Distribution, movements, and habitat use during spring, summer, and fall by mule deer in the north Salish Mountains, Montana

by Bret Jeffrey Stansberry

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
This study was conducted in the north Salish Mountains of northwest Montana during summer 1988 and spring, summer, and fall 1989 to determine deer distribution, movements, and habitat use in relation to environmental variables. Three tentative population-habitat units (PHUs), distributed in relation to winter ranges, were delineated. PHU 1 was 165.3 km^2, PHU 2 was 10.6 km^2, and PHU 3 was 13.9 km^2 . The winter range on PHU 1 was divided into 3 sub-units based on winter relocations of radio-collared deer. Deer with indistinct seasonal ranges (ISR) made up 31.5% of all radio-collared deer, deer with adjacent seasonal ranges (ASR) accounted for 16.7%, and deer with distinct seasonal ranges (DSR) comprised 51.9%. In addition to summer and winter home ranges, accessory areas were used by deer during spring and fall. Mean date of departure from winter range was earlier in 1988 than 1989 and mean date of return to winter range was later in 1988 than in 1989. All 54 radio-collared deer showed high fidelity to seasonal ranges. Summer home range size decreased significantly from 2.7 km^2in 1988 to 1.2 km^2 in 1989 possibly due to abundant precipitation and increased forage production. Lodgepole pine and mixed conifer were cover types used most heavily in spring, summer, and fall by radio-collared deer. In contrast to ISR and ASR deer, DSR deer made extensive use of sub-alpine fir cover types. Use of cover types by 5 deer occupying fall accessory areas shifted from ponderosa pine and mixed conifer to lodgepole pine and sub-alpine fir. South to west aspects were used most heavily by all deer. ISR deer used steep slopes most often, while ASR and DSR deer used moderate slopes. Comparison of plant phenology stages and deer movement indicated deer used areas as plants became green in the spring or stayed green in the fall.

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APPROVAL

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Bret Jeffrey Stansberry

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

This study was conducted in the north Salish Mountains of northwest Montana during summer 1988 and spring, summer, and fall 1989 to determine deer distribution, movements, and habitat use in relation to environmental variables. Three tentative population-habitat units (PHUs), distributed in relation to winter ranges, were delineated. PHU 1 was 165.3 km^2, PHU 2 was 10.6 km^2, and PHU 3 was 13.9 km^2. The winter range on PHU 1 was divided into 3 sub-units based on winter relocations of radio-collared deer. Deer with indistinct seasonal ranges (ISR) made up 31.5% of all radio-collared deer, deer with adjacent seasonal ranges (ASR) accounted for 16.7%, and deer with distinct seasonal ranges (DSR) comprised 51.9%. In addition to summer and winter home ranges, accessory areas were used by deer during spring and fall. Mean date of departure from winter range was earlier in 1988 than 1989 and mean date of return to winter range was later in 1988 than in 1989. All 54 radio-collared deer showed high fidelity to seasonal ranges. Summer home range size decreased significantly from 2.7 km^2 in 1988 to 1.2 km^2 in 1989 possibly due to abundant precipitation and increased forage production. Lodgepole pine and mixed conifer were cover types used most heavily in spring, summer, and fall by radio-collared deer. In contrast to ISR and ASR deer, DSR deer made extensive use of sub-alpine fir cover types. Use of cover types by 5 deer occupying fall accessory areas shifted from ponderosa pine and mixed conifer to lodgepole pine and sub-alpine fir. South to west aspects were used most heavily by all deer. ISR deer used steep slopes most often, while ASR and DSR deer used moderate slopes. Comparison of plant phenology stages and deer movement indicated deer used areas as plants became green in the spring or stayed green in the fall.

INTRODUCTION

Recent studies in mountain and mountain-foothills habitat of southwestern Montana (Pac et al. 1991) have indicated that mule deer ecology varies widely depending on the specific habitat complexes present. Also patterns of habitat use often differ among individual deer in the same population. In northwestern Montana, mule deer occupy a variety of coniferous forest habitats managed intensively for timber production. Little is known about mule deer ecology in these habitats, especially in relation to timber and habitat management.

Although mule deer have been studied extensively in mountain-foothill environments, few studies have been conducted in coniferous forest environments similar to northwest Montana. Bailey (1960) and Fairman (1966) studied winter movement and distribution in the Rattlesnake drainage in west-central Montana. Knoche (1967) studied the ecology of the Rattlesnake winter range. Yeager (1984) studied use of cover on winter range on the Flathead Indian Reservation in west-central Montana. Simpson (1988) studied seasonal distribution in south-central British Columbia.

My study was established to provide baseline information on mule deer ecology in the north Salish Mountains. Specific objectives were to determine spring, summer, and fall distribution and habitat use. Relationships between migration behavior and plant phenology were also established. Research was conducted during summer 1988 and spring, summer, and fall 1989.

STUDY AREA

The study area was located along the northwest flank of the Salish Mountains approximately 80.5 km northeast of Libby, in Lincoln County, Montana (Fig. 1). The area encompassed approximately 446 km^2, within the Rexford Ranger District of the Kootenai National Forest. Boundaries were Pinkham Creek on the north and east, Tenmile Creek on the south, and Lake Koocanusa on the west.

Geologically, the study area is underlain by strata from the Belt Super Group of the late Precambrian age (Johns 1970). This portion of the Salish range was created by faulting and folding during the Late Cretaceous to Early Tertiary ages and is characterized by north-northwest trending folds in the Belt sediments. The area was completely covered by the Cordilleran ice sheet except for the higher peaks. Elevations range from 744 m along the shore of Lake Koocanusa to 2,131 m at the top of McGuire mountain.

Topographically, the study area was comprised of 2 distinct zones (Fig. 2). From lake level to about 1,524 m, the area is characterized by very steep, broken terrain, including steep cliff faces and talus slopes. This terrain

