

**Factors Influencing Summer Habitat Use of Black-tailed
Deer on South-Central Vancouver Island**

By

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Abstract

Use of seral stage, biogeoclimatic variant, aspect and elevation by 13 radio collared black-tailed deer (*Odocoileus hemionus columbianus* Richardson) was examined at the 'within home range' level of habitat selection. Pooled data sets were evaluated for patterns of habitat use in relation to time periods within the summer of 1991. The July/August period of peak clearcut use coincided with the period of peak fireweed (*Epilobium angustifolium* L.) use identified by other research. The percentage of locations within clearcuts was 67.9% in April/May/June, 78.2% in July/August and 69.2% in September/October. Fireweed, an early successional forb, has been shown by other research to be the most important black-tailed deer summer forage species. Similar trends in fireweed use and the percent of locations within clearcuts therefore, were predictable.

The use of Montane variants of biogeoclimatic subzones was higher in the latter portions of the summer. The percentage of locations within Montane variants was 14.5% in April/May, 22.6% in June/July and 25.8% in August/September. Use of Montane habitat was lowest in the spring when forage species within the Submontane were more phenologically advanced and more nutritious. Shifts in elevation and changes in the use of aspect were not detected.

Parturient deer did not change their use of seral stage within the fawning period. Home range size (minimum convex polygon) was greater in the fawning period than in any other period. Increases in home range size during the fawning period were caused by increases in the magnitude and/or rate of movements to the peripheries of the home ranges. This finding supports the idea that sites on the periphery of the dam's home range are used for fawning, and is consistent with the 'hider strategy' model. Hiders

are known to remove their young from the birth site to prevent predators from using olfactory cues to detect their young. If black-tailed deer were to give birth within their core areas of use, they would be forced to remove their fawns from the habitats they most prefer.

Home range size was smaller in the immediate post-fawning period than in all other periods except the pre-natal period. This behavior is again consistent with the hider strategy. Immediately after fawning, the dam must remain close to her fawns, which are sedentary. Habitat use in the early summer was more concentrated in Submontane habitats where green-up occurred first. Home range size in the pre-natal period therefore, should also have been small.

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Chapter One: General Introduction

Rationale and Objectives

Forage Quality

In the Temperate and Arctic zones of the Northern Hemisphere, availability of high quality winter range is often considered to be the most important factor limiting condition and size of ungulate herds (Connolly 1981). Consequently, the habitat ecology of ungulates during other periods of the year has received relatively little attention. When habitat use and range characteristics during the summer are documented, it is often done only to provide a comparison between winter and summer ranges.

In many instances winter range quality is indeed the most important factor limiting herd productivity; there are, however, pitfalls in viewing this constraint in isolation of others. Although mortalities resulting from malnutrition usually occur in late winter or early spring, they are a function of both winter forage availability and pre-winter conditioning (Short 1981). The pre-winter conditioning that occurs while the animals are on their summer ranges is often taken for granted. In many carrying capacity models, (e.g., Errington 1945; Potvin and Huot 1983; Bartmann et al. 1992), the quality of the summer range is not considered. It is assumed that during the summer, ungulates have access to surplus quantities of forage. It follows, that they enter winter in peak condition and that, with respect to over-winter mortality, the quality of the summer range is inconsequential.

There is evidence that suggests this is not always the case. In arid regions, mule deer (*Odocoileus hemionus hemionus*) populations have been found to be limited by the quality of their summer ranges (Longhurst et al. 1952; Russo 1964; Robinette et al. 1977; Smith and LeCount 1979).

In moister regions gradual migrations of ungulates suggest individuals constantly seek out fresh, high quality summer pastures to improve their condition. Where such migrations occur, the spatial arrangement of different habitat types over the landscape, and the strategies that ungulates use to exploit them, are probably important factors affecting carrying capacity. Carrying capacity is defined as "the number of animals that a habitat maintains in a healthy and vigorous condition" (Dasmann 1981: 151).

Large herbivores such as mule deer, Rocky Mountain elk (*Cervus elaphus nelsoni*) and moose (*Alces alces*) have been observed to engage in gradual elevational migrations during summer months (Altmann 1952; Edwards and Ritcey 1956; leResche 1974). Some authors have found mule deer to undertake such movements in response to plant phenology (Russell 1932; Leopold et al. 1951). Bunnell (1990: 61) observed that "migratory deer that move to alpine and subalpine areas as the season progresses are able to profit from the higher quality forage found there during the late summer and fall".

Because most of the black-tailed deer (*Odocoileus hemionus columbianus* Richardson) research in the Pacific Northwest has focused on winter range, relatively little is known of the species' summer habitat ecology. In the mountainous habitats of this region, black-tailed deer populations usually have a component of elevational migrators (Harestad 1979; Loft et al. 1984; Schoen and Kirchhoff 1985; McNay and Doyle 1987). Although differences in elevation, aspect, and vegetation types between summer and winter ranges are often presented, the data sets are seldom scrutinized for gradual changes in habitat use that occur within the season. Seasonal home ranges are depicted as static entities in which constant foraging strategies are employed. Our knowledge of broad seasonal habitat requirements is

extensive, but potential changes in habitat use in response to changes in forage quality within a season are not well understood. During the growing season, black-tailed deer probably make constant adjustments to their foraging strategies to maintain quality in their diet. Appropriate foraging strategies could entail adjustments to the position of the home range in response to changes in vegetation quality (e.g., plant phenology). Alternatively deer might adjust their habitat use patterns within static home ranges.

The primary objective of Chapter Two is to report the use of habitat types within the summer range. A secondary objective, when appropriate, is to relate the changes in habitat use to gradual elevational migrations or range expansions.

Habitat Use During Fawning Season

One aspect of ungulate summer habitat use that has received considerable attention is birth site selection. Ungulate mortality rates are usually highest during the first few weeks after birth (Cook et al. 1971; Jackson et al. 1972; Smith and LeCount 1979; Steigers and Flinders 1980; Ozoga and Verme 1986). Neonate mortality from predation is sometimes a major limiting factor. Hatter (1988) estimated fawn mortality, within a northern Vancouver Island black-tailed deer herd, to be 63%, and concluded that wolf (*Canis lupus*) predation was the primary factor limiting deer recruitment.

Often, specific habitat types that confer anti-predator advantages to the neonate and the mother are used during calving or fawning seasons. Steep, broken and rocky sites are often selected as natal sites by bighorn sheep (*Ovis canadensis*) (Festa-Bianchet 1988). Rocky Mountain elk neonates used sites with dense brush cover (Johnson 1951; Altmann 1952). In Utah, mule deer avoided giving birth in sites with dry exposures and poor cover

(Robinette et al. 1977). Moose, caribou (*Rangifer tarandus*), and mule deer have been found using small islands as birthing sites apparently to reduce the risk of predation (Steigers and Flinders 1980; Edwards 1983; Bergerud and Page 1987).

Other authors have associated increased intraspecific avoidance and antagonistic behaviours with calving and fawning seasons. Prior to calving, parturient mountain caribou (*R. t. caribou*) dispersed to high elevation sites to evade predation (Cichowski 1989). Bergerud et al. (1984) suggest that by spacing themselves out, caribou increase the predator searching time for calves and make it difficult for predators to subsist on a diet of caribou calves. Similarly, mule deer seek isolation from conspecifics before giving birth (Robinette et al. 1977; Riley and Dood 1984) and pregnant black-tailed deer are known to be highly antagonistic during the fawning period (Dasmann and Taber 1956; Miller 1974).

Despite the knowledge that has been gained on the topic in general, the nature of fawning habitat requirements and birth site selection in black-tailed deer is poorly understood. The objectives of Chapter Three are:

- 1) to compare the use of seral stages during the fawning period versus the rest of the summer, and
- 2) to compare home range size during the fawning period with home range sizes in other summer time periods. Minimum convex polygon technique (Mohr 1947) is used as an index of peripheral movements.

Study Area

This study took place in the upper Caycuse Watershed, above and including Wilson Creek (Figure 1.1). This southwestern Vancouver Island

system flows westward into the head of Nitnat Lake, which in turn empties into the Pacific Ocean midway between the town sites of Bamfield and Port Renfrew. With its center at approximately 48° 48' N latitude and 124° 29' W longitude, the study area falls within the Windward Island Mountains Ecoregion of the Western Vancouver Island Ecoregion (British Columbia Ministry of Environment 1988).

Elevations range from 100 to 1160 m. Relative to many central and northern Vancouver Island watersheds, the Caycuse topography is gentle and rolling. Most 'height of land' ridge tops fall between 700 and 1000 m.

The predominant biogeoclimatic zone is Coastal Western Hemlock (CWH) (British Columbia Ministry of Environment 1988). The subzones Very Wet Maritime (Submontane and Montane variants), Moist Maritime (Submontane and Montane variants), and Very Dry Maritime (Western variant) occurred. The latter however, was sparsely distributed (Lewis 1988). The Submontane variants occurred from the valley bottom to approximately 600 m. The Montane variants occurred between approximately 600 and 1000 m (Klinka et al. 1984). The location of the Montane/Submontane transition was a function of elevation and aspect. Montane habitats occurred at slightly lower elevations when on east and north facing slopes. On the highest mountain tops, at approximately 1000 m and above, the Mountain Hemlock zone occurred. This zone was well forested and did not approach subalpine conditions.

A cool mesothermic climate, characterized by cool summers and mild winters, prevails over the study area. The mean daily maximum and minimum temperatures for July are 21.5 °C and 10.1 °C, respectively. For January, the mean daily maximum and minimum temperatures are 6.7 °C and 0.7 °C, respectively. Moist frontal systems from the Pacific bring an

