noted. Northeast aspects were overall the most preferred, but south slopes were also favored during the wettest year, 1978. Elk use was also high on west and northwest aspects. Distance to water did not influence elk distribution, as no selection was observed for areas close to water. However, this was not too surprising as 90% of the study area was within $\frac{1}{4}$ mile (400 m) of water.

Chamberlain elk showed little preference for different canopy coverages. Spring-fall use was about equal to the availability of different canopy cover classes, with a few exceptions. Open areas were selected for during 1977. This was attributed to the high use of clearcuts at the south end of the CSA during the summer. Also, dense (75-95%) and closed (95%) cover classes were selected for during 1979. Most of the use in these cover classes occurred during the fall, which was unusually warm and dry. During the other years, elk did not favor denser cover more during the rut than during the summer, as reported in other studies.

Most elk were located in pole-young, mixed species stands, but these stands were neither favored nor avoided. Mature-old, mixed species stands were highly preferred each year. Mesic habitat types were consistently favored. The ABLA/CACA type was the most preferred, followed by the ABLA/LIBO and ABLA/XETE-VAGL types. PSME/CARU and ABLA/MEFE habitat types were also preferred, but to a lesser extent.

Elk did not avoid open roads during the calving and summer seasons. Most of these roads, however, were lightly traveled. During the rutting season, elk avoided areas within 550 yards (500 m) of open roads. Traffic was generally moderate to heavy during this season, as most of the lightly traveled roads were closed to public access on 1 September. The greatest negative response to open roads was observed during the hunting season, when 90% or more of the elk locations were in areas farther than 1350 yards (1230 m) from open roads. Areas within 150 yards (140 m) of roads closed after 1 September were consistently avoided. This may have been caused by hunters walking on these roads during the hunting season, but the avoidance observed during the rutting season was unexplained.

Elk avoided areas within 0.5 mile (0.8 km) of active human disturbance such as logging and road building activities. Areas of disturbance were small, however, and the frequency of activity was intermittent. Better data will be available from subsequent studies when human activity in the study area will be more widespread and sustained.

Logged areas, other than clearcuts, appeared to be avoided, whereas unlogged areas appeared to be highly preferred. This pattern of use, however, was probably a result of elk preferring mesic, high elevations that happened to be unlogged, rather than an avoidance of logged areas, which were mostly at low elevations.

The overall impact of planned logging in the CSA should not be particularly detrimental to elk if recommendations mentioned in Chapter VI are followed. The greatest long-term negative impact will occur in Subunit 8 as a result of habitat changes in this highly used area. The potential for a high short-term negative impact is greatest in Subunit 3, as several major crossing points into adjacent drainages occur there, and summer use is very high.

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