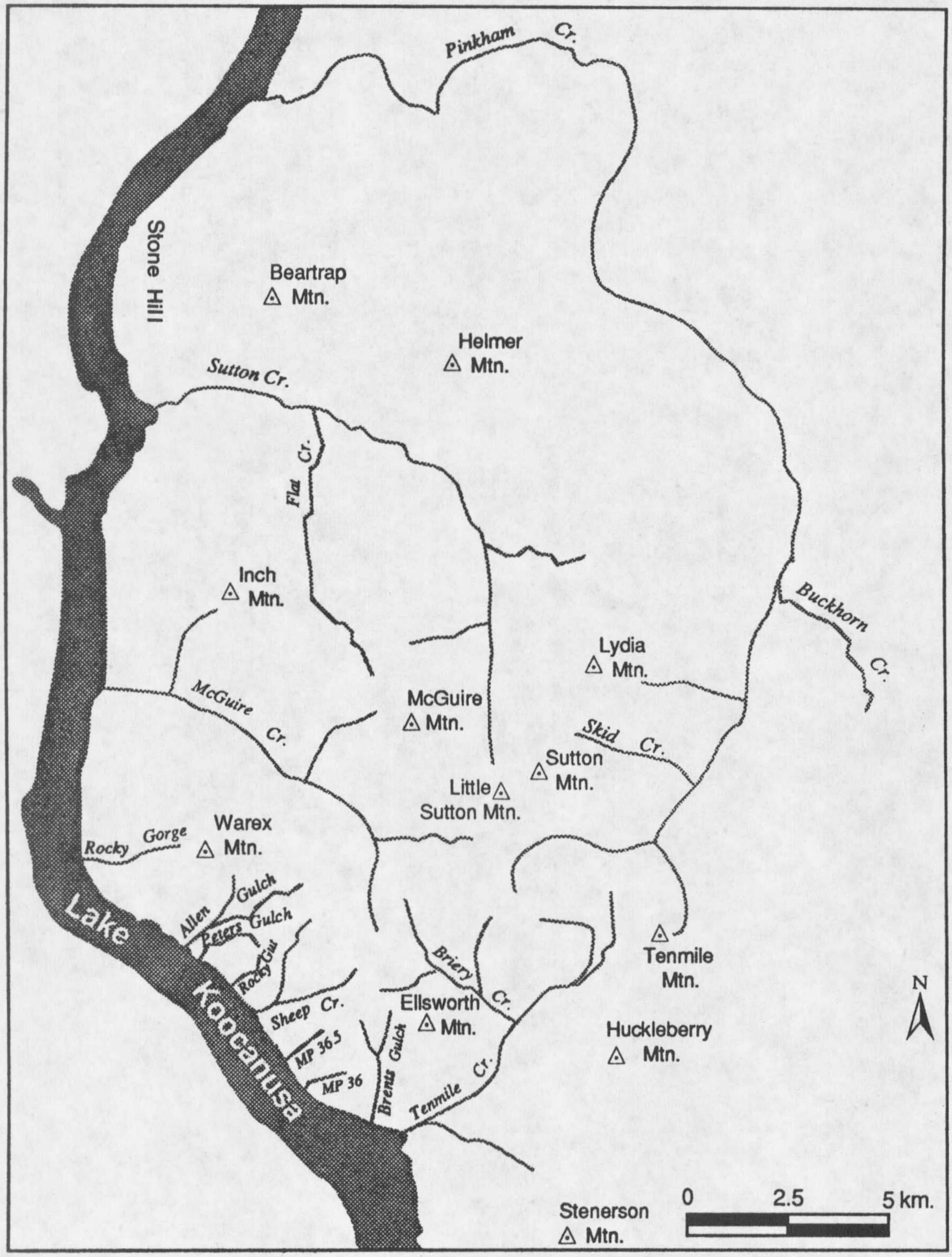

Figure 1. Map of north Salish Mountains study area showing major drainages and topographic features.

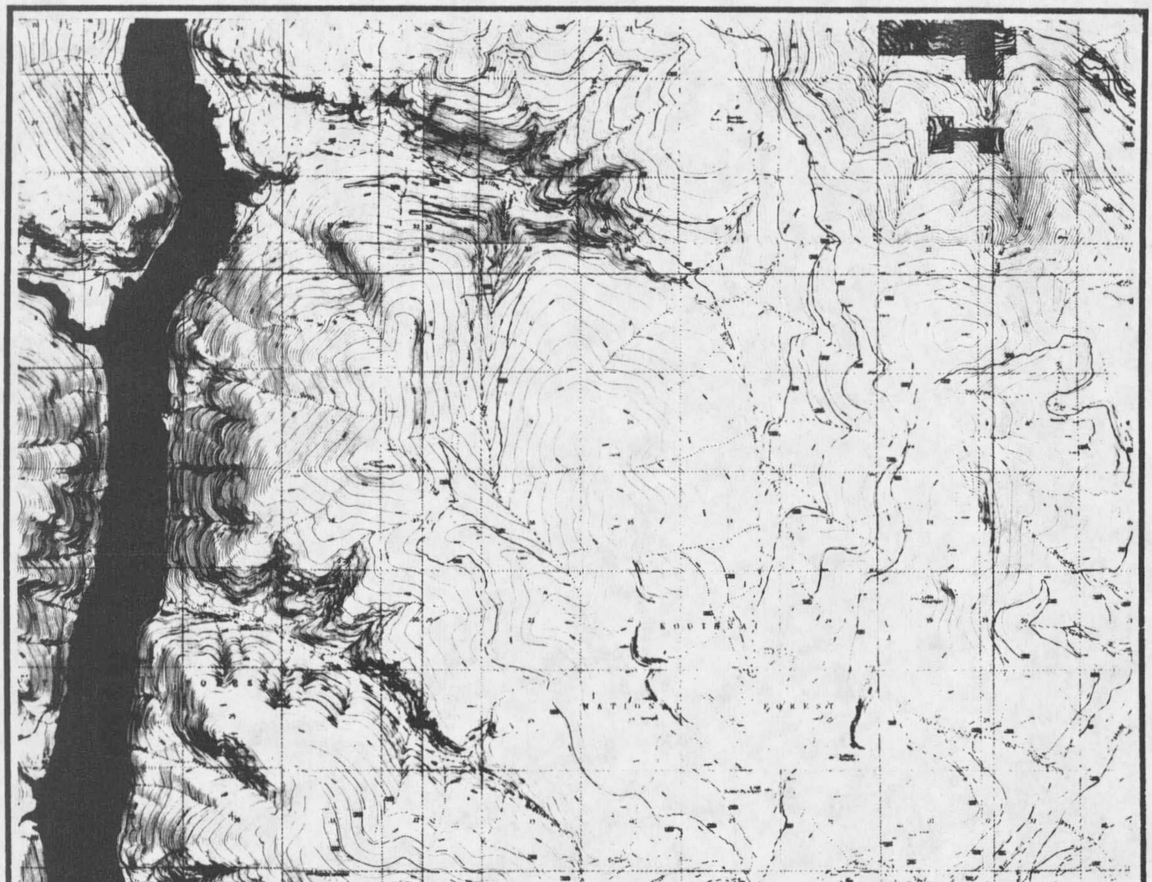

Figure 2. Contour map of north Salish Mountains study area illustrating 2 topographic zones.

provided a diversity of mesic microsites where green vegetation persisted throughout summer and often into fall. The Stone Hill area was also terraced, with some terraces being very mesic and sustaining lush vegetation much longer than adjacent areas. Above 1,524 m, in the interior of the study area, the terrain becomes less broken and steep with gentle slopes extending to ridgetops. These gentle slopes lacked topographic variation of lower areas and fewer mesic microsites occurred.

The study area lies in the path of coastal, maritime weather patterns that bring moderate temperatures and relatively abundant precipitation during all seasons. The nearest weather station at Eureka usually received less precipitation than much of the study area (National Oceanic and Atmospheric Administration 1988-89). Annual precipitation at the station ranged from 30.8 cm in 1988 to 51.9 cm in 1989 (Table 1). Total snowfall was 70.3 cm in 1988 and 83.8 cm in 1989. Annual temperature averaged about 8.1C in 1988 and 7.2C in 1989. During 1988, the annual temperature was 1.1C above the long term mean; total precipitation was 17.8 cm below mean. During 1989, annual temperature was slightly above the long term mean and precipitation was about 1 cm above normal.

Snowpack water content relative to normal at 3 Soil Conservation Service (SCS) snowcourse sites, located approximately 15.3 km southwest of the study area, is shown

Table 1. Mean monthly temperature (C), precipitation (cm), and snowfall (cm) during 1988 and 1989, Eureka Ranger Station (U.S.D.A. Soil Conservation Service).

	1988			1989		
Month	Temp.	Ppt.	Snow	Temp.	Ppt.	Snow
J	-7.4	1.68	18.0	-3.8	3.58	38.1
F	-0.3	0.89	7.1	-8.7	2.67	30.5
M	4.6	3.23	6.9	1.1	4.93	3.0
A	9.4	2.00	T[a]	9.1	3.20	0
M	13.2	4.83	0	12.8	4.85	0
J	17.9	4.55	0	17.8	1.85	0
J	19.7	1.42	0	20.4	5.54	0
A	19.3	1.07	0	17.2	11.20	0
S	13.7	2.97	0	13.1	2.36	0
O	8.2	2.24	0	7.0	3.56	0
N	2.8	2.29	1.5	2.9	5.44	1.3
D	-3.9	3.61	36.8	-3.1	2.69	10.9
Annual	8.1	30.76	70.3	7.2	51.87	83.8

[a]T = Trace

in Table 2. These sites, which are vegetatively, elevationally, and topographically similar to summer range on the study area, had much below normal snowpacks during both years, but especially in 1988. Banfield Mountain was also a Snowtel site where date when snowpack became permanent, date of melt-out, and total annual precipitation were recorded. In 1988, snowpack became permanent on November 14 and melt-out occurred May 17. During 1989, snowpack became permanent on November 4 and melt-out was June 4. Total precipitation was 73.4 cm for 1988 and 97.3 cm for 1989 (Table 3). The total for 1989 was much closer to the long term mean than that for 1988.