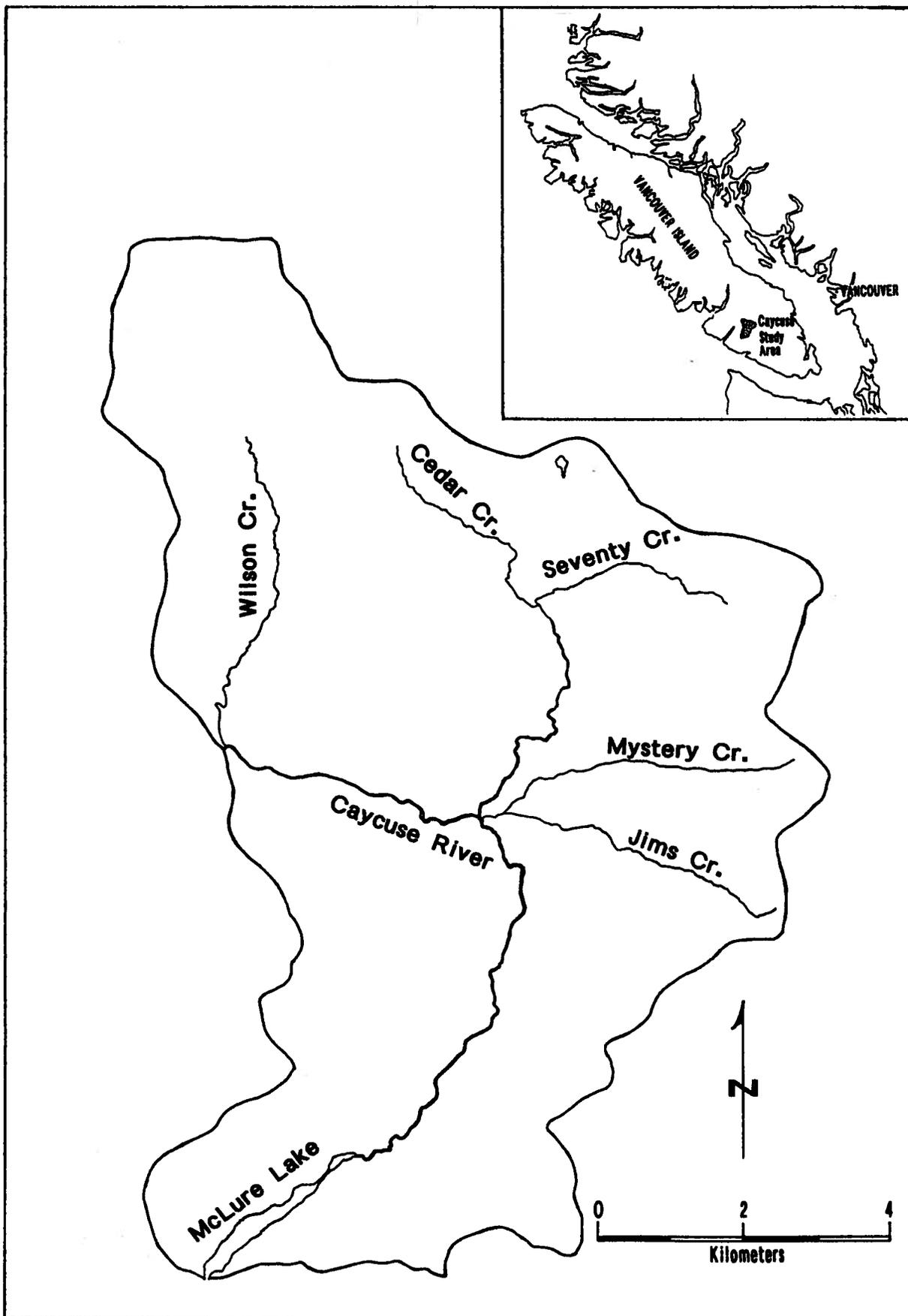


Figure 1.1 Location and major subdrainages of the Caycuse Study Area

average 3649 mm of precipitation annually (Jamie McDuff pers. comm. based on data collected by Environment Canada at the Nitnat Fish Hatchery Weather Station: 1981-1991). Snowfall and snow pack persistence is highly variable between years and between sites. During the winter of 1989-90 snow did not accumulate at a 700 m, south aspect snow station until January. A snow pack in excess of 40 cm then persisted from late January to late March. In the winter of 1990-91 snow falls in excess of 40 cm began in November however, they ceased in late January. In this winter the snow pack was highly erratic and periods of low (<10 cm) snow accumulations occurred throughout. In mild winters persistent snow accumulations may be negligible on sites as high as 900 m (pers. obs.). In other winters the same sites could have snow accumulations in excess of two m (pers. obs.). In any winter, snow accumulations within the study area are variable and influenced by elevation, aspect and proximity to Nitnat Lake. Low-elevation sites, close to Nitnat Lake usually remain snow free while high elevation, headwater sites often experience accumulations in excess of two m.

Timber extraction within the study area began in the early 1940s (Wayne Wall pers. comm.) and continues to this day. Most subdrainages have been progressively clearcut; thus, valley bottoms are dominated by second-growth stands. Most recent clearcuts are found on mid to high-elevation sites. Logged areas were slashburned. Because the study area was logged from its headwaters first, the pattern of logging along the Caycuse mainstem is different. Many of the recent clearcuts occur along the mainstem while second-growth stands dominate the sidehills. In 1990, the proportion, by area, of clearcuts, second-growth and old-growth stands within the study area were 40%, 36% and 24%, respectively (Morgan, et al. 1990).

General Methods and Materials

Deer capture operations were conducted between mid-November and mid-April during the winters of 1988-89, 1989-90 and 1990-91. When the ground was snow covered, Clover traps (Clover 1956) were set in, or adjacent to, winter ranges. Most trap sites were established in areas that were previously identified as winter ranges (typically old-growth stands located on south facing slopes between 300 and 900 meters in elevation [Nyberg et al. 1986]). Others were established on an opportunistic basis according to the presence of deer sign. In the absence of snow, free ranging deer were immobilized with succinylcholine (Anectine®). Four to 12 mg dosages were loaded into Pneu darts (Pneu Dart Inc., Williamsport, Pa.) and shot from a Palmer Cap-chure gun (Palmer Chemical Co.). Most darting activities took place at night in clearcuts. Spot lights allowed the deer to be observed and darted from vehicles.

Captured deer were fitted with a Loteck (Loteck, Aurora, Ont.) radio collar and a numbered plastic ear-tag. Adult males, which experience neck swelling in the rut, were not collared because it was feared they might be choked. Young males (8 to 10 months) were fitted with rot-away collars designed to break off before the animal became 2 1/2 years old.

A Telonics (Telonics Inc., Mesa, Ariz.) receiver and a Lotech, hand held, Adcock type antenna was used to track the collared deer. Approximate locations were based on the strength and quality of the signal and the amount of 'swing' experienced between trial positions. The precise (recorded) locations were then obtained using one of two techniques.

The most common approach involved triangulation of three or four compass bearings taken from different stations. Telemetry stations were

established every 100 meters along roadways within home ranges and were identified on a 1:20,000 planimetric map. To ensure that the bearings produced a 'fix', the angles were drawn on 1:20,000 scale field-maps. Time, date, and weather conditions were recorded for each location.

The 'Trimble' program (White and Garrot 1991) was used to estimate the position of the radio collared deer. This program calculates the Universal Transverse Mercator (UTM) coordinates for the 'maximum likelihood estimator' which is hereafter referred to as the location. In addition, a 95% error ellipse was generated for each location.

Because most collared deer could be approached by road to within a few hundred meters or less, error ellipse size was generally low. Of the triangulated locations, 75% of the error ellipses were less than 1 ha. Twelve percent were between 1 and 2 ha and 6% were between 2 and 3 ha. Only 7% of the error ellipses were greater than 3 ha.

All locations were accepted regardless of their error ellipse size. I agree with Hellgren et al. (1991) who argued that the detection of habitat preference is conservative in the presence of lowered telemetry precision. Using the same rationale, the detection of differences in home range size is also conservative in the presence of lowered precision.

By comparison, the other technique for estimating locations was simple. When in clearcuts, the study animals were often observed with the aid of spotlights and/or binoculars. These locations were recorded directly onto 1:20,000 field maps. Visual locations constituted 30% of all locations.

In the summers of 1990 and 1991 when the majority of the data were gathered, each collared deer was usually located three times per week. Locations were gathered according to a schedule that rotated through the following daily time periods: 0000-0600, 0600-1200, 1200-1800 and 1800-2400

hours. As a result, a 32-hour (24 hrs + 8 hrs) time span usually separated consecutive location observations for each deer. To reduce the autocorrelation of consecutive location observations, the minimum acceptable time interval between locations for an individual deer was 24 hours (White and Garrott 1991).

Home range estimates for individual deer were based on the minimum convex polygon (MCP) technique (Mohr 1947). The MCP technique's sensitivity to outliers made it a useful means of indexing peripheral movements during the fawning season. Home range centers are arithmetic and produced by averaging the location coordinates (UTM).

A geographic information system (Terasoft Ltd., Nanaimo, B.C.) program stored and manipulated several layers of data that were digitized from a variety of sources. A forest cover type layer, which identified stand characteristics, was digitized from B.C. Forest Service maps (1: 20,000). Another layer contained the Biogeoclimatic Ecosystem Classification information (BEC) (Meidinger and Pojar 1991) to the 'site association level' (Lewis 1988). A topographical map (1: 20,000) was used to identify and digitize general aspect polygons which were classified according to the cardinal direction that most closely approximated the orientation of the hill side; north (315-45 degrees), east (45-135 degrees), south (135-225 degrees), and west (225-315 degrees). A 1:50,000 topographical map with 20 meter contour intervals was used to determine elevations.

Description of Study Animals

This section briefly describes the 13 deer involved in this study. McNay and Doyle (1987) identified three types of migratory behaviours in black-tailed deer: 1) obligate migrators move between seasonal home ranges every year irrespective of snow accumulation, 2) facultative migrators move irregularly and in response to snow accumulation and ablation, and 3) resident deer do not migrate.

Five of the study animals were facultative migrators that occupied distinct summer ranges and did not migrate unless forced by snow accumulations. An additional deer migrated, but because it was not monitored through more than one migrational cycle, its migratory status (obligate or facultative) was not determined. Three were resident deer. Four other deer did not migrate, but because they occupied mid-elevation sites and were monitored during the relatively mild winters of 1989-90 and 1990-91, their migratory status could not be determined. Table 1.1 provides general information on the study animals.

All of the migrators summered in headwater basins and wintered on side hills that were close to the Caycuse Mainstem. Four deer (18181, 17701, 17912 and 15181) wintered on the southwest-facing, old-growth slopes northeast of the Mystery Creek/Cedar Creek/Caycuse River confluence and summered in Seventy Creek. Two others (12801 and 15301) wintered in south facing, second-growth stands north of the Cedar Creek/Caycuse River confluence and summered in Cedar Creek. The winter ranges fell between 300 and 600 m while the summer ranges fell between 500 and 1000 m.

Table 1.1. General information on Caycuse study animals, 1989-1991.

Deer * ID	Capture Date	Mode of Capture	Capture Site ** Cover Type	Migratory Status	Sex
12801	90.03.14	dart	2nd growth	facultative	F
13201	90.01.19	dart	clearcut	resident	F
13891	90.04.10	dart	clearcut	undet.	F
15181	91.01.11	trap	old growth	undet.	F
15301	90.03.16	trap	2nd growth	facultative	M
16781	90.04.17	dart	clearcut	resident	F
16781	90.04.17	dart	clearcut	resident	F
17581	90.03.21	dart	clearcut	undet.	F
17701	89.03.18	trap	old growth	facultative	F
17912	90.02.16	trap	old growth	facultative	F
17991	90.12.30	trap	old growth	undet.	F
18181	89.03.19	trap	old growth	facultative	F
18412	90.04.17	dart	clearcut	undet.	M
19212	90.03.22	dart	clearcut	resident	F
18412	90.04.17	dart	clearcut	undet.	M

* Collared deer were identified by the last four digits of their radio frequencies. A final digit was added to distinguish deer that had used the same collar but at different times.

** Clearcuts were 0-15 yrs, second growth stands were 16-149 yrs, old growth stands were 150 + yrs.

All of the resident deer (16781, 19212 and 13201) occupied home ranges that were immediately adjacent to the Caycuse Mainstem and between 100 and 400 m.

The undetermined deer occupied intermediate ground between 400 and 800 m. Three lived in the Wilson Creek drainage (17991, 18412 and 13891), the other lived near McLure Lake (17581).

Chapter Two: Changes in Habitat Use in Relation to Forage Quality

Introduction

Plant phenology refers to the periodic phenomena (growth stages) in the annual cycle of a plant that are controlled by climatic factors (Daubenmire 1974). The nutritive value of a plant is influenced by its phenology (Klein 1965; Rochelle 1980). Accordingly, the profitabilities (Krebs and McCleery 1984) of forage species vary within the annual cycle of growth.

Black-tailed deer selectively forage on a wide variety of plant species and adjust their preferences to account for changes in the nutritional quality and availability of forage species (Miller 1968; Rochelle 1980; Hanley 1984). Preference, defined as the likelihood that a resource will be chosen if offered on an equal basis with others (Johnson 1980), is dynamic and dependent on the phenology of available forage species. In cool sites, such as those on shady aspects and/or at high elevations, plant phenologies are delayed (Geiger 1961; Klein 1965; Aitken 1974). By foraging on these sites later in the growing season, deer can extend the period of time that they have access to high-value phenological stages.

Vancouver Island's mountainous habitats are very heterogeneous and because each plant species has its own growing site criteria, the abundance of each forage species is often highly variable or 'patchy'. In coastal forest ecosystems, many herbaceous forage species such as pearly everlasting (*Anaphalis margaritacea* L.), fireweed (*Epilobium angustifolium* L.) and hairy cat's-ear (*Hypochaeris radicata* L.) are most abundant in the early successional

stages that follow logging, fire or other disturbances (Rochelle 1980; Haeussler 1990). Other forage species, such as *Vaccinium* spp. exist under forest canopies and in early successional stages (Rochelle 1980; Haeussler 1990).

Given that plant species are distributed unevenly over most habitats and that their nutritive values are dynamic; changes in the habitat use patterns of black-tailed deer, while on their summer ranges, were expected. Use of habitat types at the 'within home range' level of selection was examined.

