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THE HABITAT USE PATTERNS AND ASSOCIATED MOVEMENTS OF WHITE-TAILED DEER IN SOUTHEASTERN BRITISH COLUMBIA

by

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ABSTRACT

This study of deer ecology was conducted from January, 1975, to May, 1976, in the East Kootenay region of British Columbia. Plant communities within the annual range of a population of white-tailed deer were classified into habitat types and analysed for species composition, productivity and forage utilization. Relative levels of use of winter habitat types were determined from track and pellet group counts. Use of summer habitats was determined subjectively from ground and aerial surveys. Movements associated with changes in habitat use and season were documented by observation and radio tracking of marked individuals.

Forest succession over much of the winter range was found to have resulted in substantial decreases in availability of herbaceous and deciduous browse, causing quantitative and qualitative changes in the diet of this deer population. To compensate for this situation deer feeding activity was concentrated in the open habitat types which provide maximum quantities and qualities of forage. However, snowdepth in one winter was found to reach levels which prevented deer from exploiting these areas and concentrated them in areas where a maturing overstory reduced snowpack. The impact of concentration in shelter types with consequent reduction of available food, compared to a very mild winter, was an apparent 30% reduction in the juvenile:100 adults ratio the following spring.

Summer distribution also appeared to be affected by large-scale forest succession which has produced a pattern of widely scattered, small openings. These were found mainly along water courses or rocky

slopes at mid- elevations on the west side of the Rock Mountain Trench. Deer density was low throughout the summer range, but preference was observed for the open areas just described.

Spring dispersal from the winter range was related to snow melt and green-up of vegetation, particularly cultivated alfalfa fields. Summer home ranges were relatively small and summer movements limited. The average distance travelled to summer range by nine deer was greater than that reported elsewhere in the literature and may be related to summer range habitat condition. Fall movements were apparently stimulated by lasting snowfall. Although density of deer on the winter range varied greatly between years, home range loyalty was found to be relatively high.

TABLE OF CONTENTS

List of Tables

List of Figures

Figure | Page

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INTRODUCTION

The population of white-tailed deer (*Odocoileus virginianus ochrourus*, Bailey) in the Premier Ridge region of the East Kootenays of British Columbia suffered a major die-off in the winter of 1964-65 (pers. comm. R. Demarchi). Since that time, the deer population has remained well below the level that helped bring big game hunting fame to this area in the 1950's. Local populations of other wild ungulates were also on the decline about this time. Although parasites played a major role in the die-off of big horn sheep (*Ovis canadensis canadensis*), their ability to decimate the sheep was greatly enhanced as a result of poor winter range condition (Stelfox, 1971). Russell (1967) examined the possible role of parasitic infestation in the whitetail die-off, but found nothing conclusive. Biologists in the B.C. Fish and Wildlife Branch feel that the ultimate cause of the high mortality was the condition of the habitat on the critical winter ranges.

Deterioration of the range is thought to have been the result of several concurrent events. Most important was secondary succession of forest types over large areas of the winter ranges (Demarchi, 1971). Forest succession has been shown to have generally negative influence on forage biomass and quality in such diverse ecological regions as the southern pine forests (Halls and Alcaniz, 1968), northcentral mixed woods (Wetzel et al. 1974), northern B.C. (Cowan et al. 1950) the coastal rain forests (Gates, 1968) and in the East Kootenays (Kemper, 1971). On Premier Ridge, this factor has been complicated by Christmas tree farming (c.f. Churchill, 1974) and the extensive use of some areas by cattle which had led to modifications of the vegetative composition and productivity of some areas by the early 1960's (D. Demarchi, pers. comm.). Although use of Premier Ridge by domestic stock has been reduced through the Fish and Wildlife Branch's land and grazing permit requisition program, the majority of the area supporting white-tails during winter has not yet recovered from the effects of overutilization (Demarchi, 1971; Barichello, 1975).

In view of the limited potential of the area for timber production (Kemper, 1971) and the detrimental effects of past grazing regimes, the B.C. Forest Service has agreed to cooperate with the Fish and Wildlife Branch in a Coordinated Land Use Planning program to improve the habitat for ungulates -- both domestic and wild. In order for this coordinated land use scheme to operate most efficiently with respect to white-tails, it is necessary to increase our knowledge of their habitat preferences and requirements, to document the present condition of these habitats and to formualte recommendations for future treatment of the habitats to improve their ability to support deer populations.

Recent studies have provided some of this information. Barichello (1975) and Farr (1975) have made detailed habitat assessments on property purchased by the Fish and Wildlife Branch, and a more general habitat analysis for the southern Rocky Mountain Trench was completed by the Environment Land Use Secretariat during 1975 (D. Demarchi, pers. comm).

Previous work by Demarchi (1971) and Kemper (1971) also gives insight into some of the vegetative aspects of deer ranges in this area.

Hudson et al. (1974) examined the distribution and competitive relationships of cattle, big horn sheep, elk (*Cervus canadensis nelsoni*), mule deer (*O. hemionus hemionus*) and white-tails in the Premier Ridge area. The species' general distributional elements were outlined, but they failed to make definitive comments on solutions to problems limiting ungulate populations here. They did indicate, however, that white-tails may be most seriously affected by forest succession and competition for cattle for both nutritional and distributional reasons (Hudson, et al., 1974. pp. 39-40 and 62-63).

The study reported here was designed as an intensive investigation of a single population of white-tailed deer (based on their common use of a winter range area) to answer some basic questions about deer ecology in the East Kootenay. This information is essential for the development of proper land use plans. The objectives of the various phases of the research were: 1) to identify the habitats used by the deer and determine their species composition, productivity and physical structure as this relates to climatic influences; 2) to assess the relative levels of use of these habitats and their forage resources by the deer; and 3) to document the movements of individuals within the population. This information would allow distributional and movement patterns to be related to the measured habitat characteristics and climatic variables.

Winter Range

The winter range unit chosen for study lies on the lower slopes and terraces of Premier and Wasa Ridges in the Wolf Creek drainage about 48 km north of Cranbrook, B.C. (Fig. 1.) These two ridges rise nearly 2000 and 1400 feet[1/], respectively, above the east side of the floodplain of the Kootenay River on the floor of the Rocky Mountain Trench at 2500 feet above sea level. The portions of these ridges used in most winters by white-tailed deer lie between the floodplain and 3500 feet. Physically, the region is characterized by a narrow floodplain that ends in steep slopes of 50 to 250 feet leading to rolling terraces with a complex series of slopes. Above these rise the main bodies of the ridges with moderate to steep angles and occasional bedrock outcrops. The soils of the flood plain are predominately thin, silty gleysols on a thick gravel substrate. The soils at higher elevations are primarily clay-podsols and loess deposits on gravel substrates, or are thin veneers on bedrock. These soils are all deprived from limestone/dolomite parent material and are highly calcareous. The soil pH depends on micro-climatic moisture regime.

The area is located near the border of the Interior Douglas Fir zone and the Yellow Pine/Bunchgrass zone (Krajina, 1965). The pre-1900 forest was a mature montane community of mixed stands of douglas fir (*Pseudotsuga menziesii*) and yellow pine (*Pinus ponderosa*) with the former being dominant in all cases except on drier, south aspects (Kemper, 1971).

1/ All elevations given in feet (English units) for ease of reference to existing topographic maps.

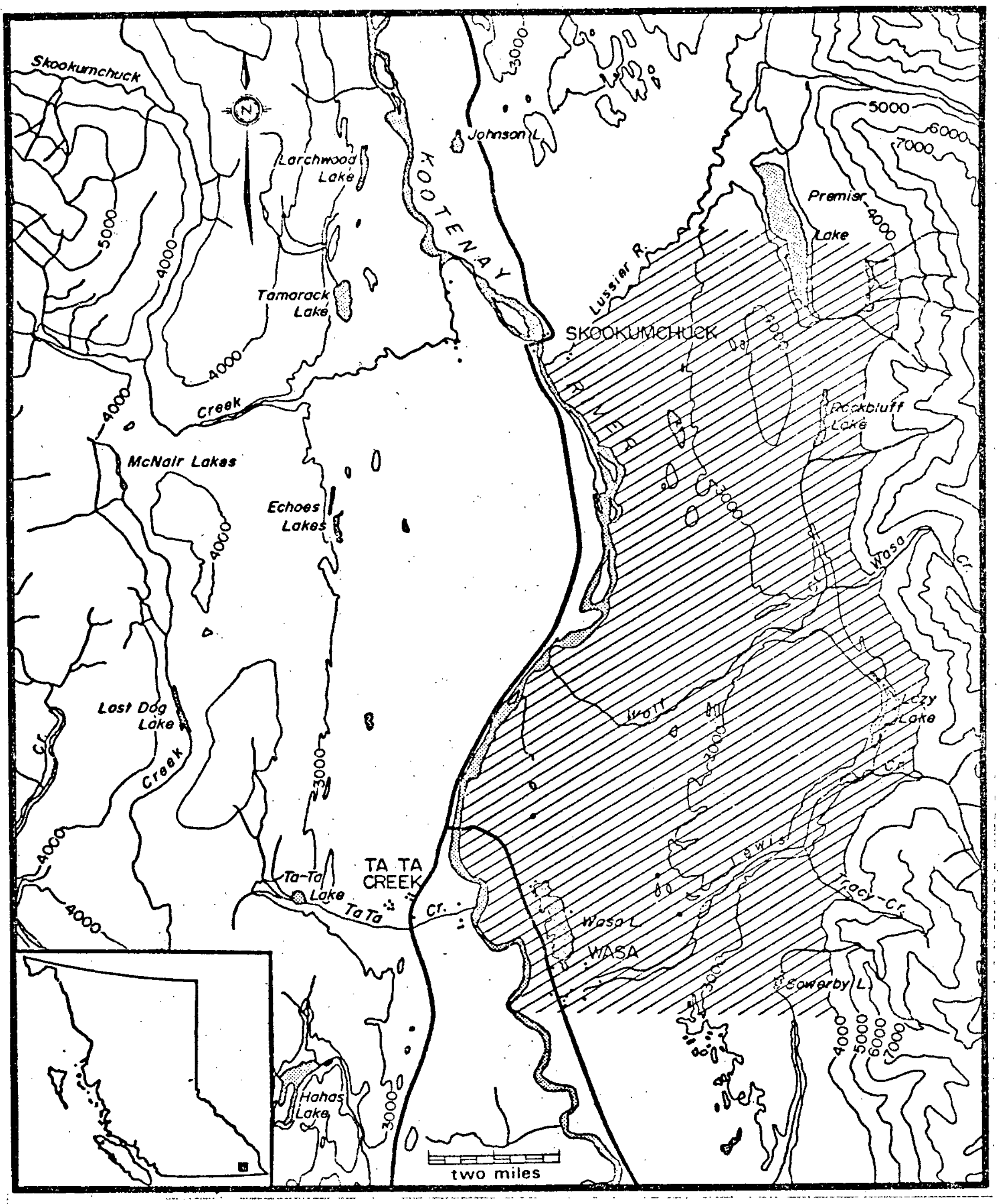


FIGURE 1. Study area. Shaded portion indicates winter range on Premier and Wasa Ridges.

Only a few patches of mature timber remain now, as sporadic logging and fires prior to 1930, and range use by wild and domestic ungulates since then, have created a complex patter of dis-climax grass- and shrublands and seral forest communities with varying ages, species composition and stocking levels (Demarchi, 1971).

The relatively dry nature of the area (annual precipitation 30 to 60 cm, mostly snow) and extremely high temperatures in the mid- and late summer months effectively reduce the growing season for grasses, forbs and shrubs from the 180 day growing period to about 70 to 80 days in the spring and early summer. A period of fall regrowth that varies annually in length has been shown to be important to big horn sheep wintering on Premier Ridge (Hebert, 1973). This period may also be important to white-tails in some years.

Summer Range

The deer from the Wolf Creek drainage disperse over an immense area during summer, and it is difficult to circumscribe a "summer range" as such. A very small number of the deer remain on the "winter range", and a few spend the summer along the Kootenay River. However, the majority of the deer migrate to the west to summer in the mid elevation valleys of Ta Ta, Lost Dog, Cherry and Skookumchuck Creeks.

The floor of the Trench on the west side of the river floodplain consists of ridges and terraces oriented along the line of the valley. These rise in gradual progression from about 2600 feet to 4500 feet.

From 4500 feet upward rise the main slopes of the Purcell Mountains. The effects of recent glaciation are clearly evident on both landforms and soil development. Morainal and fluvioglacial deposits fill the depressions between bedrock ridges that are only partially covered with colluvial veneers. The north-south stream courses and depressions in places contain small, oblong lakes and occasional bog-like areas where organic matter has been accumulating, although not yet deep enough to warrant an organic soil classification (V. Hignet, pers. comm.). The soils are predominantly calcereous brunisols up to 4000 feet, but above that they are non-calcareous.

The summer range lies almost entirely within the Interior Douglas fir zone, divided equally between the Upper and Lower sub-zones. In a few places at higher elevations the range reaches into the Engleman Spruce/Sub-alpine fir zone and a natural grassland occupies part of the valley floor. Extensive and severe burning of the area in the 1920's and 30's has all but totally removed the original forest cover. Yellow pine predominates the regenerating forest on the floodplain. At higher levels, lodgepole pine (*Pinus contorta*) is most abundant, but micro-climatic variations in soil moisture and temperature are reflected in species composition of the forest. Occasional openings from more recent spot fires or on slopes with too little soil to afford major forest regeneration are covered with a shrub community. Along most of the stream courses a type of dense, deciduous brush community exists that varies from a few to almost 100 m. in width.

Due to elevation, aspect, and shading by the Purcells, the summer range is much cooler and more moist than the winter range. Although this precludes its use in the winter months when snow depth often exceeds 100 cm at 3000 feet, it encourages a dense understory and prolonged plant growth that supplies lush vegetation until plant dormancy is forced by returning freezing weather in September or October.

METHODS

Analysis of Winter Range Habitats

Habitat types were outlined based on forest cover maps prepared by the B.C. Forest Service, aerial photographs, and personal reconnaissance of the area as suggested by Poulton and Tisdale (1961). Forested types were designated on the basis of age, species composition and/or canopy closure. Nonforested types were classified by plant community (i.e. grassland) or by soil moisture.

Except in cultivated fields where domestic grasses and alfalfa (*Medicago sativa*) were assumed to be the only significant component, species composition of the herbaceous layer was determined using Daubenmire's (1959) 1/10 m^2 technique. Frames were located at 1 m intervals along two parallel transects 25 m in length, spaced 5 m apart. These transects were randomly located within the habitat types.

Species composition of the shrub layer was determined using a modification of Passmore and Hepburn's (1955) technique based on counts of shrub stems in five circular plots of 10 m^2 surface area at 25 m intervals along a 100 m transect (Fig. 2). The number of transects per type ranged from two to eight. A shrub stem was defined as any woody part of a plant originating from the soil surface. Since determination of availability of forage in the previous winter was one of the major objectives of this survey, this definition which eliminated current year shoots seemed appropriate. A subsample of two stems per species per plot was measured for height prior to initiation of current year's growth to determine vertical distribution of forage. The generally stunted nature of the shrub layer ruled out the need for establishing an upper limit to the "available" zone used by most authors.

Use of shrubs by deer was based on the ratio of browsed to total number of twigs (expressed as percent) determined from the subsample of stems. A twig was defined as a portion of a plant that ended in a terminal bud or a browsed tip. Measurements of diameter at point of browsing (DPB) and diameter at annual growth (DAG) were also taken on the twigs of the subsampled stems to refine the percent browsed and estimate "utilization" as presented by Wetzel et al. (1974).

Minimum production of browse by major shrub species was estimated by multiplying stems/m^2 by the mean number of unbrowsed twigs per stem, times the average oven-dried weight of at least ten annual growth segments collected at random from each species in each type. Unbrowsed twigs only were used here because twigs that had been previously browsed would not produce the same amount of growth. Since they would probably produce some browse, however, the values presented here should be considered minima. Further, to be sure these values represent what is actually availably to an overwintering deer, the twigs were collected in mid-January.

Concentric with each center plot on each transect a circle of 100 m^2 was sampled for overstory composition. All trees within the circle were measured for diameter at breast height (dbh) and their height was estimated. Any tree with a dbh less than 5 cm was designated a sapling.

Demarchi and Demarchi (1967) have shown that douglas fir provides nearly one-third of the volume of the winter diet and is universally consumed by white-tails in this area. For this reason, it was felt that some estimate of available forage on fir trees should be obtained. I used a regression estimation technique developed for conifers by King (1975) for this purpose.

This method uses stem diameter measurements to estimate browse. I defined a stem as any terminal or lateral branch originating from the main trunk of the tree. I measured the diameter of 25 randomly selected stems ranging from 2.99 mm to 29.52 mm to provide independent variables for the regression. Then all leaves on the selected stems were removed and collected, and all twig setments distal to the point where twig diameter equalled 3.5 mm (the maximum observed browsing diameter) were clipped and collected. This material was oven-dried for 36 hours at 65°C and the weights of twigs and leaves were obtained. The natural logarithm of the weights were regressed on the natural logs of the stem diameters to determine the least squares equation:

$$\log_e Y = \log_e a + b(\log_e X)$$

where X = stem diameter, Y = predicted browse weight, and "a" and "b" are the regression constants.

I then sampled 10 saplings and 10 trees in each habitat where fir occurs, counted all stems below 1.6 m above ground level, and measured the diameter of 10 of the stems. Stem totals and average stem diameter were then used to estimate the average amount of browse per sapling and per tree in each habitat. With this information I could estimate fir forage biomass by the formula:

Biomass/ha = (average trees/ha)(average browse/tree) +
(average saplings/ha)(average browse/sapling)

Utilization was not quantified because the regression technique King (1975) demonstrated for determining use relied on the twig diameter at point of browsing to estimate biomass consumed. A large proportion of the fir browse eaten by deer here is in the form of leaves removed from the twigs without taking woody tissue (Demarchi and Demarchi, 1967, and pers. obs.) so using DPB would have given an unrealistically low

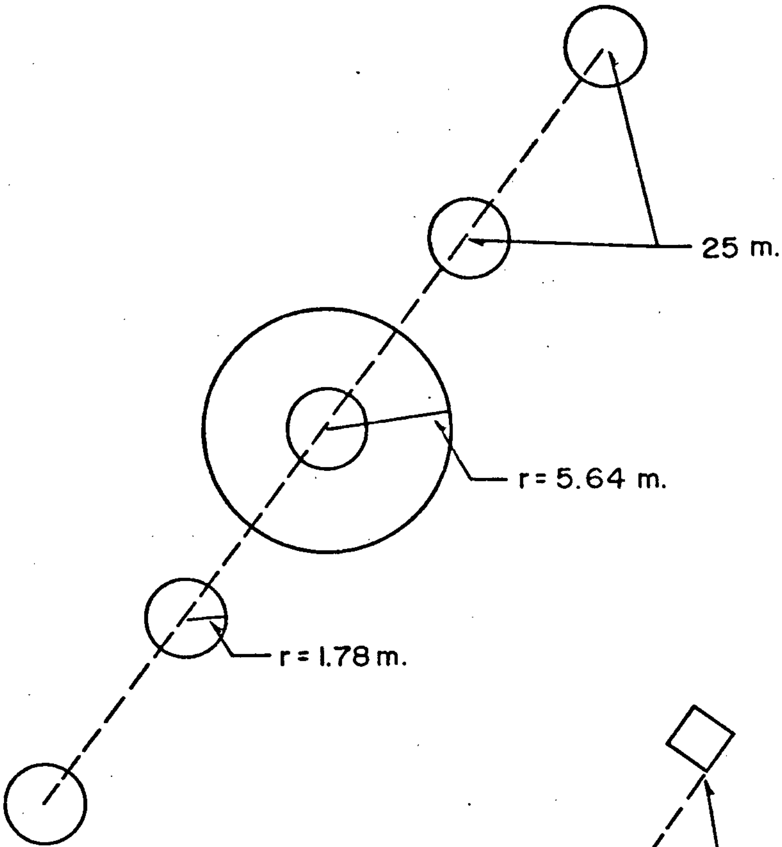


FIGURE 2. Winter range vegetation/ pellet group transect design.

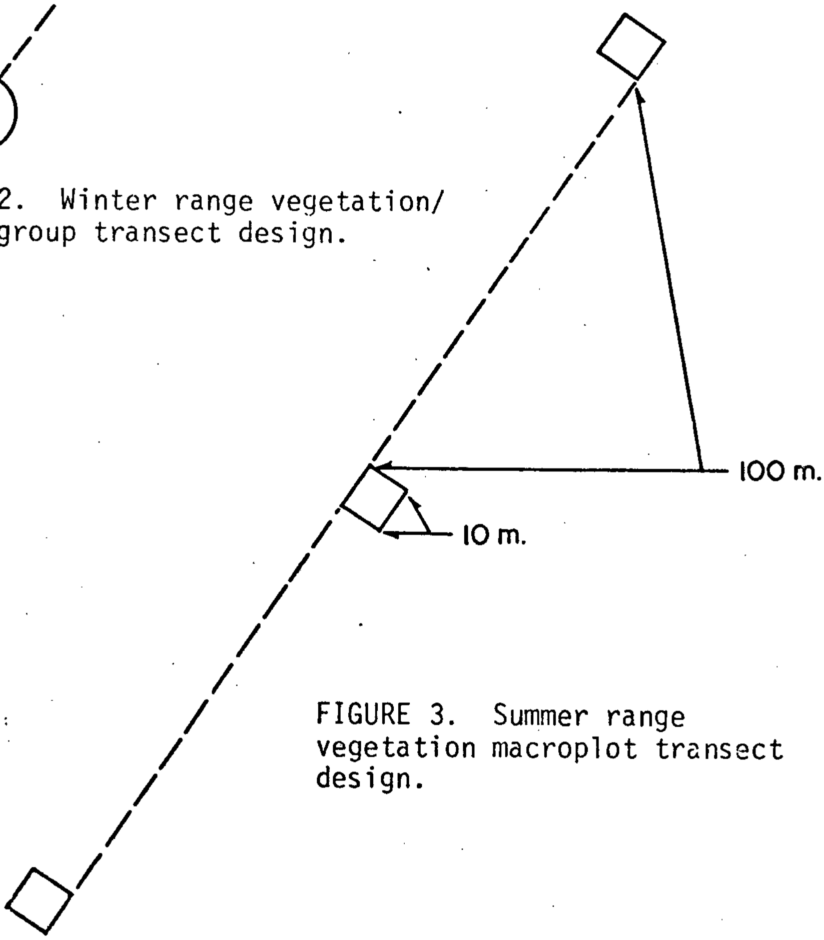


FIGURE 3. Summer range vegetation macroplot transect design.

estimate of consumption. Subjective comments on intensity and characteristics of browsing are made.

Analysis of Summer Range Habitats

The vegetative communities on the summer range are much more homogeneous than those on the winter range and consist primarily of open shrubland slopes, riparian brush, and dense immature stands of timber dominated by lodgepole pine. The major objectives of the analysis of this range were to determine the elevational trends in each of the three broad associations listed above and document present species composition. No attempt was made to assess the levels of utilization on any plant species due to the on-going nature of both plant growth and utilization through the summer survey period as well as a high degree of overlap of distribution of deer, cattle and elk on this range.

Transects with two to six square macroplots of 100 m^2 area spaced at 100 m intervals were randomly established at various elevations in the shrub and forest associations between 2600 and 4100 feet above sea level (Figure 3). Daubenmire (1959) 1/10 m^2 frames were placed at 1 m intervals along the center line of the plot to determine composition of the herbaceous layer. Shrub canopy coverage for each species was estimated for the entire plot using Daubenmire's coverage classes. All trees within the plot were measured for dbh and their height was estimated. A subjective evaluation of species composition of the riparian brush was made at several elevations ranging from 2550 to 4000 feet.

Weather

Many authors have investigated the relationships between deer behavior and the climate in an attempt to understand the role these interactions play in deer ecology. Work has ranged from early observational accounts (Hammerstrom and Blake, 1939; Cook and Hamilton, 1942; and Severinghaus and Cheatum, 1956) to the years of sophisticated energy flux studies summarized in Moen's (1973) excellent text. Based on this earlier work, I felt it was sufficient for this study to examine the variations in the patterns of temperature, sunlight and snowfall during the winter months to help in interpretation of the observed patterns of habitat use and movements.

Weather data were collected from records at the Cranbrook Airport 32 km south of the study area. Records of minimum, maximum and mean daily temperatures, hours of sunlight and precipitation were collected throughout the study period. Because of their relative positions in the Rocky Mountain Trench, the winter range would be subject to slightly lower winter and higher summer temperatures with somewhat less precipitation than the airport, while the summer range would have generally lower temperatures and higher precipitation throughout the year. The airport data show clear trends and differences between seasons and years, and when coupled with limited data gathered on the study area, they provide information helpful in the understanding of habitat use and movement patterns.

Use of Winter Range Habitats

Relative levels of use within the habitat types were determined by systematic track counts and pellet group counts. The track counts, covering seven types in 1974-75 and 10 types in 1975-76, were made 12 to 36 hours after the completion of a fresh snowfall of sufficient volume to effectively eliminate previous tracks. A network of roads (Fig. 4) was either walked, skied, or driven and all sets of tracks crossing the road were counted. This method has been used successfully in the southern United States (Harlow and Oliver, 1967) and in Minnesota (Irvin, 1975).

The proportion of the total tracks in each habitat was compared with the proportion of mileage surveyed in that type. The hypothesis that deer are uniformly distributed and therefore the proportions of tracks and mileage are not significantly different was subjected to a chi-squared test. If a significant difference did occur ($p \leq 0.01$) the data were further tested using the method of Neu et al. (1974) to determine the degree to which each habitat contributed to the chi-squared value. This technique places confidence limits on the proportion of tracks in each habitat and preference was considered to be indicated for those types in which the confidence interval on the proportion of tracks was entirely above the proportion of miles. For example, if the proportion of tracks in the Aspen type were $0.571 \pm .045$ and the proportion of km censused were 0.365, selection of the type would be inferred from the fact that the lower boundary of the confidence interval, $0.571 - .045 = 0.526$, is greater than 0.365. Inversely, avoidance was inferred from

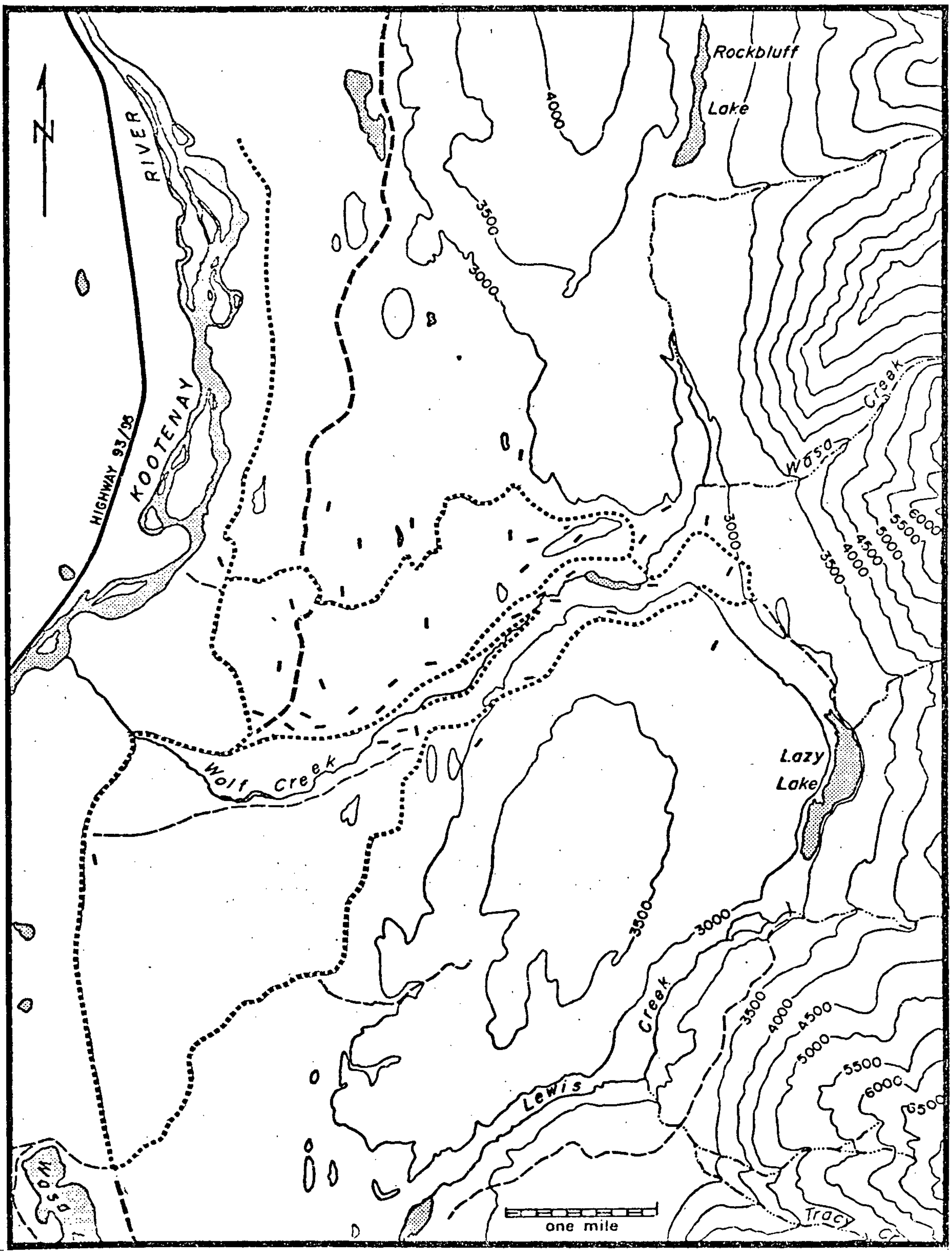


FIGURE 4. Track count transect route (••••) and pellet group transect locations ( ).

confidence intervals that fell short of the proportion of km. Use is termed proportional (meaning neither avoidance nor selection) if the confidence interval included the proportion of km.