Table 2. Monthly snowpack water equivalents(cm) and departures from normal(cm) on three Soil Conservation Service snowcourses near the study area, January-May, 1988 and 1989 (U.S.D.A. Soil Conservation Service).

		1988		1989	
Month	Location	SWE	Departure	SWE	Departure
Jan	Banfield[1]	27.1	-47.8	37.4	-37.4
	Bristow[2]				
	Lost Soul[3]				
Feb	Banfield	33.6	-73.6	82.6	-24.5
	Bristow				
	Lost Soul				
Mar	Banfield	69.7	-64.5	92.9	-41.3
	Bristow	34.8	-32.9	46.5	-21.3
	Lost Soul	58.7	-35.5	76.8	-17.4
Apr	Banfield	98.1	-54.8	126.4	-26.4
	Bristow	38.7	-23.2	58.1	-3.9
	Lost Soul	65.8	-35.5	93.5	-7.7
May	Banfield	72.3	-49.7	107.1	-14.8
	Bristow	0	-5.2	0	-5.2
	Lost Soul	15.5	-18.7	51.6	+17.4

[1]Elevation=1700 m

[2]Elevation=1190 m

[3]Elevation=1460 m

The study area was largely timbered and timber production was the primary land use. However, cattle were grazed on 1 allotment along Pinkham Creek. Other big game species also occurred on the study area. Bighorn sheep (Ovis canadensis) were present along the face above the reservoir and shared winter range with mule deer. Elk (Cervus elaphus) were most highly concentrated on Stone Hill and the Skid Creek/Sutton Creek divide. Moose (Alces alces) were distributed across the entire study area. White-tailed deer (Odocoileus virginianus) were present in small numbers, mostly along riparian areas. Black bear (Ursus americanus) were distributed across the study area in low numbers.

Table 3. Monthly precipitation(cm) at the Banfield Mountain Snowtel site during 1988 and 1989 compared with the 1961-85 mean (U.S.D.A. Soil Conservation Service).

Month	1988	1989	1961-85
J	7.62	14.48	14.48
F	6.60	6.60	10.92
M	14.73	12.70	9.65
A	10.16	6.10	6.86
M	3.05	9.14	6.35
J	4.83	3.56	7.37
J	3.05	3.81	4.06
A	1.02	9.40	3.56
S	4.32	2.54	4.32
O	0.51	4.06	5.84
N	5.59	16.51	10.41
D	11.94	8.38	13.72
Total	73.41	97.28	97.54

Habitat types in the study area have been described and mapped (U.S.F.S. unpubl.) following Pfister et.al.(1977).

From this, vegetation of the area can generally be categorized within 4 broad coniferous tree cover types:

Ponderosa pine/Douglas fir type. - This type occurred along the lake shore up to an elevation of about 1,036 m. Ponderosa pine (Pinus ponderosa) was the major overstory species with Douglas fir (Pseudotsuga menziesii) below. Common shrubs included common snowberry (Symphoricarpos albus), Saskatoon serviceberry (Amelanchier alnifolia), and bearberry (Arctostaphylos uva-ursi). Bluebunch wheatgrass (Agropyron spicatum), rough fescue (Festuca scabrella), and pinegrass (Calamagrostis rubescens)were important grasses, while western yarrow (Achillea millefolium), silky lupine (Lupinus sericeus) and various asters (Aster spp.) were common forbs.

Douglas fir type. - This type occurred at elevations up to about 1,585 m, usually on north-facing slopes. Douglas fir was the major overstory species with some mixing of ponderosa pine and western larch (Larix occidentalis). Common snowberry and bearberry were dominant shrubs. Pinegrass was the predominant grass; rough fescue was less common. Western yarrow, heartleaf arnica (Arnica cordifolia), and woodrush pussytoes (Antennaria luzuloides) were common forbs throughout, while silky lupine occurred in areas with more open canopies.

Lodgepole pine type. - This type had a lower limit of approximately 1,585 m elevation, but extended to the highest point on the study area on McGuire mountain. Lodgepole pine (Pinus contorta), the dominant species in the overstory, probably is seral, originating with large fires that occurred from 1910 to 1920. During 1940-1977, 69 additional small fires were recorded mostly on the winter range segment (Brown 1979). Western larch was numerous in the overstory of most lodgepole pine stands. Sub-alpine fir (Abies lasiocarpa) occurred as small saplings in all stands. Common shrubs were grouse whortleberry (Vaccinium scoparium), sitka alder (Alnus sinuata), and bearberry toward the lower limits of the type. Pinegrass was the most common grass. Elk sedge (Carex geyeri) was locally common. Common forbs were heartleaf arnica, mountain arnica (Arnica latifolia), and glacier lily (Erythronium grandiflorium). Silky lupine was also common in areas with open canopies.

Sub-alpine fir/Engelmann spruce type. - This type has a lower limit of 1,676 m on south-facing slopes and 1340m on north-facing slopes. Sub-alpine fir usually occurred with Engelmann spruce (Picea engelmannii), but was sometimes found in pure stands. Common shrubs were menziesia (Menziesia ferruginea), sitka alder, and grouse whortleberry. Beargrass (Xerophyllum tenax), both species of arnica, twinflower (Linnaea borealis), and queencup bead-lily (Clintonia uniflora) were common forbs. Common grasses were pinegrass and elk sedge.

In addition to the major types, small, isolated stands of western redcedar (_Thuja plicata_) and western hemlock (_Tsuga heterophylla_) occurred throughout the study area.

METHODS

Movements, Distribution, Habitat Use

Clover traps were used to capture and mark 106 mule deer on 9 different sections of winter range during 1987-1989 (Appendix Table 15). During January - May 1987, 16 deer were captured. Seven were equipped with radio collars and the others were marked with individually recognizable, 10-cm-wide vinyl neckbands. Twenty-five deer were captured during winter and spring of 1987-88. Of those, 20 were fitted with radio collars and the remainder were neckbanded. Intensified trapping effort during winter and spring 1988-89 resulted in capture of 67 deer. Thirty-two were radio-collared, 13 were neckbanded, and 22 were marked only with ear tags.

Due to the large variation in movement strategies by individual deer, standard calendar dates were not used to describe seasons. A plot of each individual's yearly home range was analyzed and seasonal home ranges were logically delineated. Home ranges described as summer ranges were often occupied during spring and fall as well; resident deer were described as having no specific seasonal ranges.

Movements, distribution, and habitat use during spring, summer, and fall were determined by aerial and ground monitoring of radio-collared deer. Aerial monitoring was accomplished using a Piper SuperCub aircraft with a belly-mounted antenna.

Deer equipped with transmitters during winter - spring 1987 were located from the air once or twice monthly by MDFWP personnel until June of 1988. From June through mid-September 1988, I continued the relocations bi-monthly. During September 1988-March 1989, MDFWP personnel resumed aerial relocations once or twice monthly. In early spring and late fall 1989, I increased the frequency of aerial relocations to 4 times a month to intensively monitor spring and fall migration patterns and to determine transitional range areas. During summer 1989, aerial monitoring was bi-monthly as in summer 1988. Additional locations were obtained by periodically walking in on each radio-collared deer at least once each month. Some deer were visited 2-3 times per month.