Seral Stage

Rochelle (1980: v-iv) stated, "fireweed was the most heavily used species during the spring to fall period" and that "it displayed the highest energy content of the species (forage) examined". He also offered that "deer appeared to select plants high in energy and other nutrients in spring and summer; availability appeared to have a stronger influence on selection in fall-winter" (Rochelle 1980: 193). When analyzing rumen contents, Rochelle used Mealy's (1975) percent importance value (IV%) to rank the dietary importance of several forage species.

IV% is defined as:

$$IV = \text{Frequency of Occurrence (percent)} \times \text{Volume (percent)}$$

$$IV\% = (IV \text{ of forage item} / \sum IV \text{ all forage items}) \times 100$$

Figure 2.1, repeated from Rochelle (1980: 64), clearly demonstrates that, during the middle and late summer periods, fireweed was by far the most important forage species in the Nimpkish Valley.

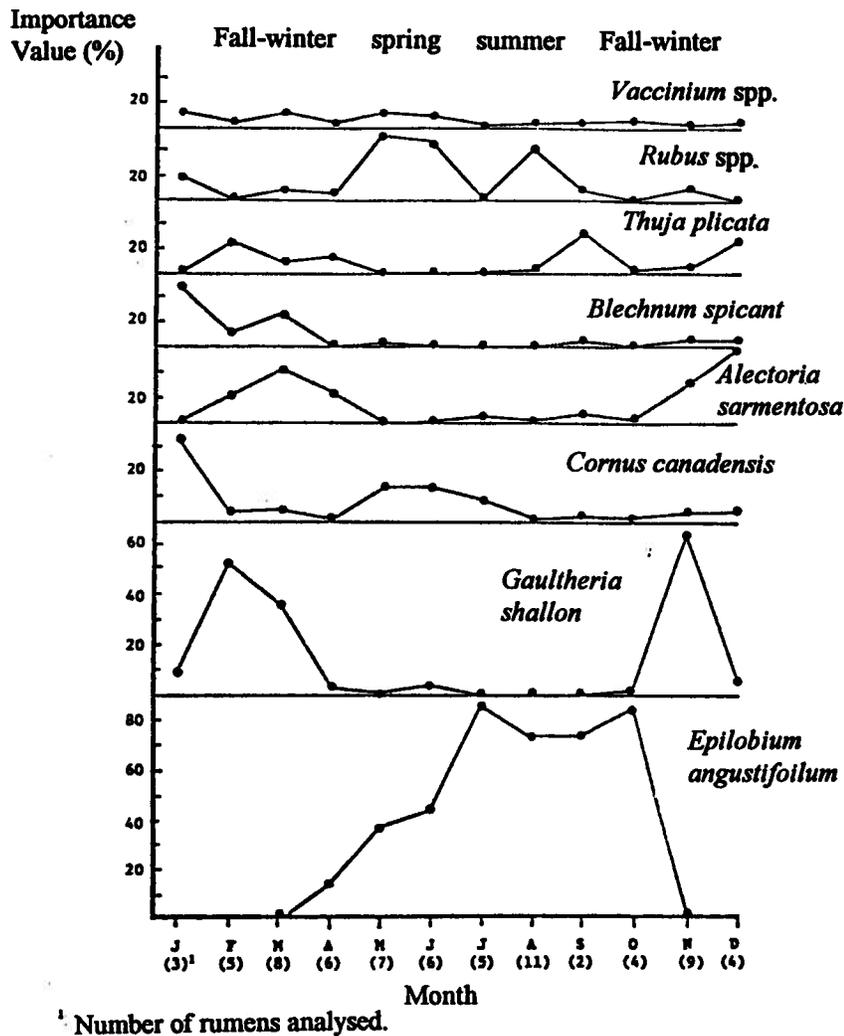


Figure 2.1. Monthly pattern of use by black-tailed deer of forage species in forested and cutover areas. (from Rochelle 1980, p. 64).

In the Caycuse and Nimpkish Valleys the Very Wet Maritime subzone of the CWH zone is predominant at elevations between 300 and 1000 m (British Columbia Ministry of Environment, 1988). In both areas, clearcut logging began in the 1940s and after logging the sites were slashburned (Harestad 1979). Because of these similarities I am assuming that the food habits of the

deer within both valleys are similar.

Haeussler et al. (1990: 90) stated that "In many areas of the province, succession is too rapid for pioneer conditions favorable to fireweed to persist for as long as 20 years" and that "In coastal British Columbia, once a canopy develops, fireweed dies out". Gates (1968) studied post-logging seral succession in a central Vancouver Island drainage and concluded, "herbaceous plants reach their peak cover-densities about three years after burning" and that "thereafter they declined gradually through competition and shading and are of minor importance by the fifteenth year." This is corroborated by Dyrness (1973) who found that invading herbaceous species dominated post-logging burned sites from the second through fourth years only. Gates also noted that in old-growth, forbs covered less than one percent of the surface.

Most Caycuse second-growth stands were devoid of fireweed. It persisted, sparsely and in lower vigor, in only a few of the stands with more open canopies (pers. obs.). In the recent clearcuts, fireweed dominated the plant community. During the July-August flowering season, most young clearcuts exhibited a pinkish hue, owing to the plant's high density.

In the later portions of the summer, when the IV% of fireweed was found to be highest (Rochelle 1980), deer should maximize their foraging efficiency by increasing their use of clearcuts. By minimizing the amount of time spent foraging deer are able remain inactive for greater proportion of time. Inactivity allows deer to be more vigilant for predators and it may reduce their risk of detection by predators. In examining the use of different seral stages through the summer months, I proposed a null and an alternate hypothesis.

- H₀ Percent use of clearcuts in the three periods: 1) April/May/June; 2) July/August and 3) September/October does not differ.
- H₁ Percent use of clearcuts correlates with Rochelle's (1980) IV%. Clearcut use should be lowest in April/May/June, highest in July/August and intermediate in September/October.

Percent use is defined as: (no. locations within a habitat type/total no. locations] × 100.

Delayed Phenology

During the mid and late summer periods, deer should seek out cooler sites where delayed phenology maintains many plants in their more nutritious stages of growth (Geiger 1961; Klein 1965; Aitken 1974, Bunnell 1990). In examining the use of cooler sites in the summer months, I proposed a null and an alternate hypothesis.

- H₀ The percent use of cooler sites does not change as the summer progresses.
- H₂ The percent use of cooler sites increases as the summer progresses.

Three temperature related habitat variables are tested independently. They are; BEC variants, elevation, and aspect.

Methods and Materials

Location data were gathered during the summer months. The time frame for 'the summer' was based on the average phenology of fireweed on the south coast of British Columbia and on the period over which Rochelle (1980) found it to be important to the diet of black-tailed deer. Fireweed begins to develop aerial shoots in late March (Haeussler et al. 1990). By early October most of fireweed's aerial shoots have died back; however, fireweed continued to be an important dietary component until November. Accordingly, 1991 data collection started on April 1st, and terminated on October 30th.

In April 1991, snow accumulations persisted in many of the summer ranges within the study area. Data collection was delayed for some study animals because of the possibility that snow accumulations, rather than forage quality, could be influencing habitat use at this time. Location data were not used if they were collected before the deer's summer range was free of snow. Trace amounts of patchy snow were acceptable but a consistent snow pack of only one centimeter in any portion of the home range was not.

In regions where appreciable snow accumulations persist well into the summer, this approach would not be feasible. The abatement of snow on southern Vancouver Island however, is usually early and rapid. The spring of 1991 was no exception. Table 2.1 summarizes the 1991 data collection periods.

Table 2.1. Data collection periods for collared deer, 1991.

ID	Start Date	Finish Date
16781, 13201, 17581	April 1st	October 31st
17991, 18181, 13891	April 10th	October 31st
15181, 12801, 15301 17912, 17701	April 18th	October 31st

In 1990, data collection started on June 1st and ended October 31st. Those data are presented (though not statistically tested) to substantiate the 1991 findings. Study animals 17991 and 15181 were not in the 1990 data set. Although study animals 19212 and 18412 were not in the 1991 data set, they were in the 1990 data set.

Four habitat variables; elevation, aspect, biogeoclimatic ecosystem classification (BEC) variants (Meidinger and Pojar 1991), and seral stage were developed from sources identified in Chapter One. The latter two require further clarification. The BEC Montane variants of the Moist Maritime and Very Wet Maritime subzones were amalgamated to form the Montane habitat type. The Submontane variants of the above subzones and the western variant of the Very Dry Maritime subzone were amalgamated into the Submontane habitat type.

Logged habitats were grouped into two seral-stage habitat types based on the dates of stand establishment after harvest, as they related to the production of herbaceous forage. Stands were considered established if they were satisfactorily stocked (> 500 stems/ha) with a commercially desirable (coniferous) species. The date of establishment was determined by the age of the tree stock. Clearcut habitats were less than 16 years post-establishment in 1990. Second-growth habitats were at least 16 years post-

establishment in 1990. Old-growth habitats were at least 150 years old and had never been logged. Because both second-growth and old-growth forests contained low quantities of herbaceous forage, they were amalgamated to form the 'forested' habitat type.

Most habitat use studies compare the use of particular habitat types with their availability, to develop preference ratings (Neu et al. 1974, Johnson 1980, Alldredge and Ratti 1986). Because the intent of this study is to document changes in the use of various habitat types through time, these calculations are not necessary. Instead the summer was divided into time periods which were, with one exception, two months long. Percent use ($[\text{no. locations within a habitat type} / \text{total no. locations}] \times 100$) of habitat types or classes for each period are then compared.

Time periods developed to test for shifts in clearcut use were April/May/June, July/August, and September/October. These periods were based on changes in Rochelle's (1980) percent importance value (IV%) and nutritive values of fireweed. Fireweed's IV% were relatively low during April, May and June (see Figure 2.1). The percent importance value rose sharply to a peak in July and remained high through to October. Because the nutritive values (digestible dry matter and caloric content) of fireweed rapidly declined after August (Rochelle 1980), the data were separated further into July/August and September/October time periods.

Time periods developed to test for increased use of cooler sites were April/May (spring), June/July (summer) and August/September (early fall). October's data were not included in this test because: 1) they were not required to test the hypotheses, 2) the possibility of a downward elevation shift in October in response to cooler weather existed and 3) by late August, any upward elevational migrations should have ceased.

Mohr's (1947) minimum convex polygon technique (MCP) was used to estimate the home range boundaries of the study animals. The 95% MCP home range, defined as the smallest convex polygon containing 95% of the sample locations (Akerman, Leban, Samuel and Garton 1989), was used.

The G-test (Sokal and Rohlf 1981) was used to test for differences in the use of the habitat types between established time periods. A one-tailed paired difference test (Sokal and Rohlf 1981) was used to test for changes in the elevation of home range centers and the average location distance from the home range center during different time periods. A type one error probability (p-values) less than 0.05 was considered to be 'strong evidence against the null hypothesis' (H_0). A probability between 0.05 and 0.10 was considered to be 'moderate evidence against the null hypothesis'. A probability greater than 0.10 was considered to be 'no evidence against the null hypothesis'.

Results

In the summer of 1991, 812 deer locations were recorded. Eleven deer were monitored during this period; however, one (15301) was killed by wolves in mid-July. Table 2.2 presents the number of locations per collared deer per month.

In the summer of 1990, 11 deer were monitored and 542 locations were recorded.

Table 2.2. Number of locations per deer per month, 1991.