Pellet groups were counted in each of the five circular plots used on the shrub survey (Fig. 2). Each plot center was marked with a stake and all groups within 1.78 m of the stake were counted. A "group" was arbitrarily defined as a collection of at least 12 pellets. Border-line groups were inlcuded only if a majority of the pellets were inside the plot. After counting, all pellets were removed from the plot with minimum disturbance to the vegetation.

The small plot size was chosed based on a review by Neff (1968) and work by Smith (1968). They felt that small plots were more efficient and more precise than large ones because of the reduction of bias associated with missed groups. Batcheler (1975) has shown, however, that the inverse relationship between plot size and estimated density of groups is mainly the result of bias due to border effect and definition of pellet groups, not missed groups. Thus small plots may be more precise, but they are not necessarily more accurate.

Although the data may not provide an accurate estimate of total deer numbers, it seems valid to assume that any bias associated with using small, bounded plots will be approximately equal in each habitat. Since my main objective in counting pellet groups was to determine relative levels of use, any consistant bias is of no consequence.

Each transect with its five plots was treated as a cluster sample, and the transects within each habitat type were grouped for analysis. Each cluster total, $Y_{i.}$, was the sum of the five individual elements (single plot counts), $y_{i,j}$. The average number of groups per plot was estimated by:

$$\bar{y} = \frac{Y_{1.} + Y_{2.} + \ldots + Y_{n.}}{m_1 + m_2 + \ldots + m_n} = \frac{\sum_{i=1}^{n} Y_i}{\sum_{i=1}^{n} m_i},$$

where n = number of transects and m = number of elements (plots) per transect. The variance estimate is:

$$s^2 \bar{y} = \frac{1}{n(\bar{m})^2} \cdot \frac{\sum_{i=1}^{n} y_i^2 - 2\bar{y} \sum_{i=1}^{n} y_i m_i + \bar{y}^2 \sum_{i=1}^{n} m_i^2}{n-1}$$

The finite population correction factor, (N - n)/N, where N = total number of clusters in the population, has been dropped from the formula since the sampling fraction is unknown. The sampling fraction is so small, however, that (N - n)/N is nearly unity and the true sample variance is only slightly lower than the estimate presented here. By considering only the variance between grouped clusters and ignoring variance between individual elements of each cluster, the variance estimate is reduced using this treatment. Mean pellet group density and variance estimates were then used in selected t-test comparisons of habitat types. t-tests were also used to evaluate the significance of changes between years within each habitat type.

The value of using both track and pellet group counts cannot be overrated. Each has an advantage over the other. Track counts, for instance, can be used to show temporal changes in habitat preference through the winter, a phenomenon impossible to detect from pellet group counts. On the other hand, track counts are useless for estimating absolute density or changes in absolute density--the most frequent objective of pellet group counts. Perhaps even more important than their specific advantages, however, these techniques have offsetting biases that gives their combined use greater strength. Track counts are biased toward active use areas and feeding behavior since deer obviously make more tracks while moving about in search of food. Observations also indicate that deer meander more in open habitats than in densely forested types, so multiple crossings of the survey road by one deer in the open could result in a higher count than a few deer in a forested area crossing once each. This bias is countered by the tendency of pellet groups to be concentrated near bedding areas (pers. obs. and V. Geist, pers. comm.) and the deers' preference for bedding in forested habitat types. By using both techniques, one gets a more valid indication of temporal patterns of use, absolute density, and the behavior most prevalent within a given habitat. Such information is essential in proper evaluation of the role of various habitats in the ecology of deer.

In order to determine what activities were being pursued in the various habitat types to help interpret the results of the track and pellet group counts, time was spent in each habitat following the tracks of individuals and groups noting feeding behavior and searching for bedding sites. This indirect approach was necessary due to the great flight distances and preferences for cover common to the whitetailed deer here. Wetzel et al. (1974) used tracking to quantify feeding behavior, but the value of such an approach is questionable. Information of this type has only been used here in the interpretation of the quantitative data gathered in the manner already discussed.

The only significant use of cultivated fields, sown mainly in alfalfa and hay grasses, and the natural grasslands occurs in the late winter and spring. The ability to observe deer on these areas at this time was exploited to directly quantify use. Although there are major differences between the composition of plant species in these two areas, the response of the deer to them is the same, and their use is treated together in the remainder of the text.

The fields and grasslands were surveyed at irregular intervals as soon as they started to become snow free. When deer use increased, the censusing became regular and classified counts of the deer using individual fields were made several times each day on at least two days per week. Counts were concentrated in the evening hours. The most heavily used fields were observed for periods of several hours at a time to detect daily patterns of use. Observations after dark in 1975 were made with a "Startron" night vision device similar to the one used by Swanson and Sargeant (1972). In 1976, a spotlight and binoculars were used.

In addition to providing information on use of the fields and grasslands, these spring observations permitted estimation of the age ratios (juveniles:100 adults) in the population at the end of the two winter periods.

Use of Summer Range Habitats

No satisfactory method of quantifying habitat use on the summer range was found. Track counts were impossible; pellet group counts impractical due to low densities, lush vegetation and continuing deposition of groups until snowfall forced deer off the range; and the extremes in vegetation density would have biased census counts. For these reasons, the use of summer range was determined subjectively from observations of deer and deer sign and limited radio tracking. Several hundred km of roads, river and trails were covered through the summer of 1975 to try to outline the areas used by white-tailed deer in this section of the Rocky Mountain Trench.

Individual Movements

To supplement the information on relative levels of use, it was desirable to obtain knowledge of the movement patterns of individual deer on the study area. Deer were captured for individual marking in three single-gate box traps (Clover, 1956) baited with alfalfa hay. The traps were generally set along trails in areas of relatively high deer density because success was too low in less-used areas. I tied the traps in such a way as to permit quick release of the guy lines and folding of the trap with the deer inside. Thus the trap became a "squeeze shoot" which greatly facilitated handling the deer when alone. Once the trap was folded and laid on its side, the deer was blindfolded and manually restrained while beging fitted with marking devices. No drugs were administered to deer in this study.

Deer were marked with both material and radio-transmitter collars, ear tags and streamers. The material collars and ear streamers were made from an orange, vinyl-coated nylon material, "Armortite." Each collar was cut four inches by 27 inches and marked with four inch high letters and numbers with an indelible black ink. The numbers could be read from either side of the deer at up to 600 m with a 60x spotting scope. The collar was placed around the neck of a trapped adult deer and the ends overlapped until a loose, but secure fit was made. The ends were then fastened with three "pop" rivets. "Ritchey" brand plastic cattle ear tags with numbers corresponding to the collar were placed in the ears of each deer with a combination of up to three streamers of "Armortite." This system provided sufficient variations in ear mark pattern to permit individual recognition of deer even if the collar was not visible or lost.

Records of sightings of marked deer were kept whenever they occurred on routine travels or while driving specific census routes in the study area. Some were also identified from the air when I had the opportunity to survey the area in mid-February, 1975 and 1976, with B. Warkenton (B.C.F.&W. Wildlife Technician) on his annual game flights.

A total of ten deer was fitted with radiotransmitter collars. These collars were made by Wildlife Material Inc. of Carbondale, Illinois and ranged in frequency from 150.898 to 151.147 Mhz. A three element yagi antenna was used with a 12 channel AVM Instrument Co. receiver to determine directional bearings from known locations to the deer for triangulating their positions during the winter and spring. Attempts were made to radio-locate each deer weekly in winter and semiweekly during spring migration. Four flights were made with a Cessna 172 aircraft during the summer of 1975 to locate the deer on their summer ranges.

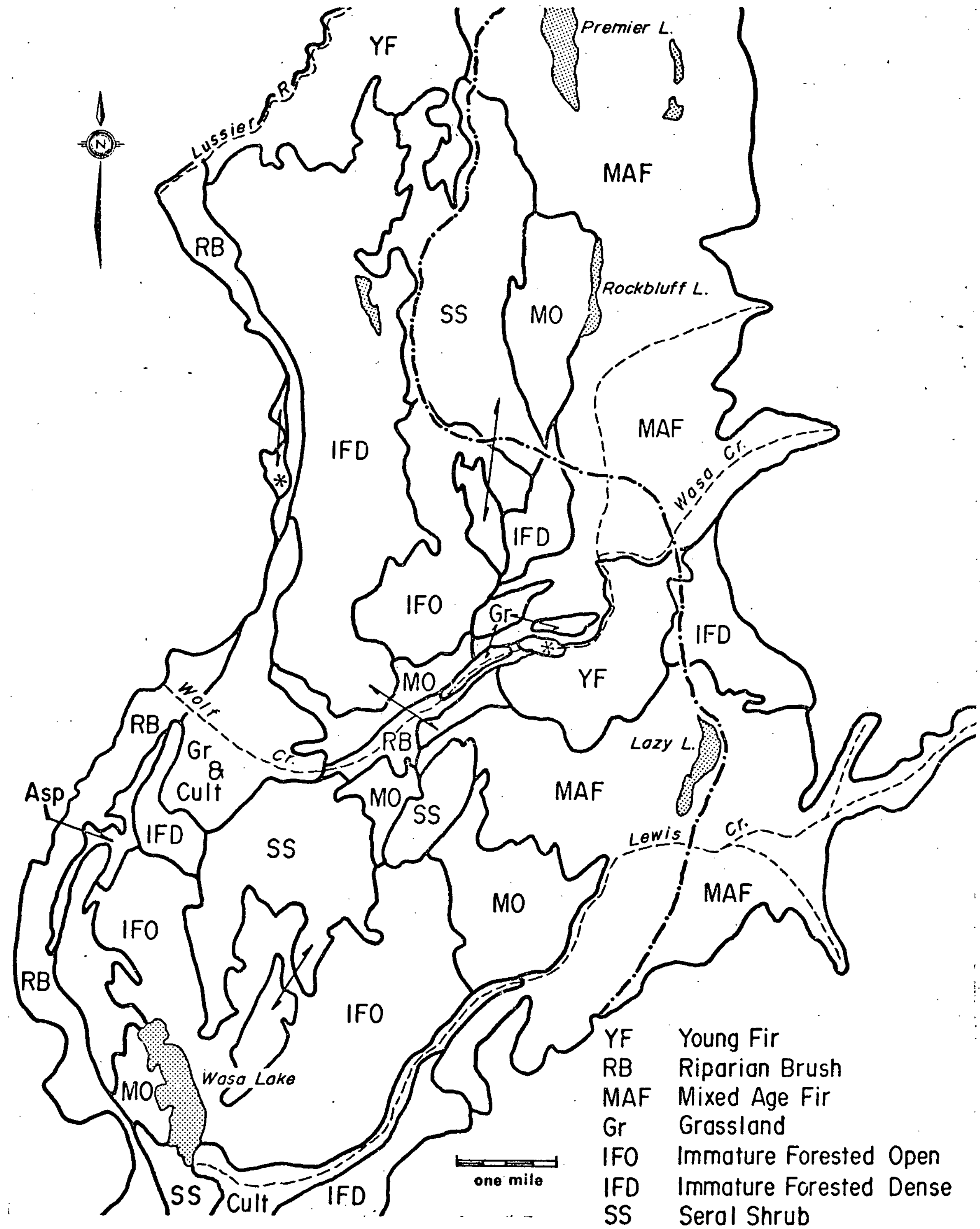
RESULTS

Analysis of Winter Range Habitat

The plant communities on the winter range were divided into eleven different habitat types based on my interpretation of the deer's response to the physical structure or species composition of the type. The names are purely descriptive. This system was felt to be more relevant to the practical approach I used than the more theoretical concepts used by Kemper (1971). Figure 5. is a map of the distribution of the habitat types on the winter range, and Table I lists their proportions.

Grassland:

On the winter range there are four grassland areas, all of which



YF Young Fir
RB Riparian Brush
MAF Mixed Age Fir
Gr Grassland
IFO Immature Forested Open
IFD Immature Forested Dense
SS Seral Shrub
MO Mature Open
Asp Aspen
Cult Cultivated
* Riparian Mature Spruce
—·— Eastern edge of white-tailed deer distribution

FIGURE 5. Distribution of habitat types on the winter range.

TABLE I

PROPORTIONS OF HABITAT TYPES ON THE WOLF CREEK WINTER RANGE

Habitat	ha.	% of the Area
Grassland	330	6
Riparian Brush	55	1
Aspen	11	1
Seral Shrub	440	8
Young Fir	714	13
Immature Forested Open	1,319	24
Immature Forested Dense	1,374	25
Maturing Open	550	10
Mixed Age Fir	660	12
Riparian Mature Spruce	15	1
Total	5,468(21 mi^2)	

show the influence of grazing by domestic stock. Kemper (1971) described a "natural" grassland in this area as being dominated by bluebunch wheatgrass (*Agropyron spicatum*), rough fescue (*Festuca scabrella*), and junegrass (*Koleria cristata*) with a combined ground cover of 80%; 10 species of forbs produced a ground cover of 6%. In contrast, the grassland areas of the white-tail winter range are dominated by needle grass (*Stipa richardsoni*, cover = 13.2%) with some bluebunch wheatgrass (cover = 6.6%), junegrass (cover = 4%) and bluegrasses (*Poa* spp., cover = 2.2%) giving a total of only 23% ground cover. Twenty-one forb species were found to cover approximately 10% of the soil surface with fleabane (*Erigeron pumilus*, cover = 5.2%) and pussytoes (*Antennaria microphylla*, cover = 1.9%) being dominant. Nearly 20% of the ground surface is bare soil (See Table II).

Riparian Brush Type:

This habitat was of limited distribution, and very difficult to sample, but it appears to be relatively important to the deer. It consists of the open brushy areas adjacent to Wolf Creek and differs from the seral shrub type in species composition due to greater soil moisture. In many places, this habitat consists only of narrow thickets of red osier dogwood (*Cornus stolonifera*) or a marshy area with various willows (*Salix* spp.) and a sedge ground cover. It was impossible to take many of the measurements in these areas. I therefore concentrated on a few spots where this type was dispersed over a drier substrate. The species composition of these areas differed somewhat from the dogwood thickets or willow marsh, but the trends in productivity and deer use are similar.

TABLE II

SPECIES COMPOSITION OF HERBACEOUS LAYER: WINTER RANGE

Species*	Habitat Type								
	Grass.**	R.B.	Asp.	S.S.	Y.F.	I.F.O.	I.F.D.	M.A.F.	M.O.
Grasses:									
Agropyron spicatum	6.6/23***	tr/20	tr/10	2.8/52		2.2/52		tr/20	
Bromus tectorum				1.0/40					
Calamagrostis rubescens				1.1/14	tr/20		8.3/76	5.7/58	4.4/65
Carex concinnoides			2.9/30	tr/10				6.4/33	
C. rossii		tr/16							
Festuca scabrella				2.5/28		tr/28		1.8/20	
Koleria cristata	4.0/35			4.6/64	tr/24				tr/14
Poa spp.	2.2/28	15.1/88	5.8/90	1.8/14	1.5/20				
Stipa richardsoni	13.2/78				5.8/62				
Forbs:									
Achilles millefolium		tr/20		7.9/42	tr/20	tr/20		tr/16	tr/10
Agroseris sp.						3.4/28	tr/14		
Allium cernuum				tr/10	tr/22	tr/14		tr/31	tr/24
Anemone patens						3.0/20			tr/26
Antennaria microphylla	1.9/18			2.3/30		2.6/30		tr/18	tr/11
Aster sp.		tr/18			tr/18				
Atragalus miser				1.8/24			tr/10		
Castilleja miniata	tr/10					tr/12			
Chryopsis vilosa					tr/20				
Collinsia grandiflora	tr/10			1.3/52	tr/26				
Crepis atrabarba				1.3/12					
Epilobium minatum				tr/32	tr/42				
Equisetum arvense			tr/16						
Erigeron filifolium				tr/20					
E. pumilus	5.2/48								
Fragaria glauca		1.3/20			1.7/28			1.2/32	
Galium boreale			tr/20						
Lathyrus nevadensis		tr/22	3.1/66						
Lomatium triternatum				tr/16					
Melilotus alba	1.8/20								
Penstemon confertus				2.5/36		tr/10	1.6/34	tr/20	1.1/14
Phlox caespitosus				3.8/52		14.6/88	tr/28	1.3/33	1.2/18
Rubeckia hirta		tr/12	10.5/74						
Taraxacum scopulorum			4.1/46	1.6/42		tr.16			tr/10
Trifolium sp.		3.4/64							
Viola adunca			1.9/34		1.7/28				
Dwarf shrubs:									
Arctostaphylos uva-ursi				29.9/88	15.1/63	10.8/45	3.3/20	4.6/42	7.6/29
Berberis nervosa					1.7/20				
Bare ground:	19.8/95	6.1/32	1.9/16	23.5/80	18.3/72	4.7/38	11.4/61	2.3/16	1.9/25

*Only species with at least 10% frequency of occurance in one type shown.
**Grass.= Grassland; R.B.= Riparian Brush; Asp.= Aspen; S.S.= Seral Shrub; Y.F.= Young Fir; I.F.O.= Immature Forested Open; I.F.D.= Immature Forested Dense; M.A.F.= Mixed Age Fir; M.O.= Maturing Open
***% cover/% frequency of occurance

Bluegrasses (cover = 15.1%) were the only abundant grasses, but *Carex rossii* and bluebunch wheatgrass were also found in trace amounts (Table II). The relatively sparse forb component included twelve species, but only strawberry (*Fragaria glauca*, cover = 1.3%) and an introduced clover (*Trifolium* sp., cover = 3.4%) were significant in contribution to the approximately 5% ground cover. The density of the shrubs, however, left only 6% of the ground bare.

Seven shrub species were common (Table III), with snowberry (*Symphoricarpus albus*) and rose (*Rosa woodsii* and *R. acicularis*) contributing most of the 248.3 twigs/m^2. Because of favorable sunlight conditions (no shading) and year-round availability of water, productivity is high, and the four most abundant species provide 21.64 g/m^2 of forage annually (Table IV). Utilization was low on snowberry (16.4%) due to its abundance and relatively low palatability, moderate on rose and willow (31.2 to 46.1%), and extremely high (105.5 to 110.0%) on the rare, but favored saskatoon (*Amelanchier alnifolia*) and choke cherry (*Prunus virginianus*) (Table V).

Aspen Type:

In a few places along Wolf Creek and on the Kootenay floodplain, stands of maturing aspen (*Populus tremuloides*) are found. The herbaceous layer in this habitat is relatively diverse containing at least 25 different species, but few of these provide ground cover in excess of 1%. Most abundant are bluegrasses (cover = 5.8%), carex (cover = 2.9%),

TABLE III

AVAILABLE SHRUB BROWSE IN TWIGS/m^2: WINTER RANGE

	Habitat Type								
Species	R.B.*	Asp.	S.S.	Y.F.	R.M.S.	M.O.	M.A.F.	I.F.O.	I.F.D.
Purshia tridentata			91.2			21.1	4.0	13.4	6.6
Amelanchier alnifolia	6.6	32.5	8.1	36.9		20.8	27.8	32.8	4.6
Symphoricarpos albus	180.2	30.2		14.8	45.4	9.2	7.4	2.0	
Rosa woodsii	6.8	48.6	2.3	13.5	0.7	1.3	3.5	0.9	
R. acicularis	46.1	26.1		0.6	9.8				
Spirea lucida				20.1	14.7		8.4	0.5	1.3
Shepherdia canadensis				0.3	0.2		1.1		
Populus tremuloides		18.0		1.7	0.2				
Salix glauca	0.3	0.6							
Cornus stolonifera					1.7				
Alnus sinuata					0.7				
Rubus parviflorus					3.0				
R. spectabilis					0.2				
Ribes irriguum	2.3				2.0				
Prunus virginianus	6.0			0.6	2.4				
Acer glabrum					0.2				
Sambucus racemosa var. arborescens					0.5				
Lonicera involucrata					0.2				
Total:	248.3	156.0	101.6	88.5	81.9	52.4	52.2	49.6	12.5
Mean:	35.5	26.0	33.8	11.1	5.5	13.1	9.7	9.9	4.2

*Habitat Type:
R.B. = Riparian Brush
S.S. = Seral Shrub
Asp. = Aspen
Y.F. = Young Fir
R.M.S.= Riparian Mature Spruce
M.O. = Maturing Open
M.A.F. = Mixed Age Fir
I.F.O. = Immature Forested Open
I.F.D. = Immature Forested Dense

TABLE IV

ANNUAL PRODUCTION OF BROWSE IN G/m^2

BY SHRUB SPECIES: WINTER RANGE

Species	R.B.*	S.S.	Asp.	Y.F.	R.M.S.	M.O.	I.F.O.	M.A.F.	I.F.D.
	Habitat Type								
Purshia tridentata		10.67				0.97	0.72	0.18	0.17
Amelanchier alnifolia	0.08	0.30	0.07	1.66		0.93	0.89	0.46	0.14
Symphoricarpos albus	19.45		0.67	0.81	2.03	0.37	0.07	0.17	
Rosa woodsii	0.42	0.18	1.01	0.63	0.13	0.05	0.02	0.17	
R. acicularis	1.69		1.09	0.04	0.96				
Populus tremuloides			0.76	0.06	0.01				
Total:	21.64	11.15	3.60	3.20	3.13	2.32	1.70	0.98	0.31
Mean:	5.41	3.72	0.72	0.64	0.78	0.58	0.43	0.25	0.16

*Habitat Type:
R.B. = Riparian Brush
S.S. = Seral Shrub
Asp. = Aspen
Y.F. = Young Fir
R.M.S. = Riparian Mature Spruce
M.O. = Maturing Open
I.F.O. = Immature Forested Open
M.A.F. = Mixed Age Fir
I.F.D. = Immature Forested Dense

TABLE V

SHRUB SPECIES UTILIZATION*: WINTER RANGE

	Habitat Type								
Species	R.B.**	Asp.	S.S.	Y.F.	I.F.O.	I.F.D.	M.O.	M.A.F.	R.M.S.
Purshia tridentata			23.1		26.2	30.9	29.5	18.3	
Amelanchier alnifolia	105.5	27.9	18.6	52.3	45.7	25.3	36.5	49.6	
Symphoricarpos albus	16.4	58.7		50.4	36.1		18.1	15.6	24.3
Rosa woodsii	46.1	83.4	17.0	54.1	48.7		28.7	45.9	40.0
R. acicularis	31.2	42.5		48.0					27.1
Spirea lucida				46.9	36.7	34.6		28.8	56.2
Populus tremuloides		44.7		61.6					59.4
Salix glauca	44.5	36.0							
Cornus stolonifera									110.8
Prunus virginianus	110.0			82.8					61.9
Mean:	59.0	48.9	19.6	56.6	38.7	30.3	28.2	31.6	54.2

*Utilization = (Diameter at Point of Browsing/Diameter at Annual Growth) x (% of twigs browsed)

**Habitat Type:
R.B. = Riparian Brush
Asp. = Aspen
S.S. = Seral Shrub
Y.F. = Young Fir
I.F.O. = Immature Forested Open
I.F.D. = Immature Forested Dense
M.O. = Maturing Open
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R.M.S. = Riparian Mature Spruce

browneyed susan (*Rubeckia hirta*, cover = 10.5%), dandelion (*Taraxacum scopulorum*, cover = 4.1%), purple pea (*Lathyrus nevadensis*, cover = 3.1%), and violets (*Viola adunca*, cover = 1.9%). This rich herb layer leaves only 1.9% of the soil surface bare (Table II).

The aspen type also has a well developed shrub layer in which five major species provide 155.4 twigs/m^2 (Table III). These species produce 3.6 g/m^2 of browse annually (Table IV), of which nearly 50% is used (Table V). The greatest use occurs on the most abundant and productive species, *Rosa woodsii*.

The overstory in this type is purely aspen; with a density of 4880 stems/ha. The average dbh is 9.91 cm and mean height is 12 m. Heavy browsing by deer and cattle has affected the growth of the 3040 saplings/ha (Table VI) and many of these were decadent.

Seral Shrub Type:

This habitat type occurs widely on Premier and Wasa Ridges, but a large portion of the shrubland habitat is at elevations unusued by white-tails in most winters. Main grass species are junegrass (cover = 4.6%), bluebunch wheatgrass (cover = 2.8%) and fescue (cover = 2.5%) with some *Bromus tectorum*, bluegrass and pinegrass (*Calamagrostis rubescens*) to total 13.8% grass ground cover (Table II). Common forbs are yarrow (*Achilles millefolium*, cover = 7.9%), pussytoes (cover = 2.3%), phlox (*Phlox caespitosus*, cover = 3.8%) and beardtongue (*Penstemon

TABLE VI

FOREST COMPOSITION: WINTER RANGE

Habitat Type	Species	Stems/ha	Ave. dbh	Ave. ht.
Aspen	Populus tremuloides	4880	9.9 cm	12 m
		3040	sapl.	3
		7920		
Young Fir	Pseudotsuga menziesii	820	7.4	6
		4120	sapl.	3
	Pinus contorta	20	sapl.	3
	Larix occidentalis	20	sapl.	3
		4980		
Immature Forested Open	Pseudotsuga menziesii	117	8.1	6
		217	sapl.	2
	Pinus ponderosa	1833	9.1	8
		1317	sapl.	3
	Pinus contorta	567	12.4	10
		100	sapl.	3
		4151		
Immature Forested Dense	Pinus ponderosa	950	10.2	10
		300	sapl.	3
	Pseudotsuga menziesii	450	6.6	6
		4100	sapl.	5
		5800		
Mixed Age Fir	Pseudotsuga menziesii	175	29.2	15
		725	9.9	8
		1275	sapl.	3
		2175		
Maturing Open	Pseudotsuga menziesii	100	31.0	15
		100	7.4	6
		113	sapl.	3
	Pinus ponderosa	88	25.3	15
		150	11.2	6
		50	sapl.	3
		601		
Riparian Mature Spruce	Picea glauca	267	36.6	16
		233	9.9	6
	Pseudotsuga menziesii	67	29.5	15
		33	sapl.	3
	Larix occidentalis	33	29.4	16
	Populus tricocarpa	33	47.2	19
		33	sapl.	6
	P. tremuloides	133	9.1	6
		33	sapl.	5
	Betula papyrifera	267	9.1	6
		333	sapl.	3
		1465		

confertus, cover 2.5%), which, with 19 other species, cover 23% of the ground. Bearberry (*Arctostatphylos uva-ursi*) covers nearly 30% of the ground surface, and 24% of the soil is bare reflecting both the dry nature of the areas and the influence of season long cattle grazing.

The dominant species in the shrub layer is bitterbrush (*Purshia tridentata*). In an earlier study of this habitat Kemper (1971) gave bitterbrush a coverage value of 25%. I found that this species provides 91.2 twigs/m^2, and saskatoon and rose (*R. woodsii*) provide 8.1 and 2.3 twigs/m^2, respectively (Table III). Annual production for these species is 10.67, 0.30, and 0.18 g/m^2, respectively (Table IV), giving a total of 11.15 g/m^2 of forage produced in the type. Utilization of these species was 23.1, 18.6, and 17.0%, respectively (Table V). Since the sampling period followed an unusually deep snow winter which reduced deer use of this open habitat, these values should be viewed as minimum levels of use for these species in this habitat.

Young Fir Type:

This habitat covers an area that was cleared and/or burned about 40 years ago on the northeast slope of Wasa Ridge and on the alluvial gravel deposits where Wasa Creek runs off the Hughes Range to join Wolf Creek. It has been subject to human influence through grazing by cattle and to Christmas tree farming. These activities tend to retard maturation of the overstory and most of the trees are less than 20 years old.

Needlegrass (cover = 5.8%) and bluegrasses (cover = 1.5%) dominated pinegrass in the sampled area, but the reverse appeared true in some of the shaded areas on more northerly exposures. Some 17 species of forbs covered about 5% of the ground, with strawberry and violets, each with 1.7% cover, most plentiful. Bearberry was abundant and covered 15.1% of the ground, and Oregon grape (*Berberis nervosa*) covered another 1.7% (Table II).

Saskatoon and flattop spirea (*Spirea lucida*) dominated the shrub layer, but six other species were common and contributed to a total of 88.5 twigs/m^2 (Table III). Annual production was moderate, averaging 0.64 g/m^2 for each species and 3.2 g/m^2 for all species combined. Utilization values are consistently high, averaging 56.6% (Table V).

The trees here are predominantly douglas fir with 4120 saplings and 820 trees/ha. Some lodgepole pine and larch (*Larix occidentalis*) also occur (Table VI). Table VII shows that this overstory provides a total of 3122 kg/ha of fir browse, of which 72% is found on the saplings. Light use of browse was noted on the trees, but moderate to heavy use was common on saplings. Some individuals were severely hedged.

Immature Forested Open Type:

Following removal of the original plant communities on the terraces or benchlands of Premier and Wasa Ridges, the initial forest regeneration in the drier areas has been a mixture of yellow pine and lodgepole pine.

TABLE VII

AVAILABLE FIR BROWSE: WINTER RANGE

Habitat Type	kg/h (Sapl.)	kg/h (Trees)	kg/h (Total)
Young Fir	618 (T)* 1638 (N)** 2256 (B)***	247 (T) 620 (N) 867 (B)	865 (T) 2258 (T) 3123 (B)
Immature Forested Dense	194 (T) 480 (N) 674 (B)	22 (T) 55 (N) 77 (B)	216 (T) 535 (N) 751 (B)
Mixed Age Fir	112 (T) 280 (N) 392 (B)	82 (T) 227 (N) 309 (B)	194 (T) 507 (N) 701 (B)
Immature Forested Open	23 (T) 56 (N) 79 (B)	17 (T) 42 (N) 59 (B)	40 (T) 98 (N) 138 (B)
Maturing Open	17 (T) 43 (N) 60 (B)	15 (T) 37 (N) 52 (B)	32 (T) 80 (N) 112 (B)

Based on the equations:

(T): $\log_e$ (twig biomass) = -3.2534 + 2.3442 ($\log_e$ stem diameter); r = .958

(N): $\log_e$ (needle biomass) = -2.7427 + 2.5913 ($\log_e$ stem diameter); r = .943

(B): $\log_e$ (browse biomass) = -2.0347 + 2.3593 ($\log_e$ stem diameter); r = .923

*(T) = twig biomass
**(N) = needle biomass
***(B) = browse biomass

These stands are relatively open and tree canopy coverage is about 40 to 50%. Most of the trees are in the later part of the 30 to 50 year age class.