Data recorded for each observation included time, Universal Transverse Mercator (UTM) coordinates, elevation, aspect, slope, habitat components, and weather conditions. Group size, composition, and activity were recorded for visual observations. For analysis, aerial and ground locations were combined for each year and season. Relocations were analyzed using the TELDAY computer program (Lonner and Burkhalter 1986) to calculate home range sizes, average activity radii (AAR), and geographic activity centers (GAC). Analysis of variance (ANOVA) and 2-sample *t*-tests (Lund 1989) were used to compare home range sizes and AAR. Differences in mean distances travelled between seasonal ranges were also evaluated with a 2-sample *t*-test.

Habitat Analysis

Habitat types (Pfister et al.1977) were not representative of existing vegetation on portions of the study area. Because of this, vegetation cover type maps developed for the U.S. Forest Service by Big Sky Resource Analysts (unpubl.) of Kalispell were used in habitat type analyses. Those maps plotted vegetation in management compartments as stands ranging from 3 to 300 acres in size. Given the small number of observation points for each radio-collared deer and the possibility of some degree of error in locations, especially under timber canopies, I used more generalized maps that combined stands with the same predominant overstory species. Topographic measures, including slope, aspect, and elevation, used in habitat analysis were mapped from U.S.G.S. topographic maps.

Availability of cover types was determined by calculating percent occurrence of each type in areas sampled. Availability of slope, aspect, and elevation was determined by using a random sampling technique (Marcum and Loftsgaarden 1980). Observed use of cover types, slope, aspect, and elevation was the number of relocations in each type or category. Tests for selection or avoidance of types or categories was conducted using chi-square goodness-of-fit tests following Byers et al. (1984).

Plant phenology was recorded only during the spring and summer of 1989. Sites for measurement of phenology were selected according to elevation, aspect, and habitat/cover type. An attempt was made to sample different combinations of these 3 site factors on or near the home ranges of individual deer. Location of sites and the number of times each was visited are presented in Appendix Table 16. When a site was visited, I recorded major species, average stage of phenology, and any evidence of usage by deer. Stages were: early leaf, full leaf, flower bud, full flower, seedhead, or dormant (Pac 1976).

RESULTS

Distribution, Movements, and Home Ranges

Population-Habitat Units

The deer inhabiting the study area were distributed among 3 tentative population-habitat units (PHUs) (Fig. 3). A PHU was "a rather discrete association of individual deer bonded together by traditional use of individual home ranges within a definable unit of yearlong habitat" (Pac et al. 1991). The winter range of each PHU was the nucleus of the unit. From there deer distributed themselves through migration to the boundaries of each PHU. Winter ranges for all units were very steep and topographically diverse. Summer ranges of migrants were more gentle and less varied.

PHU 1 spanned 165.3 km^2 and was used by 42 radio-collared deer. Yearlong, the unit encompassed upper McGuire Creek, upper Sutton Creek, upper Pinkham Creek, Buckhorn Creek, and all of Tenmile Creek.

The winter range for this unit extended from the south side of Tenmile Creek to just north of Rocky Gorge. The winter range in PHU 1 was subdivided into 3 sub-units based on winter home range locations of radio-collared deer (Fig. 4). The first sub-unit (1a) extended from Tenmile to Sheep

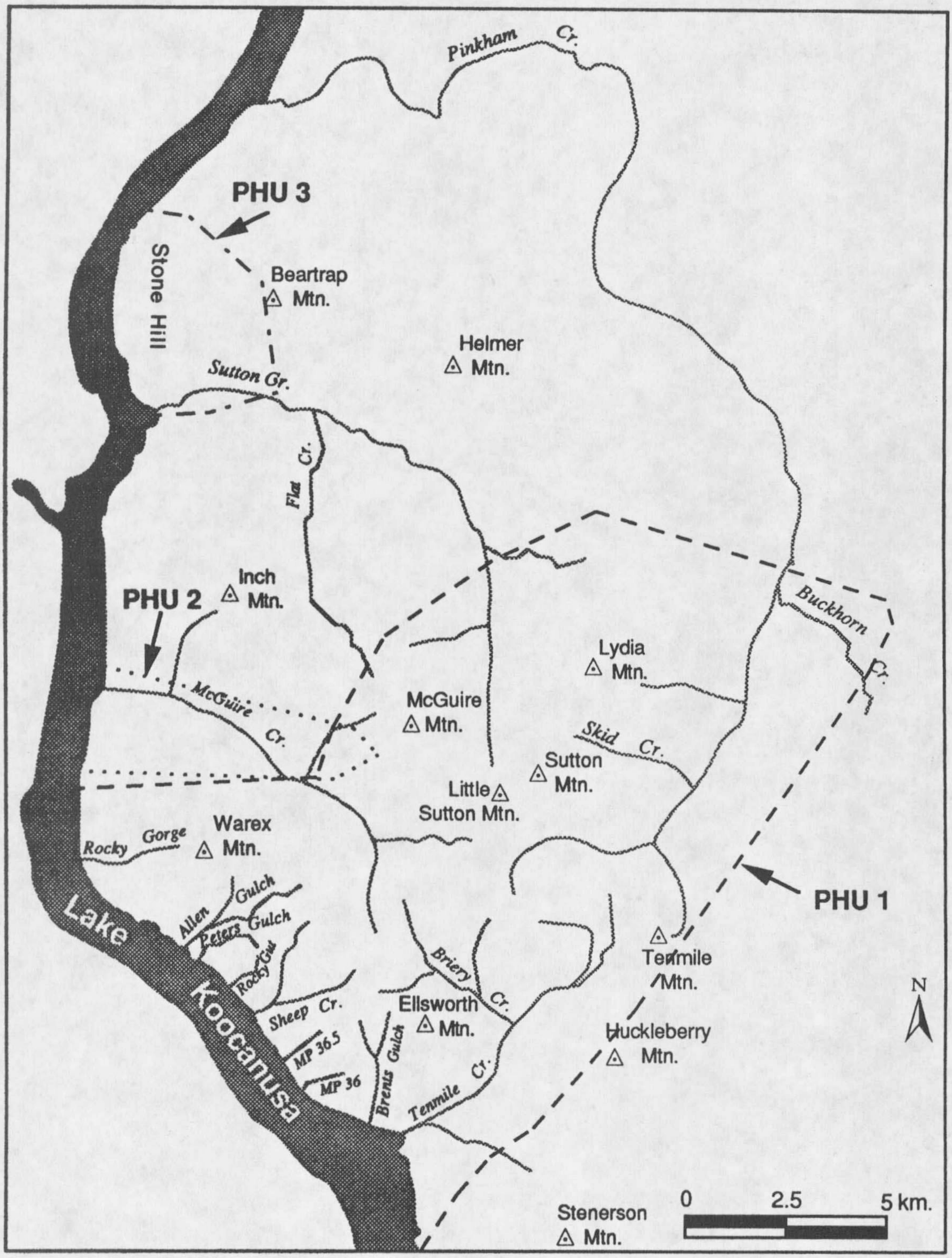

Figure 3. Map of north Salish Mountains study area showing boundaries of population-habitat units (PHUs) 1, 2, and 3.

Creeks, the second (1b) from Sheep Creek to just north of Allen Gulch, and the third (1c) from north of Allen Gulch to Rocky Gorge (Fig. 4). There were 15, 17, and 10 instrumented deer on 1a, 1b, and 1c, respectively. The entire winter range extended up to about 1,500 m elevation and was characterized by ponderosa pine, Douglas fir, and western larch interspersed with natural openings. Three helicopter logging units were situated within each of the sub-units.