Deer	April	May	June	July	Aug.	Sept.	Oct.	Total
13201	11	14	13	11	14	9	12	84
16781	10	14	12	10	14	9	12	81
17581	8	14	12	10	14	9	12	79
13891	8	14	10	10	13	10	12	77
17991	9	13	12	11	14	10	12	81
18181	8	14	13	11	14	10	12	82
17701	4	14	12	11	14	11	12	78
17912	4	14	13	11	14	10	12	78
15301	3	12	8	7	na	na	na	30
12801	4	14	9	11	14	10	12	74
15181	3	14	6	11	13	10	11	68
TOTAL	72	151	120	114	138	98	119	812
MEAN	6.5	13.7	10.9	10.4	13.8	9.8	11.9	78.2

Seral Stage

In 1991 the percent use of clearcut habitats was highest in the July/August period (Table 2.3). Pooled location data, for the nine deer which had clearcuts in their home range (708 locations), reveal that the percent use of clearcuts was 67.9% in April/May/June, 78.2% in July/August and 69.2% in September/October (Table 2.3, Fig 2.2). The G-test ($G=7.37$, $p=0.025$) provided strong evidence against the null hypothesis which predicted that the percent use of clearcuts would not change as the summer progressed.

Over the entire summer, less than 3% of the locations were within old-growth.

Table 2.3. Number of locations within clearcut and forested habitats and percent of locations within clearcut habitats, 1991.

deer id.	April/May/June		July/August		Sept./Oct.		April-October	
	cc:for*	cc %**	cc:for	cc %	cc:for	cc %	cc:for	cc %
13201	38:0	100.00	25:0	100.00	15:6	71.43	78:6	92.85
13891	17:15	53.13	21:2	91.30	12:10	54.55	50:27	64.93
15181	0:23	0.00	0:24	0.00	2:19	9.52	1:67	1.47
16781	33:3	91.67	21:3	87.50	17:4	80.95	71:10	87.65
17581	22:12	64.71	23:1	95.83	21:0	100.00	66:13	83.54
17701	28:2	93.33	25:0	100.00	22:1	95.65	75:3	96.15
17912	31:0	100.00	22:3	88.00	20:2	90.91	73:5	93.58
17991	20:14	58.82	21:4	84.00	15:7	68.18	56:25	69.13
18181	10:25	28.57	14:11	56.00	11:11	50.00	35:47	42.68
pooled	199:94	67.9	172:48	78.2	135:60	69.2	506:202	71.5

*=number of locations within clearcut and forested habitats

**=percent of locations within clearcut habitats

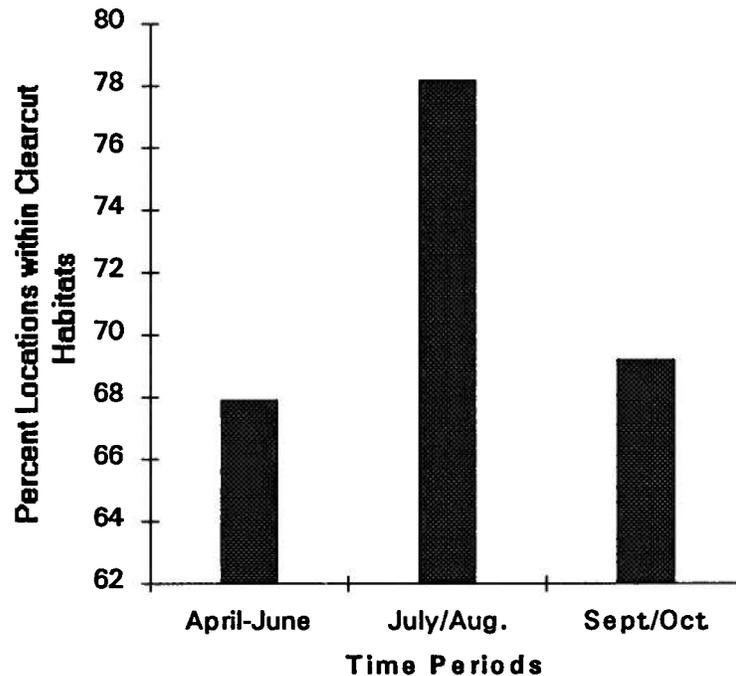


Figure 2.2. Percent of pooled locations within clearcuts, 1991.

These data compare favorably with the 1990 data (464 locations) where the percent use of clearcuts for the July/August and September/October time periods was 78.2% and 73.7% respectively.

Delayed Phenology

For the eight deer which had Montane habitat within their home range (487 locations) percent use (pooled data) of Montane habitat was 14.5% in April/May, 22.6% in June/July and 25.8% in August/September (Table 2.4, Fig. 2.3). The G-test ($G=6.67$, $p=0.036$) provided strong evidence against the null hypothesis which predicted that the percent use of Montane habitat would not change as the summer progressed.

Table 2.4. Number of locations within Montane and Submontane habitats and percent of locations within Montane habitats, 1991.

deer id.	April/May (spring)		June/July (summer)		August/Sept. (early fall)		April-September	
	Mon:Sub *	Mon. % **	Mon:Sub	Mon. %	Mon:Sub	Mon. %	Mon:Sub	Mon. %
12801	0:18	0.00	0:20	0.00	3:21	12.50	3:59	4.84
15181	6:11	35.29	11:6	64.71	14:9	60.87	31:26	54.39
15301	0:15	0.00	5:10	33.33	na	na	5:25	16.67
17581	1:21	4.55	0:22	0.00	3:20	13.04	4:63	5.97
17701	0:18	0.00	4:19	17.39	6:19	24.00	10:56	15.15
17912	4:14	22.22	10:14	41.67	7:17	29.17	21:45	31.82
17991	0:22	0.00	0:23	0.00	1:23	4.17	1:68	1.45
18181	11:11	50.00	8:16	33.33	9:15	37.50	28:42	40.00
pooled	22:130	14.5	38:130	22.6	43:124	25.8	103:384	21.2

*=number of locations within Montane and Submontane habitats

**=percent of locations within Montane habitats

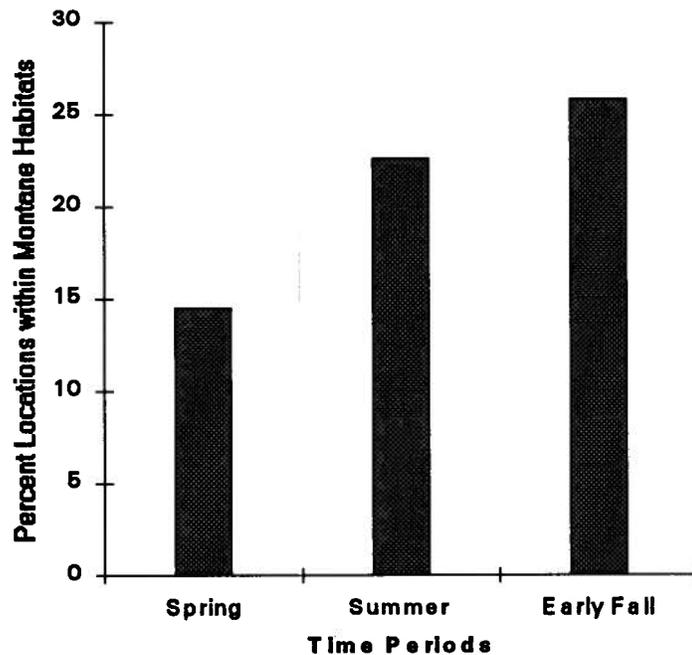


Figure 2.3. Percent of pooled locations within Montane habitats, 1991.

These results compare favorably with the 1990 data set which had percent use of Montane habitat values of 19.8% to 24.3% for June/July and August/September, respectively.

The percent use of north and east (cooler) aspects was not higher in the latter portion of the summer. Instead the 1991 pooled data set for all of the 1991 study animals (693 locations) revealed that the percent use of these aspects combined was 26.5% for April/May, 26.1% for June/July and 24.2% for September/August. When only location data from the eight deer which had Montane habitats within their summer range (487 locations) were used, the percent use of north and east aspects was not higher in the latter portion of the summer. The percent use of north and east aspects combined was 36.2% for April/May, 35.7% for June/July and 32.3% for September/August.

The distribution of Montane variants over the landscape is a function of

elevation and aspect. The higher use of Montane habitats in the latter portions of the summer without a similar trend in the use of east and north aspects suggested that the study animals were using higher elevations as the summer progressed. The elevations of the home range centers of the deer which had Montane habitats within their home ranges were averaged and compared. For the April/May, June/July and August/September time periods the mean elevations were 660.0 m (SE=33, n=7), 666 m (SE=51, n=7) and 674 meters (SE=43, n=7) respectively (1530 excluded). The mean elevation gain per deer between the home range centers of April/May and August/September was 14 m (SE=11, n=7). Although the mean elevation change was positive, a paired difference test provided no evidence against the null hypothesis ($t=0.22$, $p=0.83$) which predicted no change in elevation.

An alternate hypothesis could be formulated to account for the increased use of Montane habitats. If the majority of its home range was located below Montane variants, a deer could increase its use of Montane habitats, without shifting its home range center (and therefore its average elevation) by expanding its home range equally along the axis perpendicular to the Montane/Submontane ecotone. Such an expansion did not occur. The average distance between the locations and their respective home range centers for the spring and early fall periods were 214 m, and 205 m respectively.

Potential Confounding Variables

The pattern of logging in many Vancouver Island watersheds makes it difficult to distinguish between increases in the use of Montane habitats and increases in the use of clearcut habitats. Montane variants, were often the last to be logged and as a result they usually contain a high proportion of recently clearcut habitats. Conversely, Submontane variants usually contain

a high proportion of second-growth habitats. Before any generalizations on changes in the use of seral stage and or BEC variants can be made, the potential for these variables to be confounding must be assessed.

Animals 12801 and 15301 were not included in seral stage analysis because their summer ranges consisted entirely of one seral stage (second-growth). Similarly, animals 13201, 13891, and 16781 were not included in the BEC variant statistical analysis because their home ranges consisted entirely of Submontane variants. The 6 study animals used in both analyses were animals 15181, 17581, 17701, 17912, 17991 and 18181. The Montane portions of the home ranges belonging to animals 15181, 17581 and 17991 consisted entirely of second growth habitats; therefore, increases in the percent use of Montane and clearcut habitats could not have been correlated. Similarly, the Submontane portions of the home range occupied by animal 17912 consisted entirely of clearcuts. Again, increases in the percent use of Montane and clearcut habitats could not have been correlated. A breakdown of seral stage habitat types within the Montane and Submontane portions of the 95% MCP home ranges of the remaining two study animals is presented on Table 2.5.

The percentage of clearcut habitats within the home range of animal 18181, was lower in the Montane variants than in the Submontane variants (Table 2.5). Thus, there was not a potential for increases in the percent use of Montane and clearcut habitats to be correlated. Within the home range of animal 17701 the percentage of clearcut habitats was higher in the Montane variants than in the Submontane variants.

Table 2.5. Percent clearcut habitat within the Montane and Submontane variants within the 95% MCP home ranges of study animals 17701 and 18181.

Deer Id.	Percent Clearcut Habitat within Montane	Percent Clearcut Habitat within Submontane
17701	100.0	90.9
18181	11.8	38.2

The location data were separated by month and inspected for coincidental increases in the use of Montane and clearcut habitats. These data are summarized in Table 2.6.

Table 2.6. Percent use of Montane and clearcut habitats for study animal 17701.

Month	April	May	June	July	Aug.	Sept.	Oct.
% Clearcut	100.0	85.7	100.0	100.0	100.0	100.0	91.7
% Montane	0.0	0.0	25.0	9.1	21.4	27.3	0.0

As Table 2.6 demonstrates, animal 17701 used clearcuts regardless of whether they occurred in Montane or Submontane variants.

Discussion

Seral Stage

An increase in use of clearcuts by deer during July and August is often noted by biologists who conduct census work on Vancouver Island within that period. The deer hunting season, which on Vancouver Island starts in early September, may force deer into areas of greater visual screening and out of clearcuts. This however, would not explain the relatively low use of clearcuts during the early summer.

The observed trend in clearcut use, for the Caycuse Study Area in 1991, was similar to the trend documented by Rochelle (1980) for fireweed use (IV%) in the Nimpkish Valley. Clearcut use and IV% were lowest during April/May/June, highest during July/August and of intermediate values in September/October.