Bluebunch wheatgrass is well distributed in the understory, but the plants are stunted and cover only 2.2% of the ground surface. Other grasses are only found in trace amounts. The abundance of forbs like phlox (cover = 14.6%), *Agroseris* sp. (cover = 3.4%) and pussytoes (cover = 2.6%) point to an understory that is overutilized by grazing animals (Kemper, 1971). In all, 22 forb species were found in the understory and they cover about 25% of the surface. Bearberry covers 10.8% of the ground and nearly 5% of the soil is bare.

The shrub layer here is much reduced from the open types that lack a significant conifer canopy. Five species, dominated by saskatoon and bitterbrush, provide 49.6 twigs/m^2; a 50% reduction from the open seral shrub areas with similar soil and moisture regimes (Table III). Shade and insufficient moisture are probably important in limiting annual production to 1.7 g/m^2, averaging only 0.43 g/m^2 for each species (Table IV). Utilization is moderate, averaging 38.7% (Table V).

The overstory in this type consists of 25.7 trees and 1634 saplings/ha. The trees are 73% yellow pine, 23% lodgepole pine, and 4% douglas fir. The sapling stands are composed of these three species in the proportions of 81%, 6%, and 13%, respectively (Table VI). The pine saplings average 3.0 m tall, while the fir are only 1.5 m tall. The small fraction of fir in this mixture results in only 138 kg/ha of conifer browse being available in this habitat (Table VI). As in the Young Fir type, use of fir is light on trees and moderate to heavy on saplings.

Immature Forested Dense Type:

This habitat is interspersed with the Immature Forested Open type and represents areas on the slopes and terraces that have a more moist micro-climate due, primarily, to exposure. Yellow pine was the initial recolonizer following removal of the original montane forest, but douglas fir is rapidly taking advantage of its greater tolerance for cooler, moister soils. These stands originated about 40 to 50 years ago and generally exceed 60% canopy closure.

Due to light conditions, the understory is sparse and the little-used pine grass covers only 8.3% of the ground. Fourteen forb species were found, but only one exceeds 1% cover and total forb cover is less than 2.5%. Bearberry covers only 3.3% of the ground and 11.4% of the soil is bare. In addition to low light levels, the accumulation of heavy litter (fallen dead branches) that covers only 80% of the ground (Table II) is suppressing plant growth.

Only three species of shrub were found in the sample plots. Saskatoon, bitterbrush and flattop spirea supply only 12.5 twigs/m^2 (Table III) and annual production of only 0.31 g/m^2 for the two former species combined (Table IV). Utilization of shrubs is below average at

30.3% (Table V), possibly reflecting lower palatability of shrubs growing in shaded conditions.

Sixty-eight percent of the 1400 trees/ha in this habitat are yellow pine which are older and larger than the 32% douglas fir. However, 95% of the 5850 saplings/ha here are fir that are doing better than the pine (Table VI).

It is the large number of young fir trees that give this type its dense characteristic. The degree of canopy closure has not only reduced the understory, but most of the lower limbs on the "spindly" saplings have died. Although this type provides more fir browse per unit area than is supplied by the Immature Forested Open or Maturing Open types, on a per sapling basis this habitat provides only one-third to one-fourth the amount of the other types. Quantitative differences may be intensified by a qualitative difference since very little of the available browse in the Immature Forested Dense type is current annual growth (see also Discussion).

Some saplings growing in small openings in this type were heavily browsed, but generally the sparsely-needled, dying branches within the truly dense stands were but little used.

Mixed Age Fir Type:

This forest type represents areas that must have been selectively logged, or that were repeatedly subjected to "cool" fires and have developed a multiple-layered tree canopy composed almost exclusively of douglas fir. Canopy closure is highly variable, but generally ranges from 40 to 50% on south exposures and from 50 to 70% on north aspects.

Pinegrass (cover = 5.7%), carex (cover = 6.4%), fescue (cover = 1.8%), and traces of bluebunch wheatgrass provide a ground cover of about 14% in this habitat reflecting a good moisture regime and moderate grazing. Wild strawberry (cover = 2.3%) and 20 other forbs cover about 4% of the ground. Bearberry is common covering nearly 5% of the surface, and only 2.3% of the soil is bare (Table II).

Saskatoon is by far the most plentiful shrub with 27.8 twigs/m^2. Snowberry and flattop spirea are common, providing 7.4 and 8.4 twigs/m^2, respectively, and bitterbrush and rose also occur. Total twig availability is 52.2 twigs/m^2 (Table III), and four of these species together produce 0.98 g/m^2 annually (Table IV). Utilization of saskatoon, spirea and rose is moderate, but snowberry and bitterbrush are ratherly lightly used (Table V).

The top layer of the overstory consists of fir trees in excess of 60 years old. These have a mean dbh of 29.2 cm and average about 15.2 m tall. There are 175 of these trees/ha. The next layer of younger trees, aged 30 to 50 years have a mean dbh of 9.9 cm and average 8 m tall. There are 725 of these trees/ha. The bottom layer consists of the sapling regeneration with an average height of 3 m and a density of 1275 stems/ha.

The mature trees provide no browse for the deer, but the other two layers supply 702 kg/ha of fir browse. Use of browse on the trees is light to moderate, but on the saplings is heavy to excessive. Many very small firs (less than 1 m tall) were browsed to the point where they were stunted and deformed.

Maturing Open Type:

This habitat is also a multiple layered type, but differs from the Mixed Age Fir in both density and species composition. Canopy closure rarely exceeds 40% and the drier nature of the soils in this type allow a mixture of pine and fir.

Carex disappears from this drier type leaving pinegrass (cover = 4.4%) the predominant species in the approximately 5% grass cover. The dry nature of the soil also prevented the 22 forb species found here from covering more than 4% of the ground. Bearberry which does well on drier soils given sufficient sun covers 7.6% of the surface and only 1.9% of the soil was bare (Table II).

Shrub biomass is slightly improved over the Mixed Age Fir type with both bitterbrush and saskatoon providing over 20 twigs/m^2. Snowberry and rose also contribute to the 52.4 twigs/m^2 (Table III), and all four species produce a total of 2.32 g/m^2 annually (Table IV). The low utilization values given in Table V are most likely a reflection of the influence of the unusually deep snow during the winter prior to the sampling period.

Both mature yellow pine and mature douglas fir are found here in densities of 88 and 100 trees/ha, respectively. Younger pine and fir also occur with densities of 150 and 100 stems/ha, respectively. Fir dominates the sapling layer with 113 stems/ha compared to only 50 for pine (Table VI).

Due to the openness of this type, the browse per tree is high, but total fir browse is only 112 kg/ha (Table VII). Level of use of the fir browse is inversely proportional to tree size: the saplings are heavily used, moderate to light use occurs on the larger saplings, and the trees are only lightly browsed.

Riparian Mature Spruce:

One small area in the Wolf Creek bottom is occupied by a habitat similar to the spruce communities found on the islands and banks of the Kootenay River. Due to its limited distribution in Wolf Creek and also to the level of agriculatural disturbance along the Kootenay floodplain in this region, the type is of reduced importance on this winter range. It does appear to be a productive and preferred type where it occurs though, and future investigations of white-tailed deer habitat in the Rocky Mountain Trench should place more emphasis on the study of this, and other riparian communities in undisturbed sections of the river floodplain.

Quantitative data were not gathered on the herbaceous layer, but it was generally composed of lush sedges with a wide variety of wetland plants such as: skunk cabbage (*Lysichiton kamtchatcense*), horsetail (*Equisetum arvense*), bedstraw (*Galium boreale*) false solomon's seal (*Smilacina amplexicaulis*), twisted stalk (*Streptopus amplexifolius*) and various orchids (*Cyprpedium* spp.). Oregon grape is common and covers 8.3% of the ground.

The shrub layer here is well developed and abundant, nonwoody growth of species like elderberry (*Sambucus racemose* var. *arborescens*) and thimbleberry (*Rubus parviflorus*) add to the lushness of the understory. Fifteen different shrub species here provide a total of 81.9 twigs/m^2 (Table III). Most important in providing browse are snowberry, flattop spirea, rose, thimbleberry, and red osier dogwood. Four of the species were sampled for productivity and averaged .78 g/m^2, totaling 3.13 g/m^2 (Table IV). If all species were included, production might approach 5.0 g/m^2 in this type. Utilization values are high on all species except snowberry and rose (Table V).

Although some fir did occur on the edges of this type in Wolf Creek (Table VI), the model stand would lack this species. The more flood tolerant white spruce (*Picea glauca*) is the major tree here having a density of 267 mature trees and 233 younger trees/ha. Larch and cottonwood (*Populus trichocarpa*) are also found as mature trees, each with 33 stems/ha. Younger cottomwoods, aspen, paper birch (*Betula papyrifera*) and choke cherry also contribute to a total density of almost 2000 stems/ha. Many of the saplings of these species are heavily browsed.

Analysis of Summer Range Habitat

The plant communities of the summer range have been studied in much less detail than those of the winter range. Accordingly I have chosen to use the more general term "associations" rather than habitat types. The area has been divided into three plant associations: Shrub, Brush and Immature Forest. Sampling in each was designed only to document variations and possibly identify trends in the associations. Within the Brush and Shrub associations, elevational trends were found, but the Immature Forest association was highly variable and trends were more difficult to ascertain.

Shrub Association:

Although the "shrubby" appearance of this association is consistent, Table VIII and Figure 6. illustrate the changes in the species composition of the shrubs with increasing altitude. At lower levels the association is dominated by bitterbrush and saskatoon; a situation not too unlike the shrublands of the winter range. However, bitterbrush quickly disappears upslope and is replaced by species indicative of more moist areas: evergreen ceanothus (*Ceanothus velutinus*) and snowberry. Saskatoon and rose vary about high (16.6%) and low (1.6%) mean coverage values, respectively, and no definite trend is expressed. Incomplete data prevent analysis of elevational changes in the herbaceous layer. However, it is expected that total herb cover would increase slightly with more favorable conditions (i.e. greater moisture and reduced cattle

TABLE VIII

SPECIES COMPOSITION OF SHRUB ASSOCIATION: SUMMER RANGE

Species	Elevation			
	2650'	2800'	3300'	3600'
Shrubs:				
Amelanchier alnifolia	17.5/100*	30.0/100	6.7/100	12.0/100
Arctostaphylos uva-ursi	1.5/10	tr/10	**	**
Acer glabrum				2.0/50
Ceanothus velutinus	1.7/67	5.0/33	6.7/100	12.0/100
Populus tremuloides		tr/33		2.0/50
Purshia tridentata	15.0/100	2.5/100		
Rosa woodsii	tr/33	2.5/100	tr/33	3.0/50
Salix glauca			tr/33	2.0/50
Shepherdia canadensis		5.8/67	1.7/67	15.0/100
Spirea lucida		1.7/67	5.0/33	
Symphoricarpos albus		1.7/67	5.8/67	8.0/100
Total shrub cover	35.7	49.2	25.9	56.0
Herbs: ***			**	**
Achillea millefolium	5.5/57	2.4/43		
Agropyron spicatum	11.4/83	1.2/17		
Antennaria microphylla		5.1/40		
Arabis holboelli	tr/37	tr/10		
Astragalus miser	13.3/67	tr/10		
Balsamorhiza sagittata	1.8/10			
Bromus tectorum	tr/33			
Calamagrostis rubescens	tr/10	tr/17		
Campanula rotundifolia	tr/10			
Chryopsis vilcsa	1.0/40			
Epilobium minutum	tr/10			
Erigeron pumilus		tr/10		
Galium boreale		1.2/13		
Koleria cristata	2.6/53	7.3/60		
Penstemon confertus	1.3/20			
Poa pratens	3.2/17	7.1/57		
Solidago spathulata		3.2/27		
Tragopogon dubius	tr/27			
Total herb cover	38.3	27.5		
Other:			**	**
Bare soil	17.8/83	26.1/73		
Litter	57.9/100	40.3/97		

*% ground cover/% frequency of occurrance (tr = less than 1%)
**data not available
***only species with at least 10% frequency in at least 1 site shown.

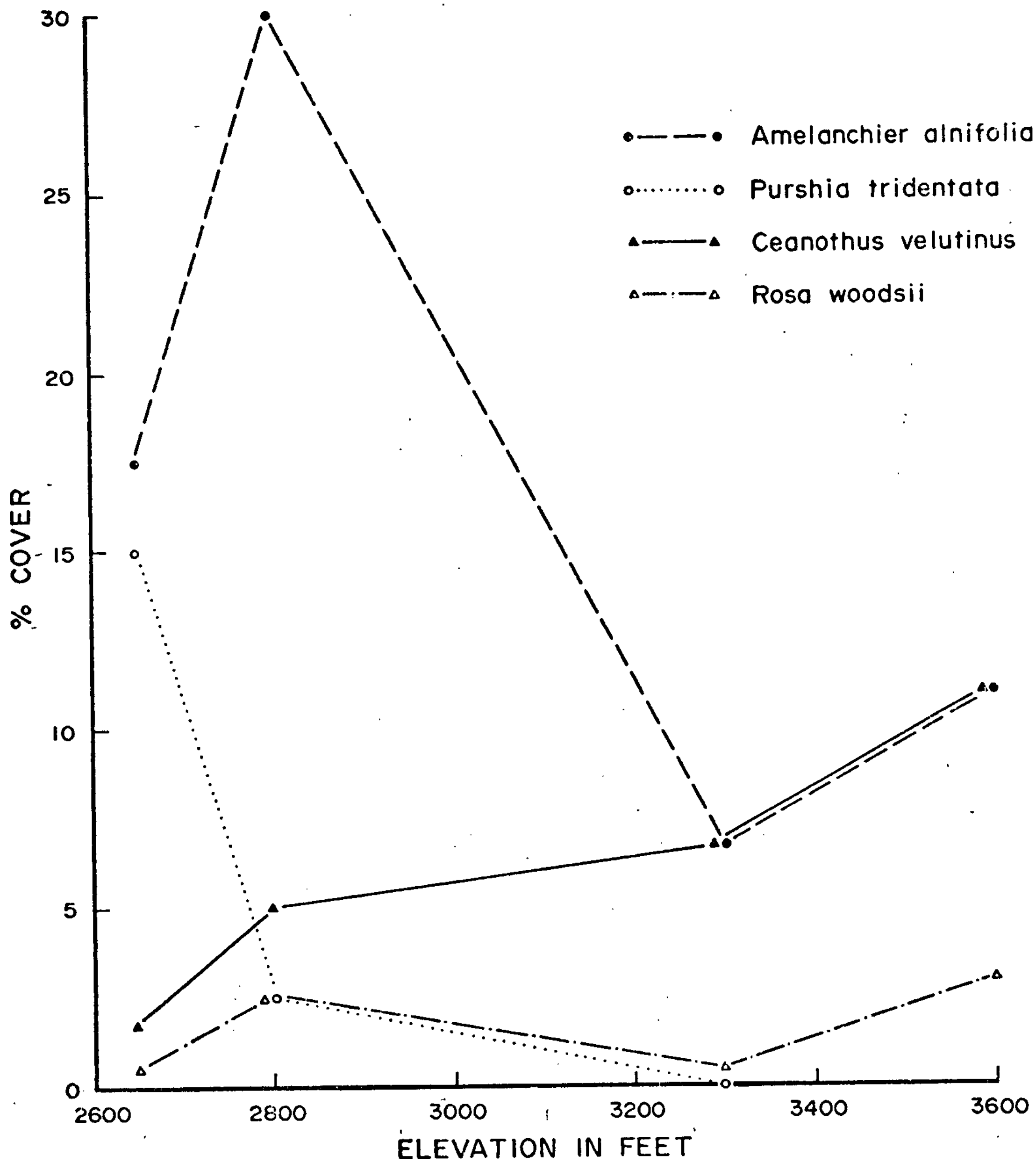

FIGURE 6. Elevational trends in coverage values of four shrub species in the Shrub Association on the summer range.

grazing) at higher elevations. Species composition should also change as "dry soil" plants like bluebunch wheatgrass, pussytoes, and *Astragalus miser* disappear and are replaced by more moisture dependent species.

Brush Association:

This riparian association occurs on islands in the Kootenay River and along streams at various elevations. On the river islands, it consists of two sub-associations. Along the banks and in old channels, a willow-dogwood-rose sub-association with a *Carex-Elymus* understory provides a dense thicket two to four meters high of varying width that supplies both forage and cover. Local, moderate use of the leaves of these shrub species was noted in late summer and fall. The other sub-association occurs on interior, drier portions of the islands and is characterized by large clumps of water birch (*Betula occidentalis*) up to 8 m tall spaced at about 10 to 15 meter intervals. The ground is almost completely covered with a layer of *Potentilla fruticosa* that is approximately 1 m high. Beneath the *Potentilla*, the only common plants are sedges. Deer were found to bed in this sub-association, but did not feed much on the plants here.

These sub-associations have been, and are, greatly affected by annual flooding. Recently, their productivity was seriously hampered due to the excessive silting that occurred during the record flood of June, 1974. The source of the silt was a section of the floodplain directly upstream that had not developed a ground cover following clearing a few years before.

Along the creeks at elevations above the floodplain, this association increases in species diversity, and composition of any particular section is influenced by surrounding vegetation. Where the creeks run through narrow channels in open areas at lower levels, the brush is dominated by aspens which occasionally reach tree size. Red osier dogwood is common, as are willows, rose, silverbush (*Eleagnus commutata*), mountain maple (*Acer glabrum*) and water birch. The herb layer is mixed sedge and forb. These areas often show abuse from cattle grazing and trampling.

At several elevations, the wet areas spread out and form sloughs or bogs. In some places the process has been encouraged through damming by beaver (*Castor canadensis*). Here, the brush is predominantly willows (*Salix glauca, S. barrattiana,* and *S. bebbiana*) with a sedge-rush-*Equisetum* understory. At the marshy margins, alders (*Alnus sinuata*) and some birch and aspen may form a dense wall of woody vegetation, with a sparse sedge-forb understory. These areas are less affected by cattle.

Where the creeks flow through established forest communities, especially at higher elevations, the Brush association becomes much less dense and willows and birches are highly reduced. Red osier dogwood, rose and some alder and maple are common, as are shade tolerant species like twinberry (*Lonicera involucrata*), thimbleberry and snowberry. Cattle rarely disturb these areas.

Immature Forest Association:

The majority of the area considered in the "summer range" was subjected to extensive severe fires in the early 1900's. These fires created ranges that supported deer, elk and "hundreds of wild horses" (H. Campsall, pers. comm.) about 30 to 40 years ago. Now, however, the range has regenerated into relatively dense immature forests.

Once tree growth began, the more favorable moisture regime west of the floodplain promoted rapid growth. Table IX lists the composition of the overstory at the forested sites sampled west of the Kootenay River. On the floodplain, immature yellow pine stands are found that are similar to the Immature Forested Open type on the winter range, except for more intense cattle use. The high degree of variation above the floodplain is the result of micro-climatic factors. As a result of more favorable growing conditions, the average dbh here is greater than on the winter range despite similar stand age. Dominance of lodgepole pine and the presence of larch, aspen and birch reflect the more severe fire history and increased moisture, respectively, relative to the winter range.

The wide variation in the overstory at the sample sites introduces another element in analysis of understory with respect to elevation. For this reason, caution must be used in evaluation of the data. Two types of changes were noted in shrub cover: density and species composition. Figure 7. shows that the total shrub cover at sites above 2800 feet was

TABLE IX

OVERSTORY COMPOSITION OF IMMATURE FOREST ASSOCIATION: SUMMER RANGE

Site	Elev.	Species	Stems/ha	Ave.dbh	Ave. ht.
1	2600'	Pinus ponderosa	840	10.7 cm	5.5 m
			400	sapl.*	2.4
		Pseudotsuga menziesii	400	10.2	5.5
			10	sapl.	1.8
			1650		
2	2800'	Pinus ponderosa	370	11.2	6.4
			240	sapl.	3.0
		Pseudotsuga menziesii	10	sapl.	3.0
		Pinus contorta	50	14.7	11.0
			670		
3	3000'	Pinus ponderosa	90	12.4	8.2
		Pinus contorta	90	15.7	12.2
		Pseudotsuga menziesii	300	8.4	7.3
			440	sapl.	3.0
		Larix occidentalis	50	11.4	10.4
			10	sapl.	4.3
		Populus tremuloides	20	6.4	6.1
			70	sapl.	3.0
			1070		
4	3300'	Pinus contorta	1433	12.2	13.7
			67	sapl.	6.1
		Larix occidentalis	733	9.9	11.9
			567	sapl.	3.4
		Populus tremuloides	167	10.9	13.7
			167	sapl.	4.6
		Pseudotsuga menziesii	33	sapl.	4.6
		Betula papyrifera	33	5.6	7.6
			67	sapl.	4.6
			3264		
5	3300'	Pseudotsuga menziesii	340	11.4	8.2
			260	sapl.	3.4
		Populus tremuloides	40	13.2	10.1
			150	sapl.	2.7
		Larix occidentalis	10	sapl.	6.1
		Pinus contorta	10	sapl.	2.4
		Pinus ponderosa	10	sapl.	6.1

TABLE IX (cont.)

Site	Elev.	Species	Stems/ha	Ave.dbh	Ave. ht.
6	3300'	Pinus contorta	440	11.4 cm	12.2 m
			80	sapl.	6.1
		Pseudotsuga menziesii	90	12.7	12.2
			90	sapl.	5.2
		Larix occidentalis	60	16.0	12.2
		Betula papyrifers	120	8.4	10.1
			410	sapl.	4.6
			1290		
7	3500'	Pinus contorta	190	10.9	12.2
			30	sapl.	3.0
		Larix occidentalis	30	13.2	13.7
			10	sapl.	1.5
		Pseudotsuga menziesii	20	sapl.	1.5
			280		
8	3700'	Pseudotsuga menziesii	733	11.7	9.1
			800	sapl.	4.0
		Larix occidentalis	533	18.0	16.2
			100	sapl.	4.0
		Pinus contorta	167	17.8	12.2
		Thuja plicata	567	sapl.	1.5
			2900		
9	4100'	Pinus contorta	1720	9.1	12.2
			550	sapl.	4.6
		Larix occidentalis	40	sapl.	4.6
		Populus tremuloides	20	sapl.	3.0
		Populus trichocarpa	10	sapl.	3.0
			2340		

*sapl. = sapling

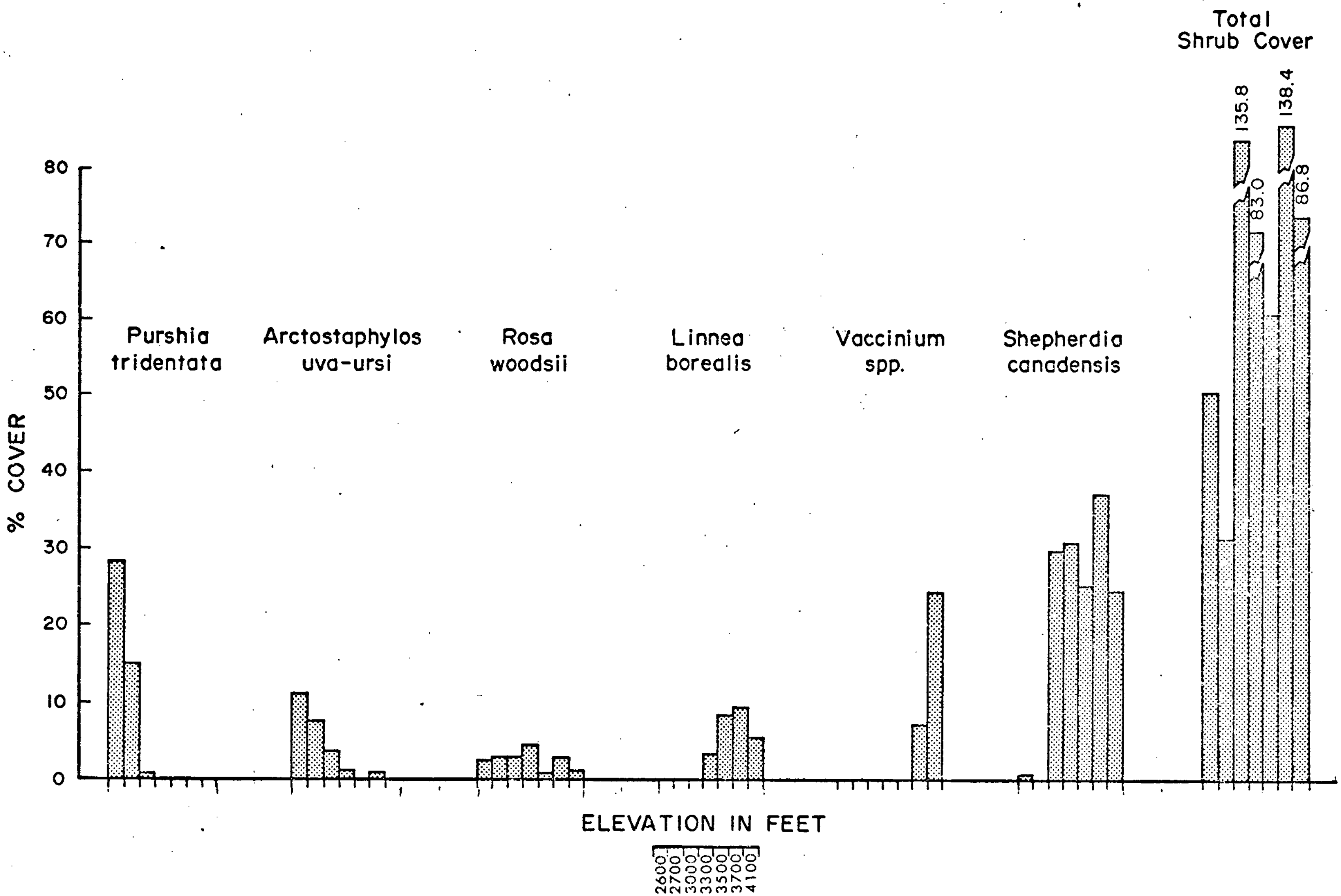

FIGURE 7. Elevational trends in coverage values of shrub species in the Immature Forest Association on the summer range.

TABLE X

UNDERSTORY COMPOSITION OF IMMATURE FOREST ASSOCIATION: SUMMER RANGE

Species*	Elevation(feet) 2600	2800	3000	3300	3300	3300	3500	3700	4100
Shrubs:									
Acer glabrum						tr/33**			1.3/50
Alnus alnifolia						1.7/67		tr/33	1.3/50
Amelanchier alnifolia	2.1/83	6.6/100	22.5/100	2.5/100		tr/33	tr/33	18.3/100	
Arctostaphylos uva-ursi	11.7/62	7.8/43	3.9/40	1.6/13	1.5/10			tr/10	
Berberis nervosa			5.6/43	10.3/37	7.8/60	8.5/37	2.5/20	3.3/33	
Ceanothus velutinus									
Cornus stolonifera									
Juniperus communis	5.0/33					tr/33	6.7/100	5.8/67	
J. scopulorum									
Linnaea borealis				10.9/63			8.2/37	9.6/50	5.7/63
Lonicera involucrata									1.3/50
L. utahensis								2.5/100	7.5/50
Menziesia ferruginea									7.5/50
Populus tremuloides	tr/33		2.5/100	1.7/67	2.5/100	tr/33			
Prunus virginianus	tr/33								
Purshia tridentata	2.5/17	15.0/100	tr/33						
Ribes irriguum									
Rosa acicularis			10.0/67				1.7/67		
R. woodsii	2.1/83	2.5/100	2.5/100	1.7/67	tr/33	10.0/67	tr/33	2.5/100	1.3/50
Rubus parviflorus						tr/33		tr/33	
R. spectabilis									
Salix agrophylla									
S. bebbiana				tr/33					1.3/50
S. glauca			10.8/100	2.5/100	5.0/33		tr/33	6.7/100	
S. mackenziana				tr/33					
Sambucus racemosa									
Shepherdia canadensis	tr/17		30.0/100	54.2/100	10.0/67	29.2/67	25.8/100	37.5/100	26.3/100
Spirea lucida			30.0/100	15.0/100	17.5/100	15.0/100	15.0/100	37.5/100	8.8/100
Symphoricarpos albus	tr/17		17.5/67	10.8/100		25.0/67		5.8/67	
Vaccinium caespitosum								5.0/33	1.3/50
V. scoparium								2.4/17	23.2/70
Herbs:									
Achillea millefolium	tr/13		tr/10						
Agropyron spicatum	1.2/30	tr/10							
Agroseris sp.	tr/10								
Allium cernuum	tr/10								
Arnica cordiflora				5.3/47		3.8/33			
Astragalus miser	2.2/15								
Calamagrostis rubescens		7.9/57	8.6/80	16.0/90	20.1/90	14.1/90	19.7/97	11.4/43	7.4/70
Carex concinoides	2.1/13	1.6/13							
Cornus canadensis									3.4/23
Festuca scabrella	tr/3		1.3/20						
Fragaria Glauca						1.0/23			
Gentiana acuta				1.5/10			tr/14		
Hedysarum sulphurescens				1.5/10			1.1/10		
Heuchera cylindrica							tr/10		
Hieracium albiflorum							1.3/20	1.3/14	
Koleria cristata	tr/18								
Melampyrum lineare							tr/27		tr/20
Penstemom confertus	tr/6	tr/17			1.3/25				
Pyrola asarifolia				1.8/17				tr/10	1.8/23
P. secunda				1.1/10					
Total herb cover	13.0	19.0	10.0	26.0	22.0	18.0	22.0	14.0	13.0
Other:									
Bare soil	6.6/32	6.0/33	1.6/13						
Litter	66.3/98	64.3/100	83.4/100	71.2/100	72.1/100	77.7/100	69.1/100	73.0/100	63.2/100

* Only species with at least 10% frequency of occurrence in at least one macroplot shown.
** % ground cover/% frequency of occurrence (tr = less than 1%).

greater than that at or below this level (see also Table X). The difference is probably due to increases soil moisture resulting from greater precipitation and greater water holding capacity due to near-surface bedrock instead of a thick gravel substrate beneath the soil. Reduced cattle grazing may also be a factor. Changes in moisture and temperature are also reflected in the species composition of the shrub layer as bitterbrush and bearberry disappear and soapolallie (*Shepherdia canadensis*), huckleberries (*Vaccinium scoparum* and *V. caespitosum*), and twinflower (*Linnaea borealis*) increase at higher levels.