When migratory deer moved off of the winter range, segmentation of the sub-units broke down (Fig. 5) as deer from different sub-units intermixed on summer ranges. Summer range was made up of several different interspersed cover types. Large, homogeneous stands of lodgepole pine, smaller stands mixed with western larch and sub-alpine/Engelmann spruce stands were most prevalent. Douglas fir was an important component on summer range adjacent to winter range. In addition to this, cutting units of varying sizes and ages were spread out over the unit in varying densities.

PHU 2 covered 10.6 km^2 and was used by 6 radio-collared deer. This unit extended along the lower half of the McGuire Creek drainage. Winter range was limited to an area about 2.3 km^2 near the mouth of the creek with the upper boundary at 914 m. Vegetation was characterized by a mixed stand of Douglas fir and Western larch. A helicopter logging unit was located on the north side of the creek. The summer range was

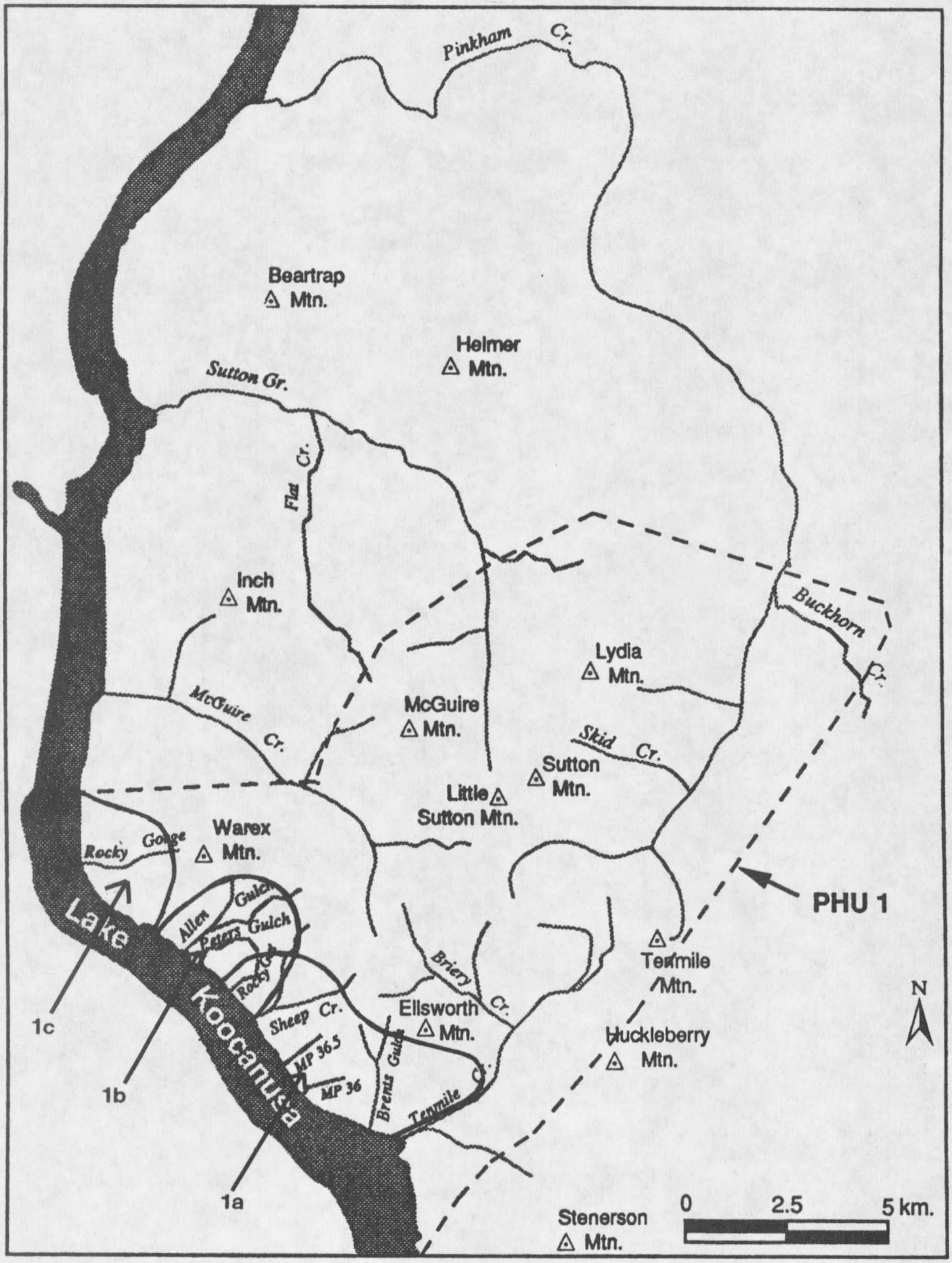

Figure 4. Winter range sub-units (1a, 1b, 1c) on population-habitat unit (PHU) 1, north Salish Mountains study area.