Old-growth and second-growth habitats within the summer ranges of the nine study animals, supported very little herbaceous forage. In the adjacent clearcut areas however, large quantities of fireweed and other pioneering herbs grew vigorously. It is not surprising therefore, that the increased fireweed use (IV%) coincides with an increase in the use of clearcut habitats.

It is difficult to determine whether the increased IV% of fireweed and the increased use of clearcuts are a function of forage availability or forage quality. Rochelle (1980) noted that when availability is high for a variety of forage species, deer appear to be selecting the forage with the highest nutritive value. Klein (1965) suggested that unless forage quality in the summer months is maintained, deer cannot consume enough to meet their optimum growth requirements.

Hanley (1984) found that in the western Cascades of Washington State, the availability (measured as biomass) for all forage species peaked in July. The biomass of fireweed increases until after its flowering stage in August however, only the most digestible, top portion of the plant is consumed (Moen 1981, pers. obs.). I believe that, between emergence and die-back, the availability of fireweed tops at any given site is constant. Fireweed availability, therefore, does explain the percent use of clearcuts or the IV% for fireweed which were highest in July and August.

The nutritive quality (dry matter digestibility and caloric value) of fireweed is at its peak in August. The percent dry matter digestibility (DDM) of fireweed increased steadily from 60% in May to 80% in August then back down slightly to 78% in October (Rochelle 1980). Similarly, the caloric value of fireweed rises sharply from 3 kcal/0.8g in May to 6 kcal/0.8g in August then back to less than 3 kcal/0.8g in October (Rochelle 1980).

A variety of non-herbaceous forage species do persist beneath forest canopies. Rochelle (1980) found that, within forested habitats, *Vaccinium alaskense* and *Vaccinium parvifolium* followed trends similar to that of fireweed. However, peak DDM values, of approximately 60%, occurred much earlier in May. Caloric values rose sharply to a plateau of approximately 5 kcal/0.8g which lasted from April to July. Given their similar phenologies (Haeussler et al. 1990), it is probable that other important shrub forage species, such as the *Rubus* spp. followed similar nutritive cycles.

In the early summer therefore, the nutritive values (DDM and Kcal/g) of several alternate forage species, found within forested habitats, are comparable to that of fireweed. As summer progresses however, fireweed exceeds the alternate forage species in nutritive value and it dominates the diet (IV%). The trends in the percent use of clearcut habitats and the IV% of

fireweed are similar.

Clearcut habitats possess fireweed in its highest density and vigor (Haeussler et al. 1990). By selecting clearcuts as foraging sites in July and August, deer maximize their foraging efficiency. In doing so, they are able to maintain quality in their diet and remain inactive for a greater proportion of the day. Inactivity allows deer to be more vigilant and it decreases the probability of detection by predators.

Delayed Phenology

During the spring months, forage phenology within the cooler Montane habitat is delayed (Gelger 1961, Altken 1974). At this time the forage within the warmer Submontane habitat is more phenologically advanced and more nutritious. Not surprisingly, the percent use of Submontane habitat is highest in the April/May period. As summer progresses the more profitable phenological stages become available in the Montane variants and the percent use of this habitat increases.

Mackie (1970) found that mule deer used drier habitat types less once the forage plants became desiccated. Movements away from sites with overmature forage and into sites with new growth enable deer to maintain quality in their diet (Klein, 1965). In Caycuse however, the percent use of Montane habitat increased between spring and early summer, well before desiccation would have occurred within Submontane habitats. Black-tailed deer summer forage species attain their maximum nutritive values in June, July and August (Rochelle 1980). The increased use of Montane habitats therefore, was not in response to lower forage quality within Submontane habitats. Instead, deer use of Montane habitat was minimal when the abundance of highly nutritious forage within it was low.

The distribution of Montane variants over the landscape is primarily a function of elevation and aspect. It is surprising therefore, that gains in elevation and/or the use of east and north aspects were not detected coincidentally with the increase in the percent use of Montane habitat. Failure to detect changes in elevation may have been a function of sample size and/or the size of the elevational movements. The 1991 summer ranges (MCP) of 10 female study animals averaged only 55 ha (Table 3.1). Thus, movements into Montane habitats usually required only small elevational gains.

Chapter Three: Changes in Habitat Use by Female Black-Tailed Deer During the Fawning Season

Introduction

Herding cervids such as caribou and elk often move to specific, well-defined calving habitats (Altmann 1952; de Vos 1960). The natal habitats of the more solitary members of the deer family such as moose, white-tailed deer (*Odocoileus virginianus*) and black-tailed deer are more difficult to characterize (Miller 1974; Stringham 1974). Parturient deer should seek habitats that confer anti-predator advantages during this period of vulnerability. Livezey (1991) and Mackie (1970) found that black-tailed deer and mule deer respectively, used the same areas during fawning each year. They did not, however, identify favored habitat attributes in such areas.

To prevent predators from detecting their newborn fawns, black-tailed deer employ the 'hider strategy'. When very young, 'hidiers' have little scent, are cryptically colored, and crouch when threatened (Lent 1974; Geist 1981). During their first weeks of life hidiers do not follow their mothers. Instead they remain hidden, often for many hours, while their dams forage or bed in other areas. Red deer dams infrequently visit their offspring to nurse them and to stimulate them to defecate by licking their anal region (Clutton-Brock et al. 1982). Feces and urine are ingested by the dam to remove evidence that would betray the presence of the fawns. Geist (1981) noted that the hider strategy often includes ingesting the placenta and birth fluid soaked substrate, early removal of young from birth sites, conspecific segregation during fawning and movements where possible, into escape terrain.

Neonate hidiers have been found to use habitats with dense ground cover (Johnson 1951, Altmann 1952, Huegel et al. 1986). Although forests

provide screening cover, they often lack the dense ground cover found in more open sites. Johnson (1951) found that new-born Rocky Mountain elk calves were likely to be found in sagebrush (*Atemisia* spp.) habitats and that their use of forested habitats decreased as the distance from the forest edge increased. Calving sites were associated with the dense ground cover found in earlier successional stages, not beneath coniferous canopies. Huegel et al. (1986) found shrub and sapling densities to be higher at or around white-tailed deer fawn bedsites and Robinette et al. (1977) found that areas with denser cover were used by mule deer for fawning. On Vancouver Island Gates (1968) found that "shrubs and young deciduous trees dominate the low stratum of vegetation from the third year through to at least the fifteenth year". If black-tailed deer prefer to fawn in areas with dense ground cover, then their use of clearcut habitats in the fawning season should increase.

In 1991, all clearcut habitat polygons used by collared deer, except one, were between three and 16 years of age and supported dense ground cover (herbaceous, shrub and seedling percent cover ≤ 2 m from the ground). The adjacent second- and old-growth stands supported sparser ground cover (pers. obs.). In examining the use of clearcut habitats during the fawning period versus other summer periods, I proposed a null and an alternate hypothesis.

- H₀ The percent use of clearcuts by maternal black-tailed deer is not different during the fawning season than in the remainder of the summer.
- H₁ The percent use of clearcuts by maternal black-tailed deer is higher during the fawning season than in the remainder of the summer.

During the fawning period, adult females appeared to move outside their typical area of use with greater frequency. Often only a short time was spent outside the typical area of use before the doe returned. These observations led me to postulate that black-tailed deer give birth outside of their core areas of use to avoid contaminating their preferred sites with scents associated with parturition. After a few days, they lead their fawns back into their core area and away from scents that might attract predators. If these postulates are true, then we should expect to measure an increase in home range size during the fawning period. In examining this relationship, I proposed a null and an alternate hypothesis.

H₀ Home range size of maternal black-tailed deer is not different during the fawning period than in other summer periods.

H₂ Home range size of maternal black-tailed deer is larger during the fawning period than in other summer periods.

I also suspected that maternal females would reduce their area of use in the period immediately after fawning because of their tendency to remain near their sedentary fawns. I again proposed a null and an alternate hypothesis.

H₀ Home range size of maternal black-tailed deer is not different during the period immediately after fawning than in other summer periods.

H3 Home range size of maternal black-tailed deer is smaller during the period immediately after fawning than in other summer periods.

Methods and Materials

The summer of 1991 was divided into the following 29-day periods: the pre-natal period (PrNP), May 8 to June 5; the fawning period (FP), June 6 to July 4; and three post-natal periods, (PoNP1) July 5 to August 2, (PoNP2) August 3 to September 1, and (PoNP3) September 2 to September 30. Because the average number of locations per deer was lower in the PoNP3 than in the FP, an adjusted PoNP3 was also analyzed. To produce the 'PoNP3-adjusted' data set, locations from early October were added in the order of their chronology to the PoNP3 data set. The locations were added (or subtracted) until the number of locations for each deer was the same in the PoNP3-adjusted as in the FP. In the case of 15181 and 12801, locations were removed. The number of locations per period and per deer are summarized on Table 3.1.

During the summers of 1988, 1989, 1990 and 1991, an affiliated research project captured a total of 246 neonate fawns in the Caycuse Study Area and in the South Fork of the Nanaimo River. The Nanaimo River Study Area is 30 km north of the Caycuse Study Area. The earliest and latest fawn capture dates within any summer were June 6th and July 4th, respectively. These dates were used to define the 29 day range of the fawning period (FP). Like white-tailed deer fawns (Heugel et al. 1985), black-tailed deer fawns, up to approximately 10 days old, could be captured by a person on foot. The FP therefore, extends further into the summer than it would have if it had been based on the time of parturition. The median for

parturition. The median for the FP fell between the 19th and 20th of June. Thomas (1970) estimated the mean date of birth for a central Vancouver Island watershed to be 4.5 days earlier, June 14th.

The fawning period for this study was designed to produce information on natal sites and habitat selection. Because black-tailed deer neonates are not immediately mobile (Miller 1965) and because I could not be sure of locating the study animals at the exact time when they gave birth, the lag in the Caycuse FP was appropriate for this analysis.

As in Chapter Two, forest age determined stand class. Forested habitats were old-growth or at least 16 years post stocking in 1990. Sites logged and restocked more recently were classified as clearcuts.

The G-test (Sokal and Rohlf 1981) was used to test for interactions between the percent use of the stand class variable and the established time periods.

The second section of this chapter examines home range size during the time periods. The minimum convex polygon technique (Mohr, 1947) was used to estimate home range size for each study animal in all time periods. A one-tailed paired difference test (Sokal and Rohlf 1981) was used to compare the home range sizes of different time periods. Type one error probabilities (p-values) less than 0.05 were considered to be 'strong evidence against the null hypothesis' (H_0). Probabilities between 0.05 and 0.10 were considered to be 'moderate evidence against the null hypothesis'. Probabilities greater than 0.10 were considered to be 'no evidence against the null hypothesis'.

Anecdotal information depicting the fawning movements of some study animals is also provided. The data for this section were collected in the summers of 1989, 1990 and 1991. Many of the locations used for the

'Fawning Site Selection' section were not separated in time by a 24 hour minimum. Many of the locations were separated by only a few hours while others were separated by a few days. In this section, the post-natal home range was not subdivided into three post-natal home ranges. The 95% home ranges (Hartigan 1987) were calculated by program Home Range (Ackerman et al. 1989). Pre- and post-natal home ranges were separated in time by the 'fawning movements'. Fawning movements were those that occurred between June 6th to July 4th and that were known, or were suspected, to be movements to, or from, the natal site.

Results

During the summer of 1991, ten adult (>1.5 years old) females were monitored through five time periods producing a total of 563 locations.

All of the study animals except 12801 and 17581 were observed interacting with fawns that appeared to be theirs. Animals 12801 and 17581 may have fawned, but because they occupied home ranges with heavy visual screening, their reproductive status was not determined.

Habitat Use

Percent use of clearcuts did not increase during the FP. Pooled location data (563 locations) revealed that 67.9% and 65.6% of locations were within clearcuts during the FP and during the remainder of the summer (PrNP, PoNP1, PoNP2 and PoNP3 combined) respectively. The G-test provided no evidence against the null hypothesis ($G=0.20$, $p=0.66$).