At all elevations, herbaceous plant cover was limited due to the overstory. No distinct trends were found except for an increase in pinegrass at mid-elevations that declined farther up slope, possibly because of the dense overstory of both trees and shrubs (see Table X).

Deer use of available forage in the Immature Forest association was impossible to estimate. At lower elevations, cattle use, which in some areas was excessive, compounded deer use. At higher elevations, the understory was so dense and deer were so widely distributed that it was impractical to attempt any type of forage consumption survey.

Weather

Temperature:

Figure 8. is a graph of the averages of the minimum temperatures

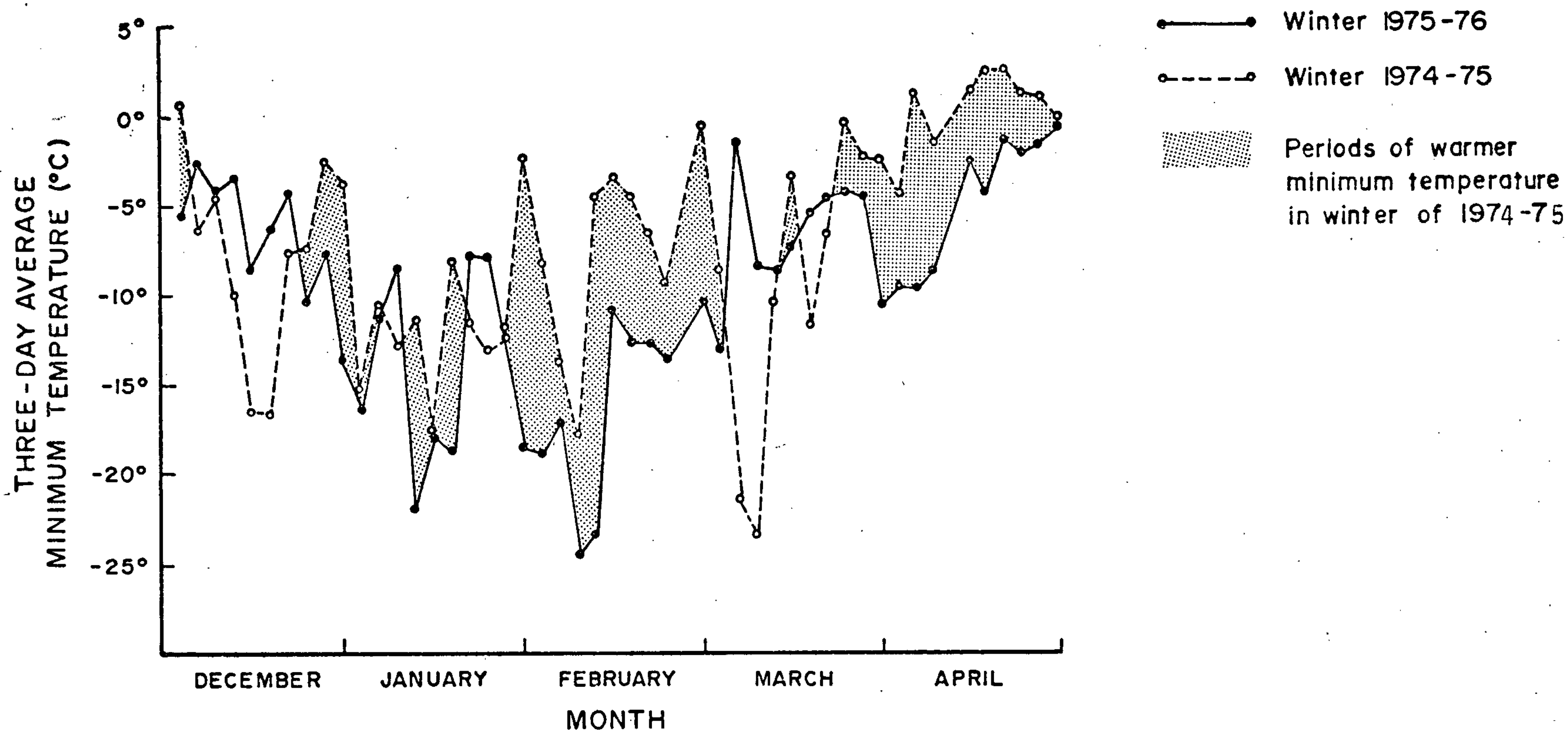

FIGURE 8. Three-day average minimum temperatures, December to April, 1974-75 and 1975-76.

for three day periods from 1 December to 30 April, 1974-75, and 1975-76. The three day average was chosen because it smoothed out the curves while maintaining clear evidence of the temperature patterns. From this it can be seen that the winter of 1975-76 was not as cold as 1974-75. The only notable exceptions to this were the month of December, and the first two weeks of March which were warmer during the first winter.

Sunshine:

Figure 9. illustrates the average daily amount of direct sunlight. during the winter months in both years. It demonstrates that the winter of 1975-76 was sunnier from mid-January to late March, the period of maximum thermal stress.

Snow:

Thermal stress is one aspect of winter severity; the others are snowfall and the characteristics of the snowpack. Snow conditions are important because they influence the deer's ability to deal with thermal stress by 1.) increasing the energy cost of moving about, 2.) restricting the use of some habitat types and, 3.) burying certain portions of the understory making them unavailable for feeding. Snow may also increase vulnerability to certain predators. Although a crusted snow that will support a deer may raise the upper limits of the available forage zone, such conditions were not observed on the study area.

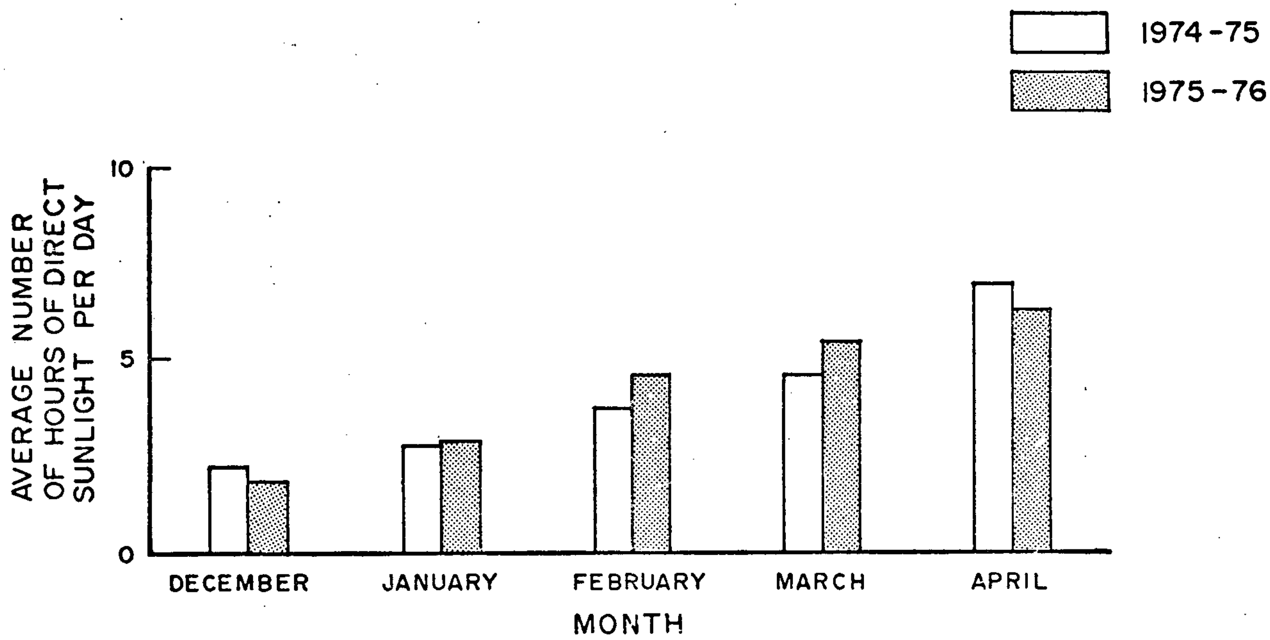

FIGURE 9. Average hours of direct sunlight, December to April, 1974-75 and 1975-76.

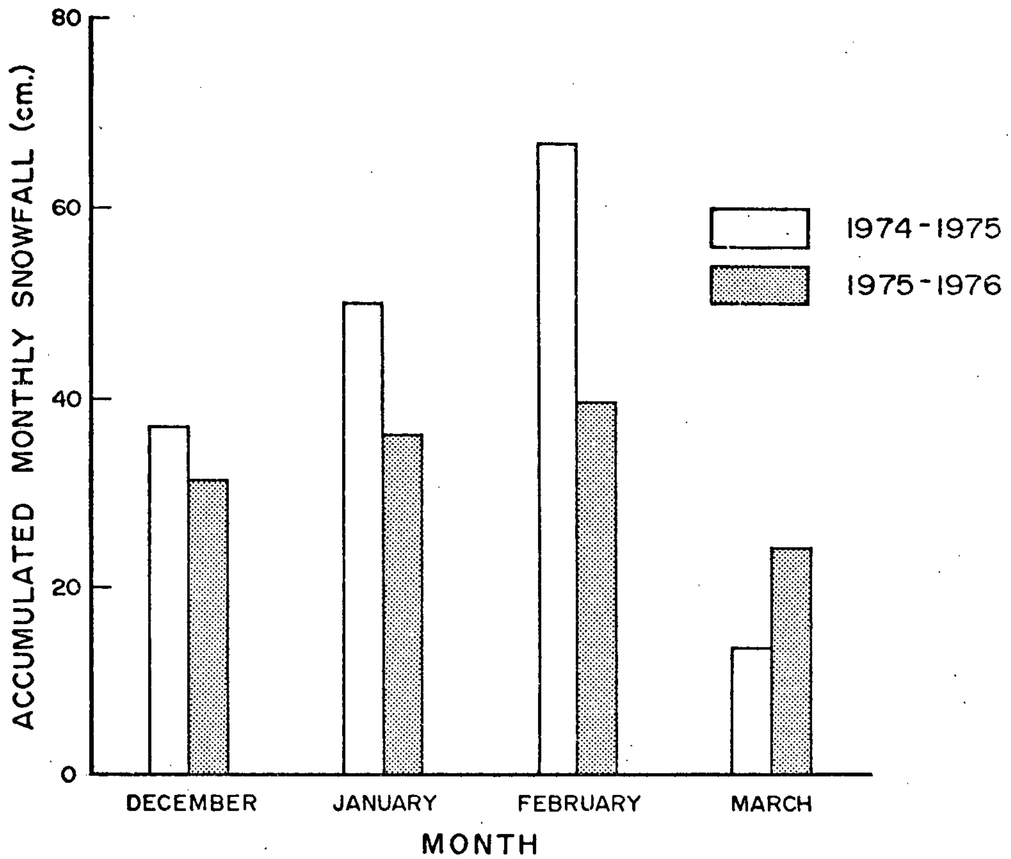

FIGURE 10. Total snowfall, December to March, 1974-75 and 1975-76.

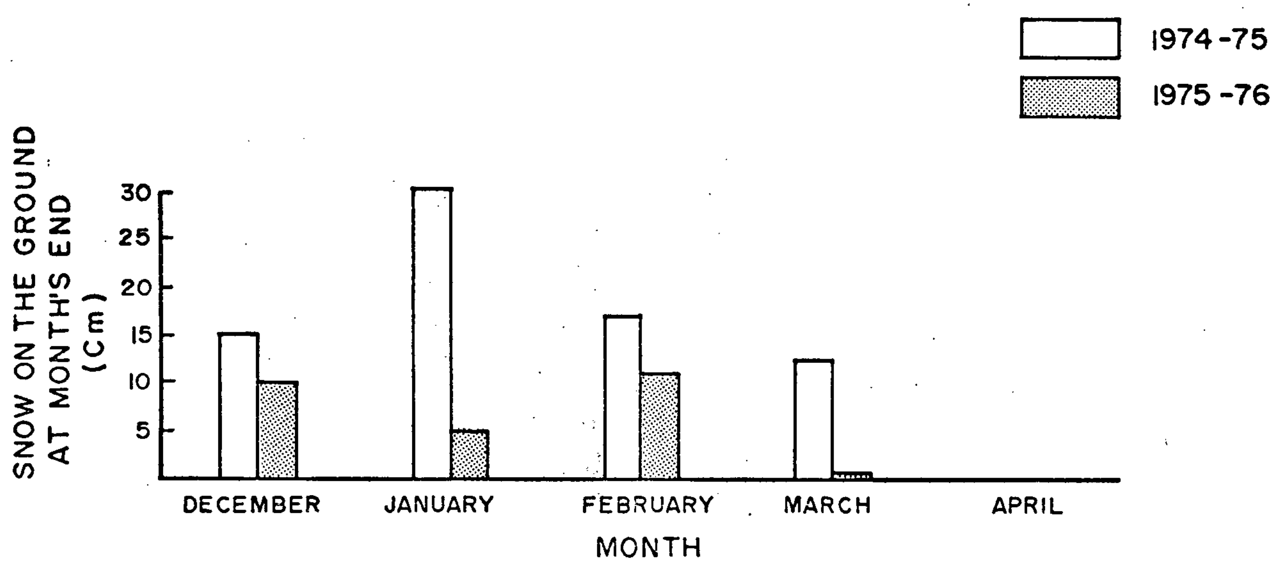

FIGURE 11. Depth of snow at month's end, December to April, 1974-75 and 1975-76.

Figure 10. shows the pattern of snowfall and Figure 11. the depth of snow on the ground at the Cranbrook Airport for both winters. It can be seen that not only was there substantially more snow in 1974-75, but the cold weather during that winter prevented melting and settling of the snow, and the snowpack lasted longer. The same patterns were displayed on the study area, but the different degrees of canopy closure and aspect resulted in habitat-specific depths and melting rates.

Although density was not quantified, it is intuitively obvious that the prolonged cold weather in 1974-75 kept the deep snow very soft.

Use of Winter Range Habitats:

Tables XI, XII and XIII list the results of the systematic track counts and their statistical treatment. In all cases the chi-squared test showed highly significant differences from a "uniform" distribution ($p \leq 0.01$), so I have only tabulated the information on degree of habitat selection.

Table XIV lists the results of the pellet group counts for both winter periods. The estimated mean number of groups per plot and the sample variance in each year as well as the percent change between years are presented for each type.

Two habitats were found to occupy more than one aspect, and it was felt that better understanding of their use might be gained by sub-

TABLE XI

TRACK COUNT ANALYSIS: WINTER 1974-75

Habitat	Transect Length (km)	Proportion of Total Transect Length	Track	Proportion of Track	Confidence Interval (α=0.05)	Degree of Selection[a]	Snow Depth
Grassland	1.13	.146	0[b]	.000	--	-	30 cm
			0[c]	.000	--	-	50 cm
			2[d]	.024	$.000 \leq p \leq .063$	-	40 cm
Riparian Brush	0.32	.041	3	.042	$.000 \leq p \leq .097$	0	30 cm
			3	.103	$.000 \leq p \leq .235$	0	40 cm
			20	.244	$.133 \leq p \leq .355$	+	30 cm
Y.F. (west aspect)[e]	0.64	.083	7	.097	$.014 \leq p \leq .180$	0	25 cm
			3	.103	$.000 \leq p \leq .235$	0	40 cm
			15	.183	$.173 \leq p \leq .193$	+	30 cm
M.O.	3.06	.396	42	.583	$.445 \leq p \leq .719$	+	20 cm
			4	.138	$.000 \leq p \leq .287$	-	50 cm
			15	.183	$.173 \leq p \leq .193$	-	40 cm
M.A.F. (south aspect)	2.58	.333	20	.278	$.152 \leq p \leq .402$	0	15 cm
			19	.655	$.449 \leq p \leq .861$	+	25 cm
			30	.366	$.242 \leq p \leq .490$	0	20 cm
Total	7.73		72				
			29				
			82				

a. Degree of Selection: - = avoidance; 0 = proportional; + = selective.
b. Count conducted on 18 January, 1975.
c. Count conducted on 16 February, 1975.
d. Count conducted on 10 March, 1975.
e. Y.F. = Young Fir; M.O. = Maturing Open; M.A.F. = Mixed Age Fir.

TABLE XII

TRACK COUNT ANALYSIS: 24 JANUARY, 1975

Habitat	Transect Length (km)	Proportion of Total Transect Length	Track	Proportion of Track	Confidence Interval (α=0.05)[a]	Degree of Selection[b]	Snow Depth
Grassland	1.61	.251	39	.115	$.109 \leq p \leq .201$	-	30 cm
Seral Shrub	0.16	.026	19	.056	$.049 \leq p \leq .063$	+	25 cm
Y.F. (north aspect)[c]	0.48	.077	19	.056	$.049 \leq p \leq .063$	-	25 cm
I.F.O.	0.32	.051	10	.029	$.008 \leq p \leq .050$	-	20 cm
M.A.F. (north aspect)	3.70	.590	252	.743	$.688 \leq p \leq .798$	+	15 cm
Total	6.27		339				

a. Confidence interval on proportion of tracks ($\alpha = 0.05$).
b. Degree of Selection: - = avoidance; 0 = proportional; + = selective.
c. Y.F. = Young Fir; I.F.O. = Immature Forested Open; M.A.F. = Mixed Age Fir.

TABLE XIII

TRACK COUNT ANALYSIS: WINTER 1975-76

Habitat	Transect Length (km)	Proportion of Total Transect Length	Track	Proportion of Track	Confidence Interval (α=0.05)[a]	Degree of Selection[b]	Snow Depth
Aspen	0.32	.010	0[c]	.000	-	-	2 cm
	0.32	.009	2[d]	.001	$.000 \leq p \leq .004$	-	15 cm
	0.32	.011	11[e]	.019	$.003 \leq p \leq .035$	0	15 cm
Riparian Brush	1.61	.048	12	.022	$.005 \leq p \leq .039$	-	2 cm
	2.25	.066	90	.055	$.038 \leq p \leq .072$	0	15 cm
	0.32	.011	45	.080	$.048 \leq p \leq .112$	+	15 cm
Grassland	2.74	.082	7	.013	$.000 \leq p \leq .027$	-	4 cm
	3.06	.090	27	.016	$.007 \leq p \leq .025$	-	15 cm
	2.25	.075	3	.005	$.000 \leq p \leq .013$	-	15 cm
Seral Shrub	1.93	.058	80	.147	$.104 \leq p \leq .190$	+	2 cm
	1.77	.052	203	.123	$.100 \leq p \leq .146$	+	15 cm
	1.77	.059	23	.041	$.017 \leq p \leq .065$	0	15 cm
Y.F. (north aspect)[f]	2.25	.067	10	.018	$.002 \leq p \leq .034$	-	2 cm
	2.25	.066	120	.073	$.055 \leq p \leq .091$	0	15 cm
	2.25	.075	40	.071	$.041 \leq p \leq .101$	0	15 cm
Y.F. (west aspect)	1.29	.039	18	.033	$.012 \leq p \leq .054$	0	2 cm
	1.29	.038	150	.091	$.071 \leq p \leq .111$	+	15 cm
	0.64	.021	60	.106	$.070 \leq p \leq .142$	+	5 cm
I.F.D.	5.47	.163	79	.145	$.102 \leq p \leq .192$	0	2 cm
	3.86	.114	115	.070	$.053 \leq p \leq .087$	-	15 cm
	4.18	.139	31	.055	$.028 \leq p \leq .082$	-	15 cm
I.F.O.	8.37	.250	131	.240	$.188 \leq p \leq .292$	0	2 cm
	8.53	.251	220	.133	$.110 \leq p \leq .156$	-	15 cm
	8.37	.278	75	.133	$.094 \leq p \leq .172$	-	15 cm
M.O.	5.15	.154	146	.267	$.214 \leq p \leq .316$	+	2 cm
	5.63	.165	305	.185	$.158 \leq p \leq .212$	0	15 cm
	4.83	.161	176	.312	$.257 \leq p \leq .367$	+	5 cm
M.A.F.	4.35	.130	63	.115	$.078 \leq p \leq .152$	0	2 cm
	4.99	.147	416	.253	$.219 \leq p \leq .277$	+	15 cm
	5.15	.171	101	.179	$.133 \leq p \leq .225$	0	15 cm
Total	33.48		546				
	33.95		1648				
	30.08		565				

a. Confidence interval on the proportion of tracks (α = 0.05).
b. Degree of Selection : - = avoidance; 0 = proportional; + = selection.
c. Count conducted on 31 December, 1975.
d. Count conducted on 12 January, 1976.
e. Count conducted on 27 February, 1976.
f. Y.F. = Young Fir; I.F.D. = Immature Forested Dense; I.F.O. = Immature Forested Open; M.O. = Maturing Open; M.A. F. = Mixed Age Fir.

TABLE XIV

PELLET GROUP COUNT ANALYSIS

	1975			1976			
Habitat type	Mean	Var.	Rating	Mean	Var.	Rating	% Change
Aspen	0.20	0.00		a			
Grassland	1.15	1.00		0.15	0.01		-87*
Riparian Brush	2.00	1.00		2.40	4.00		+20
Seral Shrub	1.00	0.07		0.55	0.02		-45*
Y.F.[b] (North aspect)	0.80	0.04	6	0.53	0.14	6*	-34*
Y.F. (West aspect)	5.40	0.80	1*	1.60	0.45	1*	-70*
I.F.O.	0.77	0.08	7	0.37	0.06	7	-48*
I.F.D.	1.50	0.11	3*	0.73	0.06	4	-51*
M.O.	1.23	0.05	4	1.18	0.04	2*	- 4
M.A.F. (North aspect)	0.90	0.25	5	0.60	0.20	5	-33
M.A.F. (South aspect)	4.35	0.16	2*	0.85	0.05	3	-80*
Overall average[c]	1.59	0.05		0.79	0.02		-50*

a. uncountable due to flooding
b. Y.F. = Young Fir; I.F.O. = Immature Forested Open; I.F.D. = Immature Forested Dense; M.O. = Maturing Open; M.A.F. = Mixed Age Fir
c. total number of groups/total number of plots (excluding Aspen)
* Significant at the 0.05% level.

dividing them. Thus the Young Fir type is split into north and west aspect, and Mixed Age Fir type is split into north and south aspect.

Aspen:

This minor component of the Wolf Creek winter range was not surveyed for tracks during the 1974-75 winter, but pellet groups were counted here in the early summer of 1975 to determine previous winter use. The reverse was true the next year as tracks were counted, but flooding prevented counting of pellet groups.

Both Table XIII and Table XIV reveal little winter use of the Aspen habitat type. The track counts indicate deer avoid this type through much of the winter, and the pellet group density was lowest here.

Grassland and Cultivated Fields:

The track count data (Tables XI, XII and XIII) demonstrate that throughout the winter deer avoid the Grasslands and Cultivated areas regardless of snow depth. The levels of use indicated by the pellet group densities are the result of spring grazing of these areas by the deer.

The temporal pattern of use of these areas in the spring has two aspects: seasonal and daily. These are generally similar for both types, but the Grasslands receive much less use. Data from several

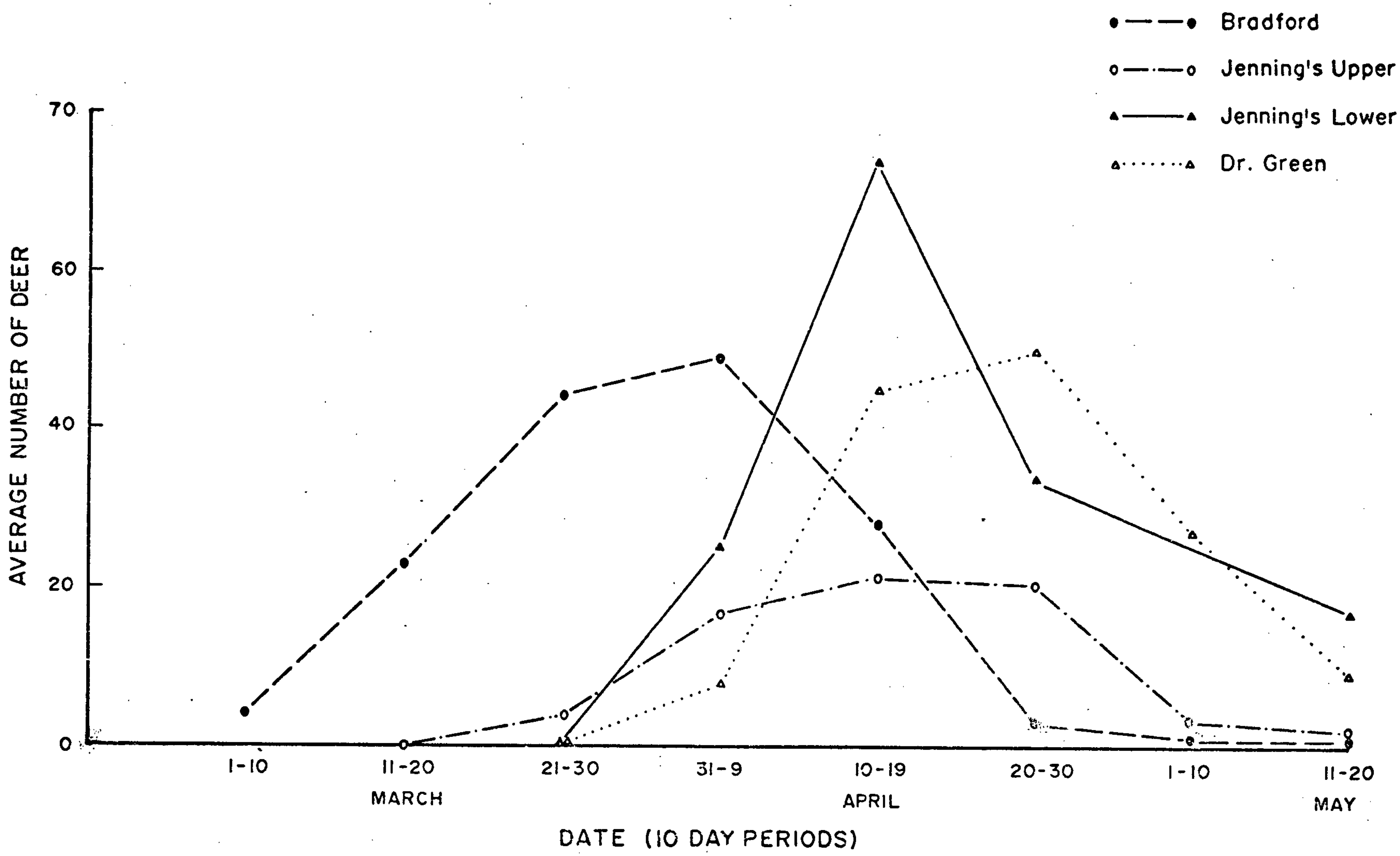

FIGURE 12. Seasonal pattern of use of four alfalfa fields on the study area, March to May, 1975.