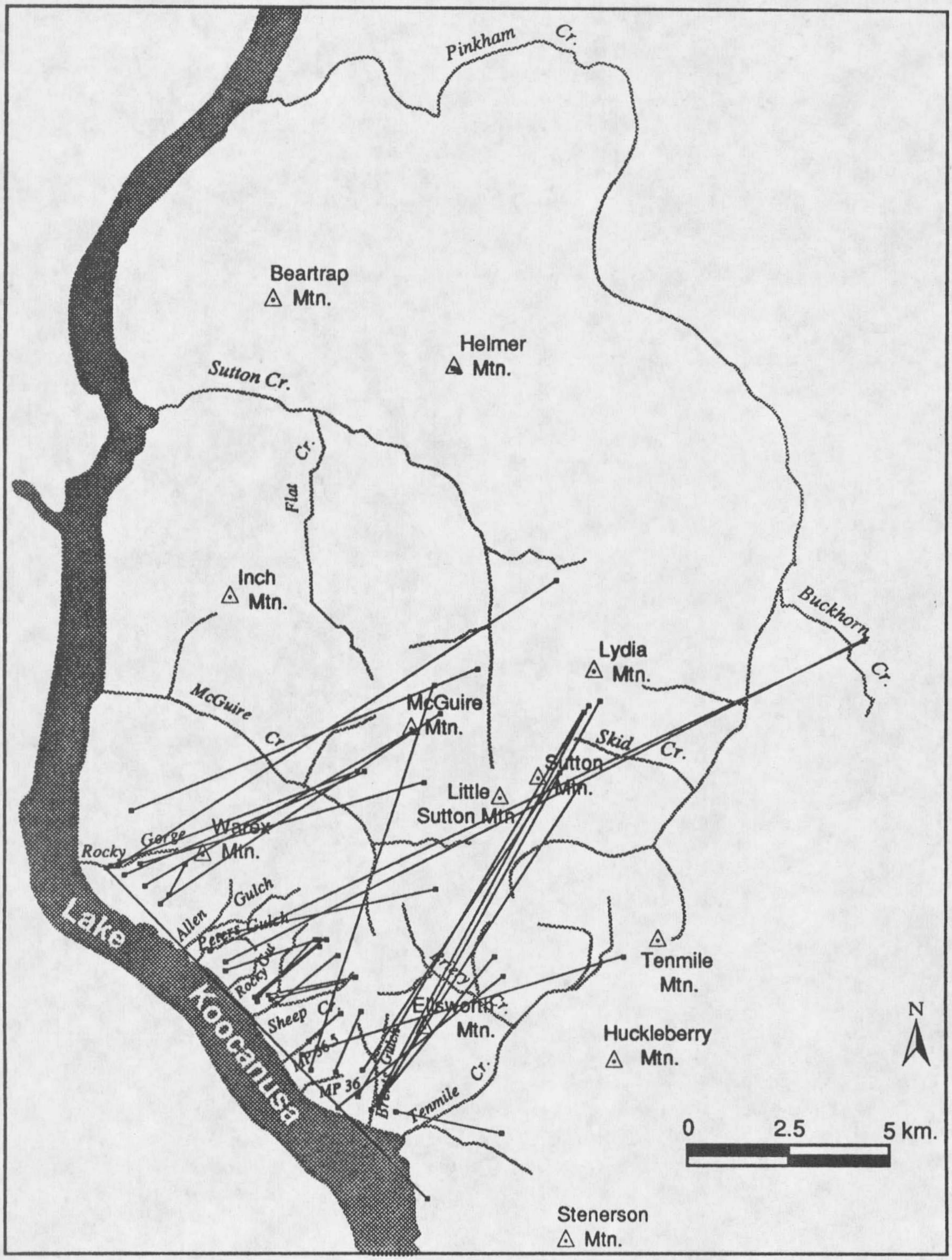

Figure 5. Winter and summer geographic activity centers (GACs) of radio-collared mule deer on population-habitat unit (PHU) 1, north Salish Mountains study area.

dominated almost exclusively by lodgepole pine through which several new cutting units were interspersed.

PHU 3 included 13.9 km^2 and the home ranges of 7 radio-collared deer. The unit was situated on Stone Hill and covered the western slope and part of the top of this landform. Because all 7 radio-collared deer used the same areas yearlong, no summer or winter range was delineated. The unit as a whole was characterized by Douglas fir and Western larch mixed with Lodgepole pine at the upper portions of the unit and Ponderosa pine at the lower portions. A relatively large portion of the unit was covered by non-forested land, consisting of either natural, grassy openings or cliffs and talus slopes.

Movements

Three different categories of deer were delineated based on distances separating seasonal ranges (Pac et al. 1991). Seasons were not delineated by standardized calendar dates. Instead, a logical separation of seasonal ranges was made from a plot of all relocations for each individual. Deer with indistinct seasonal ranges (ISR deer) occupied all or a portion of the winter range throughout the year. There was equal probability of relocating them on any portion of their home ranges during any season. Deer with adjacent seasonal ranges (ASR deer) occupied winter and summer ranges that were clearly distinguishable, but usually no more than 1.5 km from each other. ASR deer drifted back to the winter range quite frequently. The third category, deer with distinct seasonal ranges (DSR deer), had seasonal ranges separated by at least 1.5 km (Fig. 6).

Fifty-four female deer were assigned to 1 of 3 categories based on their movements over 1 or more years (Table 4). DSR deer made up the largest component of radio-collared deer, ISR deer had the second largest percentage, and ASR deer were the smallest group. However, considerable variability occurred among PHU's. For example, PHU 1 had representatives from all movement patterns in varying numbers, while PHU 2 had only DSR deer, and PHU 3 had only ISR deer.

Table 4. Number and percentage of 54 radio-collared deer that followed indistinct seasonal range, adjacent seasonal range, and distinct seasonal range movement patterns in each population-habitat unit and among all PHUs combined, north Salish Mountains, 1988 and 1989.

PHU	ISR		ASR		DSR	
	no.	%	no.	%	no.	%
1	10	23.8	9	21.4	23	54.8
2	0	0.0	0	0.0	5	100.0
3	7	100.0	0	0.0	0	0.0
Total	17	31.5	9	16.7	28	51.9

In addition to the 3 movement categories recognized on the basis of juxtaposition of seasonal ranges, deer showed further variability in individual movement patterns by using accessory areas (Pac et al. 1991). These were areas used locally for varying periods of time in addition to the

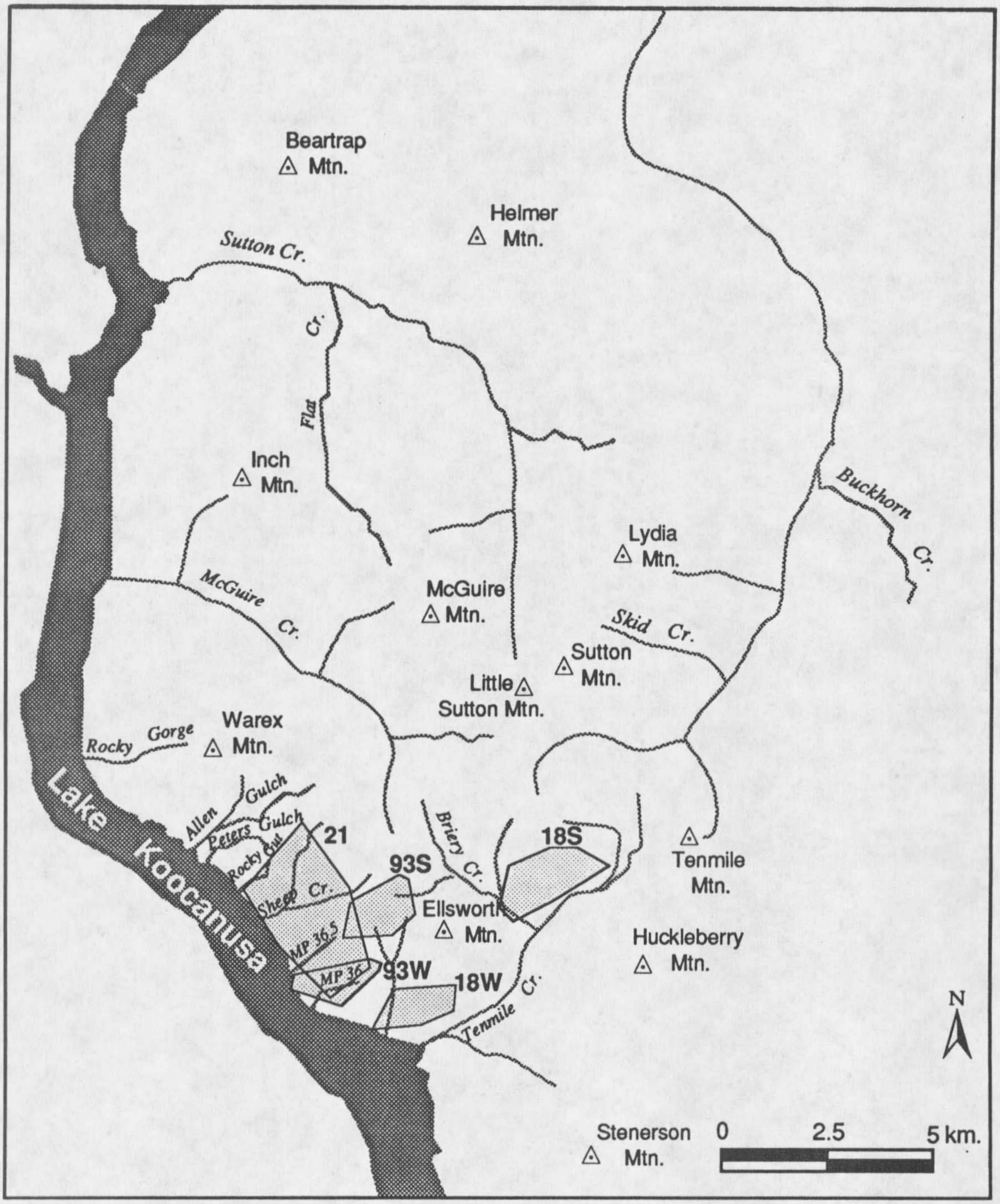

Figure 6. Examples of indistinct seasonal range (#21), adjacent seasonal range (#93), and distinct seasonal range (#18) deer on population-habitat unit 1, north Salish Mountains study area. W = winter home range and S = summer home range.

normal seasonal ranges. Distances between accessory areas and normal seasonal home ranges varied from 0.4 km to 35 km. The number of days deer spent on accessory areas ranged from 5 days to 105 days. ISR deer that used fall accessory areas spent the greatest amount of time on accessory areas. DSR deer using fall accessory areas spent the second longest time on those areas. Deer with spring and summer accessory areas usually occupied those areas for 30 days or less regardless of their movement patterns.