Fawning Site Selection

Exact fawning sites were determined in only two instances. In June of 1989 and 1990 study animal 18181 was located once every three hours for a three-day monitoring period. Her natal sites were found in both years. They

were within 70 m of one another and both were beyond the animal's typical area of use. The 1989 and 1990 natal sites were 250 m and 600 m respectively outside of the 95% pre-natal home ranges (Figs. 3.1 and 3.2). Similarly, the 1989 and 1990 natal sites were 28 m inside and 35 m respectively outside their 95% post-natal home ranges. The 'fawning movements' shown on Figs. 3.1 and 3.2 were from all locations taken during the three-day monitoring periods.

In 1991, 13201 made several movements beyond the northwestern periphery of her 95% home range (Fig. 3.3). Although the natal site was never detected, the fawn was first observed on the northern periphery of the 95% post-natal home range. The 'fawning movements' shown on Fig. 3.3 were developed from all locations collected within the FP.

In other instances, large erratic movements were made during the FP. In 1991, animals 17991 and 12801 were found 1.6 and 3.5 km respectively outside of their 95% pre- and post-natal summer ranges (Figures 3.4 and 3.5). Since both movements were single events involving only one peripheral location each, the fawning movements are the departures from, and returns to, the 95 % home ranges.

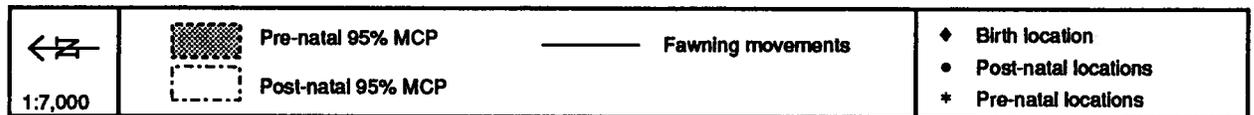
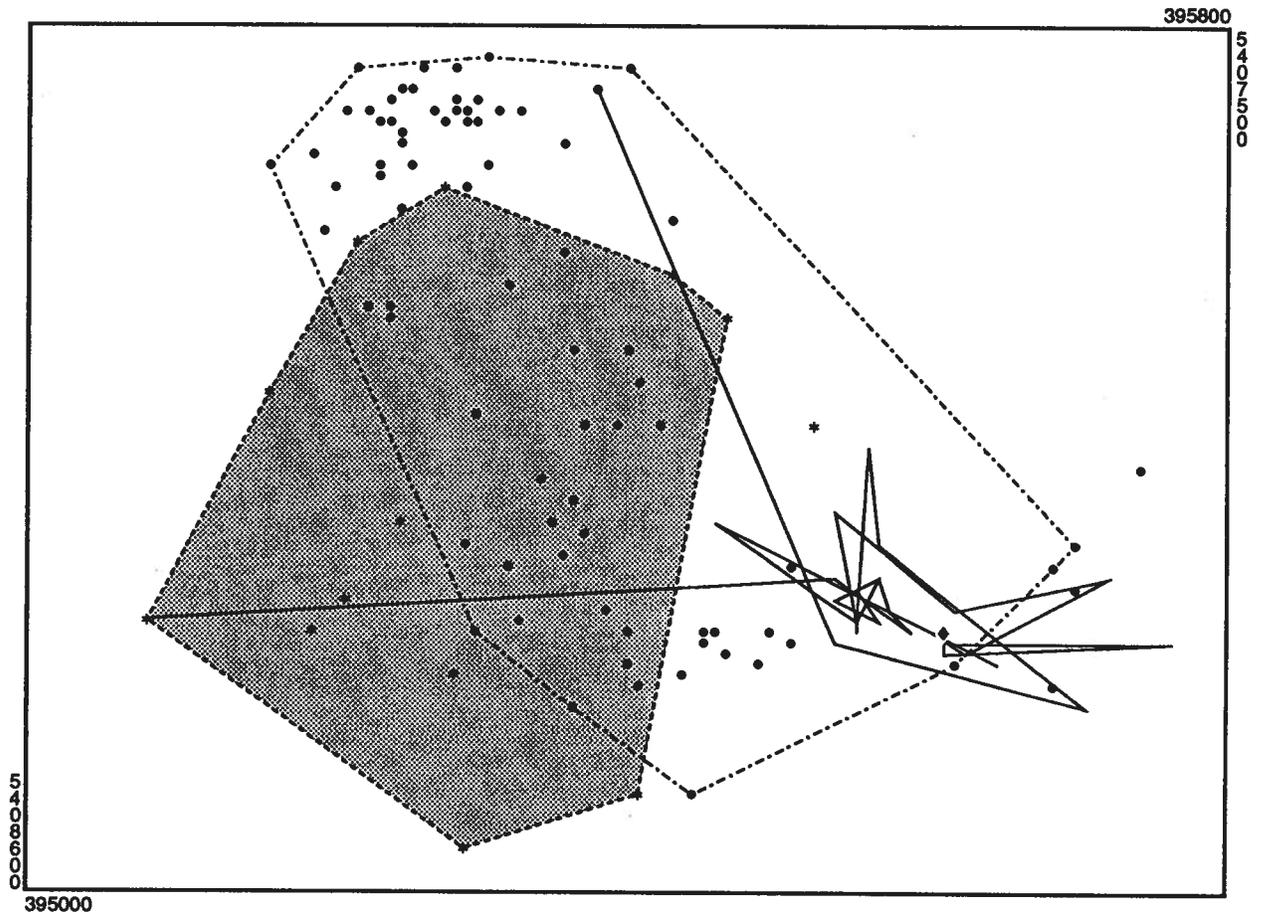


Fig. 3.1. The 1989 fawning movements of study animal 18181.

*Two locations that were out side the typical home range area that occurred in July are not shown. Their UTM coordinates are (393320, 5406590) and (394620, 5408850).

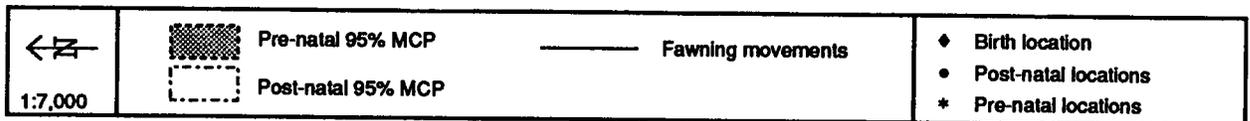
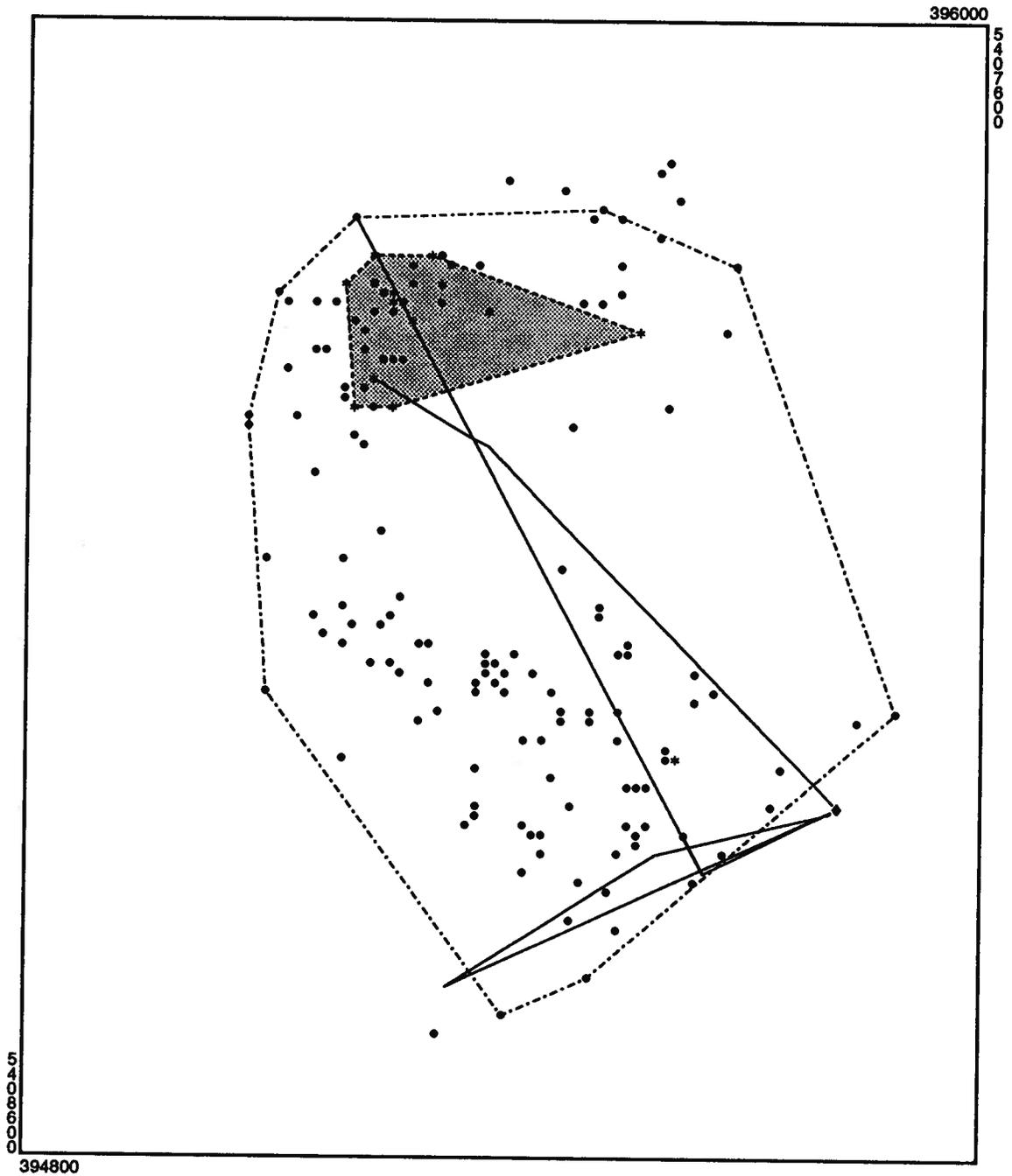


Fig. 3.2. The 1990 fawning movements of study animal 18181.