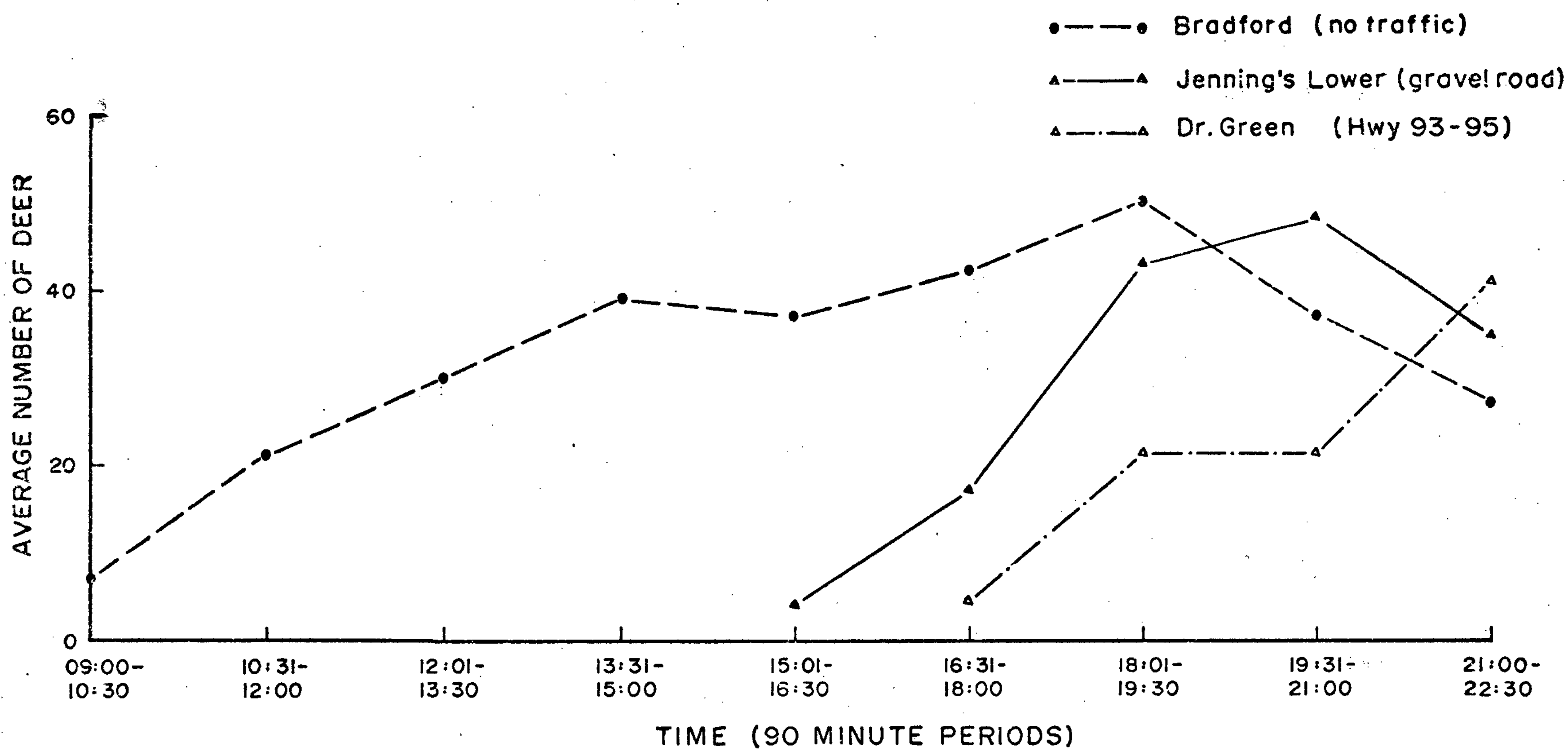

FIGURE 13. Daily pattern of use of three alfalfa fields on the study area, March to May, 1975.

fields are presented here to demonstrate the characteristics of use. Figure 12. shows the average number of deer seen in four fields for 10 day periods in the spring of 1975. There is a definite rise and fall in numbers over a period of several weeks in each field. Figure 13. illustrates the daily pattern of use for three fields combining several days' data for major use periods in the spring of 1975. Data from the "tails" of the lines in Figure 12. were omitted, as were counts on unseasonably cold or rainy days. The influence of distrubance can be seen by examining the diel patterns of use of the three fields. In a field with no road past it (Bradford's), use may begin early in the day and rise steadily to a peak in the evening. Increasing levels of traffic on a gravel road (Jenning's Lower) and a major highway (Dr. Green's) act to suppress diurnal use of the fields. There are insufficient data to carry the comparison beyond 22:30 hours.

Deer use of the fields and Grasslands in spring made it possible to obtain composition counts to estimate the adult:juvenile ratio in the population at the end of the two winters. Table XV lists the results of these counts and indicates a significant difference in juvenile survival in the two winters. In the spring of 1975, there were only 42 juveniles per 100 adults whereas in 1976, there were 60 per 100 adults.

Riparian Brush Type:

The Riparian Brush type along Wolf Creek is thought to be important to the deer on this winter range. With the exception of the Seral Shrub

TABLE XV

AGE RATIOS OF WHITE-TAILED DEER: APRIL AND MAY, 1975 & 1976

Year	Number Classified	Juveniles: 100 Adults
1975	1226	42
1976	421	60

habitat, this is the only type that supplies large quantities of deciduous browse. It is highly productive (Table IV), the browse is well used (Table V) and the extended growing season due to lack of moisture limitations may lead to more nutritious forage.

Pellet group densities in this type were high, but so variable (Table XIV) that it is impossible to make clear statements about its relative standing based on this statistic alone. The track data in Tables XI and XIII and Figure 14a. show that there is a distinct seasonal trend in use. In both years, intensity of use increased as winter progressed.

The only significant use of this type was for feeding at night and an obvious daily movement of deer down from the terraces into the brush at dusk was observed. When use intensified in late winter (particularly in 1974-75) deer were found in some parts of this type during the day, but generally they moved back up onto the terraces by sun-up. This movement can be demonstrated by analysing the proportions of tracks going up or down the slope from the creek to the terraces. A count of 58 sets of tracks that were made between 1:00 AM and 9:00 AM on 18 January, 1975, indicated that 90% of the morning movement is upslope. By contrast, a count of 329 sets of tracks representing 24 hours of movement on 23 and 24 January, 1975, indicated 51% downslope and 49% upslope movement.

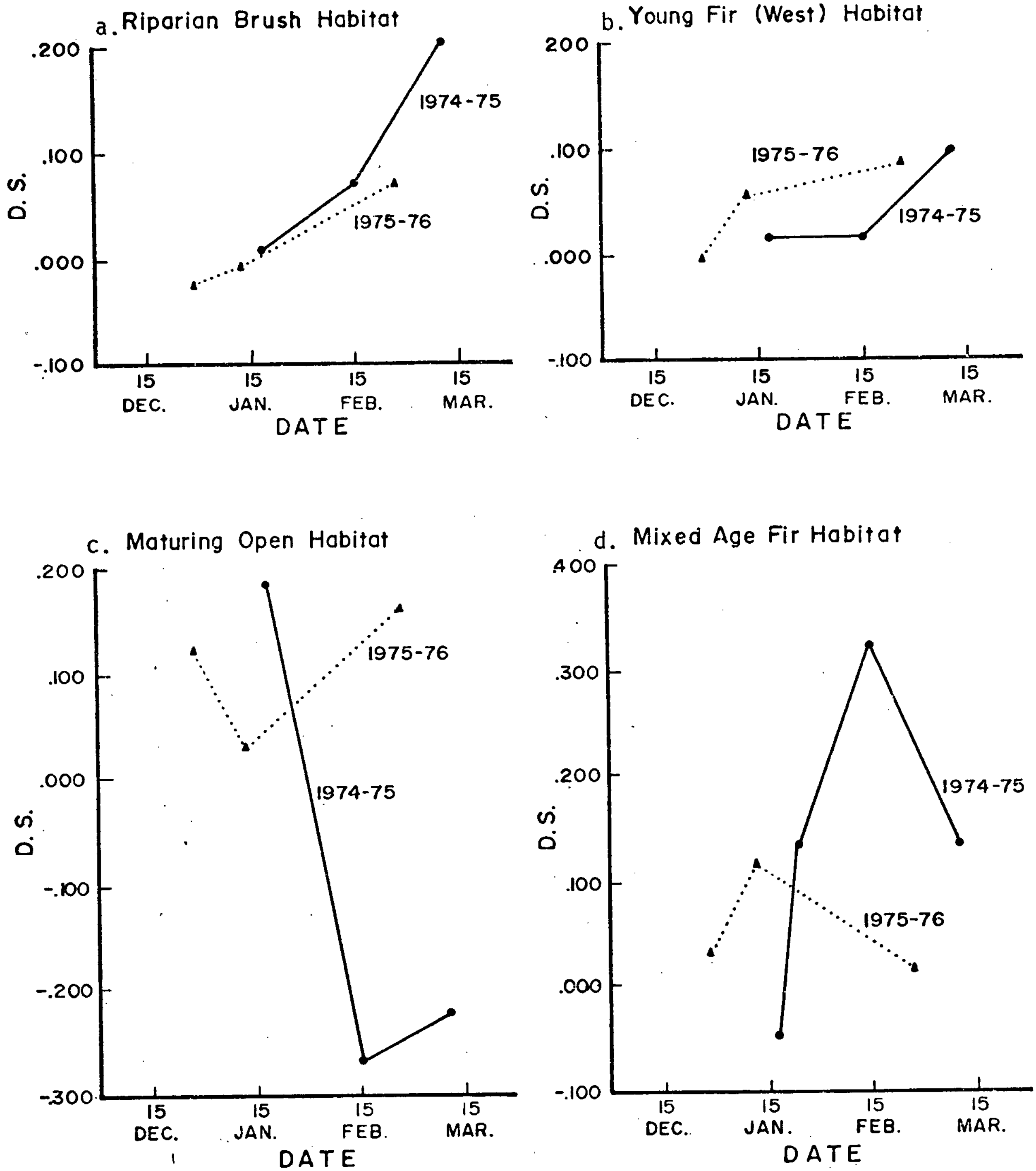

FIGURE 14. Degree of Selection for four habitat types, December to March, 1974-75 and 1975-76. (D.S.= proportion of tracks minum proportion of transect.)

Seral Shrub Type:

This type has received a great deal of attention in the East Kootenay. It is generally felt that the carrying capacity of ungulate winter ranges in the East Kootenays is directly related to the proportion of Seral Shrub type on the area. Kemper's (1971) thesis clearly explains why this should be the case.

Whitetailed deer use of this habitat was found to be strongly influenced by snow depth during the study period. In late January, 1975, deer were found to be selecting this type despite 20 cm of light snow on the ground (Table XII). It was obvious at that time that they were feeding heavily on the remaining leaves and the tips of the leaders of bitterbrush. Although no other systematic track count covered this type in 1974-75, use is known to have decreased dramatically in early February when snow depth quickly passed the 40 cm mark. Only occasional tracks were seen here, usually at the ecotone between this and a forested type, until very late in the winter when snow density increased. Even in late winter, however, use did not reach earlier levels as the only exposed vegetation was the tops of the larger bitterbrush plants.

In 1975-76 with different nival conditions, this pattern of use changed markedly. Table XIII shows that this habitat was being selected throughout early and midwinter. Although use was estimated to be proportional in late winter, it is believed that the track count on 27 February, 1976, underestimated use of this type (see Discussion, p. 93.).

The pellet group data may underestimate actual use of the seral shrublands, but increased selection of this habitat in 1975-76 relative to 1974-75 seems to be indicated by its rise in relative standing. Another possible indicator of greater use during the second winter is the cange in estimated pellet group density between years, 45%, which is somewhat less than the drop in the overall average density (50%).

Young Fir Type:

This habitat type was divided into two aspect classes, west and north, on the basis of the 1975 pellet group data. The first winter's track count data was insufficient for drawing conclusions about the importance of aspect from this measure, but Table XIII clearly supports the concept that use based on track counts varies with aspect. Furthermore, use of this type was found to increase through the winter in both years on the west aspect (Figure 14b.), and in at least one year on the north.

The intense use of the west facing portion of this type in mid to late winter led to its having the highest pellet group density of all forested types in 1975. This was also true in 1976, although the 70% decline in density between years is above average and indicates relatively less use during the second winter. The densities on the north slope, however, were less than anywhere else except the Immature Forested Open, which was lower, and the north facing Mixed Age Fir which was not significantly higher (Table IV). The below average drop in density between years indicates relatively more use in 1975-76 than in the previous winter. It may be that the frequency of bedding is somewhat lower on the cooler north slope than in other areas, so these pellet group densities may underestimate actual value of the habitat.

Immature Forested Open Type:

This habitat type was covered only once in the track counts in the 1974-75 winter (Table XII) and was found to be avoided in late January, 1975. Snow depths here reached 30 to 35 cm by mid-February, 1975, and use appeared to decline further. A similar pattern of decreasing use was seen in 1975-76, even with very little snow (Table XIII).

The lack of use of this habitat is further substantiated by the pellet group counts. The estimated densities here following both winters were significantly lower than any other forested type (Table IV).

Immature Forested Dense Type:

Unfortunately, this type was not sampled by track counts in 1974-75, so the temporal pattern of use cannot be determined in that winter of deep snow. However, the pellet group density here was little below the overall average and ranked third among the forested types in 1975. Although it slipped to fourth in 1976, the difference between this type and the one above it, south facing Mixed Age Fir, was not statistically significant. Careful interpretation of these densities must be made though, since the track data in Table XIII indicate that deer avoid this type under certain conditions.

Maturing Open Type:

Use of this type was also markedly affected by snow depth. Although the deer were selecting the Maturing Open type in early winter 1974-75, the excessive snow in January and February caused the deer to avoid this type in mid and late winter (Table XI). Heavy use of this type during the transitional period between winter and spring helped elevate its pellet group density somewhat, but the habitat still ranked fourth and had a below average density in 1975. In the winter of 1975-76 with less snow, use decline only briefly in mid-winter (Table XIII). The decline in pellet group density between years was statistically insignificant (Table XIV), indicating a large increase in relative use. Only the west facing Young Fir type ranked higher in the second year. These trends are shown in Figure 14c.

Mixed Age Fir Type:

This habitat occupies sections on both sides of the Wolf Creek drainage, and thus has both north and south aspects. Although track data were largely missing for the north facing slope in 1974-75, the pellet group data indicated that splitting the type was justified (Table IV). However, the expected difference in tracks the following winter did not appear, as neither slope was preferred over the other in the first count, the north facing slope was preferred in the second count, and the south facing slope was more heavily used at the time of the third count. As a result, the data have been pooled in Table XIII and Figure 14d.

During both winters, use of this type based on track counts displayed a "peaked" pattern, being proportional at both ends of the winter, but selective in mid-winter (Figure 14d). The degree of selection was greater in the snowy winter of 1974-75 as indicated in Figure 14d.

Intense use of this habitat during the 1974-75 winter when snow depths were significantly lower ($p \leq 0.05$) than in any other habitat led to high pellet group densities on the south facing slope (second only to the Young Fir west aspect) while the north facing slope could be grouped with the Maturing Open (not significantly higher) and the Young Fir north slope (not significantly lower). During the second winter, there was an 80% decrease in use as measured by pellet groups on the south facing slope, while on the north slope, use was down 33% (Table IV). These changes in density eliminated statistical significance between densities with respect to aspect indicating more uniform use of this habitat in a year when critical snow relief was not needed.

Riparian Mature Spruce:

Use of this habitat was not quantified for evaluation in relation to the other forested types on the winter range due to its limited distribution and more complex flooding pattern. However, use was felt to be light to moderate in 1974-75 and moderate to heavy in 1975-76. There also appeared to be two types of use of this habitat. A small number of deer spent most of their time here, and others used this type only when crossing from one slope to the other or for cover between feeding periods in the open brush along the creek.

Use of Summer Range Habitats

For the reasons already mentioned, statements about summer range use must be subjective and cannot be based on quantified data. There is value however in documenting what was observed during the study.

Use of the three associations on the summer range can be categorized in the following way. Brush: use is consistent and the nature of use is predominantly for feeding. Shrub: use is inconsistent and varies with location of the association and species composition, with most use being for feeding. Immature Forest: use is extremely variable being practically nil in the dense stands, moderate in the more open areas and highest in areas near small meadows, stream courses and the Brush association where time is spent between feeding periods. In no place did densities approach those common on the winter range.

Of the two deer with radio-collars that were monitored through the summer, both had seasonal ranges that included the open associations.

Adult male #1B centered his activities around a series of sloughs, creeks and beaver ponds in a small tributary drainage of Lost Dog Creek. Adult doe #R2 spent most of the summer months just north of Lost Dog Lake in an area composed of Brush association, stream bottom and a slope that was divided about equally between an open Immature Forest association and Shrub association dominated by *Ceanothus velutinus*.

Individual Movements:

The study of individual movements was based on 33 deer live trapped between 21 January and 18 April, 1975, and between 21 December, 1975, and 22 February, 1976. During the first winter 6 adult males, 19 adult females, 2 male fawns and 3 female fawns (Table XVI) were captured. Of these, 1 adult male and 5 adult females were fitted with radio-transmitter collars, the remainder with material markings. In the second winter, 3 adult males and 1 adult female were trapped and radio collared, and one female fawn was ear tagged. (Table XVI).

A total of 84 visual sightings of 21 positively identified deer provided information on individual movements during the study period. Another 17 sightings of unidentified marked deer gave futher details for the population. Some of these unidentified deer were reported to me by local people who knew of my work. Others were deer I saw but was not able to positively identify due to insufficient sighting time or due to loss of markers.

TABLE XVI

LIVE-TRAPPING RESULTS

Dates	Trap nights	Male adults	Female adults	Male fawns	Female fawns	Total	% Succ.*
21 January to 18 April, 1975	108	6(1)**	19(7)	2	3	38	35
21 December, 1975 to 22 February, 1976	59	3***	1	0	1	6	10

* % Success = total number of captures/total number of trap nights x 100
** ( ) indicates number of recaptures.
***Note: Two of these were recaptures of deer tagged the previous winter.

Rate and quantity of tag loss for all deer is unknown. However, one deer tore its collar off within 23 days while crossing a barbed-wire fence, and a few lost one streamer within 39 days. Adult doe #1A lost her ear tag between 57 and 60 days after capture, and stepped through her collar at some time between 72 and 146 days. At 160 days, the collar was still around her neck, over her left shoulder and under the left foreleg and she was seen favoring this leg (B. Jamieson, pers. comm.). She was not seen again and it is unknown how long the collar remained on this deer. Of the six deer marked in the winter of 1974-75 and positively identified again in 1975-76, two does retained all markers (totalling 2 collars, 2 tags and 4 streamers), the fawn already mentioned had lost 1 of 2 streamers, one doe had lost a streamer by 357 days and its collar by 397 days (retaining 1 tag and 2 streamers) and two bucks each lost their collars and two streamers within 327 and 337 days respectively, retaining 1 tag each and one streamer on one. This 20% sample of the marked deer implies that, after about one year, a minimum of 40 to 60% of the collars were shed, 14% of the tags were lost, and 43% of the streamers were missing. This high level of loss of markings suggests that estimates of the proportion of the deer returning to this winter range in 1975-76 based on sightings of deer marked in 1974-75 are probably low. How much too low is unknown.

The high collar losses are thought to be the result of using the loose-fitting material collars which could catch on the brush or numerous wire fences and tear off. Subsequent studies should find alternatives. Ear tag losses were similar to those experienced in cattle using the same type of tag (H. Campsall, pers. comm.). The 14% could possible be cut by using metal tags, but these would not provide identification at a distance like the tags used here. Streamer loss might be lowered by shortening the running ends thus reducing the chance of tagling in brush and being ripped out.

The duration of contact with deer fitted with radio-transmitter collars varied from 33 days for 2 does to 427 days for two other does, and averaged 135 days. The number of radio-locations varied from five to 19 and averaged 10. It was found that it generally took almost an hour to locate a deer with precision. The varied topography deflected the signals and it was often necessary to obtain more than two bearings before a true location could be determined.

Figure 15 is a map of the 84 sightings of marked deer made between February 1975, and April 1976, divided into winter, spring, and summer-fall periods to show the seasonal distribution of the population. Of the 33 deer captured, 17 with material collars and 7 with radio collars were relocated and identified a sufficient number of times to provide useful movement data. The details of these movements are mapped and described in Appendix I; they can be summarized as follows.

Throughout the winter of 1974-75 the track counts and general observations indicated a definite shift of the population to the eastern portion of the winter range as snow depth reached unusual levels in the study area. This shift was exemplified by the movements of 7 deer

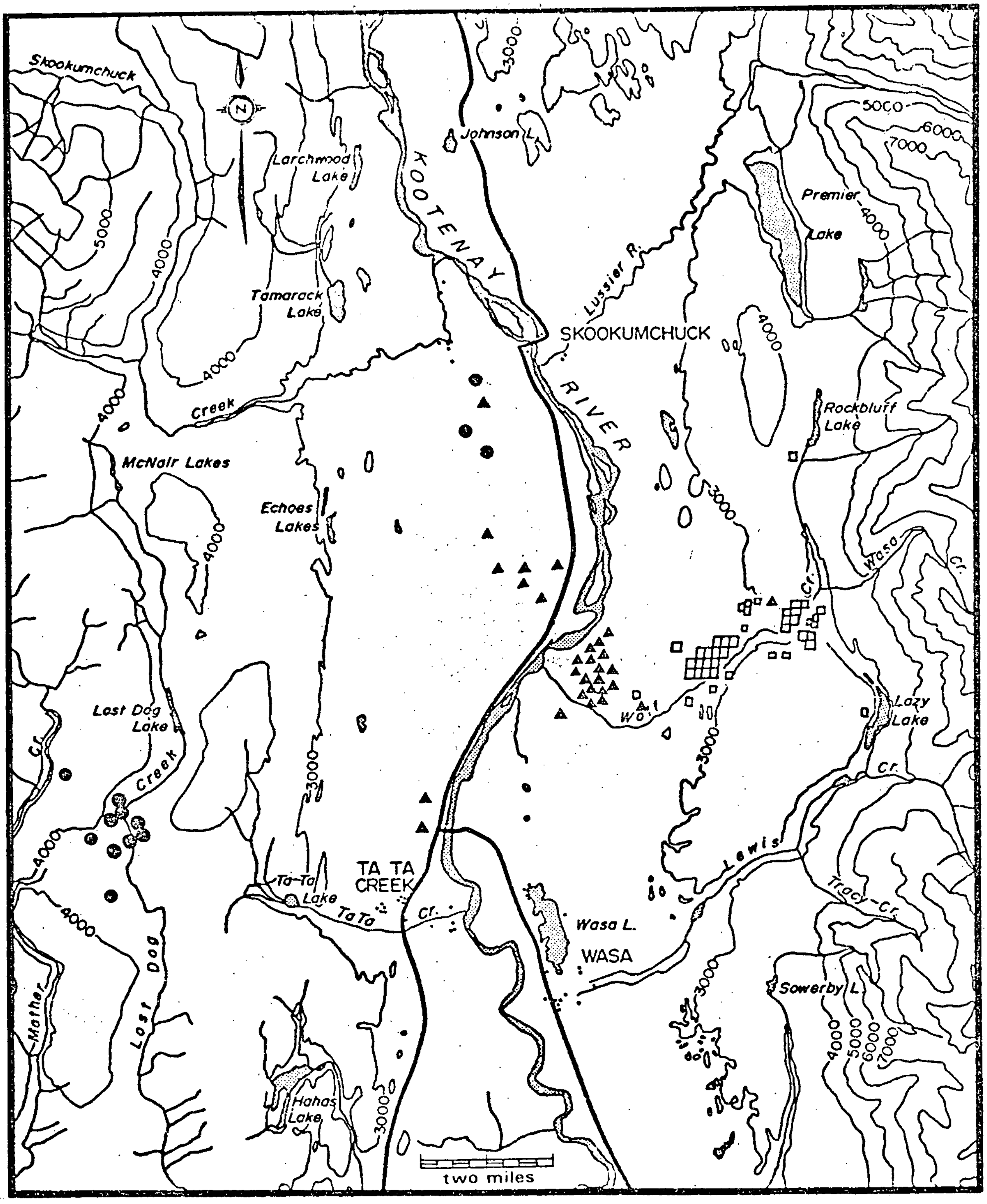

FIGURE 15. Winter (▫), Spring (▲), and Summer-Fall (●) observations of marked deer.

mapped in Figures A1 to A3. In late winter, as the snow began settling and south facing slopes became snow free, the deer began to expand back to the west. These movements resulted in several relocations in areas used in early winter (see Fig. A1, A3 and A4), and eventually deer were seen in the fields on the benches to the east of the Kootenay River.

As spring progressed and the westward procession of green-up continued, the deer kept moving west. The movements of 7 deer illustrated in Figures A4, A7 and A8 typify the spring redistribution that took place from late april through early June 1975. Figure 15 also shows that most of the spring relocations were made on the floodplain and valley floor. Many of these were associated with intensive use of cultivated fields in late April and May.

Following mid-June, relatively few deer were seen along the river or at elevations below 3000 feet west of the river. The majority of the summer-fall observations were made in the Lost Dog Canyon-McNair Lakes area. The movements of 5 marked deer illustrated in Figures A5, A7 and A8 coincided with this general pattern and it was felt that the majority of the population did move to mid-elevation levels on the west side of the Trench. However, two extreme movements were noted. One adult male (believed to be #4B) was seen on 24 July, 1975 by a forestry-wildlife graduate student, Brian Churchill, near the confluence of Mary Anne Creek and the Kootenay River. That is over 65 km northeast of the trap site. Another buck (believed to be #6B) was reported at the confluence of Findlay and Lavington Creeks, 40 km northwest of the trap site in the first week of September, 1975. These animals were recaptured in January and February, 1976 in the Wolf Creek drainage indicating that these extremes are probably not dispersals, but seasonal movements.

Although the data are limited, the summer home ranges of the deer appear to be relatively small. No two summer relocations for one deer were more than 3 km apart and the home ranges for two radio tagged deer were less than 200 ha in total area.

Detailed information regarding timing of fall movements was not obtained from marked animals. No signals were received from any of the six radio collared deer from August to December.

Other information on fall movements is very limited. Tracks in the snow indicated that deer were still west of the river using the area from 3800 to 4300 feet on 27 November, 1975, although heavier use was occurring at the 3300 to 3800 foot level. However, by 10 December snow depths had surpassed 20 cm at 3500 feet and no deer tracks could be found above that level. At that time deer were beginning to be seen on the floodplain and on Premier and Wasa Ridges.

Prebaiting for the second trapping period was initiated on Premier Ridge on 12 December, 1975, and limited use of the hay occurred prior to 21 December. However, use increased rapidly after that date and the first capture of the winter was made on 27 December. Of the four adult deer captured in the 1975-76 winter, two were recaptures from the previous winter (see Fig. A11 and A12 and accompanying text). This indicated that some white-tailed deer in this area return to the same winter home range in consecutive years.

In contrast, the lower density of deer on the ridges and higher density of the floodplain in 1975-76 compared to the previous winter indicates that not all deer return to exactly the same area each winter. This was found to be the case for doe #4A (see Fig. A8).

No eastward shift of the population was noted in the low snowfall winter of 1975-76. The home ranges of four radio-tracked adult deer (Fig. A9 to A12) showed continued use of western portions of the winter range. These home ranges averaged 279 ha and had a mean value of 4.9 km for the maximum distance between extreme relocations.

Spring movements in 1976 followed the same pattern as in 1975 (see Fig. 15, A11 and A12). However, the milder winter weather resulted in an earlier greenup, and the redistribution occurred approximately two weeks sooner in 1976.

DISCUSSION

The process of forest succession and its detrimental effects on ungulate winter ranges throughout the East Kootenays has been well documented. The scale of this change was shown by Demarchi (1971) who stated that there had been "...a reduction of 58% of the potential big game winter ranges in 40 years." This statement applied to the loss of open, seral shrub communities to young forests on all the winter range areas in the southern Rocky Mountain Trench. Considering the distribution of white-tailed deer and habitat types on Premier and Wasa Ridges (Fig. 5 and Table 1A), the proportional loss of this productive habitat has been even greater. Less than 10% of the area remains in seral shrub habitat and over 50% of the area is now covered by unproductive habitat types.

The limiting nature of this tremendous reduction in unforested habitat becomes clear when changes in forage production are analyzed. Kemper (1971) found that the productivity of the herbaceous layer declines to 25% of the level in the open, and the shrubs lose over 70% of their productivity by the time a forest on Premier Ridge reaches 50 years of age or 50% canopy coverage. My results concur with these. Figure 16 illustrates the change in shrub productivity with increasing canopy coverage. The same general trend has been reported by numerous other authors (Cowan et al. 1950; Kelbenow, 1965; Halls and Alcaniz, 1968; Blair and Enghardt, 1976; see Kemper, 1971, for others.)

Kemper has also discussed the influence of changes in species composition within the herbaceous and shrub layers and indicated that many preferred species decrease and non-preferred species increase (i.e. soapollalie) under forest canopies. In addition to this, my data indicate that increasing canopy closure influences the intensity of utilization, possibly reflecting lower palatability of the preferred

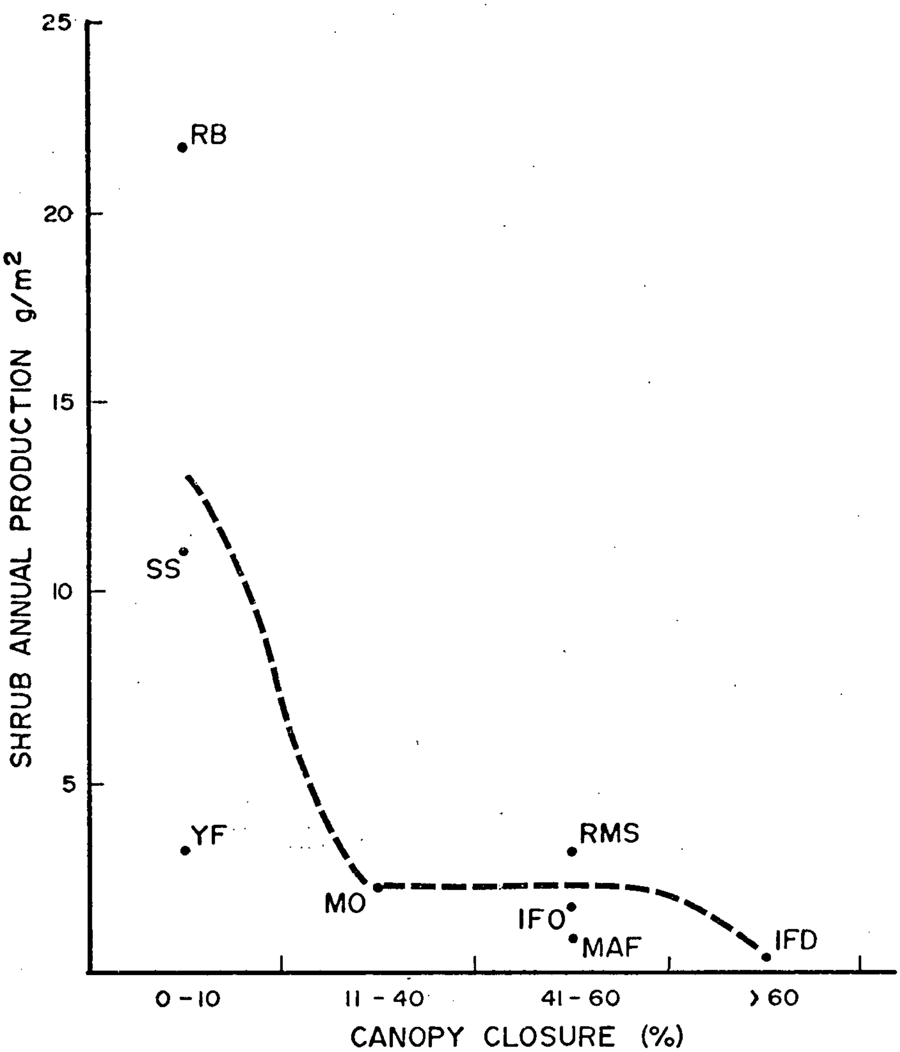

FIGURE 16. Relationship between forage production by shrubs and percent canopy closure on the winter range.

species of shrubs (Figure 17). Klebenow (1965) found a similar trend on a Montana mule deer winter range. These relationships are not surprising in view of the facts that palatability is at least partially a function of the nutritive quality of a plant (Longhurst et al. 1968) and nutritional quality of forage plants is inversely related to canopy coverage (Cowan et al. 1950; Lay, 1956).