Spring accessory areas were used most heavily by deer occupying accessory areas (Table 5). Among movement patterns, about half or all deer used spring accessory areas (Table 6). Fall accessory areas were occupied by about a third of deer using accessory areas. About 36% of ISR deer and 27% of DSR deer used fall accessory areas. Overall, 50.0% of accessory area occupants were ISR deer, 42.3% were DSR deer, and 7.7% were ASR deer.

Table 5. Number and percentage of deer that used spring, summer, and fall accessory areas in each population-habitat unit and among all PHU's combined, north Salish Mountains, 1988 and 1989.

	Spring		Summer		Fall	
PHU	no.	%	no.	%	no.	%
1	7	38.9	2	11.1	9	50.0
2	2	100.0	0	0.0	0	0.0
3	6	100.0	0	0.0	0	0.0
Total	15	57.7	2	7.7	9	34.6

Table 6. Percentage of indistinct seasonal range, adjacent seasonal range, and distinct seasonal range deer that used spring, summer, and fall accessory areas, north Salish Mountains, 1988 and 1989.

Movement	Spring		Summer		Fall	
pattern	no.	%	no.	%	no.	%
ISR[a]	6	54.5	1	9.1	6	36.4
ASR[b]	2	100.0	0	0.0	0	0.0
DSR[c]	7	63.6	1	9.1	3	27.3

[a]-indistinct seasonal range.

[b]-adjacent seasonal range.

[c]-distinct seasonal range.

Use of accessory areas usually involved a significant change in elevation from normal seasonal ranges. In general, accessory areas were higher than winter ranges (Table 7). Summer and fall accessory areas were higher than summer home ranges, and spring accessory areas were intermediate between winter and summer home ranges. For ISR deer, spring accessory areas were lower in elevation than annual home ranges.

Movements or migrations between seasonal ranges did not appear to occur along any particular corridor. In leaving the winter range, most radio-collared animals moved east to northeast to summer range. The longest distance moved by an individual was 35 km from its summer range to a fall accessory area (deer #15, PHU 1). In contrast, several radio-collared animals in PHU 1 moved 1 km or less between winter and adjacent summer range. The overall mean distance between seasonal ranges in PHU 1 and 2 was 6.6 km.

Table 7. Mean elevation (m) of spring, summer, and fall accessory areas; winter home ranges; and summer home ranges for each movement pattern, north Salish Mountains, 1988 and 1989.

Pattern	N	WHR[a]	Spring	Summer	Fall	SHR[b]
DSR/ASR[c]	13	1019	1324	1608	1604	1520
ISR[d]	13	1121	925	1582	1729	

[a]-Winter home range.

[b]-Summer home range.

[c]-Distinct seasonal range, adjacent seasonal range.

[d]-Indistinct seasonal range, annual home range was used in place of winter home range.

During 1988, mean date of departure of radio-collared deer from winter range was June 1. This was 7 days earlier than 1989. The mean date of return to the winter range in 1988 was November 11, about 21 days later than for 1989.

Departure dates from winter to summer range were about the same for deer following the DSR and ASR movement patterns. These were approximately June 1 in 1988 and June 6 in 1989. However the mean date of departure of ASR deer from summer range was December 11 in 1988, more than 1 month later than the mean date DSR deer left summer range. ASR deer returned to winter range at least 1 month later than DSR deer in 1989 as well.

All radio-collared deer showed high fidelity to individual seasonal ranges. Only 2 deer shifted their ranges or changed movement patterns between years. One of these shifted her summer home range between years but occupied the same winter range. The other used the same winter range both years, but shifted from an ISR pattern in 1988 to an ASR pattern in 1989.

Home Ranges

Mean polygon home range sizes and AAR during summer for females following different movement patterns in each PHU during 1988 and 1989 are given in Table 8. They generally decreased between 1988 and 1989. Deer in PHU 2 were monitored only during 1989. All declines between years in PHU 1 and 3 were significant ($p<.05$).

Mean AAR for radio-collared deer in PHU 1 and 3 also decreased between years. Again, these decreases were significant ($p<.05$).

Mean polygon home range size and mean AAR for summer were compared between movement patterns and PHUs for both years. During 1988, only ISR deer were compared between PHU 1 and 3; no ASR deer or DSR deer were monitored in PHU 2 that year. Polygon home range size was significantly larger ($p<.05$) for ISR deer in PHU 3. There was no significant difference ($p>.05$) between AAR. During 1989, there was no significant difference ($p>.05$) between ISR deer in PHU's 1 and 3 for either measurement. Similarly, there were no significant differences ($p>.05$) between pooled measurements for ASR and DSR deer in PHU 1 and those for DSR deer in PHU 2.

Table 8. Mean convex polygon home range sizes (PHR)(km^2) and average activiy radii (AAR)(km) for female deer following indistinct seasonal range, adjacent seasonal range, and distinct seasonal range movement patterns in population-habitat units 1, 2, and 3, north Salish Mountains, 1988-89.

	1988			1989		
PHU	N	PHR	AAR	N	PHR	AAR
1 ISR[a]	7	5.7	1.1	8	3.2	0.8
ASR	3	1.9	0.6	10	0.8	0.4
DSR	9	4.6	1.2	21	1.3	0.6
2 DSR				5	0.9	0.5
3 ISR[a]	7	8.1	1.1	7	3.3	0.8

[a] Annual home range was used rather than summer home ranges.

Winter home range sizes and AAR for females in PHUs 1 and 2 are presented in Table 9. Mean polygon home range size and mean AAR for winter in PHU 1 and 2 were not significantly different ($p>.05$).

Table 9. Convex polygon home range (PHR) size and average activity radii (AAR) of female mule deer for winter in population-habitat units (PHUs) 1 and 2, north Salish Mountains, 1988-89.

		PHR(km^2)		AAR(km)	
PHU	N	x	S.D.	x	S.D.
1	32	1.4	0.3	0.7	0.2
2	5	1.9	0.8	0.8	0.3

Differences in home range measurements associated with age were apparent. Generally, fawns and yearlings had larger home ranges than adult females. Younger females also tended to move more sporadically throughout the summer. For example, a fawn in PHU 1, moved several kilometers at sporadic times during the summer for only a few days. As a yearling, she settled into a fairly small summer home range and stayed there the entire summer.

Habitat Use

Use of Cover Types

Relative occurrence of the 6 major cover types within PHUs is shown in Table 10. A key to abbreviations of cover types is found in Appendix Table 17. About 60% of the cover type was lodgepole pine and mixed conifer combined in PHU 1 and mixed conifer alone in PHU 2 and 3. PHU 3 also had the largest amount of non-forested cover types.

Relative use of cover types by radio-collared deer was extremely variable within and between PHUs (Table 11). Coefficients of variation (C.V.s) are included to give a measure of variation within PHUs. Lodgepole pine and mixed conifer were used about equally in PHU 1. Lodgepole pine was used most heavily in PHU 2. Mixed conifer was the most heavily used cover type in PHU 3, while non-forested types received secondary use. Variation in use of cover types was lowest for lodgepole pine in PHU 1 and 2 and mixed conifer in PHU 3.