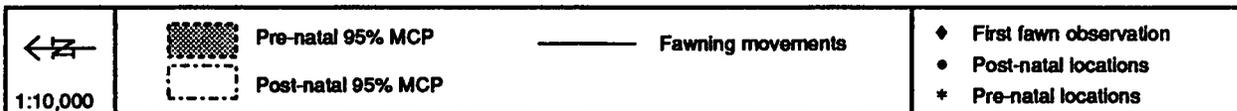
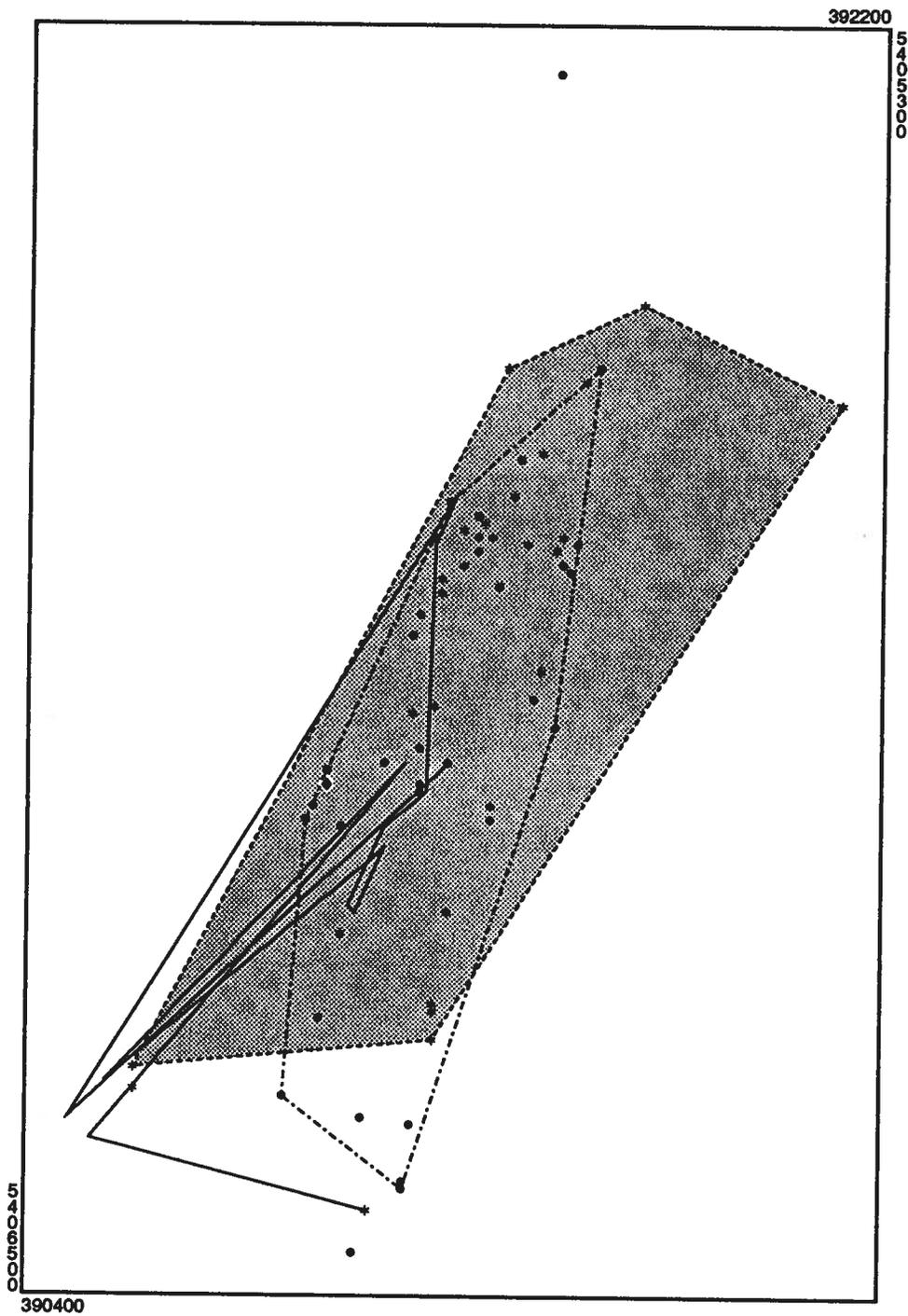


Fig. 3.3. The 1990 fawning movements of study animal 13201.

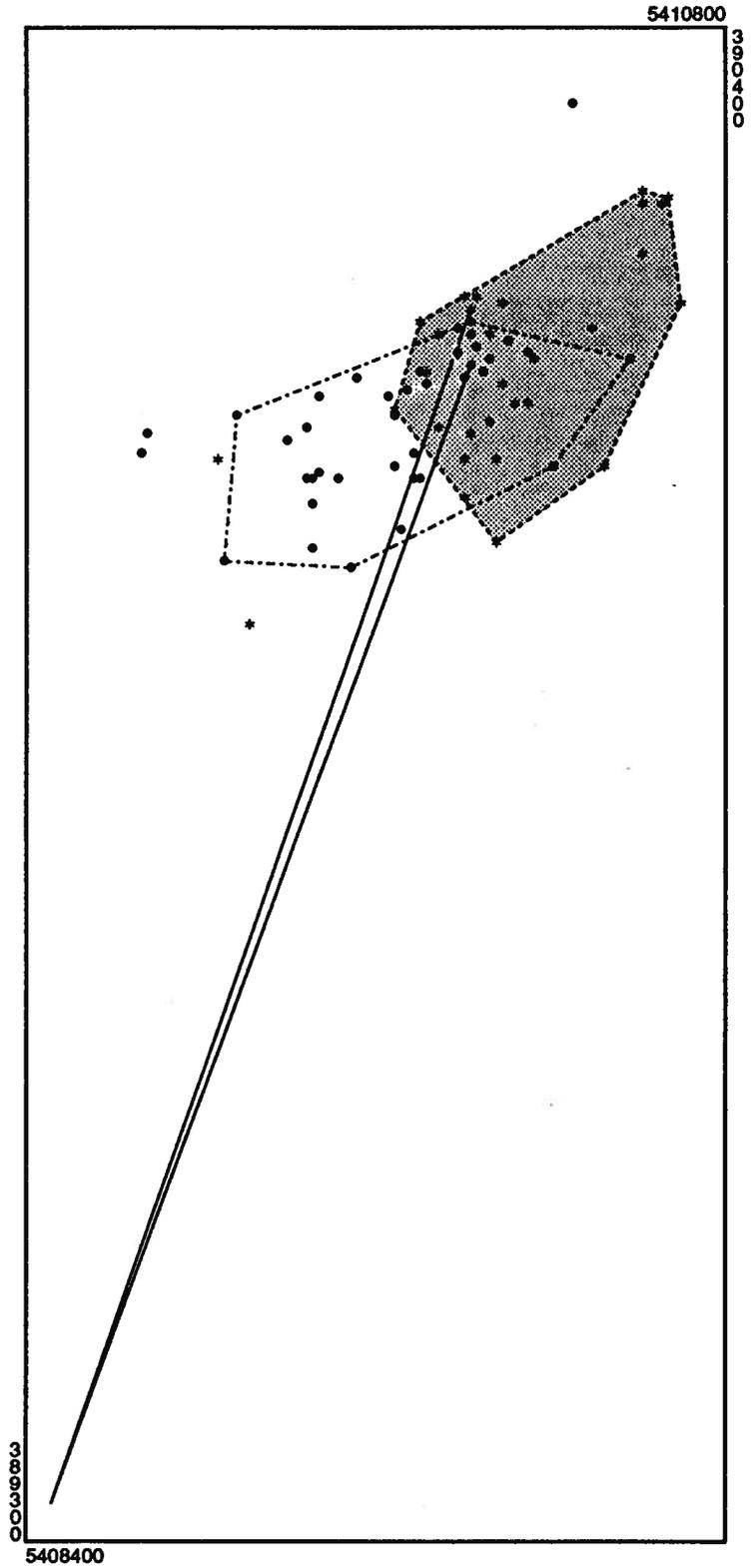


Fig. 3.4. The 1991 fawning movements of study animal 17991.

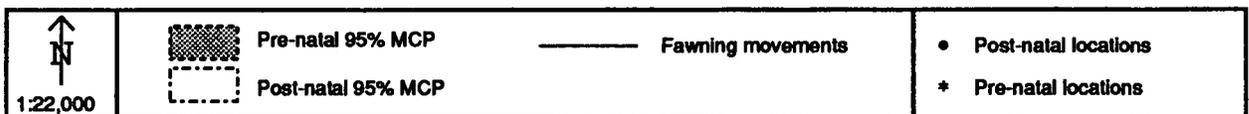
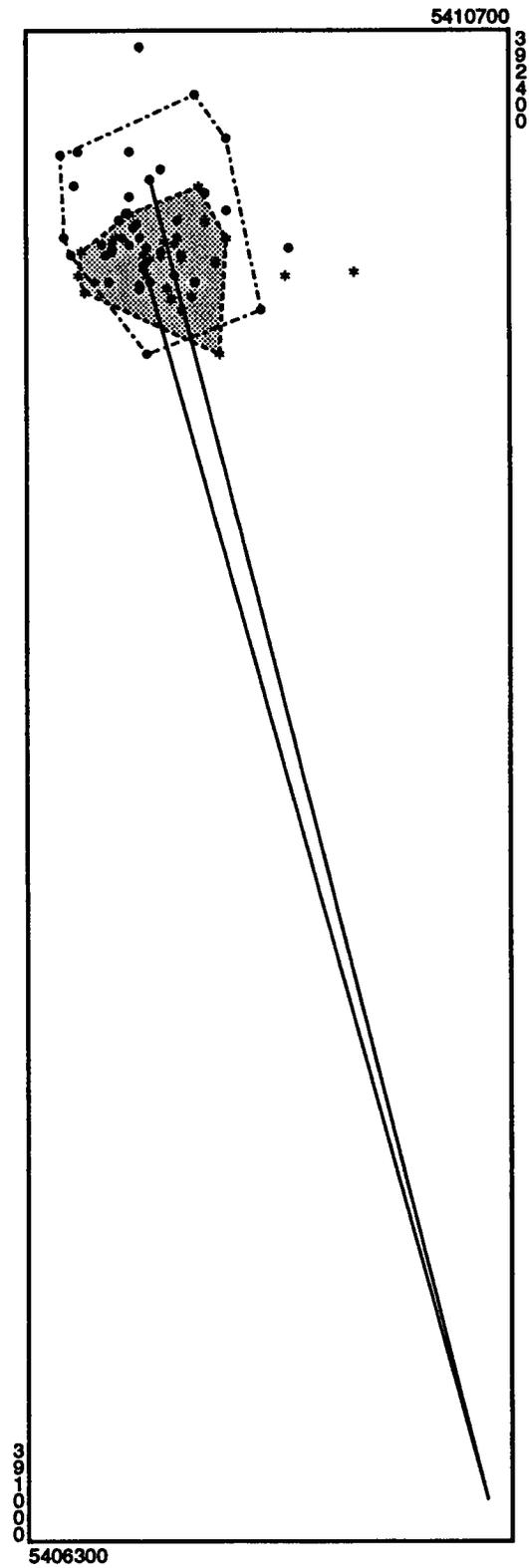


Fig. 3.5. The 1991 fawning movements of study animal 12801.

Home Range Size

Home range sizes (100%) for each study animal within all time periods are summarized in Table 3.1. The size of each deer's total summer range (occupied from May 8 to September 30) is also given. The mean home range size for each period is also presented graphically in Fig. 3.6.

Table 3.1. Home range size (hectares) by time period.

Deer ID	Total Summer Home Range	n	PtNP	n	FP	n	PoNP1	n	PoNP2	n	PoNP3	n	PoNP3 adjusted	n
12801	140.88	55	6.08	12	67.28	9	11.93	12	15.78	12	20.60	10	15.81	9
13201	77.50	57	21.64	11	25.53	13	18.17	12	16.87	12	22.31	9	51.46	13
13891	32.32	54	7.54	12	14.64	10	5.85	11	14.28	11	9.27	10	9.27	10
15181	73.54	51	4.74	12	16.11	6	16.53	12	16.52	11	34.85	10	10.93	6
16781	34.92	55	17.16	11	12.34	12	16.10	11	13.82	12	17.33	9	17.46	12
17581	19.36	57	3.08	13	7.14	12	4.80	11	10.61	12	6.52	9	6.52	12
17701	28.42	59	12.65	12	12.53	12	8.44	12	7.75	12	10.76	11	10.76	12
17912	30.33	59	11.73	12	12.06	13	6.37	12	12.15	12	13.28	10	13.28	13
17991	86.58	57	16.91	11	49.82	12	5.47	12	10.47	12	13.22	10	15.11	12
18181	28.02	59	12.21	12	17.19	13	13.25	12	10.25	12	3.89	10	4.41	13
mean	55.19	56.3	11.37	11.8	23.46	11.2	10.69	11.7	12.85	11.8	15.13	9.8	15.50	11.2
SE	12.23		1.91		6.17		1.62		0.97		2.81		4.20	