Another major element in the successional influence on the nutrition of the deer is the composition of the diet. Demarchi and Demarchi (1967) have shown that, in general, the winter diet of deer on the Wolf Creek winter range consists of 60% browse, 25% forbs, 5% grass and sedges and 10% miscellaneous other items. These percentages are similar to those reported by Martinka (1968) who found that white-tails in Montana have winter diets composed of 74% browse, 24% forbs and 2% grasses. However there are major differences in the species composition of the browse segments in the two diets. The major species for the populaton that Martinka studied are aspen (32%) and saskatoon (22%); for the Wolf Creek deer they are douglas fir (33%), bearberry (19%) and other deciduous shrubs dominated by bitterbrush (8%).

Martinka's population was assumed to be expanding slowly, and showed no signs of intra- or inter-specific competition. The high use of aspen (mainly dead leaves) is probably significant to their well being since this browse averages about 10% crude protein in winter (Tew, 1970). The other important species, saskatoon, has been found to be lower in protein in late fall at about 6.2% (Dietz et al. 1958 <u>in</u> Ullrey

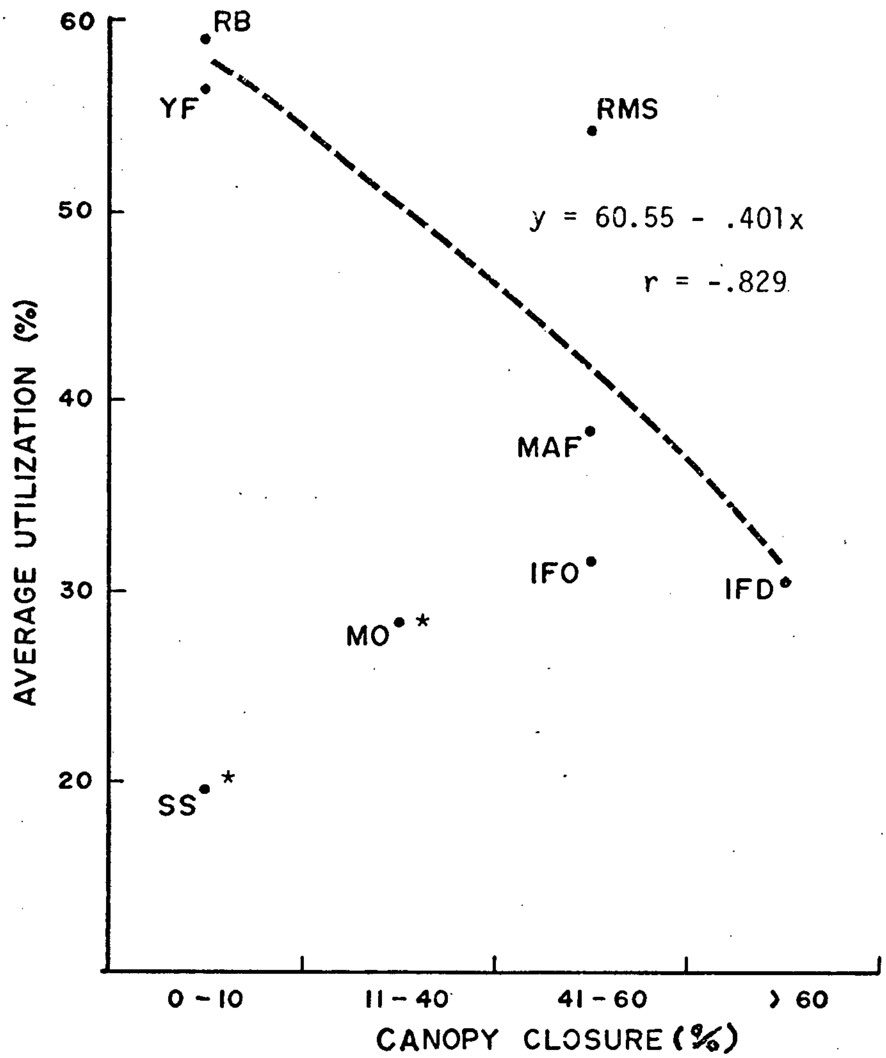

FIGURE 17. Relationship between average utilization of shrub species (Table V) and percent canopy closure on the winter range. *These values may be depressed due to deep snow in the winter prior to sampling, and they were deleted in the calculation of the line equation.

et al. 1967), but protein content on a dry matter basis would increase slightly through the winter (Ullrey et al. 1967). Thus their diet appears to be satsifactory in both quantity and quality. I do not believe this is the case in the Wolf Creek area.

Various authors have reported that douglas fir has crude protein levels between 6 and 9% in the current annual growth and 4 to 6% in old needles (Longhurst et al. 1968; Oh et al. 1970). However, douglas fir also contains various essential oils that can inhibit rumen function (Oh et al. 1967 and 1970) and the concentration of these oils increases with age of the twigs and needles. The ability of a deer to obtain sufficient value from ingested fir browse is a function of the balance between nutrient and essential oil content (Longhurst et al. 1969). Among black-tailed deer (*O. h. columbianus*) in California, this balance is such that use of fir is limited to new growth and only occurs for a short time in spring when protein is at its peak, and the essential oils are lowest (Oh et al. 1970).

Deer use of fir in the northwestern states, however, is almost entirely limited to winter during periods when snowfall makes other forage less available (Crouch, 1966 and Miller, 1968). The same pattern of use generally holds true in the East Kootenays (Demarchi and Demarchi, 1967), but succession and competition have led to a situation in which other forages are quantitatively limited regardless of snow depth. As a result, the deer are forced to rely heavily on this browse. Although there are substantial quantities of fir browse available in the

Wolf Creek drainage (Table VI), only a very small percentage of this is current annual growth except in the Young Fir type. The browsing survey showed that on certain trees the deer are using much more than the current annual growth, particularly in the areas where they are concentrated during severe winters. As a result, they must be consuming browse with high levels of inhibiting oils and low nutrient quality. Unless they can obtain sufficient quantities of other forages to compensate for this, they are bound to suffer from poor nutrition through the winter months.

Interpretation of the distribution and movements of the white-tailed deer provides insight into their attempts to compensate for the reduced forage availability and quanity on this winter range.

Use of the unforested habitats, which permits exploitation of the maximum observed forage production, was found to be selective much of the time. However, their ability to use these areas can be strongly influenced by nival conditions. Within the Riparian Brush type in the winter of 1974-75, deep, soft snow made it very difficult for the deer to move about and use was only proportional to availability in early and mid-winter. It late winter, with warmer daytime temperatures and nocturnal freezing, the density of the snow increased enough to prevent a deer's sinking in more than 10 to 15 cm and the deer responded by selecting this type at that time. Jones (1975) observed similar use of open areas by black-tailed deer on Vancouver Island when snow density in clearcuts reached a level that would support a deer.

Snow depth cannot be the only factor involved in the temporal pattern of use of this type, however. In the winter of 1975-76 snow depth never surpassed the 25 cm level Hepburn (1959) called "restrictive" for whitetails. In spite of this lack of snow, early winter use was even lower than before as deer were found to be avoiding this type at that time. As before, use increased as the season passed (Fig. 14a).

It seems likely that use in early and mid-winter 1975-76 may have been low due to lower densities on the winter range and the deers' abilities to obtain sufficient food in other types. As forage in the other types was reduced through browsing during early and mid-winter; as nonbrowse foods became less available due to increasing snow and less nutritious due to aging; and as body fat reserves were depleted, it became increasingly necessary to concentrate feeding activity in the Riparian Brush type. The relative importance of the browse in this type due to forage reduction in less productive areas would increase even more through a winter with a heavy snowpack since the deer rapidly deplete food when concentrated in the sheltered areas. This may, in fact, be indicated by the higher use observed in the deep snow winter of 1974-75 (Fig. 14a).

Use of the Seral Shrub type was also found to vary inversely with snow depth. The selection of this type at times of low snow is thought to be a function of forage preference for the components of the herbaceous layer and especially for the productive and well-used shrubs found here. The decrease in use in mid and late winter, 1974-75, can be simply related to increasing snow depth, but the drop in late winter, 1975-76, requires more explanation.

The apparent drop in use in late winter is thought to be a result of a biased sample rather than a true decrease in use. The unseasonably warm weather in February led to incomplete snow cover on the winter range at this time. This weather and lack of snow brought about a shift in the deers' distribution. Part of the population moved to higher levels on the southwest slopes of both ridges and continued to use the Seral Shrub type up to nearly 4000 feet elevation. However, their tracks were not counted on the survey route that only covered portions of this type at lower levels. The track count technique could not be applied at the higher elevation because of the presence of mule deer with the white-tails there.

The high selection of this type based on track counts indicates that it is a favored feeding area for the deer throughout a winter of low to moderate snow depth. Coupled with the relatively high productivity of this type and its potential for covering large acreages, this information further emphasizes the importance of this habitat to the wellbeing of wild ungulate populations in the southern Rocky Mountain Trench. The deer were also found to make selective use of the Riparian Brush type during late winter critical periods in both years. Such use implies that they do respond to the availability of concentrated quantities of higher quality forage in the open habitat types.

Of all the forested types, the Young Fir habitat is especially valuable. It is favored because it has the most productive shrub layer of the conifer types, the super abundant browse on the healthy young fir trees is probably more nutritious than elsewhere because a greater proportion of it is represented by current annual growth, and the trees provide excellent cover except under severe snow conditions. The large increase in use of the west slope in both late winter periods was also related to the deers' response to the warm afternoon sun. The lack of a closed canopy provided numerous sunny bedding sites with sufficient hedge effect to break any wind and isolate the deer from disturbance. The increase in use began later in 1974-75 (Fig. 14b) due to the deep, soft snow in February which did not settle and become dense enough to support deer until March. The reduced snowpack in 1975-76 permitted exploitation of this type throughout the winter.

It can also be seen from Figure 14b. and the pellet group data that late winter use of this type was substantially higher in 1974-75 than in the following year. As with the Riparian Brush type, this may have been related to the deers' greater need to seek forage in types that were less used during the times of confinement by snow conditions. It was probably also the result of the concentration of deer in the eastern portion of the winter range during that first winter.

Excessive snow depths in the more open types on the western half of the area (Immature Forested Open, Maturing Open, Seral Shrub, Cultivated, Aspen, and Riparian Brush) forced the deer onto the lee side of the ridges and into the relief of the Mixed Age Fir habitat. The movements of several of the marked deer which were seen at this time from 0.5 to over 4 km to the east of their trap sites exemplified this redistribution of the deer (Figs. A1-A3).

During mid-February, 1975, when snow depth in the open were exceeding 40 to 50 cm, much of the ground in the Mixed Age Fir type was covered with less than 30 cm. Snow depth here was significantly less than in other types ($p \leq 0.05$) and, in fact, within this type the areas used by the deer as indicated by the presence of tracks and beds had a mean snow depth of 24 cm which was significantly less than the 37 cm mean depth in unused areas. Thus the deer were not only heavily concentrated in this type, but within this habitat they selected the low snow areas and especially for bedding, they selected the warmer south aspect. This shelter seeking movement was the cause of the temporal pattern of use of the Mixed Fir type displayed in Figure 14d.

During the winter of 1975-76, conditions were much milder and snow relief was unnecessary. No eastward shift occurred; in fact, many deer, like doe #4A (Fig. A8) remained west of the Kootenay River for the second winter. Although the basic shape of the temporal use curse of this type (Fig. 14d) was the same, the degree of selection was much lower since deer were still able to use other, more productive types such as the Young Fir (west aspect) and the Maturing Open. The pellet group counts also indicated higher levels of use for this habitat in the severe winter with preference for the south aspect, and more uniform distribution of fewer deer in this type in the mild year. These results lend further support to the interpretation of the value of this type as a snow relief habitat.

It is important to note, however, that at no time was observed use less than expected (which would indicate avoidance). Thus use is dedicated to this habitat regardless of the need for snow relief. This is related to its provision of good cover, a moderately productive understory, and the presence of quantities of fir browse that are intermediate in quality to those in the Young Fir and Immature Forested Dense types.

Canopy coverage in the Maturing Open type is relatively low, and as with the other open types, forage productivity and availability are improved relative to the densely forested types. The deer respond by selecting this type whenever snow depth permits. However, the open nature of the canopy provides for relatively little snow being intercepted by the trees. In 1974-75, this led to mid-February snow depths that averaged over 40 cm. As a result, use, which had been high in the early winter fell off sharply (Fig. 14c). The failure of use to increase significantly in early March when snow density increased allowing exploitation of other open types (i.e. Riparian Brush and Young Fir), is related to two factors. These are the mid-winter shift of the population to the east away from this type, and past grazing pressure which causes the growth of the understory to be vertically stunted. Thus very little browse including fir which is relatively scarce in the Maturing Open type was available above the dense snow.

The open canopy and the generally south facing aspect of the Maturing Open type results in an extremely early melt off of snow in late winter. Almost the entire surface of the ground here was snow free in 1975 long before patches began to open up in any other type. The deer were seen to respond quickly to snow melt and the initiation of forb growth which commenced in late March, 1975.

New growth attracted deer to the Maturing Open type, initiating expansion of the deer back toward the summer range. Although no track counts could be made at this time, direct observation indicated very heavy use of this type in April, 1975. This was demonstrated by several marked deer (Figs. A1-A3). Hudson et al. (1974) reported the same population shift to southwest slopes in the late winter-spring period.

With the change in snow conditions in 1975-76, several things were altered in the pattern of use in the Maturing Open habitat. First, as Table XIII and Figure 14c indicate, use remained high throughout the winter since snow depth was never excessive. Second, the pellet group density here in 1976 ranked second and was only 4% lower than in 1975. Since the overall average dropped by 50% and the average drop by types was 43%, this slight decrease in the Maturing Open indicates a substantial increase in relative use in the mild winter. Finally, a large influx of deer to this type in late winter-spring was not observed in the second year. This is also a result of the reduced snowfall in 1975-76. Because there was so little snow everywhere that year, the Maturing Open did not represent the only habitat with bare ground and a source of new growth of forbs. In fact, the period that had been late winter in the first year (25 March to 10 April, 1975) was spring in 1976, and use of fields and grasslands was beginning.

The Immature Forested habitats, both Open and Dense represent areas that are generally avoided by white-tailed deer. In the Immature Forested Open the explanation for this low use in 1974-75 is simplified by snow depth. The relatively open pine canopy intercepted but little snow, and the deer could not exploit this type without excessive energy costs in traveling about. The deers' requirement for relief from deep snow in dense stands in that cold, snowy weather led them to seek other forested habitats.

The repetition of this pattern of low use in a relatively mild winter (1975-76) indicated, however, that snow depth was not alone in discouraging use of this type. The understory is poorly developed and locally affected by heavy grazing so available forage is low regardless of snow pack and the limited amount of fir in the overstory provides very little of this important browse. Hout (1974) found that white-tails in Quebec not only selected types that provided cover, but bedded near the larger trees in those types. I generally noted the same here and Dr. R. Ream (pers. comm.) found this to hold true for elk in Montana. Moen (1968 a. and b.) has given energetic evidence to show why this selection occurs. Given this selection and its energetic basis, the relatively open nature of this type composed almost entirely of small trees would give it a very low shelter preference rating. Lacking both food and shelter, this habitat is of little value to the deer, and they respond accordingly.

Interpretation of the use and value of the Immature Forested Dense type is not as simple. There appears to be a discrepancy in the data since the track counts indicate avoidance of this type through much of the winter, but the pellet group densities indicate that this type receives only slightly less than average use.

The explanation for this discrepancy lies in the fact that the structure of the habitat is such that its use intensified the two biases in the sampling techniques. It has already been shown that this type virtually lacks an understory and that although the total quantity of fir browse is high, the growth form of the individual trees is such that they produce very little, and probably very low quality forage. Therefore, the deer spend little time feeding here. On the other hand, the high degree of canopy closure results in the interception of much of the snowfall and the density of saplings makes it ideal cover. It is used heavily for bedding and relief from the occasional severe storms in winter. Since track counts are biased toward feeding sites while pellet groups are highest where there is a concentration of bedding, the two use estimates are drawn in opposite directions in a habitat like this that offers shelter, but little food.

Since this habitat is used primarily for relief from climatic stresses, the influence of the proportion of the winter range covered by this type must be evaluated in relation to the general winter conditions and the distribution and productivity of surrounding habitats that fulfill other life support requisites. There are good indications that too much of the Wolf Creek winter range is allocated to the Immature Forested Dense type for the maximum benefit of the whitetailed deer in view of typical winter weather and the potential productivity of the unforested types.

The remaining two forested types, Aspen and Riparian Mature Spruce, were relatively minor and apparently unimportant components of this winter range. In the former habitat, forage production is relatively high and more use might be expected in this type. Martinka (1968) and Allen (1968) both found white-tails to use a similar habitat extensively in Montana. Along Wolf Creek, however, the patches of Aspen habitat are very small and offer no cover whatsoever. They are also located near a road so diurnal use is restricted as the deer here do not generally tolerate vehicular and human disturbance. Finally, the lack of a conifer overstory means that snow builds up here almost as quickly as in the open types and in a winter like 1974-75, use would be limited by nival conditions.

The Riparian Mature Spruce type was also found to be relatively productive, and the spruce canopy intercepted much of the snowfall. However, the level of use was found to be light to moderate in 1974-75 and moderate to high in 1975-76. This pattern of use could be related to the habitat's being uncomfortable in cold winters due to its shaded and humid nature.

Both the Aspen and Spruce habitats are more significant components of the riparian deer ranges found north of Skookumchuck and south of Fort Steel. The present study may not provide a complete analysis of the value of these types and future research on white- tailed deer range in the Rocky Mountain Trench should include a more thorough examination of these areas.

The grasslands and fields in the Wolf Creek drainage are virtually untouched in the winter months. This is probably related to their lack of cover and the influence of heavy grazing or the mowing of alfalfa. On the natural grasslands, cattle grazing has altered the community by eliminating the bunch grasses that can withstand fall rains and snow and that remain nutritious in winter (Kemper, 1971). The increased forb and annual grass cover is decadent, prostrate and of little value following the typically hot, dry summer weather in this area.

On the cultivated fields, two cuttings of hay are the rule and many ranchers then fall-graze the stubble. This practice severely reduces the quantity, quality and height of the available forage regardless of snow cover. That deer would use these fields under different treatments was demonstrated by several deer feeding for a few weeks from late November, 1974, to January, 1975, in a section of one field that was not cut a second time nor grazed in the fall. The deer were even "cratering" in 24 cm of snow to feed on the alfalfa. (Cratering observed in natural habitats occurred in snow no deeper than 17 cm with *Balsamorhiza saggittata* and bearberry as target species.) Similar behavior in other single cut fields was reported to me by G. Seaton, a local conservation officer.

The very conditions that eliminate usefulness of these habitats during the winter enhance their value in spring. The almost complete removal of above ground material creates a situation in which new growth begins early and is immediately available to spring-grazing deer. The animals respond quickly to this high quality forage and spend many hours in the spring feeding in these areas. The advanced availability of these types in spring, however, should not be viewed as justification for continuation of present treatment of these areas. Continued complete removal of annual production on cultivated fields may be of minor importance in terms of overall winter deer forage availability and the negative soil effects can be offset to some degree by heavy fertilizing (which is not generally done), but continued abuse of natural grasslands will lead to severe depletion of soil nutrients and will eventually reduce their value as spring range. The 20% bare ground in the grasslands (Table I) may indicate that some nutrient depletion has already occurred. (It should be noted here that season- long grazing by domestic livestock which lead to this deterioration was replaced in 1976 with a system of deferred and rest rotations on the area north of Wolf Creek. R. Demarchi, pers. comm.).

The initial use of these areas in spring is relatively low and probably represents pioneering use by those individuals whose winter home ranges border on the field. At this time, only a few patches may be bare of snow. As more snow melts and the alfalfa initiates growth, other deer are attracted to the field and shift their activity to the field and the cover at its edges. This shift was demonstrated by marked deer #2C (Fig. A4), and several authors have reported similar behavior in white-tailed deer in eastern North America (Marchinton, 1968; Downing et al., 1969; and Byford, 1969). As forage green-up occurs in other areas, deer become less dependent upon alfalfa and shift their activity away from the fields. A similar rise and fall pattern was reported by Bartmann (1974) for mule deer on alfalfa fields in Colorado.

To some extent, the drift of the population toward the summer range was responsible for the observed series of peaks of use in the fields illustrated in Figure 9. These peaks occur in an east to west fashion in relation to the rate of snowmelt (earliest in the east) and distribution of the population as indicated by observations of marked deer. Thus although use of the easternmost field dropped off after 9 April, some (and probably most) of these deer had just moved to the west and were using other fields. It can be seen then that these fields, and to a lesser extent the grasslands, are a highly used type throughout April and May.

Hall (1973) has shown that the availability of high quality forage during this period is critical to late term fetal development and neonatal survival in white-tailed deer. Availability, however, is not just a function of what is actually growing in the field as determined by the arrival of spring weather. The timing of initiation and amount of use of these areas is controlled by several factors.

Detailed studies of deer use of alfalfa fields have indicated that weather exerts an important influence on deer use of fields. Boyd (1960) and Progulske and Duerre (1964) found that cold, rainy weather reduced the numbers of deer using study fields. This was also noted in my observations, but it was not sufficiently quantified for statistical evaluation. An especially cold or rainy spring could be detrimental by reducing both rate of plant growth and exploitation of the new growth by the deer.

Another important factor is human disturbance, and the influence of this on the daily pattern of use. I have shown that human dis turbance can influence the initiation of daily use of fields (Fig. 10). The data are too incomplete to carry the comparisoon on through the night, but the trend in all fields was for a consistent, gradual decline resulting in the fields being empty at sunup. This pattern was also found by Boyd (1960) and Bartmann (1974). It would appear then that traffic and associated human activity have the effect of reducing deer use of the fields. Although the "late starters" might be able to compensate by feeding in the fields for longer periods through the night, I have no data to indicate that this occurs. Also, their ability to do this would be limited somewhat by the fact that the peak of use on Dr. Green's field occurs two weeks later than on Bradford's and the night is almost an hour shorter at that time.

Thus the potential value of the open, non-shrubby habitats is a function of their location, their treatment, the weather and the proximity of human disturbance.

Verme (1968) has stated that winter severity is a function of two things: the physical restraints of the snowpack and cold weather. The different amounts of snowfall on the study area in the two winters have been shown to have had different influences on the winter distribution of the deer and their ability to exploit the forage resources on the winter range. The identicle phenomenon was documented in New Brunswick by Drolet (1976). In general, the deep snow of 1974-75 confined the deer at high densities to the nonproductive, closed canopy forested types, whereas the minimal snows of 1975-76 did not physically restrict use of any area. As a result, the deer not only had to expend relatively more energy to move about in the first winter, but also suffered from intraspecific competition and the inability to utilize the most productive forage areas. From this standpoint then, the first winter was more severe.

The intensity of cold weather is a function of several climatic variables. Verme (1968) found that the most important of these is temperature and it is obvious that the colder the weater, the greater the energetic cost of maintaining homeothermy. Once again, the winter of 1974-75 rates more severe since average temperatures then were lower than in 1975-76 (Fig. 8).

Another environmental factor that is involved in the thermal regime of a deer is direct solar radiation. Although Verme (1968) found poor correlation between this and air chill, his "chillometers" were shaded from direct sunlight for the majority of the time, and their shiny metal surfaces reflected much of any light that struck them. On the contrary, a deer has the option of moving to place itself in direct sunlight and its surface is not as reflective as metal. On many occasions, deer were found bedding in sunny areas, and the previously discussed differences in track counts and pellet group densities indicate obvious selection for aspects that receive direct solar radiation. Loveless (1964) has discussed similar behavior in mule deer in Colorado.

It has been shown that the winter of 1975-76 was sunnier from mid-January to late March. This means that the deer had the option of exposing themselves to more solar radiation in the second winter. Whether or not they exercised this option--or indeed if they needed to exercise it--during this warmer winter is unknown.

The weather data I gathered indicated that the winter of 1974-75 was much more severe in all aspects than the following year. I believe that this severity is an important agent in the different age ratios found in the spring. There is no indication that anything other than greater forage availability due to decreased snow and reduced energy costs due to milder weather influenced the population in such a way as to bring about a 50% increase in the proportion of yearlings in the population in the second spring.

The fact that white-tails are found in many areas where they experience longer, more severe winters does not necessarily imply that weather is not important in this population, or that the differences between years is of no significance. As Moen (1968 a.) has emphasized, the dietary level is the regulating element in the deers' ability to withstand adverse climatic conditions. Secondary succession has been shown to have reduced the quantity and quality of the forage available to this deer population. It seems logical that restrictive snow conditions--such as those observed in 1974-75--may be sufficient to reduce nutritional levels and raise energy costs to the point where thermal stress can exert a significant effect on survival.

Forest succession has also affected the summer range of this deer population. The total quantity and average quality of the forage is undoubtedly less than what was found during the peak deer population years. However, nutritious forage that is lightly used relative to what is available is still found in small openings in the Immature Forest association and throughout the Brush and Shrub associations.

Deer densities are so low on the summer range that each individual has the opportunity of selecting highly nutritious forage in quantities unlimited by competition or environmental factors such as snow depth. My analysis of summer range use indicates that individuals in this population do take advantage of this opportunity by distributing themselves in relation to these open areas. Elsehwere in North America, summer distribution of white-tailed deer has also been found to be primarily related to availability of preferred foods (Kohn and Mooty, 1971).

Some authors have discussed the limitations of summer range for northern deer populations (i.e. McCaffery and Creed, 1974) and relate its importance to the need for deer to obtain body reserves for use in the winter period when available food is limited by climatic factors. Summer range can become a limiting factor when deer are no longer able to build up these required reserves.

All the deer I had the opportunity to examine in the fall of 1975, from both hunter kills and accidental road kills, were in excellent condition with large deposits of subcutaneous and mesenteric fat. These deer are apparently able to obtain sufficient excess energy and nutrients in summer to permit storage of these resources for use in the coming winter. It is not known to what degree the present level of energy and nutrient storage approaches the maximum physiologically possible for white-tailed deer.

The greatest value of information gathered from individually marked deer is that it verifies the movements associated with the observed shifts in distribution of the deer resulting from changes in relative levels of use of the habitat types in response to environmental factors. Unfortunately, the data are insufficient and the sample size too small to allow critical analysis of the influence of specific factors such as snow depth or succession on individual home ranges.

However, general observations indicated that home range size and distances moved daily varied inversely with snow depth. Such a relationship should be expected and Drolet (1976) and several others authors have clearly demonstrated that this occurs in other white-tail populations.

The average distance from the trap site to summer relocation for nine deer sighted between the end of June and the end of November, 1975, was 24.0 km. Because those relocations made in October and November may have been of deer already moving back to the winter range from their point of maximum summer dispersal, 24 km should be considered a minimum estimate. Even so, this value is well above all of the average dispersals for white-tailed deer found in numerous studies listed by Verme (1973). The highest average he found in the literature was 15.6 km reported by Carlsen and Farmes (1957) for the prairie-deciduous biome.

There appears to be an inverse relationship between habitat diversity and average distance from winter to summer range (Verme, 1973). It may be that forest succession on the summer range of the Wolf Creek deer has progressed to the point where the patches of preferred forage are becoming more widely dispersed, and as a result, the deer must move greater distances from winter to summer range.

Although the sample size is extremely small (4) it is interesting to note that 50% of the adult deer trapped in 1975-76 were recaptures from the previous year (Table XIV). These were the two males believed to have traveled a minimum of 40 and 65 km and were both recaptured within 100 m of their 1974-75 trap site. At least five other marked deer returned to the Wolf Creek area and there is no way of knowing how many others came back but had either lost their tages or were not seen. Winter range fidelity appears to be as high in the East Kootenay region as in any other area even though the deer here may range farther between seasons.

CONCLUSION

Forty years of forest succession on the terraces of Premier and Wasa Ridges aided by at least 25 years of intensive fire control has resulted in major changes in the winter range used by the white-tailed deer in the Wolf Creek drainage. Seral Shrub habitat, which once covered the majority of this area, is now limited to less than 10%. Various forested habitats in which forage production is less than half that in the Seral Shrub type now cover over 80% of the winter range. The quantitive reduction of forage has been intensified by a generally, negative change in forage quality.

As a result of these changes in the shrub and herb vegetation, the deer have come to rely heavily on douglas fir as a winter food. Information in the literature indicates that the timing and intensity of these animals' browsing on douglas fir is such that they are obtaining very little nutritional value from this food, and must have alternate sources of energy and nutrients to survive the winter. This becomes more important each year as the trees mature and the ratio of current annual growth to older needles gets smaller.

In a winter when snow depth does not reach a confining level, distribution of the deer appears to be controlled by the availability of forage in the understory as the deer selectively use the more productive, open-canopied or unforested habitats. In such years, survival of young animals is high. During winters when snow depths in the open exceed 30 to 40 cm these deer change their distributional patterns by selecting the habitats which afford the greatest amount of relief from the physical restraints of the snow pack. These types have closed forest canopies, however, and available forage is seriously reduced. As a result, over-winter survival is lowered, especially for juveniles.