Table 10. Percent occurrence of 6 vegetation cover types in population-habitat units 1, 2, and 3, north Salish Mountains, 1989.

PHU	NS[1]	LPP[2]	MC[3]	SAF[4]	PP[5]	NF[6]
1	15.7	27.8	30.0	20.9	3.7	1.6
2	3.4	27.1	63.3	0.0	4.9	1.4
3	9.8	5.5	59.3	0.6	9.7	15.1

[1] Non-stocked.

[2] Lodgepole pine.

[3] Mixed conifer.

[4] Sub-alpine fir.

[5] Ponderosa pine.

[6] Non-forested.

See Appendix Table 17 for further explanation.

Table 11. Mean percent use and coefficients of variation (C.V.) by female mule deer of 6 vegetation cover types in 3 population-habitat units during summer, north Salish Mountains, 1988 and 1989.

Cover type	1		2		3	
	%	C.V.[1]	%	C.V.	%	C.V.
NS[2]	14.1	96	25.0	44	4.4	133
LPP	27.2	75	65.4	12	1.0	125
MC	29.4	128	9.6	0	59.5	18
SAF	16.3	163	0.0	0	0.0	0
PP	8.5	229	0.0	0	13.5	51
NF	4.5	205	0.0	0	21.6	79

[1] C.V.=S.D.(100)/Mean.

[2] See Table 10 for definitions of abbreviations.

Use of cover types varied among deer following different movement patterns (Table 12) as well as among PHUs. For example, lodgepole pine accounted for over 50% of total use by ASR deer, but less than 10% for ISR deer. Sub-alpine fir types were also heavily used by DSR deer, but received use of less than 1% by ISR deer and less than 10% by ASR deer. More than 50% of total use by ISR deer occurred on mixed conifer types, while use by ASR and DSR deer was less than 25%. Variation was least for DSR and ASR deer in lodgepole pine types, and ISR deer in mixed conifer.

Table 12. Mean use of major cover types and coefficients of variation of radio-collared deer following indistinct seasonal range, adjacent seasonal range, and distinct seasonal range movement patterns during summer, north Salish Mountains, 1988 and 1989.

Cover type	ISR		ASR		DSR	
	%	C.V.	%	C.V.	%	C.V.
NS	4.9	129	15.5	87	21.8	82
LPP	7.3	137	52.3	55	33.5	66
MC	53.7	43	23.2	74	14.4	146
SAF	0.7	239	7.7	145	29.3	139
PP	17.6	65	0.0	0	0.5	529
NF	15.8	98	1.3	332	0.5	367

Differences in use of cover types between fall accessory areas and summer ranges were analyzed for 5 deer. On summer range, mixed conifer and ponderosa pine types

Table 13. Summary of chi-square analysis for selection of vegetation cover type, aspect, and slope during summer, 1988 and 1989. O = use in proportion to availability, + = use greater than expected by chance, and - = use less than expected by chance.

Environmental variable	PHU1	PHU2	PHU3
Cover types			
NS	O	+	-
LPP	O	+	-
MC	O	-	O
SAF	-		
PP	+		O
NF	+		+
Aspect			
N	-		
NE	-		
E	-		
SE	-		
S	O		
SW	+		
W	+		
NW	-		
Slope			
Level	O		
Gentle	-		
Moderate	O		
Steep	+		

received 48.1 and 21.9% of the total use, respectively. This probably occurred because the 5 deer were ISR or ASR deer with access to those types. On the fall accessory areas, lodgepole pine and sub-alpine fir received 47.6 and 21.4%,

respectively, of the total use; a clear shift in use from summer.

Patterns of use of cover types relative to their availability were analyzed on all 3 PHUs using chi-square analysis (Table 13). In PHU 1, ponderosa pine and non-forested cover types were used more than expected ($p<.01$), while in PHU 2 non-stocked and lodgepole pine were used more than expected ($p<.01$). In contrast to both PHU 1 and 2, non-stocked and lodgepole pine were used less than expected and non-forested was used more than expected ($p<.01$) in PHU 3.

Use of aspect and slope in relation to availability for PHU 1 (Table 13) indicated that north, east, northeast, southeast, and northwest exposures were used less than expected ($p<.01$). Southwest and west exposures were used more than expected ($p<.01$), and south exposures were used about in proportion to availability. Gentle slopes were used less than expected ($p<.01$) and steep slopes were used more than expected ($p<.01$). Level and moderate slopes were used in proportion to availability.

Use of Other Habitat Components

Use of aspect by ISR, ASR, and DSR deer was tabulated for PHU 1 (Fig. 7). The highest percentage of relocations for all 3 types of deer occurred on south to west aspects. This was especially true for ASR deer. Greatest relative use occurred on south aspects in PHU 2 (Fig. 8), and on west aspects in PHU 3. When relocations were pooled for each movement pattern (Fig. 9), ISR and ASR deer appeared to use southwest aspects most heavily. DSR deer occurred most often on west aspects. In addition, DSR deer used all exposures more evenly than deer with other movement patterns.

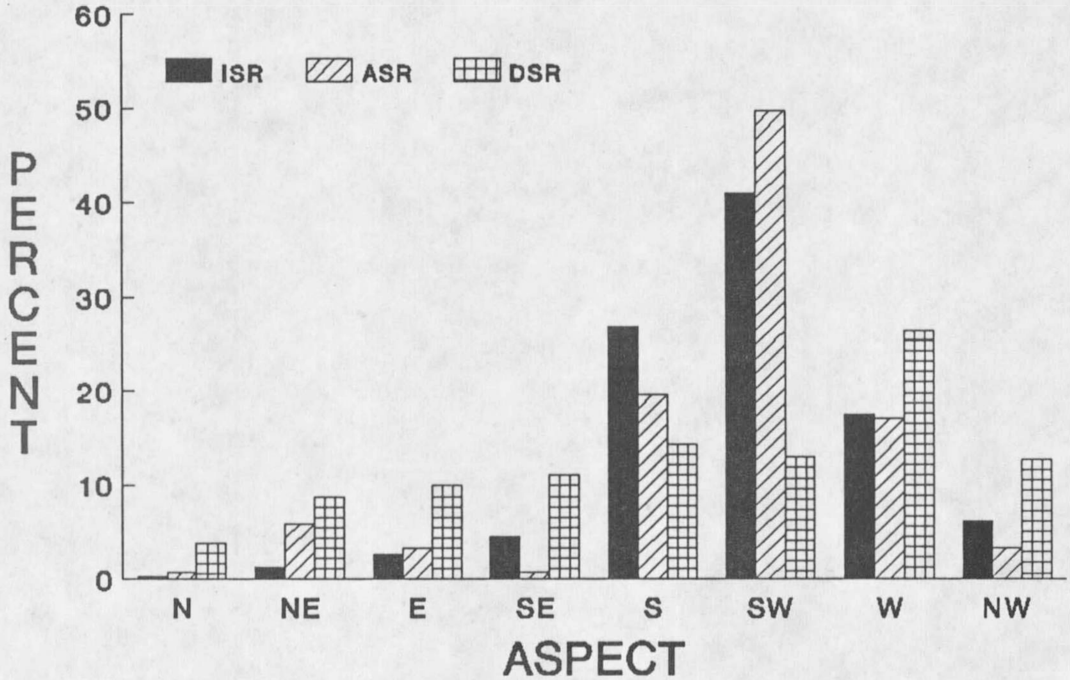

Figure 7. Percent use of aspect by radio-collared deer following indistinct seasonal range, adjacent seasonal range, and distinct seasonal range movement patterns in population-habitat unit 1.