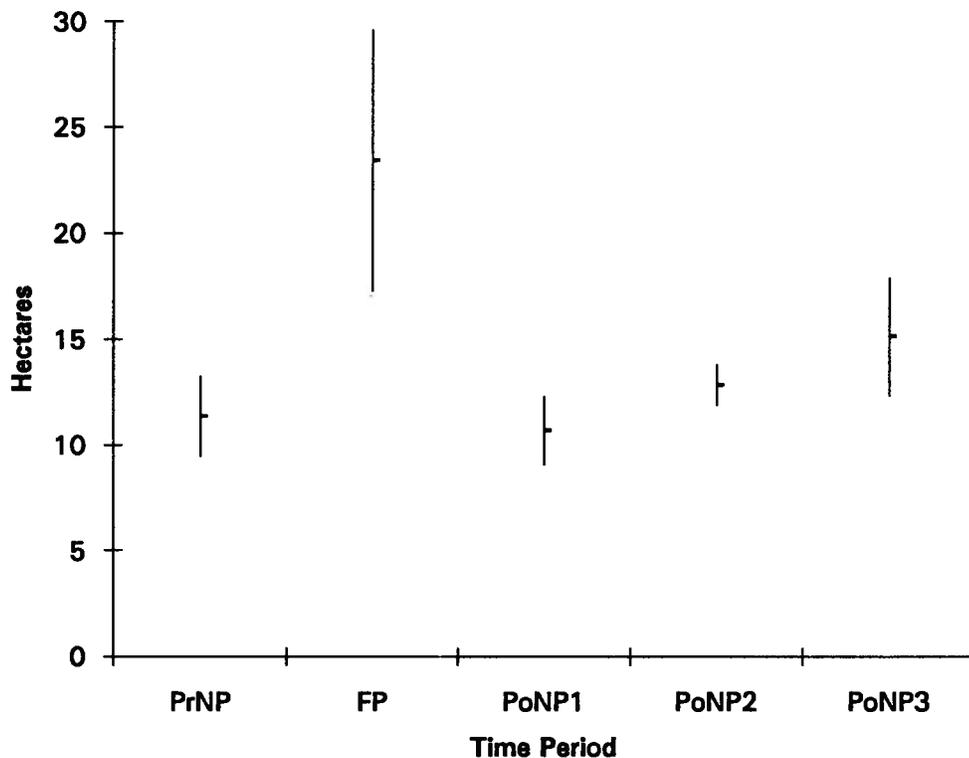


Figure 3.6. Mean summer home range size and standard error for 10 female deer in five periods during the summer of 1991.

The distribution of the home range size data set (PrNP, FP, PoNP1, PoNP2 and PoNP3 combined) was not normal (*Sharpiro-Wilk normality test*, $W=0.71$, $p \leq 0.001$ [SAS 1988]). A natural log ($\ln x$) transformation improved the value of the W-statistic to 0.97 ($p=0.32$).

Home range sizes during the FP were compared to those of the other time periods with a paired difference test. The test results of the transformed ($\ln x$) data are summarized in Table 3.2.

Table 3.2. Paired difference test comparison of home range size during the fawning period versus all other periods.

Comparison	FP-PrNP	FP-PoNP1	FP-PoNP2	FP-PoNP3	FP-PoNP3 adjusted
Mean Difference in Hectares	12.1	12.8	10.6	8.3	8.0
t-value	2.54	2.71	1.89	1.53	1.70
Probability (p-value)	0.016	0.012	0.046	0.080	0.061

Home range size was greater in the FP than in any other period. When the FP was compared to the PrNP, the PoNP1 and the PoNP2 the t-test provided strong evidence against the null hypothesis. When the FP was compared to the PoNP3 and the PoNP3-adjusted the t-test provided moderate evidence against the null hypothesis.

A migration in the FP away from an early-spring range might explain the large home ranges in this period. The mean distance between the PrNP and the PoNP1 home range centers however, was determined to be only 162 m (SE=30). This small shift was less than the 190 m mean difference (SE=30) between the home range centers of the PoNP1 and PoNP3. Shifts in home range location therefore, were not larger in the early portion of the summer than in the late portion and they can not be used to explain the larger home ranges during the FP.

Home range sizes in the immediate post-fawning period (PoNP1) were compared to those of other time periods with a paired difference test. The results are summarized in Table 3.3.

Table 3.3. Paired difference test comparison of home range size during the immediate post-fawning period versus all other summer periods.

Comparison	PrNP-PoNP1	FP-PoNP1	PoNP2-PoNP1	PoNP3-PoNP1
Mean Difference in Hectares	0.68	12.8	2.2	4.4
t value	0.088	2.71	1.95	1.58
Probability (p-value)	0.466	0.012	0.042	0.075

Home range size was smaller in the PoNP1 than in all other time periods except the PrNP. When the PoNP1 was compared to the FP and the PoNP2 the t-test provided strong evidence against the null hypothesis. When the PoNP1 was compared to the PoNP3 the t-test provided moderate evidence against the null hypothesis.

Discussion

Habitat Use

The hider strategy predicts that mother and offspring are together for only brief periods. A fawning-related increase in the use of any habitat type therefore, would be difficult to detect because the relationship between the sites occupied by the dams and those of their offspring is weak.

It is probable however, that a relationship between clearcuts and fawning habitats did not exist. Forest canopy and shrub layer heterogeneity could have allowed the parturient study animals to meet their cover requirements within forested habitats. Although ground-cover was usually

less dense in the forested habitats, many pockets of dense ground cover were present along creeks, slides, wet areas, and in other areas of low stand density. Depending on the site conditions, shrubs, such as red huckleberry, devil's club (*Oplopanox horridus* (Smith) Miq.) and salal (*Gaultheria shallon* Pursh), often thrive within second- and old-growth forests.

Area of Use

Because the locations of fawning sites were rarely determined, the anecdotal evidence presented serves only to illustrate the development of the alternate hypothesis (H₂); 'home range size of maternal black-tailed deer is larger during the fawning period than in other summer periods'.

Average home range size was larger in the fawning period than in all other periods. Increases in home range size during the FP were caused by increases in the magnitude and/or rate of movements to the peripheries of the home ranges. Similar peripheral movements of parturient black-tailed deer and mule deer were found by Livezey (1991) and Riley and Dood (1984) respectively. Livezey reported that "three deer (of 16) fawned in areas that were at least 150 m (range 150-450) higher in elevation than the maximum elevation of their ranges during the rest of the year". Riley and Dood stated that "no relationship was evident between the point of capture and a fawn's summer home range". They found that 37% of the fawns were never reobserved in their area of capture and that an additional 22% were captured on the periphery of their summer range. My findings, and those of the others, support the idea that sites on the periphery of the dam's home range are used for fawning. This behavior conforms to the 'hider strategy' model. Hiders are known to ingest the placenta and to remove their young from the birth site to prevent predators from using olfactory cues to detect their young. If black-tailed deer were to give birth within their core areas of

use, they would be forced to remove their fawns from the habitats they most prefer. By giving birth on the periphery of their home ranges, female black-tailed deer avoid contaminating favorite areas and are able to move back into them immediately after parturition.

It could be argued that core areas are avoided during fawning because they are already laden with the scent of deer. This is not a likely explanation for two reasons. First, on Vancouver Island, black-tailed deer are ubiquitous and their densities are usually high. By moving outside their core areas to give birth, it would be difficult not to enter another deer's core area. The known birth sites of animal 18181 were within an area that was heavily used by animals 17912 and 17701. Thus the dam's movements did not remove her from areas with deer scent. Second, the study animals often continued to frequent their core areas during the fawning period and they usually brought their fawns into their core areas a few days after their peripheral movement(s). It is doubtful therefore, that scent dissipation within the core area would have occurred before the return of the dam and offspring.

Average home range size was lower in the immediate post fawning period (PoNP1) than in all other periods except the pre-natal period (PrNP). Miller (1974) also found that "maternal black-tailed deer reduce the sizes of their home ranges during the post fawning period". This behavior is also consistent with the hider strategy. During the period immediately after fawning, the mother must remain close to her fawns which are sedentary. Large distances between foraging sites and the fawn's hiding place would increase the dam's travel costs and risk of predation. By minimizing this distance, energy savings may be transferred to the fawns or used by the female. A reduction in travel would also allow the dam to remain motionless

and vigilant for greater periods and thereby reduce predation risks.

Chapter Two suggested that in the earlier portions of the summer, habitat use was more concentrated in Submontane habitats where green-up occurred first. It is predictable therefore, that home range size should also be small during the pre-natal period (PrNP).

Chapter Four: Summary and Conclusions

Changes in Habitat Use in Relation to Forage Quality

The habitat use patterns of 13 radio collared black-tailed deer were investigated in the summers of 1990 (June 1-October 31) and 1991 (April 1-October 31). Because the location gathering in 1990 started late, these data were not statistically tested. They were, however, used to substantiate the 1991 findings. The summers were subdivided into time periods and the percent use of various habitat types were compared. The use of seral stage, biogeoclimatic ecosystem variants, elevation and aspect within the time periods was examined.

The data sets of the nine study animals that had clearcut habitats within their summer ranges were pooled. Their use of clearcuts was highest in the same period that Rochelle (1980) found fireweed to receive its highest use. Percent use of clearcuts was 67.9% in April/May/June, 78.2% in July/August and 69.2% in September/October. Given that fireweed is an early successional species and that it is the black-tailed deer's most important summer forage species (Rochelle 1980), the relationship is not surprising. I suggest that the availability of fireweed was not higher in the July/August period than in the other periods. Increased clearcut use therefore, was probably in response to the nutritional values (digestibility and caloric) of fireweed which peak in August.

The use of Montane variants (BEC) was higher in the Later portions of the summer. The pooled data set for the eight deer that had Montane habitats within their summer range revealed that the percent use of Montane was 14.5% in April/May, 22.6% in June/July and 25.8% August/September. The use of Montane habitats therefore, was lowest when

the forage species within Submontane were more phenologically advanced and of greater nutritional value. As the summer progressed and as forage phenology within the Montane habitats advanced, the use of Montane increased.

Although the distribution of Montane variants over the landscape is primarily a function of elevation and aspect, changes in the use of the latter two habitat variables were not detected. With respect to elevation, the lack of a significant difference may have been an artifact of sample size.

Changes in Habitat use During the Fawning Season

During the summer of 1991, ten adult females were monitored through five periods producing a total of 563 locations. The summer was divided into the following 29-day periods: the pre-natal period (PrNP), May 8 to June 5; the fawning period (FP), June 6 to July 4; and three post-natal periods, (PoNP1) July 5 to August 2, (PoNP2) August 3 to September 1, and (PoNP3) September 2 to September 30.

Unlike other researchers who have found relationships between natal sites and early seral stages, the use of clearcut habitats did not change during the fawning period. Forest canopy and shrub layer heterogeneity could have allowed the parturient study animals to meet their cover requirements within forested habitats. Many pockets of dense ground cover were present in areas of low stand density and many species of shrubs, such as red huckleberry, devil's club and salal, often thrive in the second and old-growth forests of coastal British Columbia.

Home range size was greater in the fawning period than in any other period. Increases in home range size during the fawning period were caused by increases in the magnitude and/or rate of movements to the peripheries of the home ranges. This finding supports the idea that sites on the periphery

of the dam's home range are used for fawning and is consistent with the 'hider strategy' model. Hiders are known to remove their young from the birth site to prevent predators from using olfactory cues to detect their young. If black-tailed deer were to give birth within their core areas of use, they would be forced to remove their fawns from the habitats they most prefer.

Home range size was lower in the immediate post fawning period (PoNP1) than in all other periods except the pre-natal period. This behavior is also consistent with the hider strategy. During the period immediately after fawning, the mother must remain close to her fawns which are sedentary. Large distances between foraging sites and the fawn's hiding place would increase the dam's travel costs and risk of predation.

In the early portion of the summer, habitat use was more concentrated in the Submontane where green-up occurs first. The home range sizes in the pre-natal period therefore, should also be small.

Recommendations and Implications

- 1) In the logged watersheds of coastal British Columbia fireweed and other early successional species are important summer forage species for black-tailed deer. To ensure that black-tailed deer have access to high quality forage throughout the summer, shifts in habitat use that occur within the summer must be recognized by forest managers. A proportion of early successional habitats within both the Submontane and Montane variants should be maintained throughout the rotation of the forest.
- 2) My findings, and those of others, suggest that black-tailed deer prefer to fawn on the periphery of, or outside of, their typical home ranges. Researchers should consider this when interpreting dispersal results that are based on neonate capture and adult return locations only. Such results

could be biased in favor of dispersal if the scale of fawning movements is not taken into account.

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