In late winter and spring the population undergoes a redistribution as individuals concentrate on those areas where forage greenup has begun. Initially, these are the southfacing, open slopes and later the natural grasslands and cultivated fields. Use of these fields is influenced by the level of human disturbance and their position on the gradient from winter to summer range as well as climatic factors.

Movement of the deer from winter to summer range begins in late April and continues into May. The majority of the deer from Wolf Creek spend the summer months on the west side of the Kootenay River on the benchlands that extend to the Purcell Mountains. Their distribution here is primarily controlled by the availability of preferred forage species.

Forest succession has also influenced the habitat on the summer range and resulted in wide dispersal of the remaining areas of nutritious forage. The deer seem to be responding to this by moving a greater average distance between seasonal home ranges than is true of other populations of white-tailed deer. The deer are still able to obtain sufficient excess energy and nutrients to permit storage for the following winter, so summer range is not judged to be a limiting factor.

Little information was obtained on fall movements back to the winter range, but the deer appeared to move only as they were forced to by snow depth. The lower densities observed on the winter range in the second year were the result of wider dispersal of the deer indicating that they remain off the winter range as long as possible. Despite this change in the two winters, loyalty to the winter home range was high and several deer were found to use the same area in both years.

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APPENDIX I

INDIVIDUAL MOVEMENT ACCOUNTS

Adult Females #5A, #7A and #2B:

Figure A1 illustrates the known movements of three adult females in the winter of 1974-75. Doe #7A was captured along Wolf Creek 2 February, 1975. She was next seen just west of Lazy Lake on an aerial survey flight, 18 February. She was not seen again until late March when she was found feeding twice daily on both 27 and 29 March on a southfacing slope just west of the trap site. (This slope, in Maturing Open habitat, was heavily used in late winter, 1975.) Her initial "transitional" or spring movement was detected the next day when she was located in an alfalfa field in lot 8103 on the afternoon of 30 March 1975.

Doe #5A was captured on 31 January, 1975, and recaptured 200 m to the east on 16 February. She was next seen on the morning of 6 March feeding on an open, southeast facing slope with doe #2B which had also been trapped 1.9 km to the west on 19 February. This association may have lasted some time, as both deer were seen together again on the evening of 2 April about 0.5 km west of their original trap site. Although no spring movement locations were determined for these does, #2B was seen several times in the late summer-fall period (see Fig. A5).

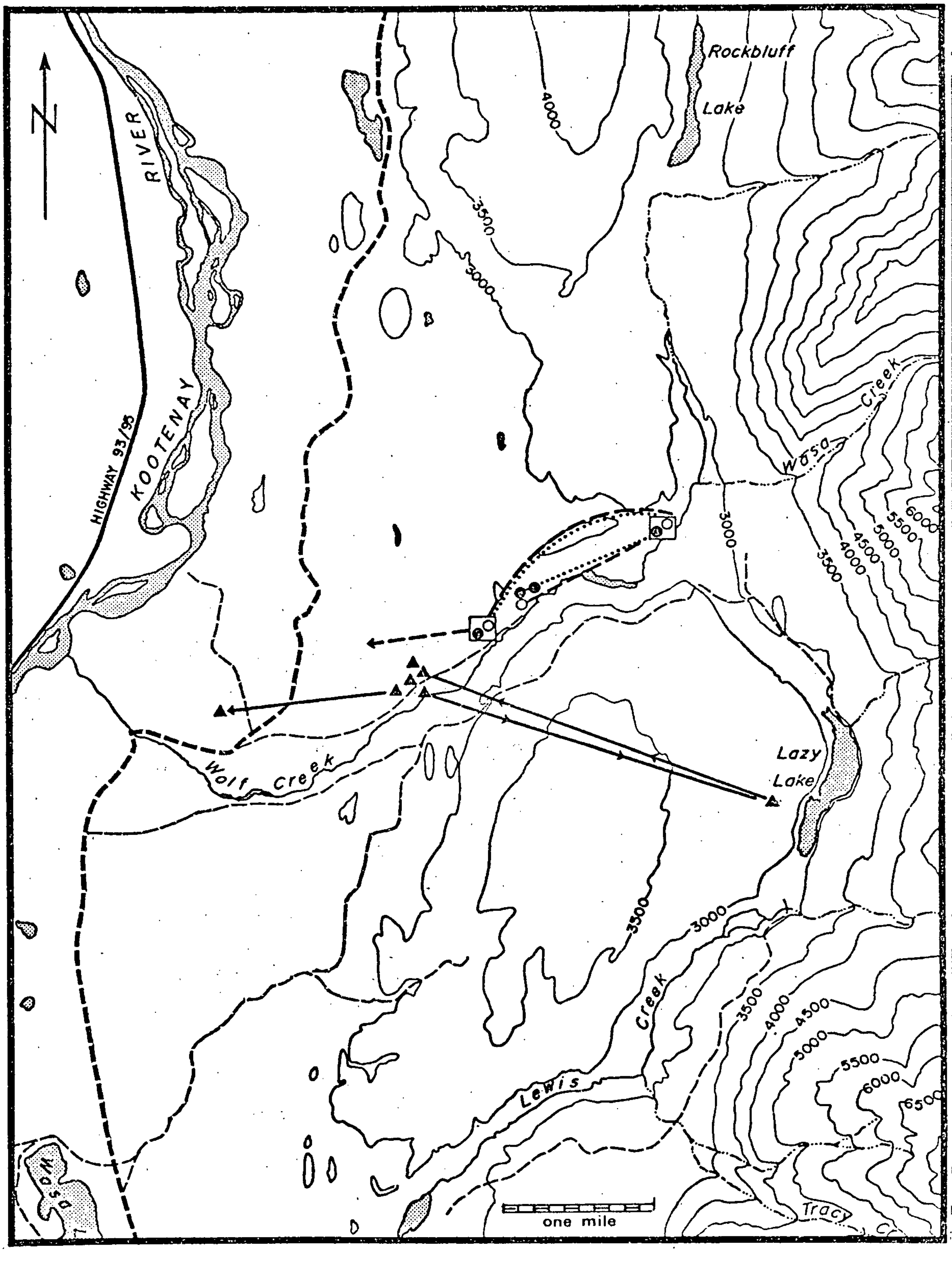

FIGURE A1. Known movements of adult females 7A (▲→), 2B (⊙--), and 5A (⊙···) in the winter of 1974-75. [symbol] indicates deer seen together and dotted arrow indicates direction to summer range of 2B (see text and Fig. A5.).

Adult Female #9B and Female Fawns #2F and #4F:

Figure A2 is a map of the known movements of an adult doe, #9B, and two female fawns, #2F and #4F, both believed to be her offspring. The first one of the three captured was fawn #2F on 16 February 1975. The other fawn and the doe were captured together about 2 km. to the east on 3 March. This pair was seen again by B. Jamieson another 2 km to the east feeding with 7 to 10 other deer in the brush along Wolf Creek on 19 March at 3:00 p.m. The three deer were seen together in the same general area on 27 March at 12:05 p.m.; #4F was seen here with 6 unmarked does and 4 unmarked fawns on 29 March at 5:30 p.m.; and the three (#9B, #2F, and #4F) were again together feeding in the brush on 3 April at 10:04 a.m. with 15 other deer. The trio was next seen 1 km to the west on 8 April at 5:35 p.m. Although all three were not seen together again, #9B and #2F were seen 3 km to the west on the previously mentioned heavily used southfacing slope on 14 April at 5:00 p.m. The next sighting was of #9B with #4F in an alfalfa field at 4:15 p.m. on 22 April. Fawn #2F was not noticed among the 20 other deer in the field at that time. This was repeated on 24 April at the same time. #9B was seen again in that field at 11:30 a.m. on 7 May with two unmarked deer.

None of these three deer were seen again until the following year on 31 March, 1976, when #9B and #2F were seen in that same field at 7:30 p.m. feeding with 31 other deer.

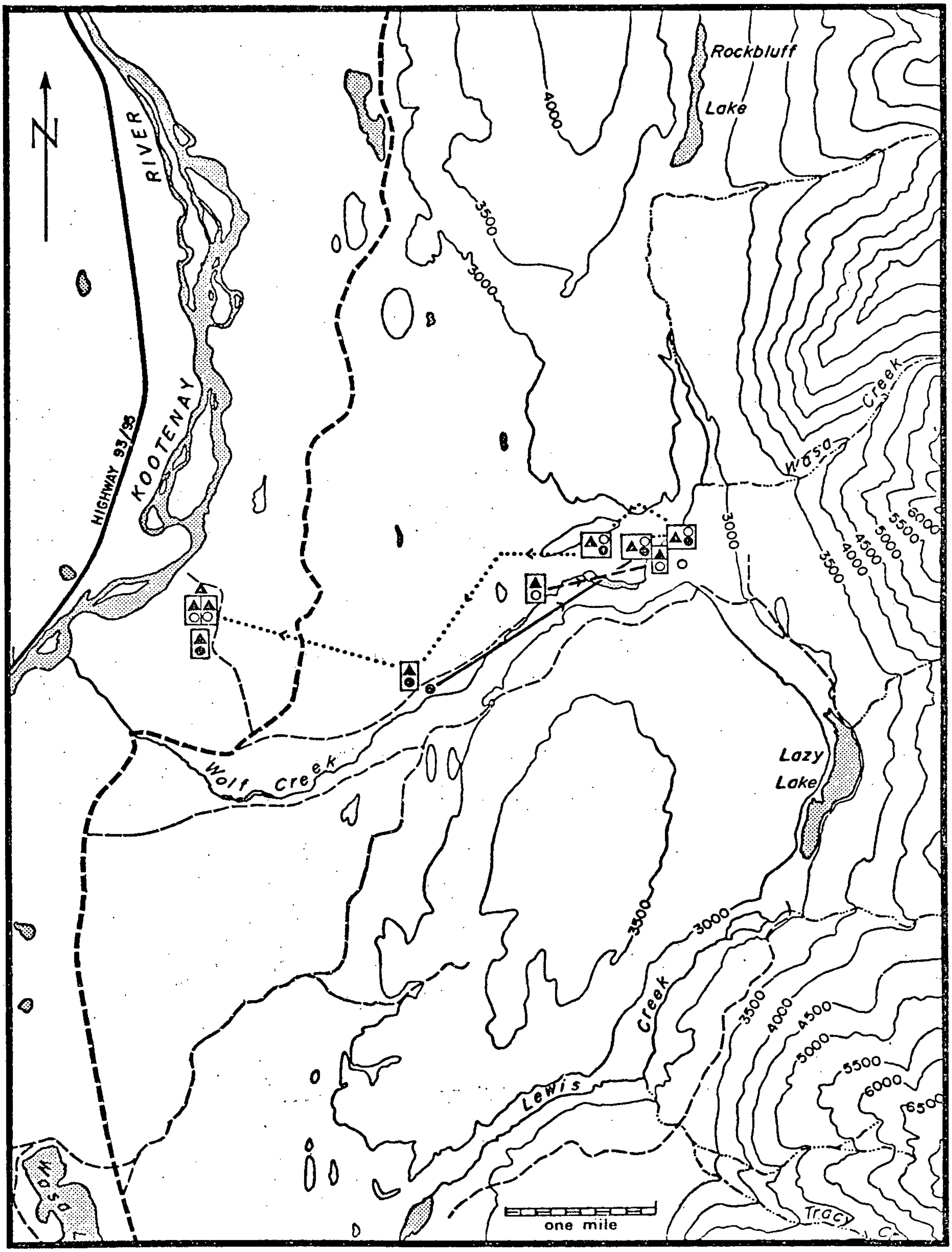

FIGURE A2. Known movements of adult female 9B (▲) and female fawns 2F (●) and 4F (○) in winter, 1974-75. ⟶ indicates movement of 2F; - - -→ indicates movements of 9B and 4F; and ·····> indicates movements of all three. [▲/○] indicates deer seen together.

Adult Females #9A and #7B:

Figure A3 is a map of the known movements of two adult females, #9A and #7B. The former was captured on 17 February, 1975. One month later on 15 March, she was seen 2.4 km to the northeast in the Mixed Age Fir type. After that, she was seen six times between 20 March and 9 April feeding on the heavily used Maturing Open slope. She was usually seen in the company of three or four other deer including #1A once and #7A twice. The single point west of Highway 95 in lot 338 represents a sighting a year later on 19 April, 1976.

Doe #7B was initially captured in the Mixed Age Fir type on 1 March, 1975. She was seen 12 days later 1.2 km to the southeast moving toward the southfacing slope. On 2 April, she was seen another 1 km to the southwest fedding on the heavily-used slope at 6:30 p.m. with six unmarked deer. The other two points for this deer were locations on 19 February and 31 March, 1976, indicating use of the same general area in both winters.

Adult Females #1A and #2A and Adult Males #2C and #3C:

Figure A4 is a map of the known locations of four adult deer and is provided to show spring movements. Doe #1A was captured on 24 January, 1975, and was not seen again for two months. Like many other deer in the late winter of 1975, however, she was frequently seen in the Maturing Open habitat on the south facing slope northwest of her trap site. She

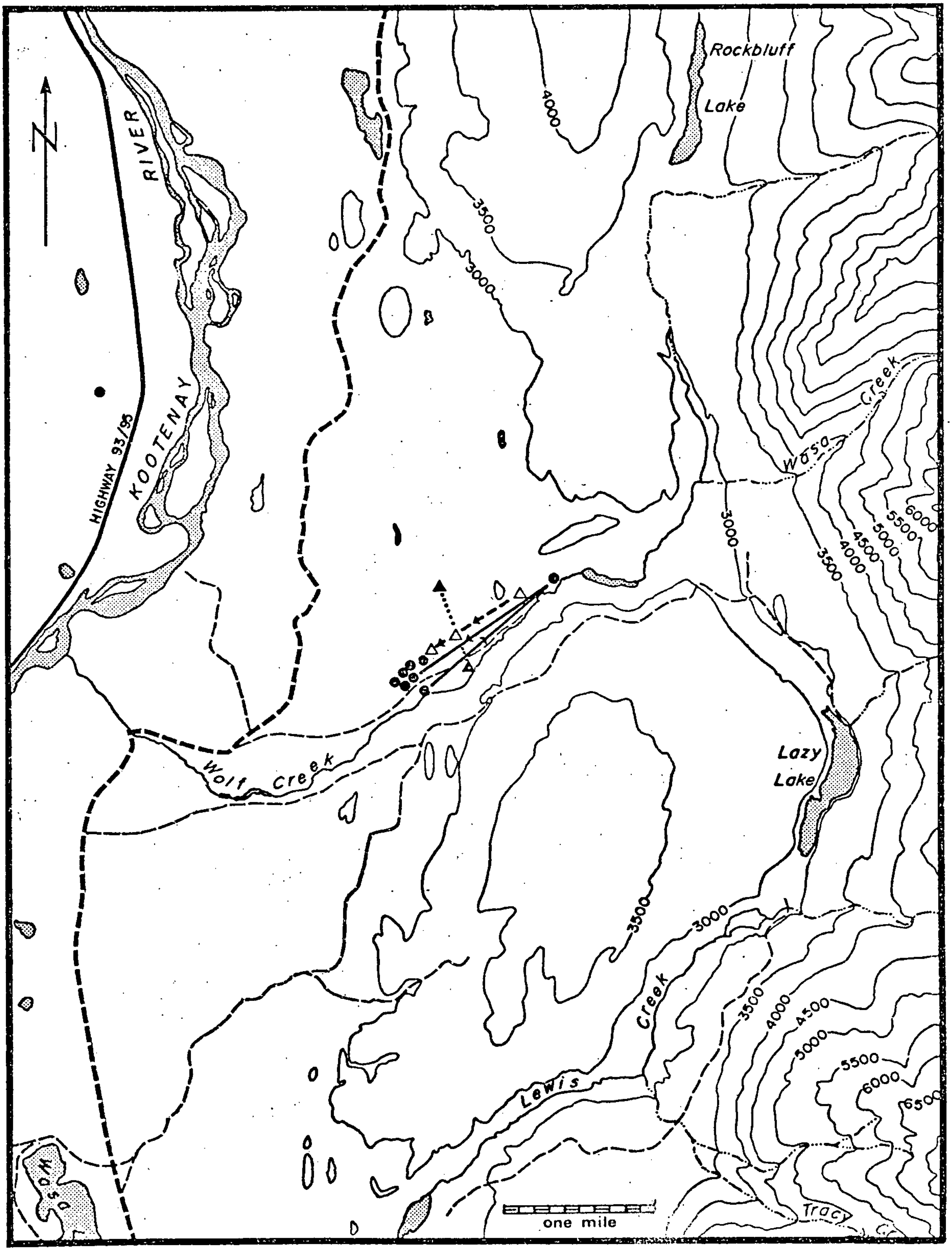

FIGURE A3. Known movements of adult females 9A (⊙→⊙) and 7B (△- -→ 1974-75; ▲···· 1975-76).

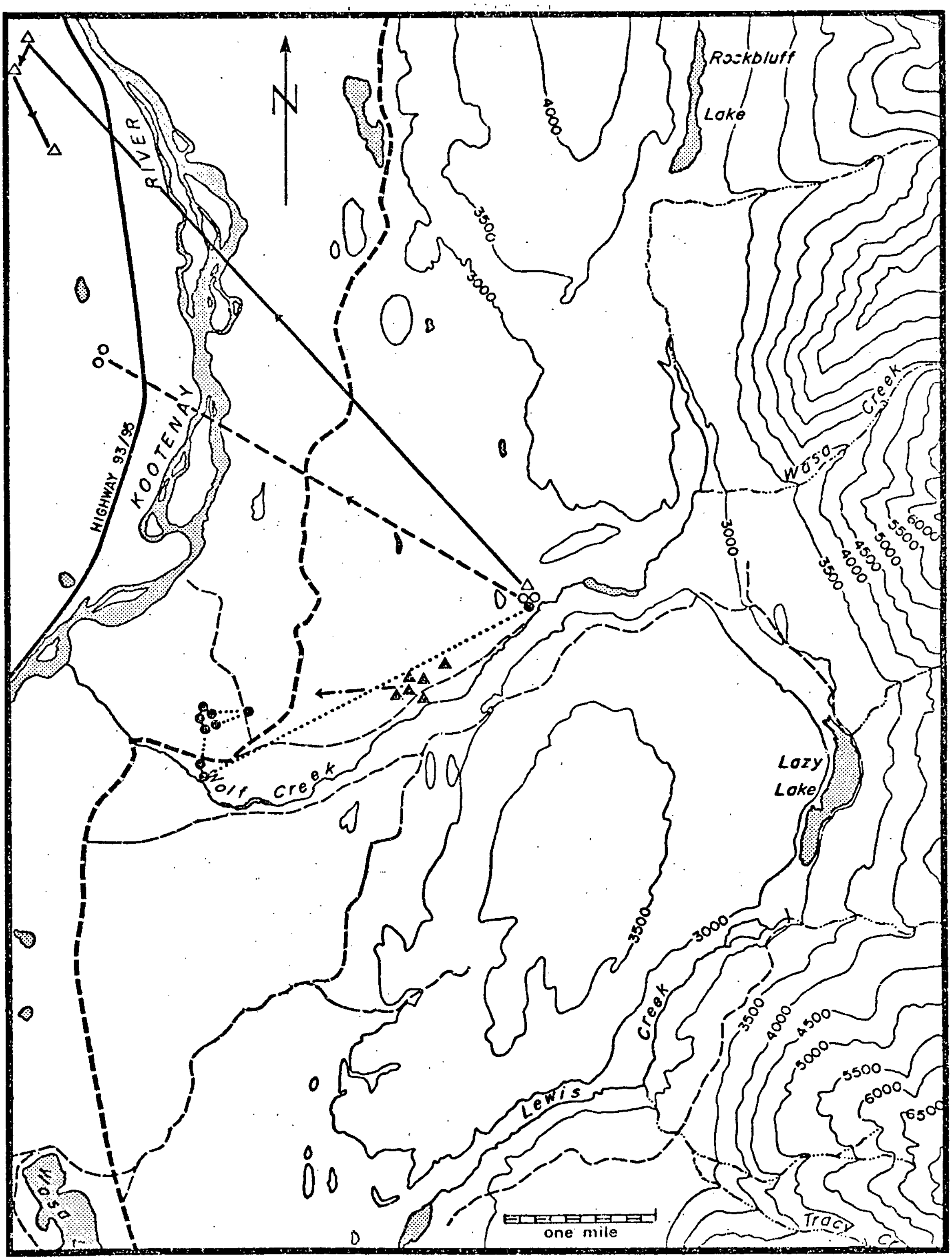

FIGURE A4. Known movements of adult females 1A (▲) and 2A (o) and adult males 2C (◉) and 3C (△) in the spring of 1975. indicates direction to 1A's summer range-was seen here five times between 22 March and 9 April, once in the company of #9A. She was not seen again during spring, but Figure A5 shows several relocations during the early summer of 1975.

Doe #2A was initially captured on 30 January, 1975, and recaptured about 200 m to the east on 17 February. She was relocated twice during spring on the evenings of 24 and 26 April at the edge of Skookumchuck Prairie in lot 338.

Buck #2C was trapped on 16 February. He was not seen again until 6:00 p.m. on 7 April when he was found feeding in an alfalfa field 1 km to the west. (He could have made this move earlier if he were the "collared deer" reported in the same field by M. Jamieson on 27 March.) For the next month, he was seen a total of six times feeding on two neighboring fields and the adjacent grassland.

Buck #3C was captured on 25 February, 1975. He was next seen on the open shrublands west of Highway 95, just south of Skookumchuck in late June by several men who work at the nearby pulp mill. From then until late August he was occasionally found in that area. He was killed by a hunter at the final mark on the map at 6:30 p.m. on 14 September, 1975.

Adult Females #1A and #2B:

Figure A5 is a map of the known movements of does #1A and #2B

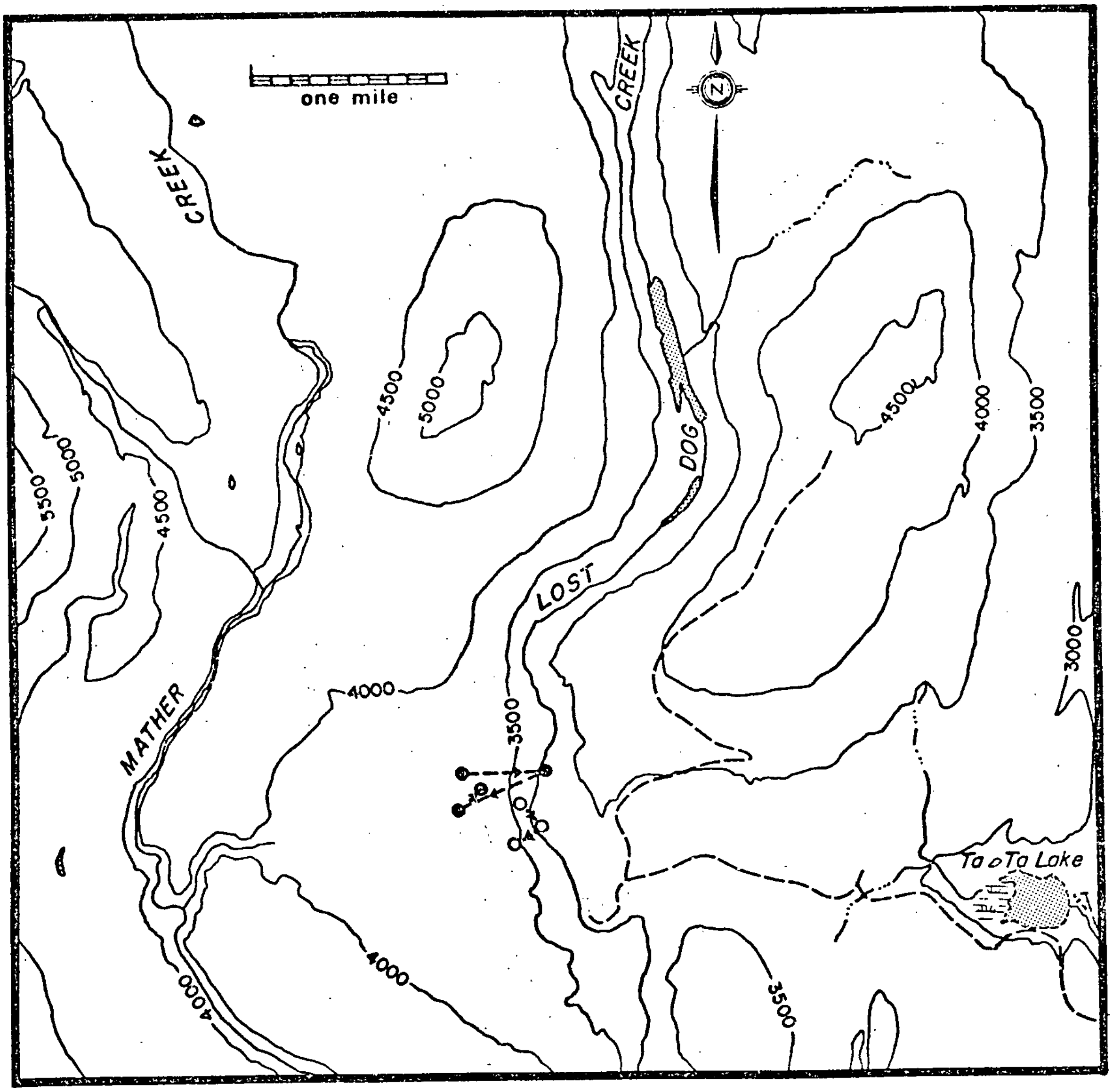

FIGURE A5. Known movements of adult females 1A (o) and 2B (•) during the summer of 1975.

during the 1975 summer and fall, respectively. Doe #1A was seen on 22 June, 6 and 8 July at the locations shown. These are all very close to a large cleared "grassland." Several deer were seen feeding in this clearing each night in early summer and it is thought that this doe's movements were centered here at that time.

Doe #2B was seen four times between 3 and 27 November, 1975, as shown in Fig.A5. This doe's movements at this time were observed in the clearing mentioned above, and on the slope up to 1 km to the west. It is not known whether she used this area throughout the summer or not.

Adult Females #6A and #R3:

Figure A6 is a map of the sighting and radiolocations of two adult females, #6A and #R3. Doe #6A was initially captured on 1 February, 1975, sighted about 0.4 km to the northwest on 20 March, and recaptured in the same trap and radio-tagged on 2 April. She was next located 2.4 km to the south on Wasa Ridge on 18 April and then made a move to the west side of the Skookumchuck Prairie where she was found six times between 24 April and 12 May, 1975. Here her spring range (the area circumscribed by a line connecting the outer locations) was about 13 ha in area and included Grassland, Immature Forest and Brush areas around a small lake. No signal could be heard in this area from 19 May to 28 May, and it was not until I made an aerial search of the area on 4 June that I found her again. At that time, she had returned to Wasa Ridge. I spent most of 5 June in that area on the ground trying to relocate her, but no other signal was ever received from this deer.

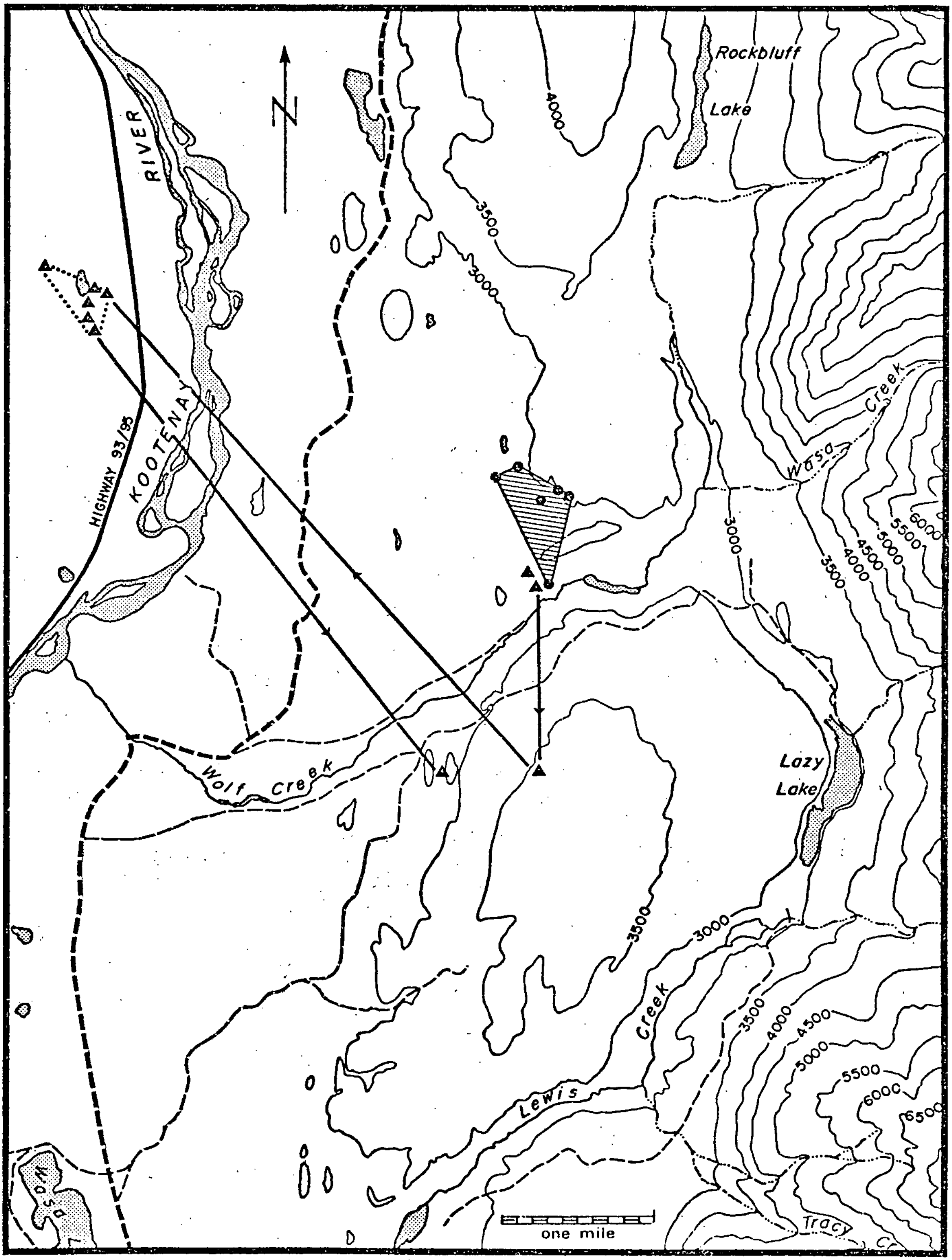

FIGURE A6. Late winter - spring range of adult female R3 (●) and known movements and spring range of adult female 6A (▲) in 1975.

Doe #R3 was trapped on 19 April and thereafter was only radio-located five times in an area about 1 km to the north between 5 and 22 May, 1975. No more signals were received after that date. The total area in the late winter-spring range used by this deer was about 40 ha, predominantly in the Immature Forested Open habitat type.

Adult Female #R1 and Adult Male #1B:

Figure A7 is a map of the relocations of adult doe #R1 and adult male #1B. The doe was captured and radio-tagged on 3 April, 1975. All subsequent locations from 18 April to 21 May were to the south, with the final location being near some alfalfa fields south of Lazy Lake. Total area for her late winter-spring range was approximately 65 ha.

Buck #1B was initially caught on 19 February, 1975, and seen on 6 March 4 km to the northeast with does #5A and #2B. He returned to the area northwest of the capture site by 20 March, and was seen twice (20 March and 2 April) and recaptured and radio-tagged (9 April) on the heavily used southfacing slope. Four radio-locations from then until 12 May provided the outline of his late winter range that totaled 31 ha. His initial movement toward summer range occurred between 12 and 19 May when he was found on the Kootenay floodplain. No signal could be heard from the floodplain from 20 May on, and it is believed that he continued on toward his summer range on the night of 19 May. Five relocations between 4 June and 5 August indicated a minimum summer range of 195 ha for this buck. No signal could be detected after 5 August, 1975.

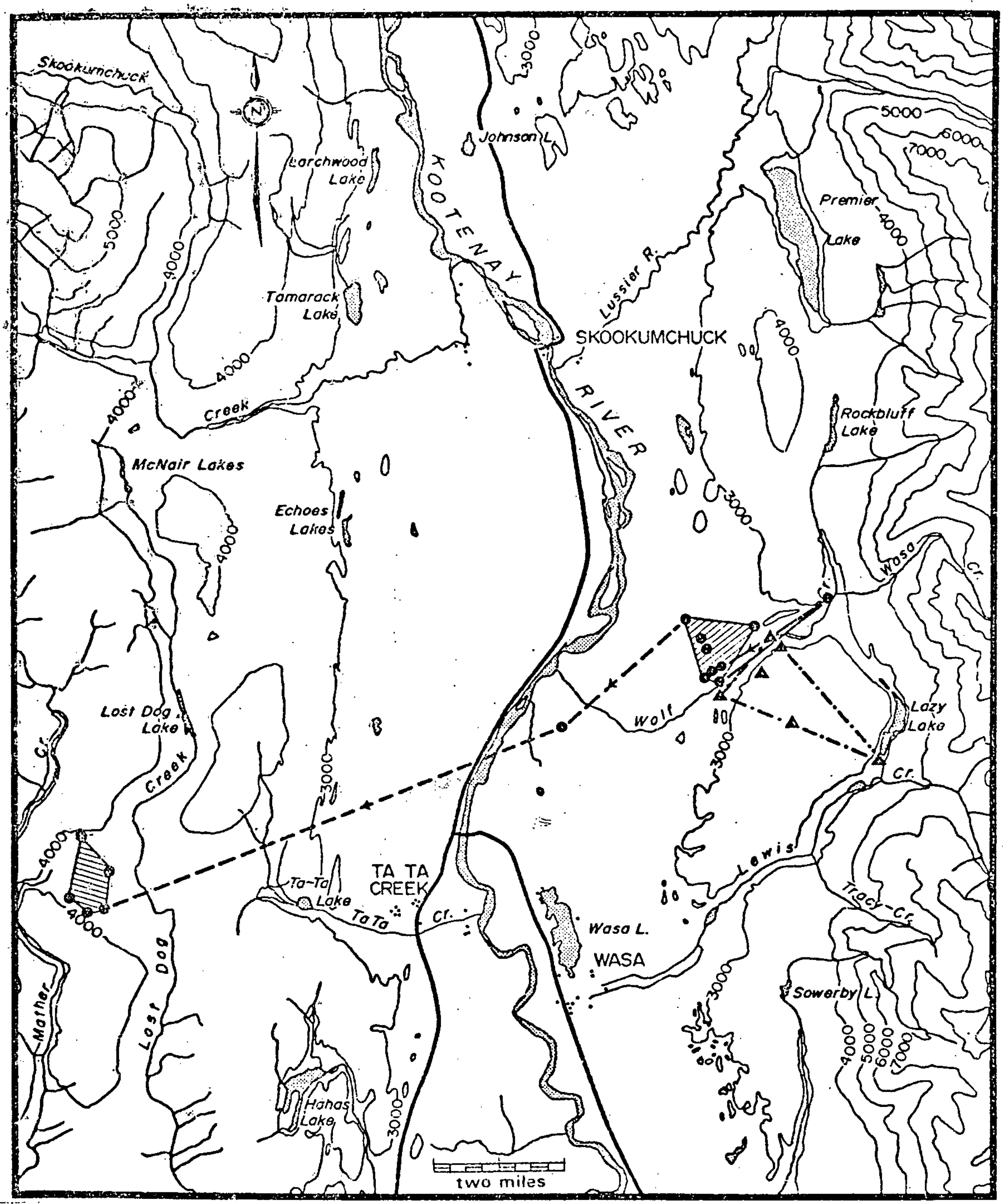

FIGURE A7. Late winter - spring range of adult female R1 (▲) and winter movements (●⟶), late winter - spring range, spring movements (● - →) and summer range of adult male 1B.

Adult Females #4A and #R2:

Figure A8 is a map of the sightings and radio-locations of two adult females, #4A and #R2. Radio contact was maintained for the greatest time with these deer.

Doe #4A was initially captured on 31 January, 1975. She was recaptured 200 m to the east on 21 February and again on 29 March at which time she was fitted with a radio-collar. She was seen crossing the road, moving upslope above the trap site to the north of Wolf Creek at 9:45 a.m. on 3 April and once again trapped at the same spot on 8 April. Two subsequent radio-locations and a sighting (with #R2 and #4B) between 9 April and 7 May, along with frequent radio contact that could not provide exact locations, indicated this doe used a relatively small late winter range of about 7 ha. This range included both Grassland and Mixed Age Fir habitat.

Contact was lost from 7 to 19 May during which time she crossed to the west side of the floodplain. No clear signal could again be heard from 20 May until a flight on 4 June found her another 2 km to the norhtwest. On 3 July, she was again found from the air another 3 km northwest. Flights throughout the Trench in early August and September failed to pick up a signal and none was heard from the ground. On a final flight on 10 December, 1975, I received a good signal in the same area where she had been on 19 May, and intermittent contact was maintained with this doe in this area from then until 20 March, 1976. Here her 10

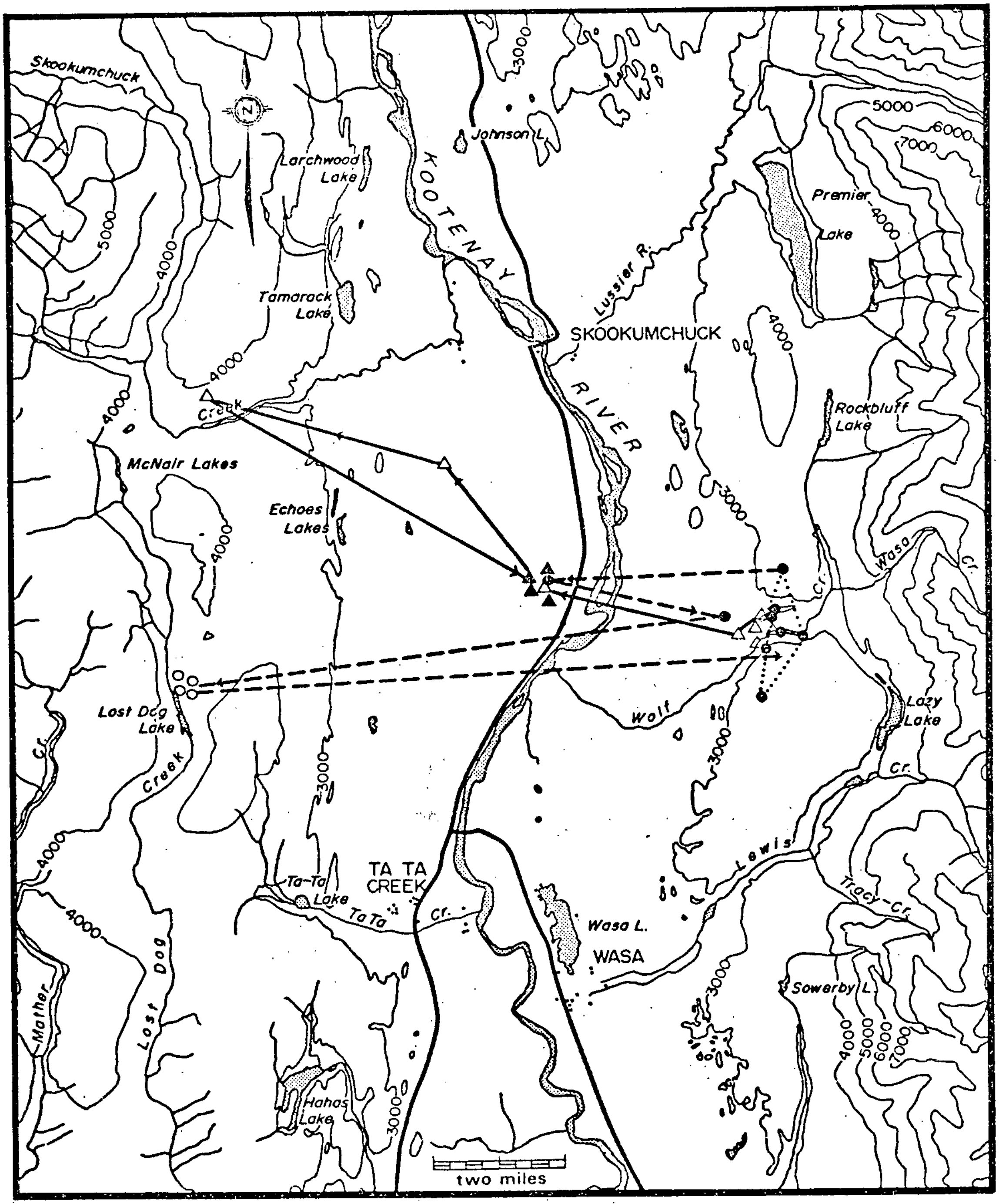

FIGURE A8. Known locations and movements of adult females 4A in 1975 (△⟶) and 1976 (▲) and R2 in the winter of 1974-75 (●-→) and the summer of 1975 (○). R2 returned to the same winter range in 1975-76.

ha range was located in a small section of what would have been classified Maturing Open habitat had it been on the terraces of Premier or Wasa Ridges where detailed habitat analysis was conducted.

Doe #R2 provided complete information on the annual cycle of movement. First trapped on 9 April, 1975, she was radio-located three times and sighted once between then and 7 May. The next signal was picked up on the west side of the floodplain on 19 May where she was still with #4A (as just described). At this point, however, the association broke up at #4A continued to the northwest and #R2 had returned to Premier Ridge between 22 and 28 May. She then moved to her summer range (by 4 June) and was relocated there several times between 4 June and 5 August. No signals were picked up from the ground after that, nor from the air on 10 December. However, on 14 January, 1976, a good signal was received on Premier Ridge in the vicinity of her previous winter home range. From then until mid-March, 1976, she was relocated within the same home range area although she moved very little. After 15 March, the bearings to the radio failed to change direction and it is thought the collar was either shed or the deer was dead. A search for her body was unsuccessful as the area inhabited at the time was in the Riparian Mature Spruce habitat with a dense underbrush and complex series of beaver ponds.

Adult Male #R5:

Figure A9 is a map of the trap site and radio locations for adult

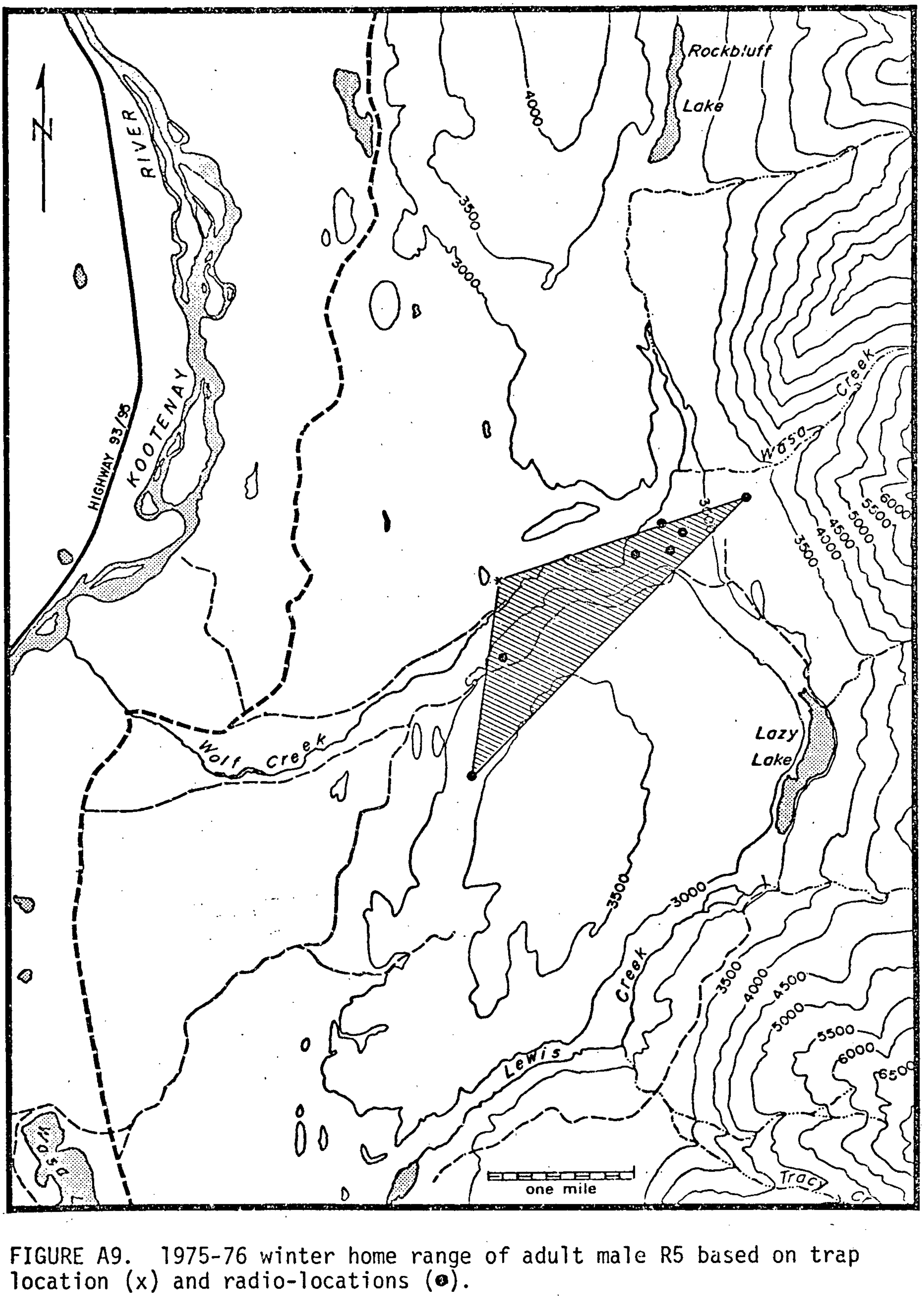

FIGURE A9. 1975-76 winter home range of adult male R5 based on trap location (x) and radio-locations (●).

male #R5. He was captured on 19 February, 1976, and seven subsequent locations between then and 16 April indicated a minimum home range of 233 ha located primarily within the Young Fir and Mixed Age Fir habitats. No signal was received after 16 April, but it is unknown whether this is the result of radio failure or the deer's leaving the study area.

Adult Female #R6:

Figure A10 is a map of the trap site and radio-locations of an adult female, #R6. After her capture on 22 February, 1976, she was found to occupy a home range area of approximately 190 ha mainly in the Mixed Age Fir habitat to the northeast until contact with her was lost on 7 May, 1976.

Adult Male #6B:

Figure A11 is a map of the movements of adult male #6B. He was initially captured on 21 February, 1975. Although not positively identified again until his recapture 200 m to the northeast of the first trap site a year later on 18 February, 1976, it is believed from the observer's description that this is the buck reported from the Lavington and Findlay Creek confluence area in September, 1975. If so this would indicate a minimum of 40 km between his winter and summer range.

This buck was the most mobile of any deer that was radio-tracked. Extensive movements from the Wolf Creek drainage to the westfacing

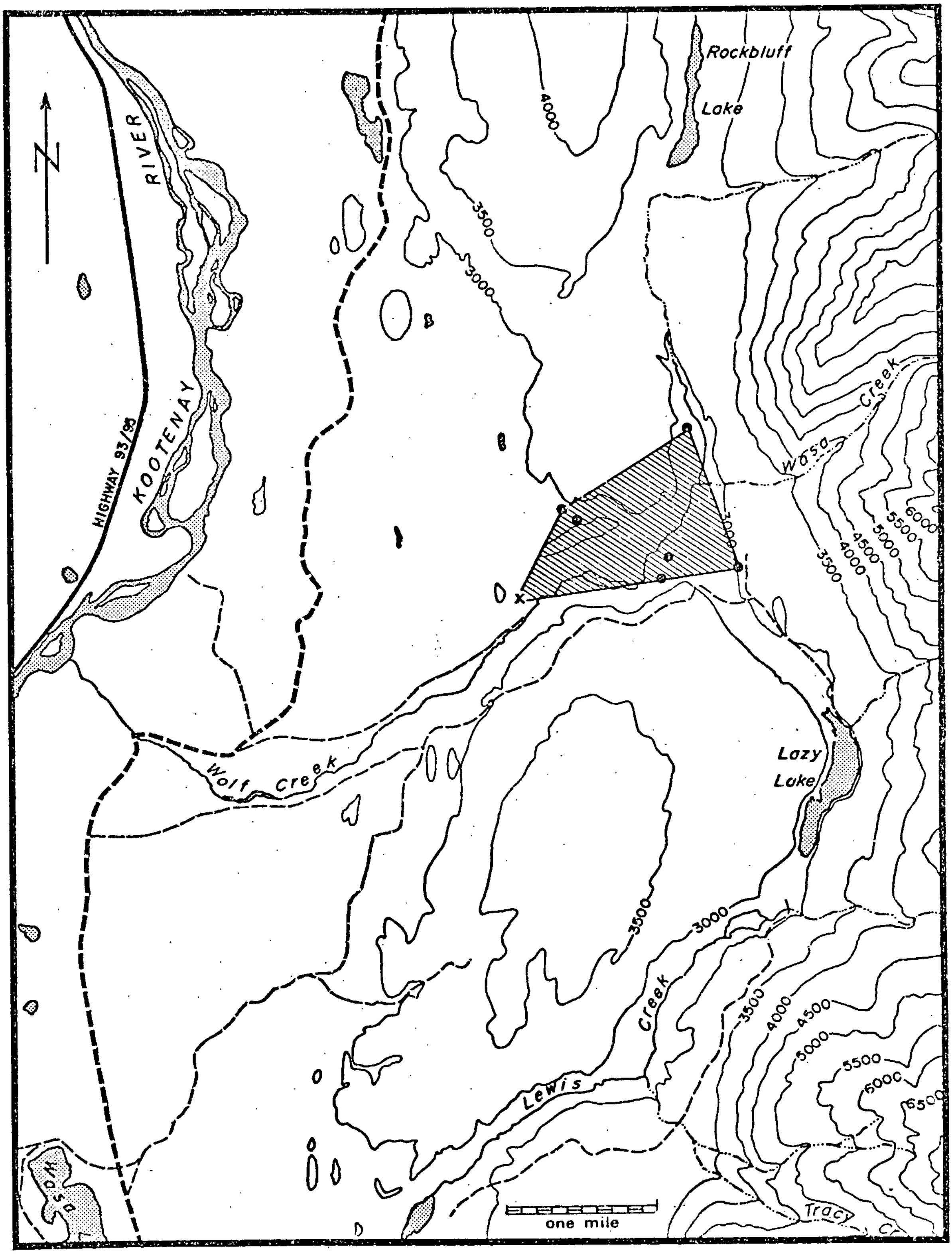

FIGURE A10. 1975-76 winter home range of adult female R6 based on trap location (x) and radio-locations (•).

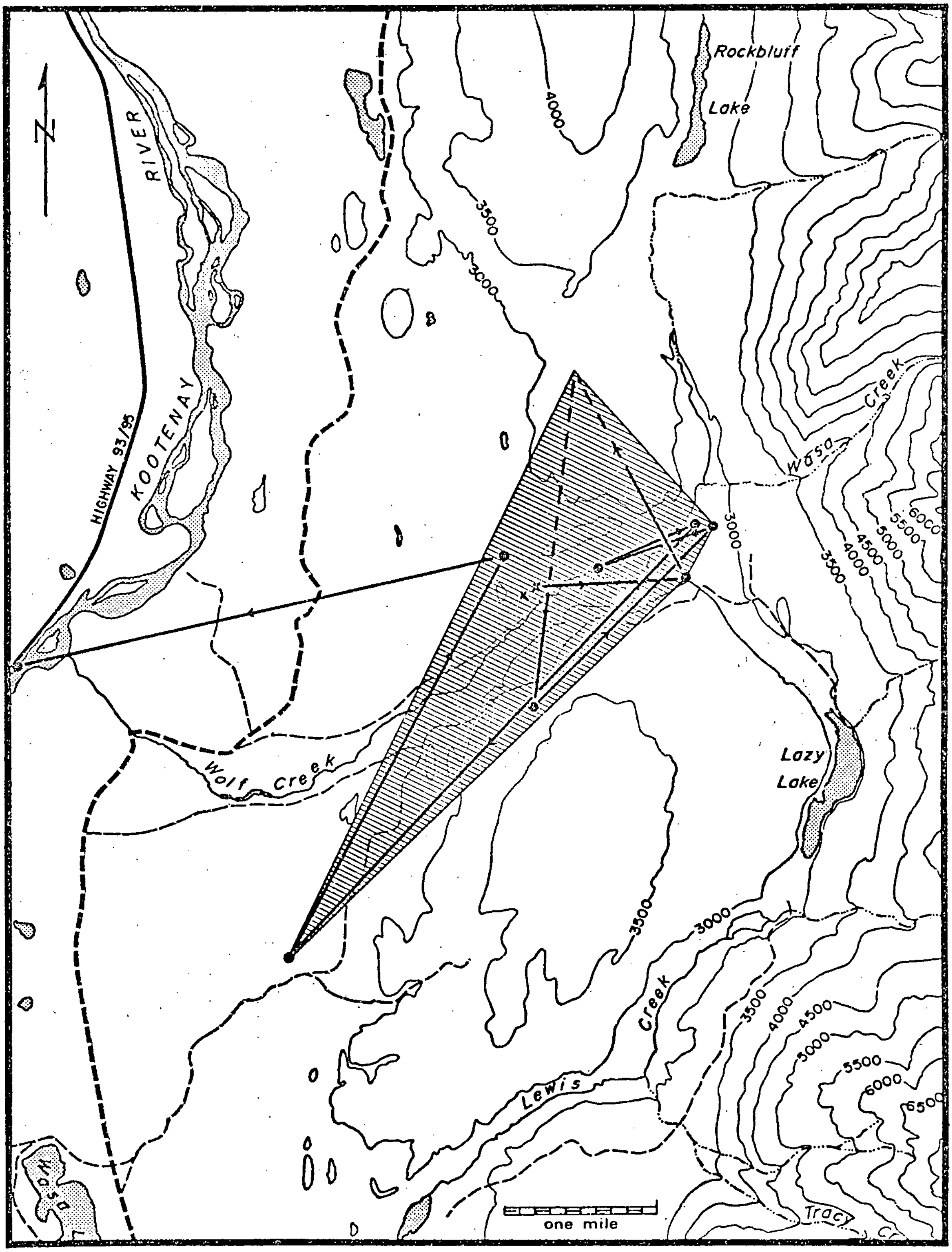

FIGURE A11. 1975-76 winter movements and home range of adult male 6B based on trap location (x) and radio-locations (●). Dotted line indicates exact location unknown.

slopes of Premier and Wasa Ridges indicated that this animal ranged over 670 ha between 18 February and 7 May, 1976. He began to move toward a summer range between 2 and 24 May when he was located on the bank of the Kootenay River. He continued from there 4 km farther to the northwest by 28 May, 1976.

Adult Male #4B:

Figure A12 is a map of the known locations of adult male #4B. He was captured at the same spot on 20 February, 1975, and 13 January, 1976. Two resightings in 1975 fell just outside of his 122 ha 1976 winter home range indicating use of the same general area in both winters. This home range loyalty is especially interesting since this is almost certainly the deer reported over 65 km to the north during the intervening summer. This buck's initial spring movement between 16 April and 8 May, 1976, indicated that he might be heading back to the upper Kootenay Valley. No signal could be heard in the study area as far north as Skookumchuck between 9 and 28 May, 1976.

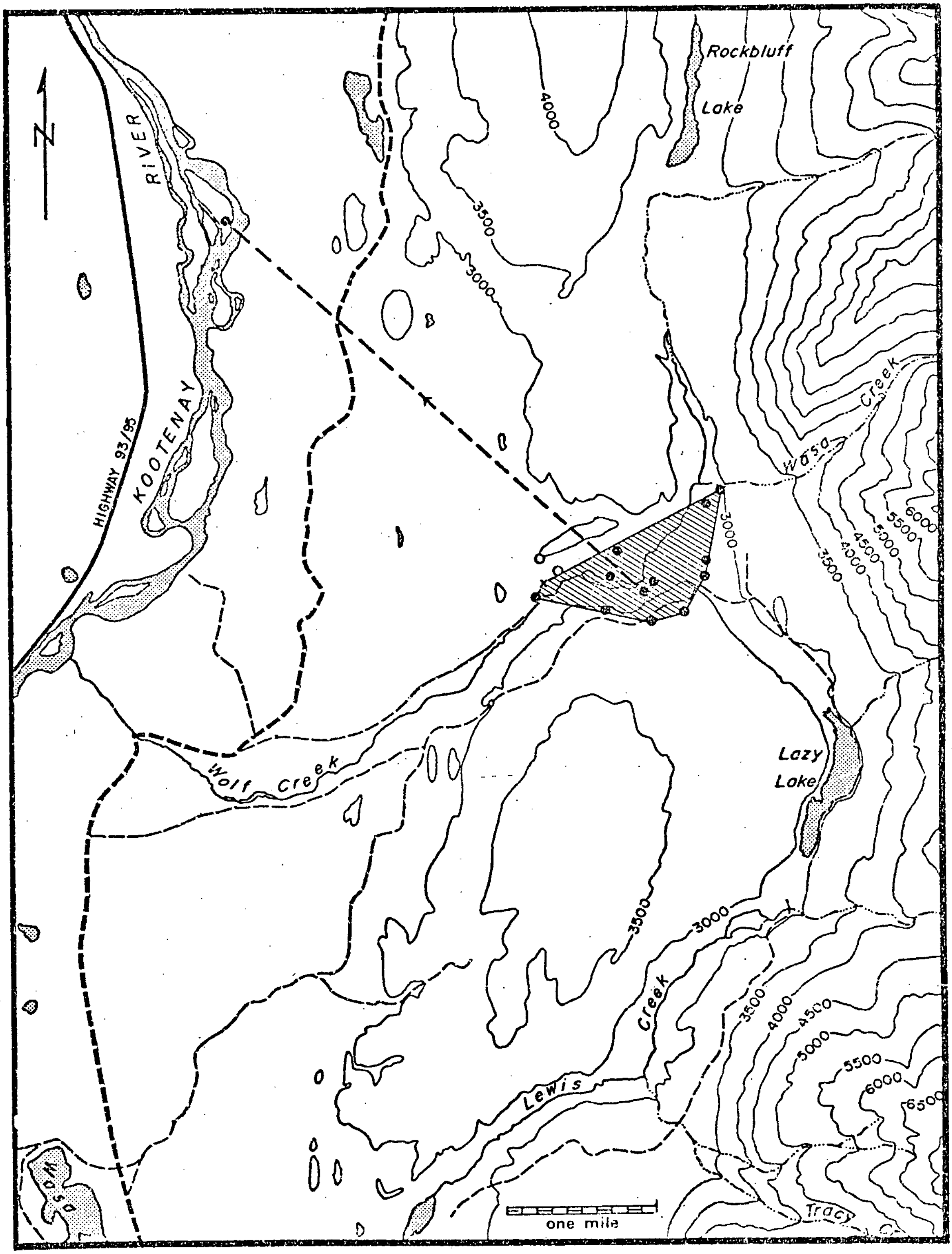

FIGURE A12. 1975-76 winter home range and spring movement of adult male 4B based on trap location (x) and radio-locations (⊘). o indicate sightings in the previous winter.